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ORLEN Unipetrol RPA s.r.o. (without branches)

BASIC REQUIREMENTS FOR PROCESSING OF HAZOP STUDY

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List of Changes

Change No.	Page No.		Subject of the Change	Valid from	Approved by (position, signature)
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Notice: The change management of this document is carried out according to Directive 821.

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1 Purpose

This document serves to determine the minimum mandatory requirements for the planning and implementation of safety and operability studies, abbreviated as the HAZOP study, of the listed companies. It also lists the mandatory parts and appendices of the study. The document serves as a basis for Assignment of the study and introduces the participants to the methodology of the HAZOP study. This document does not replace the ČSN EN 61882 standard in the latest valid edition, but only provides clarification for the correct study assignment in accordance with the needs and requirements of the Company.

The document defines the basic differences in the preparation of studies for investment projects, for the equipment in operation and for the revision of the study. It determines the mandatory basic definition of the aim of the study and the Assignment of the study, which is one of the basic preconditions for obtaining a quality output. It is important to realise that in connection with the subject of the study, it is appropriate to extend the Assignment beyond the minimum requirements listed below. The document also prescribes the minimum composition of the work team and the minimum conditions for conducting the study. It offers possible basic properties and guide words for determining deviations for steady operation, start-ups and shut-downs of the equipment. It prescribes how to proceed in evaluating the loss of auxiliary mediums (utilities) during operation. It specifies the mandatory parts of the Final Report, worksheets and the minimal structure of the record. It defines the basic rules for the use of the risk assessment matrix and the evaluation of the recommendations that will result from the study after its completion.

Requirements for follow-up studies may arise from the HAZOP study.

2 Scope of Validity

The document is valid for the following designated companies / spin-off plants:

- ☑ ORLEN Unipetrol RPA s.r.o.
- ☐ BENZINA, odštěpný závod
- ☐ POLYMER INSTITUTE BRNO, odštěpný závod

The document is also binding on the employees of external organisations, for whom the document is available on the Internet ORLEN Unipetrol RPA s.r.o.

3 Terms, Definitions and Abbreviations

BO	Business Owner
Bow-tie	One of the risk assessment techniques
ČSN EN 61882:2016	Czech technical standard – Hazard and Operability Study (HAZOP study). It contains processing instructions.
Check list	One of the risk assessment techniques
Recommendation	A text with any specific or general suggestions for improving the safety and operability (reliability of operation) of the equipment that the team wishes to communicate to the responsible Company manager.
Contractor	An individual or legal person who is in a commercial or civil relationship with the Company and, as a contracting party, provides or is obliged to provide contractual (or statutory) performance for the Company.
ETA	Event Tree Analysis – One of the risk assessment techniques
FMEA	Failure Mode and Effect Analysis – One of the risk assessment techniques
HAZOP	Hazard and Operability

HAZOP team	The team designated to conduct the study. It is defined in the Assignment. These persons have the knowledges about evaluated unit under study. It provides data for the study.
Accident prevention	A set of policies, measures and means aimed at preventing undesirable incidents (to prevent a major accident) and, if they occur, to eliminate them and minimise their impact.
Severity	The severity of the impact quantified within the range defined by the severity table in Appendix A2 as well as possible categories for risk classification using the risk matrix.
LOPA	Layers of Protection Analysis – One of the risk assessment techniques
Consequence	A text set out for each cause separately, describing the worst realistic impact of the cause described
Deviation	Instructional text for a systematic and clear elaboration of the study. A definite combination of a property, a guide word (and an element) for which the causes are then determined. Each deviation can have an unlimited number of separate causes.
OPBE	Process Safety Department
P&ID	Process and Instrumentation Diagram.
PBM	Project Business Manager – Person responsible for monitoring the implementation Assignment of the HAZOP study for investments where HAZOP is required.
PEFS	Process Engineering Flow Scheme
PEM	Project Executive Manager – The responsible person defined in the assignment for investment projects and responsible for monitoring and supervision during the preparation and implementation of the HAZOP during investments (compliance with Assignment of the HAZOP study).
Utility medium	e.g. instrument / process air, heating system / heating steam, purge / process nitrogen, circuit water, fire water, coolant, lubricant, sealant, activated carbon, sorbent.
Cause	A text explaining the reason of the deviation from the studied condition. The knowledge and experience of the team is key to maintaining the purpose of the study – to increase the safety and operability of the assessed unit. Typically, only one cause of failure at a time is considered during describing of the cause and associated effects. Multiple failures may be considered on a case-by-case basis, if it is important to maintain the purpose of the study. It strongly depends on the experience with the assessed system and the knowledge of the team.
PSMS	Process Safety Management System

Reduced risk (RR)	Indicative data set by the team, generated by classification using a risk matrix. The team determines the data for defined consequences for each cause separately. In making the determination, the team takes into account all existing measures to minimise the impact. At the same time, the team takes into account the expected reliability of existing measures based on the team's knowledge and statistical data.
Company	ORLEN Unipetrol RPA s.r.o.
HAZOP study	Hazard And Operability Study
Safeguards	Existing safeguards are listed after the classification of the raw risks. This is any type of specific systematic protection that prevents the occurrence of an impact or allows the impact to be identified and minimized in time. (Existing safeguards are not basic general preconditions for the operation of the equipment, such as professionalism or trained staff).
Risk (R)	Indicative data for quantification of the impact set by the team resulting from the classification using the risk matrix. The raw risk is determined based on defined consequences for each cause separately. Existing measures to minimise the impact are not considered in the determination of the raw risk.
UBEZ	Safety Department
Node	A smaller logical part of the unit that allows a partially independent assessment.
Leader of Work Meetings	Processor. The person who discusses the Assignment of the study, prepares, implements and finalises the study in accordance with the Assignment and in cooperation with the Project Manager and the Client, from the Assignment to the receipt of the output.
Study leader	Term defined by the ČSN EN 61882 standard. The person responsible for the preparation, organisation, implementation and finalisation of the study.
Settlement of recommendations	The step that follows the acceptance of the final version of the HAZOP study. It is carried out by the Company manager responsible for the operation and safety of the assessed unit (Client), or by a specifically appointed representative with appropriate knowledge and authority. In the case of an investment of a representative of the Company and a representative of the designer. Reduced risks are used to speed up orientation during sorting recommendations and prioritization. The settlement of recommendations must be documented and the agreed actions timed.
Template	Internal Company template. A real study that can be used as a background for realization of the HAZOP study for a significantly similar unit.

What-if (SWIFT)	One of the risk assessment techniques “What happens if…”
Assignment of the study	A document compiled during the preparation that demonstrates the consideration of key aspects of the study. The basis is designed by the Client and finalised at the meeting of the Client / Client's representative (Manager), the Project Manager / Company's representative (Study Leader) and the Meeting Manager (Study Developer).
Client	The person in charge of the operation who submits a request for the study. The selected equipment in operation must have a HAZOP study.
Recorder	An associate of the Work Meetings Leader who creates record of the study and is responsible for its structure and comprehensibility in accordance with the Assignment.
Company representative	The responsible person defined in the Assignment. Prepares and coordinates the implementation of the HAZOP study. Checks the creation of Assignment and compliance with the Assignment.
Final Report	A document that summarises all the outputs of the study. In addition to worksheets, it is crucial for the use and revision of the HAZOP study.
Serious accident	An extraordinary, partially or completely uncontrollable, time and space-limited incident, in particular a serious leakage of a hazardous substance, fire or explosion which has occurred or is imminent in connection with the use of a facility, leading to serious danger or serious impact to human and animal life and health, the environment or property and involving one or more hazardous substances.

4 Hazard and Operability Study (HAZOP)

The HAZOP study serves to determine the safety risks associated with the operation of an equipment, as well as the risks leading to the limitation of operability. The HAZOP study is used to document the risk assessment in relation to the existing unit. It is possible to inspect the unit at the design stage, as well as the equipment in operation. Appropriate documentation always need to be used.

The HAZOP Studies are one of the documents demonstrating the implementation of major accidents prevention. Furthermore, the Studies are a valuable basis for familiarising employees with operational risks, and outputs can be used as a basis for initiating and defending investment projects. The HAZOP Studies are the basis for accident investigations, audits of owners and reinsurers (insurance companies). The value of the study for further use depends on the quality of the recorded data, completeness and clarity of the output.

4.1 Specifics of the HAZOP Study Implementation

The required HAZOP study have to meet the requirements of the latest edition of the ČSN EN 61882 standard, including the preparation of the study described in the standard (clauses 4.3.1; 4.3.2; 6.3.1).

The HAZOP study has a large number of uses in many sectors. At the same time, it is always demanding in terms of finances, human resources and time. To obtain a quality output, the following must be observed. In general, the objectives/scope of the HAZOP study and the roles/responsibilities of the team need to be defined as precisely as possible. Roles and responsibilities must correspond to the realistic capabilities of the nominated working group

members within the Company. During the development, it is necessary to strive for a simple, clear and understandable output that allows further use of the study and future revisions.

The HAZOP study can be used to assess almost any proposed procedure and project. Before beginning of Assignment definition, it is always necessary to consider whether the HAZOP study is appropriate and required. Other safety studies can also be used for risk assessment, which can fully replace the HAZOP in justified cases. These include the following: Check-list, What-If, FMEA, ETA, LOPA, Bow-tie.

4.1.1 The HAZOP must be performed if

1) The investment action results in the creation of, or a change to, an equipment with a source of risk of a major accident.
2) It is required in the BOD/TZIP phase (Compliance with the Directive 027 "Investment Project Management" or CAPEX Policy), the implementation requirement is set by the PBM and the Client. In BOD/TZIP, it is necessary to state the basic requirements for HAZOP before preparing the team / checking the study Assignment form.
3) The equipment may cause a major accident or is important from the point of view of accident prevention and a HAZOP study has not been performed on it.
4) The equipment is not a source of risk of a major accident, but is crucial for such operation (including units providing auxiliary agents).
5) A change in operating parameters or intensification of operation is being implemented.
6) The revision of the HAZOP study prior to the completion of the investment project must take place if a major change in design has been made during the implementation of the accepted recommendations from the study.
7) The revision of the HAZOP study within the units is performed in the required cycle of 5 years.

4.1.2 Defining the Assignment of the study

1) The Client provides basic technical information for the preparation of the HAZOP study and the Project Manager (PBM) / Company's representative checks that the study is required. They will indicate their names on the Study Assignment Form, see Appendix C. If necessary, they will consult with the OPBE.
2) The Project Manager (PBM) / Company's representative will design the initial draft of the variables of the Assignment and make additions and specification together with the Client.
3) If the study is conducted by an external company, the Assignment (assignment form prior to the specification) is prepared in cooperation with one of the selected HAZOP study leaders and that Contractor is indicated in the contract as a dedicated HAZOP study leader for the project assesment.
4) In accordance with the provision in the contract for the given project, which defines the requirement to prepare the HAZOP study with reference to the Assignment before specification in an appendix, the Project Manager (PEM) / Company's representative will conduct a meeting with the Client / client's representative and the selected Contractor (designer) for the final completion and specification of the Assignment.
5) The nominated team for both the Company and the Contractor will familiarise with the Assignment and the study documentation before the start of the workshop meetings. In case of inaccuracies, the team will discuss with the Leader of Work Meetings (Study Developer) how to resolve them.

Upon completion of the work, the draft must be revised and accepted only if they meet the requirments of the Assignment. Comments will be made by the Company's employees as defined in the Assignment. In case of disputable comments, the decision is up to the persons listed in the heading of the Assignment.

Commenting is not used to redo the study, but to address fundamental shortcomings. It can be a reason for non-acceptance of the output.

4.1.3 HAZOP is usually not performed if:

1) The equipment is not a potential source of risk of a major accident and no such operation is directly dependent on it, or
2) An action is taken on a part of the equipment that is a source of risk of a major accident, but the changed part is not related to this risk, or
3) Only the replacements in kind of the equipment in accordance with technical standards is carried out without changing the mode of operation – for example, the use of better construction material without changing the operating conditions of the equipment (such as temperature, pressure, flow,…) and operating conditions in the related equipment.

5 Realization of HAZOP Study

5.1 Conditions for the realization of HAZOP Study

The requirement for a HAZOP study, including how it will be conducted and the determination of responsibility for the costs resulting on actions related with the recommendations, must be included in the contract with the equipment supplier. The Assignment must be attached to the contract if the HAZOP is required. Specification of the Assignment (Assignment Form) must be carried out as described in this Directive. Final specification is made after the contract with the project Contractor is signed when the necessary documents are available, but well in advance of the workshop meetings to enable a proper team preparation. At the time of contract signing, there must be a designate (defined in the Assignment) HAZOP study Leader of Work Meetings, who is not associated with the Contractor (designer). Any exceptions must be approved by the Process Safety Department.

The outputs of the HAZOP study must be clear, comprehensible, auditable, usable for revisions and available for various working groups on request. In practice, this means that:

1) The Assignment – goals, scope, expectations, team – must always be clearly defined in writing separately for the study before the study begins. See the form Appendix C.
2) The necessary documentation for the study must be prepared (drawings, operational and technological documentation, technical documentation,…). The study must be performed on the basis of valid documentation. For specific nodes, all documentation actually used to process the node must be indicated.
3) The minimum composition of the working group approved before the start of the study must be respected. If the participation of the working group is not respected, the discussion must be suspended. Before initiating the study, it is necessary to check that human resources are available to conduct the study. There must be a list of members of the working group and proof of attendance in each session. In the Assignment of the study, it is possible to define, in addition to the obligatory members of the work meetings, other specialists who will attend the meeting only for part of the time at the request of the Leader of Work Meetings.
4) The study must contain a summary of basic information about the assessed equipment, about design and operational parameters - that are essential for the performance of the study. If the output is a single file, all data, including the Final Report, can be presented in one document while maintaining the structure and purpose of the Final Report. If the study consists of several separate parts, it is necessary to prepare a separate Final Report, which will include a summary of basic information about the project and a list of all appendices to the study.
5) The Leader of Work Meetings have to supervise the realization of the study record in simple and clear terms, explaining all abbreviations used and in a simple consistent structure. The output must be understandable to anyone with general knowledge of the assessed technology (even without participating in the performance of the study).
   In the study – only clear and simple referencing to the identical text can be used. No other reference on the another reference can be made. For clarity and ease of further use, referencing within only one node is allowed.
6) It must be defined in advance in the Assignment, which organisational units/persons will do revision of the pre-final outputs. There must be a written (e-mail) confirmation of agreement to the final version by all reviewers defined in the Assignment. In the case of comments, a record of the settlement of comments must be prepared, which is then one of the appendices to the study. If the agreement of the commentators cannot be reached, an appendix with comments that have not been incorporated should be attached to the outputs, including the reasons for not incorporating them.
7) The OPBE shall be notified by e-mail of the preparation of any HAZOP study with the attached adapted Assignment no later than after the completion of the preparation. In the case of an investment by the Project Manager (PEM), if the OPBE representative is not a member of the project team. After the completion of the study, the accepted final output, including the Assignment of the study and all appendices, must be distributed by the Project Manager (PEM) according to the rules of the Company. At least two electronic versions of the final output must always be submitted: A version editable by common software (e.g. docx, xlsx) and a locked version (e.g. pdf).

5.2 Scope of the Study

When assignment of the study is prepared, the minimum scope of the study must be defined as accurately as possible by the Company representative and the designated Leader of Work Meetings. The Assignment must be a part of the contract with the equipment supplier. The design of the scope of the study is prepared by the Client in cooperation with

the Project Manager and the Leader of Work Meetings. It must meet the requirements of this document and be adapted accordingly to the specifics of the equipment under assessment. The accuracy and clarity of the scope of the study can be commented on by UBEZ.

Subsequently, meetings with the Leader of Work Meetings and the Contractor need to be proceed to finalise the Assignment and add justified additional requirements/conditions.

The study without preparation cannot be accepted. The Assignment must be fill in and optimized. It shall serve as a verifiable study preparation for a revision. Without finalising the variable (highlighted) parts of the Assignment Form with the Leader of Work Meetings, a realistic estimation of the time required for the HAZOP study, the team and the documentation required or the cost of conducting the HAZOP study cannot be expected. Furthermore, it is not possible to effectively manage the performance and control the quality of the output without the Assignment. Problems may arise, including the risk of producing a non-value added output.

The HAZOP can be performed at all stages of the equipment life cycle, including:

a) the design (the greatest importance is usually at the stage when the technological diagrams are completed by the construction contractor),
b) the implementation of changes, including modernisations, renovations, investment projects, etc.,
c) periodic inspections of the condition of the equipment,
d) other situations that may have a significant impact on the process safety.

The HAZOP must take into account normal process conditions and non-standard operating conditions:

a) start-up,
b) shutdown,
c) emergency shutdown
d) other emergency conditions, such as failures of utility media supply (water, nitrogen, steam, electricity, etc.).

Scope of the Assignment can be divided for better understanding.

Auxiliary agents (utilities) failures need to be handled within a steady operational condition for individual nodes. The possibility of a safe shutdown must be checked during an utility media supply failure at least.

Start-up, shutdown or emergency shutdown should be ideally prepared as separate procedural studies of a specific procedure divided into steps. With regard to the high time complexity of procedural studies and variability of procedures, a specific approach to handling non-steady operating conditions needs to be agreed upon during the specification of the Assignment. The aim is to maintain the purpose – to discover hazardous conditions and to improve the possibility of carrying out start-ups and shutdowns with verification of the existing safeguards. The implementation can be accepted within the defined narrowed scope, which is stated in the Assignment and explained in the Final Report. It can be followed up in the revision of the study. Implementation, that cannot be followed up, cannot be accepted.

The basic preconditions for the operation of the equipment – such as professionalism and the existence of a procedure – cannot be considered as existing safeguards for start-ups and shutdowns without checking the procedure and checking that it is followed correctly.

The Assignment Form in Appendix C is used for assignment. The Assignment Form has fixed parts and parts that must be adapted to the requirements of a specific project.

5.2.1 Contents of the Study Assignment Form

The Assignment Form is used to document the Assignment and its preparation. It consists of defined parts. The fixed parts are not highlighted. The parts that always need to be adapted to the project are highlighted in light red, light green and light blue. The colouring is indicative of who should have the necessary information and interest for a clear set-up during preparation. There must always be a meeting to fine-tune the Assignment. This meeting is initiated by the PEM and during the meeting the persons defined in the form header will complete the Form and check the accuracy of the Assignment. The Assignment Form is in Appendix C2. The content of the Assignment Form includes the information contained in the following chapters.

5.2.1.1 Summary information

The Assignment must include information about:

1) who process the study (Client, Contractor, Subcontractor, etc.),

2) what the roles of the working group members are (Study Leader, Recorder, Project Manager,…),
3) the reason for the implementation of the study and basic information about the assessed technology (functions, use, specific risks),
4) definition of the boundaries of the assessed part of the technology and key interfaces, where the studied part of the technology fundamentally influences / is fundamentally influenced by other connected units.

5.2.1.2 Definition of the structure

The following must be set:

1) Determination of used record ("full" or "exception only"). Full record is preferred.
2) Determination of basic properties and guide words. The basic set of properties and guide words must be used systematically for all nodes in the study. In combination with the elements (listed in the node description) it is used to indicate a deviation. The properties and guide words for indicating deviations can vary significantly depend on the type of assessed unit and the operating mode. It is therefore necessary to define them carefully during the Assignment. The Leader of Work Meetings must revise and approve, together with the Company's representatives, a basic set of properties and guide words. If necessary, a change to the set may be made by agreement of the parties involved prior to the beginning of study realization. The additional set of properties and guide words defined during implementation must (if used) be specified in the description of the node for which it was used.
   It is recommended to use the basic combinations listed in Table 1 to set the basic set of properties and guide words.
   In addition to the normal operating condition, including failures of auxiliary agents, HAZOP studies must also process non-standard operating conditions (start-ups, shutdowns, emergency shutdowns).

***Table No. 1**: Recommended basic properties and guide words and examples of resulting deviations*

	Property	Guide word					Example element	Example of a resulting deviation
Continuous operation and steady condition								
1	Pressure	Low/Lower		High/Higher			*Furnace XY*	*Lower pressure furnace XY*
2	Temperature	Low/Lower		High/Higher			*Reactor AB*	*Temperature lower reactor AB*
3	Flow	No/Lower	Higher	Reverse	Other than	Same as	*Agent A*	*Flow the same as agent (A + B)*
4	Level	Higher		Lower/No			*Separator CD*	*Level none separator CD*
5	Composition/Quality	Other than					*Tank EF*	*Composition other than tank EF*
6	Maintenance Risks	No		Late		Other than	*Pipeline xyz*	*Maintenance none pipeline xyz*
Failures of auxiliary agents (utilities) on the edge of the assessed unit								
Water	Electric power	Process air		Inert		Steam	*Exchanger AB*	*Failure Water exchanger AB*
Other operational risks of start-ups, shutdowns and emergency shutdowns								
1	Pressure	Early		Late		Other than	*Pipeline AB*	*Pressure other than pipeline AB*

	Property	Guide word			Example element	Example of a resulting deviation
2	Temperature				*Catalyst D*	*Temperature other than catalyst*
3	Flow				*Route to XY*	*Flow early to XY*
4	Level				*Column GH*	*Level late column GH*
5	Composition				*Reactor JK*	*Composition Reactor JK other than*
Emergency shutdown – for the whole node (large/catastrophic impact according to the matrix, entry for an unacceptable risk)						
1	Emergency shutdown node AB	Too late			*Valve in front of the furnace AB*	*Emergency shutdown AB, too late, valve in front of furnace AB*
Specific combinations for the equipment in operation for the node						
1	Operation	Other than			*Node XY*	*Effects of the equipment age*
2	Operation	Other than			*Node XY*	*Technological changes / Design compliance*
3	Operation	Other than			*Node XY*	*Recorded serious incidents*

Process of start-ups and shutdowns – in principle, there are several HAZOP studies for different stages of equipment operation, for which different documents are often required. The complete processing can be very challenging, as it is necessary to examine the exact procedures and determine the steps of the start-up and shutdown procedures. It is therefore always necessary to carefully set up the Assignment and the supporting documents so that the team is able to carry out the study in the required time and the purpose of the study is not lost. The Leader of Work Meetings must understand the depth of the work required, and engage constructively and actively in the preparation of the Assignment. Within the study, it is required to analyse aspects such as:

- Incorrect route setting (e.g. leaving or placing the blank in the wrong place).
- Closure or opening of the wrong valve that will result in stopping the flow and/or the wrong flow direction and/or deliver the wrong substance to the system.
- Running the process and/or shutting down the process and/or loading phase in the wrong sequence, too fast or too slow or even skipping a step.

For further assistance with preparing the Assignment, a broader list of properties (Table 2) and guide words (Table 3) is provided below.

***Table No. 2**: Properties to identify important characteristics of the analysed system*

Possible properties			
Flow	Time	Frequency	Mixing
Pressure	Components	Viscosity	Addition
Temperature	pH	Voltage	Separation
Level	Speed	Information	Reaction

Operation/action	Drainage/Ventilation	Maintenance	Corrosion
Operating mode	Location	Load	Auxiliary agent (utility)
Electricity	Weather (weather conditions)	Concentration	Density
Release	Integrity	Other	Other (specified by the study team)

***Table No. 3**: Guide words, their meaning and examples of deviations*

Guide word	Deviation type	Meaning	Example of interpretation
NONE, THERE IS NONE OR NO	Negation	Complete negation of the project objective	No part of the intended objective (function) has been reached, e.g. no flow
HIGHER	Quantitative change	Quantitative increase, quantitative plus	Quantitative increase, e.g. higher temperature
LOWER	Quantitative change	Quantitative decrease, quantitative minus	Quantitative decrease, e.g. lower temperature
AND ALSO, AS WELL AS, SIMILARLY	Qualitative change	Qualitative increase, qualitative plus	Impurities are present. Another operation/step is being performed at the same time
PARTIALLY	Qualitative change	Qualitative decrease, qualitative minus	Only something of the intended objective is achieved, e.g. the intended transport of the fluid only occurs partially
REVERSED, REVERSE	Substitution, replacement	The logical opposite of the project objective	This guide word is used, for example, for reversed flow in a pipeline and reverse chemical reaction
DIFFERENT THAN	Substitution, replacement	Complete substitution/replacement	A different result from the original objective was achieved, e.g. the wrong material was transferred
EARLY	Time	With respect to the specified time	Something, e.g. cooling or filtration, occurred relatively early with respect to the specified time
DELAYED	Time	With respect to the specified time	Something, e.g. cooling or filtration, occurred relatively late with respect to the specified time
BEFORE	Order or sequence	Due to order or sequence	Something, e.g. mixing or heating, occurred too early in a sequence
AFTER	Order or sequence	Due to order or sequence	Something, e.g. mixing or heating, occurred too late in a sequence

During non-standard operation, there is usually a maximum but short-term load on the equipment. It is always necessary to consider the expected/monitored time of the operating cycle of the equipment. In the Final Report, it is advisable that realistic estimates of the number of start-ups, shutdowns and emergency shutdowns of the unit under study are given. For a new equipment, it is possible to make an estimation according to the reliability of the units supplying the raw material or taking the (intermediate) product.

In case, that it is not the objective of the study to examine the start-ups / shutdowns / emergency shutdowns in detail, it is recommended to record only the deviations/causes/effects for which unacceptable raw risk (including manual handling) has been identified in these non-standard conditions. The key to implementation is the involvement of the Company's employees who have practical experience with non-standard operating conditions,

associated risks and recorded incidents. If simplifications are adopted in the implementation of the evaluation of the non-standard operating conditions to speed up the study, information on the used simplifications must be provided in the Assignment and the Final Report. However, all required operating conditions must always be realistically reviewed. An assumption must never be made against the purpose and reason for conducting a HAZOP study (e.g. that everything is already set up correctly and therefore nothing can fail).

3) The elements are the equipment in operation being assessed. Relevant elements must be determined with regard to the part of technology under assessment. When larger nodes are defined, specifying the element is crucial for the orientation in the output during subsequent use. Any part of the system that is important for its safety/operability can be defined as an element. The selection of the elements will be made by the Leader of Work meetings when defining the nodes in accordance with the set objective and scope of the study. When designing the elements, the Company's representative – the Client or the person responsible for the operation verify that all elements essential for safety and operability are defined in accordance with the Assignment.
The elements have to be clearly identifiable on the basis of the documentation used. Where there is no direct unique identification of the element under study, a clear reference to the nearest unique element shall be used Example (directly: Column XY, indirectly: fitting output from pantograph tank AB). Examples of elements: Column XY; Compressor AB; Electric motor – CF; Pipeline – abc; node no. n; Distillation column (pyrolysis gasoline),….
For elements, it is always necessary to know and state the design parameters and it is recommended to state the operating parameters.

4) Nodes are smaller parts into which the studied unit is divided. It is necessary to remember – the HAZOP study is a source of information in retrospective examination and follow-up studies. What is not written in the study is not valid / has not been studied. It is therefore necessary that the data obtained are clear, complete and easy to understand. The basic proposal for the splitting of the studied unit into nodes is made by the Leader of Work Meetings. The inspection is performed by a designated team (see Assignment).

   The study must include information on each evaluated node. If the node list format is chosen, this list is part of the Final Report. The node definition have to include basic information about the technology (its parts) and agents needed to perform the assessment of the studied node. The description of each node must include:

   a) The significance of the studied part
   b) Point summary of key information (e.g. counterstream leachate scrubber xy is used to remove n% H_2 S from a gas of composition x, y, z)
   c) List of elements (assessed equipment, agents), information on standard operating conditions of the node equipment (temperature, pressure, flow, etc.) and design parameters of the equipment (pressure, temperature, material dimensions, composition, etc.)
   d) Information about the used agents
   e) List of documentation used to process the node (P& ID/PEFS, operational transcript, etc.)
   f) Boundaries of the studied node
   g) Additional guide words and properties, if defined
   h) See Appendix B for an example of a worksheet

5.2.1.3 Record in a worksheet

1) Deviation is a combination of a property, a guide word (and an element). It serves as a guide phrase to determine the cause. To obtain all deviations, a systematic matrix combination of properties, guide words and elements is performed.
2) The cause is determined for defined deviations. There may be several causes for a deviation. In this case, each cause must always be recorded separately (separate cell, entry…) and the rest of the entry must be written separately.
   If there is no cause for a deviation, in is necessary to proceed in accordance with the approved type of entry. In the case of only exception entry, this entry is omitted. In the case of a full entry, indicate the reasons: N/A.
3) The consequences are specific to each cause. The worst realistic consequence corresponding to the described cause are always given without considering any existing mitigation safeguards.
   In the case of a small number and understandable consequences, it is possible to write all the effects in one cell/line of the record and then assess this small group together. In the case of a larger number of consequences, or consequences that are significantly different (for example, in two remote places that cannot be considered simultaneously), it is better to break down the effects into several cells and then record the rest of record separately. The key is to maintain the clarity of the output, not to underestimate the consequences or not to omit the existing safeguards due to the accumulation of effects in one cell.

In a full entry, if the identified cause does not have significant safety or operability implications, N/A can be entered. In the case of an exception entry, no entry shall be made for the cause without effects.

4) The risk matrix must be used for an indicative quantification of all consequences (see Appendix A). Two classifications shall be made. For Risks, i.e. risks for which the existing safeguards are not considered and for reduced risks, i.e. risks that remain after the described safeguards. The frequency of an consequences (cause/deviation) and the Severity of consequences must be determined during classification.

   There are five categories (Cat.) for quantifying the Severity of the consequences. The classification of unmitigated Risks must be done for at least one category with the worst estimated consequences as described. Where an incident has unacceptable consequences in multiple categories that require significantly different risk mitigation measures, it is recommended that the classification be made for multiple categories and the reduced risks be examined as well. Multi-category classification is also needed if the effects described are in different parts of the system under assessment that cannot be assessed together.

   Reduced risks (RR) are determined after describing all relevant existing safeguards to reduce the risks associated with the cause and the effects described. The determination assumes that all measures listed are working, taking into account their reliability (e.g. using statistical data or team experience.) Reduced risks show how the existing safeguards based on the team's knowledge reduce the risks of cause and effect of the consequences.
   As this is only a team estimate based on the effects described and the existing safeguards, higher frequency (F) and more severe consequences (C) of an incident should always be considered when in doubt.

   The classification data are used for further work with the study outputs. It should be emphasised that the purpose of using the matrix is an **indicative assessment of the whole working group** to quickly identify key risks. The classification only has added value if it is reasonable and consistent. The immediate use of the identified reduced risks is in classifying the recommendations from the study and setting priorities for their implementation.
   The use of the matrix in the HAZOP study does not serve to replace seemingly similar but differently defined follow-up studies such as SIL/SIF or LOPA.

5) Existing safeguards reduce the risk of cause and effect. All relevant existing safeguards, both active and passive (foam tanks, fire-fighting system, detection systems, shutdown systems, safety devices, combustion unit, sumps, etc.) must be listed in the study. Once the existing safeguards have been described, the reduced risk (RR) needs to be determined taking into account all existing safeguards. The classification shall be based on the previously determined Risks and the existing safeguards described and shall take into account the reliability/relevance of those existing safeguards.

6) Recommendations shall be designed clearly and unambiguously. Recommendations can be defined by the work group for any cause/effect and are intended to improve the safety and reliability of the equipment. They must always be defined when unacceptable reduced risks are identified (TNA, NA according to the matrix). Recommendations must then be designed to mitigate risks to an acceptable level. If the team does not have sufficient knowledge to propose a specific recommendation for action to achieve the necessary risk reduction, it may propose a general recommendation (e.g. a follow-up study, a design review,…) or bring in other specialists to define a more precise recommendation. The specific action will then be determined when sorting the recommendations.

5.3 Determining the structure of the Work Group and the Responsibilities of the Study Participants

The correct definition of the team directly determines the quality of the output. Each member of the team should have a defined role and the team must not be too small or too large to maintain the efficiency of the process. According to the ČSN EN 61882 standard, the following team should participate in the HAZOP study:

- Project Manager,
- Study Leader,
- Recorder,
- Designer (for investment),
- User,
- Experts,
- Maintenance worker.

To align with the internal requirements, i.e. the PSMS and the structure of the Company, a specification is required. The participation of at least the following persons is mandatory for the performance of the study:

- Study Leader,

- Recorder,
- competent production/operation employee (foreman/operator),
- production technologist/engineer.

Beyond the minimum mandatory team, the remaining team members need to be defined so that all necessary specialisations are represented with respect to the studied part of the technology. Use the form in Appendix C to document the splitting of roles and responsibilities for realization of the study.

The role of the Manager

The role of Manager as defined in the ČSN EN 61882 standard belongs to the Client of the study (see Table No. 4). In practice, this role may be divided between several persons in the Company, where their cooperation is required for the implementation of the study.

***Table No. 4**: The role of the owner of the assessed technology*

Position Manager according to the ČSN EN 61882 standard	Role (activities)	Responsibility
Study Client / technology owner / client representative	- Assign the study and basic information - Establish an indicative scope, boundaries of the study, expectations, objectives and minimal conditions for fulfilment - Propose core team members	- Assign the study and collaborate to finalise the Assignment - Provide an operations representative for the project team - Provide study documentation (for the existing equipment) - Familiarise yourself with the data for the study (for investments) - Review the proposed splitting of the study into nodes and the choice of elements - Categorise the recommendations from the study and determine which will be implemented with a deadline and a responsible person. For those not implemented, provide reasons. (For the existing equipment) - Categorise in cooperation with the representative of the designer the recommendations from the study and determine which will be implemented. For those not implemented, provide reasons. (For investments) - Monitor the implementation of recommendations

The Client may designate a representative from his/her organisational unit to carry out his/her responsibilities and this person is listed in the Assignment.

Prior to the start of the study, communication between the Company's representatives and the Contractor must take place to specify the Assignment of the study.

The role of the Study Leader

To apply the standard, it is necessary to be well aware of the role of the Study Leader – see Table No. 5. This role is key to the realization of a meaningful study and at the same time has maximum authority and responsibilities in the preparation, implementation and finalisation of outputs. Therefore, when using the HAZOP methodology, it is usually recommended that this role be assigned to regular staff members whose responsibilities continue beyond the completion of the study. The role of the Leader is not to provide information on the functioning of the assessed unit, but to prepare and coordinate the conduct of the study and the creation of the record, for which he/she obtains information from the members of the work group through appropriate systematic questions. The Leader creates the conditions for the study.

For the application of the ČSN EN 61882: 2016 standard when using an external Contractor for the implementation of a HAZOP study in the Company, the following splitting of duties, authorities and responsibilities of the Study Leader between a clearly defined Company's representative and the Leader of Work Meetings (Contractor's representative) must be observed.

The Company's representative (usually PEM for investment projects) has an important role mainly in the preparation of the Assignment of the study and in monitoring compliance with the agreed conditions.

The Leader of Work Meetings must be involved in the finalisation of the Assignment, he/she carries out the preparation and implementation of the study and finalisation of the output. Roles and responsibilities are then divided as follows.

***Table No. 5**: The role and responsibilities of the Study Leader*

Position Study Leader according to the ČSN standard	Role (activities)	Responsibilities
Project Manager (Company's representative)	- Prepare the conditions for the realization of the study by the Company - Suggest the basic organisation of the study (location, necessary equipment, refreshments, responsibility for its preparation…) - Facilitate the communication between stakeholders involved in the planning of the study - Handover the draft Assignment for the study - Distribute materials for the preparation to the team (in accordance with the fine-tuned Assignment) - Project coordination / study contractor management (compliance with the Assignment) - Quality monitoring and compliance with the Assignment	- Organise a meeting (Client, Leader of Work Meetings, Project Manager (Company's representative)) to tailor the Assignment to the exact project and set of organization - Monitor the system of the study implementation mechanism (participate in the development and specification of the Assignment Form and check the compliance with the Assignment) - Do random controls of the progress of work meetings (compliance with the Assignment – form, team, conditions for the implementation of the study) - In case of non-compliance with the basic specified conditions of the implementation according to the Assignment, do not begin or suspend the realization of the HAZOP study until the correction - Accept only the output that is in accordance with the Assignment - Responsibility for the quality of the work received from the Leader of Work Meetings within the scope of the described role – compliance of the output with the Assignment - Distribute the approved final version upon completion
Leader of Work Meetings (Contractor's representative)	- Prepare the realization of the study - Cooperation with the Project Manager / Company's representative - Propose and discuss the specification of the Assignment – supplement the composition of the team, specify the composition and size of the team and review the responsibilities of team members, discuss the organisation, specify study boundaries and clarify properties, guide words, and property / guide word combinations… - Provide materials for team preparation (in accordance with the Assignment) from the parties involved in cooperation with the Project Manager - Provide a Recorder - Propose the division of the studied unit into nodes and design of the elements - Plan the study and implementation; communicate with team members during the implementation - Verify team availability with the Project Manager (Company's representative)	- Conduct the study preparation and review of the Assignment. Participate in the finalisation of the Assignment. - Comply with the Assignment (form, content, scope and minimum conditions for the implementation of work meetings to achieve the results of the study) - Set the meeting process for the implementation of the study; accuracy, clarity and completeness of the study output - Finalise the study outputs and settle the comments - Submit the output in accordance with the Assignment, including all appendices, to the Project Manager (Company's representative)

Position Study Leader according to the ČSN standard	Role (activities)	Responsibilities
	- Ensure and manage the record and progress of the realisation of the study in accordance with the Assignment - Finalise the outputs in accordance with the Assignment of the HAZOP study	

All employees of the Company in the work team defined in the Assignment must be internally trained in the basics of the HAZOP methodology (provided by PSD – https://intranet.unipetrol.cz/hse/Stranky/skoleni.aspx).

In the case of a project designed and delivered by an external contractor – investment, the team needs to be supplemented by the contractor's designer (technical designers) provided by the investment contractor. Everyone must understand their role and be prepared to conduct the study.

***Table No. 6**: The role of other team members*

Position	Role (activity)	Responsibilities
Recorder (mandatory)	Take structured clear record of what is discussed and assist the Meeting Leader as required	Take accurate notes of what is discussed
Designer (for investments, mandatory)	Explain the project / technical design, design and context. Actively engage and describe the expected causes, and effects, existing safeguards and propose recommendations. Classify risks according to the matrix.	Provide accurate and truthful information
User/Technologist (mandatory)	Explain the context of operation and technology, giving previous practice and experience (if any). Actively engage and describe the expected causes, and effects, existing safeguards and propose recommendations. Classify risks according to the matrix.	Provide accurate and truthful information
User / Operational employee (mandatory)	Explain the context of operation and technology, giving previous practice and experience (if any). Actively engage and describe the expected causes, and effects, existing safeguards and propose recommendations. Classify risks according to the matrix.	Provide accurate and truthful information
Experts (recommended)	According to their specialisation and knowledge, provide information for the implementation of the study. Actively engage and supplement the expected causes and effects, existing safeguards and propose recommendations. Classify risks according to the matrix.	Provide accurate and truthful information

It is recommended to conduct a HAZOP study with more than the minimum required team. Neither the technologist nor the operational employee do not have to be familiar with all the regulations and laws that apply to the unit being studied. Therefore, it is necessary to add to the team other experts, with participation for the entire duration of the meeting (mandatory) or only part of the time (optional).

The selection of the team is based on the type of the unit assessed and the Project Manager (Company's representative) must verify the availability of the team for the implementation of the HAZOP study. Team members need to be agreed upon when commissioning the study. They must always be employees with knowledge of the assessed unit and, for investments, experience and ability to consider the assessed unit. The team must be aware of the importance of the study.

5.4 Background Materials for the HAZOP Study

The basis for the implementation of the HAZOP study varies according to the required objective and scope of the study. However, it is always includes:

- the Assignment,
- a description of nodes,
- a drawing documentation with highlighted nodes (e.g. P&ID),
- available operational and technological documentation.

When commissioning the study, other necessary documents shall be determined by the Leader of Work Meetings and their availability have to be confirmed by the Project Manager and the Client (representative of the Client) at the meeting for finalisation of the Assignment with the Contractor. The documents actually used for the implementation have to be always listed in the description of individual nodes.

Members of the team realizing the study must have the opportunity to familiarise themselves with the Assignment and background materials before the start of the first work meeting. If they find any inaccuracy/incompleteness in the documents, they need to notify the Leader of Work Meetings so that corrections can be made. It is recommended that a shared folder be created and kept up to date for the use of the working group.

5.5 Structure of the Final Report

The Final Report and worksheets must be understandable to anyone with a basic understanding of the technology and contain all information relevant to the future use of the study, including the Assignment.

It applies that what is not defined/listed in the study and Final Report has not been studied. In particular, the report have to contain all information on the defined study scope, equipment and objectives (see Chapter 5.2) and clearly stated outputs, conclusions and recommendations.

Recommendations resulting from the study must be understandable on their own. The Client must confirm that he/she understands all the recommendations before accepting the study.

Structure of the Final Report:

1) Introduction
2) A brief description of the project
3) Objectives
4) Scope
5) Recommendations
6) Conclusions

The Final Report must also include in its text or in the appendices:

1) Assignment of the study
2) Really used documentation (P&ID with nodes and repairs marked, work procedures, etc.)
3) Nodes description
4) Attendance sheets
5) Worksheets
6) List of recommendations

5.6 Recommendations from the HAZOP Study

The recommendations serve to point out any possible discrepancies or opportunities for improvement identified during the study. The recommendations are formulated to improve the safety and operability of the equipment and must be comprehensible, clear and feasible. They may be specific suggestions or requests for further investigation of a particular issue. The recommendations are proposed by the team that conducts the study based on their experience with the operation of the studied system or similar systems.

Information on the level of risk is used to facilitate the classification and prioritisation of recommendations. This indicative classification of Risks and Reduced risks is performed by the team conducting the study. It is a way of alerting the equipment owner to key issues. To maintain the purpose of the study, the classification must be balanced and consistent. By performing the quantification using a risk matrix, the team acquires reduced risks in addition to Risks. If, after quantifying the reduced risks, the team obtains unacceptable risks, it must propose recommendations that reduce the risks to tolerable-acceptable (TA) or acceptable (A) levels.

For recommendations on records with tolerable reduced risk, the cost and benefit of the recommendation must always be considered before acceptance. For a recommendation, it is important, among other things, that it is balanced and that the team takes into account all existing realistic risk mitigation measures when making the recommendation.

Upon completion of the study and its acceptance, the study, including recommendations, is provided to the Client. The Client must classify the recommendations (acceptance and stating of a realization deadline or reasoned rejection). Each recommendation must either be accepted with a realistic implementation deadline or reasonably rejected/amended. Recommendations must not be rejected for lack of understanding, nor they must not be rejected without proper justification for unacceptable risks (NA), tolerable-unacceptable risks (TNA) and tolerable-acceptable risks (TA). The economic cost can be used as an argument only for tolerable-acceptable (TA) risks. For operational units, the classification is performed by the Client / Client's representative. The list of recommendations supplemented by the deadlines for implementation and the specific responsible person / reasoned rejection of the recommendation will be provided by the Client / Client's representative to the Process Safety Department for inclusion in the HAZOP study no later than 2 months after the acceptance of the study. For the equipment in operation, the accepted recommendations will be entered into the safety study database by the Safety Department representative.

For investment projects, a classification must be made on the basis of negotiations among the Client / Client's representative, the Contractor and the Project Manager. The list of recommendations supplemented by the deadlines for implementation and the responsible person / reasoned rejection of the recommendation is / will be attached to the final project documentation. The cost of the agreed risk reduction action for recommendations with unacceptable reduced risk (NA) and tolerable-unacceptable reduced risk (TNA) shall be borne by the Contractor, unless otherwise agreed by the Client / Client's representative as part of the recommendation settlement. Who will bear the cost of the remaining actions resulting from accepted recommendations must be agreed at the time of recommendation settlement.

5.6.1 Monitoring the implementation of recommendations

The use and status of recommendations (classification, implementation) shall be monitored for the equipment in operation – OPBE twice a year.

For investment projects, the recommendations must be categorised and accepted before the project is handed over to the Client. It is the responsibility of the respective Project Manager (PEM) and the Client's representative responsible for the operation of the equipment to verify the use of the recommendations and check their implementation.

5.7 Revision of HAZOP Studies

Conducting a detailed HAZOP study is challenging. Therefore, the Assignment defines the limited scope that is processed. A HAZOP study can be carried out at different stages of the project, for different types of operation and to different depths. The most general is the concept stage study, which assesses the main parts of the system when the details are not yet determined. The study can be supplemented and extended by a suitably set up revision. Revisions can be repeated as needed, taking into account specifying requirements and implemented changes.

In order to carry out a revision, the record of the original study must be clear and understandable for anyone who is familiar with the methodology and the unit studied.

If the basis cannot be revised, the entire study must be performed again.

5.7.1 Revision of the HAZOP study in various phases of the project – investment

Revisions during project preparation and implementation are carried out in accordance with the project specification and the Assignment.

"Development phase" – design phase: follows the concept stage and revisions can be made to the concept. The advantage is that changes can still be made to a detailed project during the project development.

"Implementation phase" – implementation phase: follows the development stage and can be a valuable tool for monitoring changes made during the implementation. Changes can occur for various reasons, for example as a result of incorporating recommendations from the development phase – the design phase. Compared to the design phase study, changes are usually more difficult and costly at this stage, but it is a useful inspection tool before putting an equipment into operation. The request for a revision is specified at the time of the Assignment (by filling in the Study Assignment Form) or subsequently by a separate assignment. The Company's representatives responsible for the project and future operation of the assessed unit decide on the implementation of the revisions, see 4.1.1.

5.7.2 Revision of the HAZOP study on the equipment in operation

Revisions are carried out on the existing equipment at five-year intervals. The head of unit is responsible for carrying out the revision. Any Study Leader / Leader of Work Meetings must be able to carry out the revision of the HAZOP study.

Usage phase: only when the equipment is in operation can it be verified that the design and implementation have succeeded. The system in operation needs to be monitored and the data of it updated. A properly set up study will reveal the risks of slow changes associated with the operation of the equipment. It is also a good basis for planning changes, investigating operational deviations, investigating incidents and familiarising selected employees with the risks of deviations and their impacts.

Improvement phase: the study serves to identify the risks associated with changes. Any change from the original mode of operation can be assessed. When monitoring changes, it is always important to remember that the change will not only affect the part being changed, but also the rest of the equipment. It is necessary to keep this in mind and therefore indicate in the Assignment which other parts will be affected by the change. As part of the improvement, it is always necessary to adjust the assignment of the study revision so that it meets the current requirements for HAZOP studies. This may also mean a significant extension of the original study. It is advisable to take into account within the output all changes made to the studied equipment since the last HAZOP study, data related to the age of the equipment and identified incidents. Improvements also include investment projects that are undertaken for maintenance purposes to improve the condition of the equipment in operation.

5.7.3 When a revision cannot be made

It is not fitting to revise the study if:

- The basis on which the original study was prepared does not exist
- There is no original study assignment
- There is no Final Report
- There is no current drawing documentation
- There are no current operating regulations
- The original study did not involve even the minimum team from ORLEN Unipetrol, i.e. an operational employee (foreman/operator) and a technologist (production technologist/engineer)
- There is no original list of recommendations and information on their settlement

The study cannot be revised if:

- There is no Assignment – to perform a revision
- There is no entry of revised worksheets and node descriptions or it is not clearly understandable
- There is no drawing documentation
- A study team cannot be assembled

If the basis cannot be revised for the reasons described, the entire study must be performed again.

5.8 Limitations of the HAZOP Study

5.8.1 Limits of preparations

The Study Leader must be trained, knowledgeable and have experience in conducting the study. In the event that an unrealistic/inaccurate Assignment is identified at any stage of the project preparation, the Client, the Project Manager and the Leader of Work Meetings must propose an adjustment to the scope of the Assignment. The default Assignment must be the same for everyone. The implementation team must have an agreed time for preparation (see Study Assignment Form – Appendix C). Assembling the team and creating the conditions necessary for a quality study is fundamentally influenced by the approach of the Client, the Project Manager and the Leader of Work Meetings in the preparation phase of the study. Starting an unprepared study has a negative effect on the quality and duration of the study. An unprepared study should not be performed.

5.8.2 Implementation limits

The HAZOP study is heavily dependent on the team's knowledge of the methodology and team members' understanding of why the study is needed and their ability to participate. Team members always need to know the documentation in advance of the study, know their role and have time to commit to the study. The team,

documentation, scope of the study and objective of the study must be established and should not be significantly changed during the course of the study. Significant changes during implementation may lead to a justified termination of the study by the Leader of Work Meetings or the Project Manager, or OPBE and the necessity to repeat the study.

5.8.3 Quality of the HAZOP study and use of outputs

It is forbidden to change the approved HAZOP study. If it is necessary to repeat the HAZOP study due to significant incompleteness or inaccuracies and 1 year or less have elapsed since the Final Report was issued and accepted, another study Contractor must be selected to repeat the study and the original Contractor must not be involved in this revision. Only the new output shall then be considered valid. In this case, the OPBE must always approve the repeat study.

Upon determination and substantiation of serious errors on the part of the HAZOP study Contractor, the OPBE may temporarily or even permanently exclude the Contractor / Subcontractor / Leader of Work Meetings from tendering/conducting HAZOP studies for the Company. The bans are scaled to 1 year / 5 years / permanent ban.

The use of outputs is conditioned by the client's approach. If the outputs – mainly recommendations – are not used, the study will not deliver the desired effect – i.e. improved safety and operability. In addition to the recommendations, the output of the HAZOP study is a structured valuable source of information about the equipment in operation, related hazards and operability. Employees responsible for the operation of the equipment must have the opportunity to familiarise themselves with the HAZOP study.

5.9 Creation of Internal Templates of HAZOP Studies and Conditions for Use of the Templates

Internal patterns and templates are a potentially valuable tool for making HAZOP studies cheaper and faster for the Company. They also provide the opportunity to add parts to studies that were not evaluated in full detail in previous work (for example, due to time constraints). The template must always be a real valid quality study prepared for the Company. In order for the use of templates to work, the following points must be observed:

1) The new study unit may only differ from the template in detail and an approved template for a given type of equipment must already exist (and be stored in the Company's HAZOP study database). Approved templates will be stored and updated in this database.
2) The template study and its output (which will only be revised) must meet all the points set out in this guideline.
3) The development of the HAZOP study by **revising** the template must be approved by the Company, optimally specified in the Assignment when selecting a Contractor.
4) The template study must be provided to the selected Contractor for the preparation and implementation of modifications as a basis.

Studies authorised for use as a template are defined by the OPBE. The study database is managed by the OPBE.

6 Responsibility

Activity	BO	PBM / Client's representative (manager)	PEM / Company's representative (Study Leader)	OPBE	Leader of Work Meetings	Production Engineer / Technologist	Team (conducting the study)	Project/equipment Contractor	Article number
Decision to conduct a HAZOP study	R/A	I	I	I	-	-	-	-	4.1.1; 4.1.2; 5.1; 5.3.
The Assignment of the HAZOP study	R/A	C	C	I	I	I	-	-	4.1.1; 5.1; 5.2.1.
Specification of the Assignment without the Contractor	A	R*	R*	C	R*	C	-	-	4.1.1; 5.2.1; 5.3.
Specification of the Assignment with the Contractor + preparation	I	R*	R*/A	C	R*	C	C	R*	5.1.; 5.2; 5.3.; 5.4.
Implementation of the study	I	I	A	C	R*	C	R*	R*	5.2.1.3; Appendix A; Appendix B; Appendix C
Commenting on the results of the study	I	I	A	C	C	R*	C	R*/C	4.1.1; 5.1.; 5.3
Acceptance of study outputs in accordance with the Assignment	-	-	R/A	-	-	I	-	C	5.3; 5.5; 5.2
Distribution of the outputs of the study	I	I	R/A	I	-	I	-	-	5.3; 5.1.
Categorisation of study outputs, setup of deadlines	R/A	-	-	I	-	C	-	-	5.3.

Activity	BO	PBM / Client's representative (manager)	PEM / Company's representative (Study Leader)	OPBE	Leader of Work Meetings	Production Engineer / Technologist	Team (conducting the study)	Project/equipment Contractor	Article number
and implementation of recommendations									
Other uses of the outputs	A	-	-	-	-	R	-	-	5.8.3.

Notes:

R - RESPONSIBLE „The responsible"
A - ACCOUNTABLE „Bears full blame for non-performance"
C - CONSULT „Included in the process"
I - INFORM „Keep informed"

RACI matrix with comment (according to the Policy of "Efficiency Improvement of Processes and their Optimisation")

R * according to the Assignment

7 List of Related Documents

Act No. 224/2015 Coll.,	on the prevention of serious accidents caused by selected hazardous chemical substances or chemical mixtures and on the amendment of Act No. 634/2004 Coll., on administrative fees, as amended, (Act on the prevention of serious accidents)
ČSN EN 61882: 2016 standard	Hazard and Operability study (HAZOP study) – Instructions for use
Decision 2020/06	Application of the Process Safety Management System
Decision 2020/06 – Appendix A	Process Safety Management System as part of the overall management and organisation
Decision 2020/06 – Appendix B	Instructions
Directive 430	Crisis Management and Emergency Prevention
Directive 432	Serious Incidents
Directive 027	Management of Investment Projects
Policy	CAPEX Policy

Appendix A Process Risk Assessment Matrix

Appendix A.1 Risk Matrix

- The risk matrix is identical in meaning and content to the matrix in Decision 2020/06 for use in the implementation of HAZOP studies. For the needs of easy orientation of HAZOP groups, the name of some of the symbols has been changed. Both matrices can be used – an example of the used matrix must always be in the Final Report.
  For the classification to make sense, it must be consistent and realistic. The team must be aware of why they are doing it and actually do it. One of the important uses of classification (especially for reduced risks) is in classifying recommendations and planning their implementation.

Category of consequences (S) / Frequencies of consequences 1/year (P)		Number marking	*Negligible*	*Minor*	*Moderate*	*Major*	*Catastrophic*
			1	*2*	*3*	*4*	*5*
Very frequent	**<10^{0} – 10^{-1})**	*1*	**TA**	**TNA**	**NA**	**NA**	**NA**
Frequent	**<10^{-1} – 10^{-2})**	*2*	**TA**	**TNA**	**TNA**	**NA**	**NA**
Possible	**<10^{-2} – 10^{-3})**	*3*	**TA**	**TA**	**TNA**	**TNA**	**NA**
Sporadic	**<10^{-3} – 10^{-4})**	*4*	**A**	**TA**	**TA**	**TNA**	**TNA**
Rare	**<10^{-4} – 10^{-5})**	*5*	**A**	**A**	**TA**	**TA**	**TNA**
Very rare	**<10^{-5} – 10^{-6})**	*6*	**A**	**A**	**A**	**TA**	**TA**
Almost impossible	**<10^{-6} – 10^{-7}>**	*7*	**A**	**A**	**A**	**A**	**A**

Note:

A **A**cceptable Risk (theoretically no recommendations are requested, but they may be defined and highlighted)

TA **T**olerable – **A**cceptable Risk (ALARP, revision of alternatives)

TNA **T**olerable – **N**on**a**cceptable Risk (must be defined recommendation/s including the defined date of realization)

NA **N**on**a**cceptable **R**isk (process must be stop immediately)

(in case of the no risk cross the cell out)

Appendix A.2 Effect Category (Cat.) and Consequences/Severity (C)

Classification is usually sufficient for one category with the worst effects. If there are serious impacts in more than one category, it makes sense to classify both raw and reduced risks in selected cases. There is a need to ensure that existing measures reduce significant risks in all categories to at least an acceptable level.

Consequences	People	Citizens	Environment	Asset	Reputation
Negligible	no injury	no injury	no effect	to 10 000 €	no impact
Minor	minor injury *(not affecting of work performance or without days away from work)*	bed smell, noise *(no evacuation or first aid)*	minor, reported (unit report) *(small pollution on equipment site)*	to 100 000 €	minor impact *(maintaining trust – the possibility of quick trust reinstate with low costs; public awareness may exist)*
Moderate	moderate injury, single severe injury *(limitation of work performance or absence for few days for full recovery; small, reversible health effects, for example: skin irritation, food poisoning)*	minor injury *(no evacuation, but first aid needed)*	moderate effect *(damage or emission to environment, but no lasting effect; violation of single law limit or complaint)*	to 1.000 000 €	limited impact *(breach of trust – the trust reinstate with long term cooperation with PR, negative attention in local media or attention of political parties)*
Major	multiple severe injury *(irreversible health effect with large impact to work ability, for example: caustic burs, noise / explosion induced hearing loss, burns)*	intermediate injury *(limited health impact, without evacuation, medical treatment in single cases)*	major effect *(necessity of major action from Company to environment recovery; violation of law limits)*	to 10 000 000 €	national effect *(significant breach of trust - trust can be reinstated, but with significant costs. Negative national media attention)*
Catastrophic	fatality *(one or more fatalities)*	severe injury *(irreversible health effects, necessity of evacuation and medical treatment for multiple of people)*	ecological catastrophe *(persistent, severe damages on environment with large financial consequences for Company; consequences significantly violates law limitations)*	more than 10 000 000 €	international effect *(permanent significant breach of trust – impossible to fully reinstated; international public attention; large, negative international media attention)*

Appendix A.3 Supporting Failure Frequency Table

The use of this table does not replace and does not imply the performance of a follow-up study (e.g. SIL and LOPA). It is recommended to use the table for determining the frequency of failure only if the team is not sure about the frequency (probability) of the cause.

Cause	Frequency per year
Instrumentation – monitoring and supporting controls	
Control System loop failure (BPCS)	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Instrumentation failure	$1x10^{-1}$ (more often than once in 10 years)
Regulation failure	$1x10^{-1}$ (more often than once in 10 years)
Valve failure	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Cooling water failure	$1x10^{-1}$ (more often than once in 10 years)
Loss of energy supply	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Integrity failure and mechanical damage	
Hoses (for filling/bottling)	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Total pipeline failure – 100 m – full length	$1x10^{-5}$ to $1x10^{-6}$ (1 x in 100,000 –1,000,000 years)
Leakage from the pipeline (partial 10% of 100 m)	$1x10^{-3}$ to $1x10^{-4}$ (1x in 1,000–10,000 years)
Total blockage of the pipeline	$1x10^{-1}$ (more often than once in 10 years)
Total pressure vessel failure	$1x10^{-5}$ to $1x10^{-7}$ (1x in 100,000–10,000,000 years)
Atmospheric reservoir failure	$1x10^{-3}$ to $1x10^{-4}$ (1x in 1,000–10,000 years)
Turbine/diesel engine failure – overload with standard damage	$1x10^{-3}$ to $1x10^{-4}$ (1x in 1,000–10,000 years)
Compressor/pump overload	$1x10^{-1}$ (more often than once in 10 years)
Pump/rotating machine failure	$1x10^{-1}$ (more often than once in 10 years)
Packing failure	$1x10^{-1}$ (more often than once in 10 years)
Packing stamping	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Fixed equipment failure (e.g. heat exchanger tube failure)	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Safety valve failure (spontaneous opening)	$1x10^{-2}$ to $1x10^{-4}$ (1x in 100–10,000 years)
Human failure (negligence)	
Operator failure (when performing routine activities – a prerequisite for good training, without stress and without fatigue)	$1x10^{-2}$ to $1x10^{-4}$ (1x in 100–10,000 years)
LOTO procedure failure (total failure of a multi-element process)	$1x10^{-3}$ to $1x10^{-4}$ (1x in 1,000–10,000 years)
External Influences	
Third party intervention (damage by an excavator, a vehicle…)	$1x10^{-2}$ to $1x10^{-4}$ (1x in 100–10,000 years)
Lightning strike	$1x10^{-3}$ to $1x10^{-4}$ (1x in 1,000–10,000 years)
Small external fire	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Big external fire	$1x10^{-2}$ to $1x10^{-3}$ (1x per 100 –1,000 years)

Appendix A.4 Probability of Failure on Demand of Safety Function

The existing measures listed have limited reliability when called upon. This must be taken into account when classifying reduced risks and reducing the frequency (probability of occurrence). The following table can be used to help determine the reduction in the frequency of an effect (how much the probability of the effect occurring can be reduced).

Existing safeguards	Frequency per year (Var. 1)
Good engineering practice	1 (more often than once a year)
Inspections	1 (more often than once a year)
Control system (if it did not cause the incident)	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Cooling system	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Reaction suppression system	$1x10^{-1}$ (more often than once in 10 years)
Emergency sources of auxiliary agents and UPS (backup energy, water, steam, air, inert)	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Safety valves and rupture disc	$1x10^{-1}$ to $1x10^{-5}$ (1x in 10–100,000 years)
Safety tables	$1x10^{-1}$ to $1x10^{-5}$ (1x in 10–100,000 years)
Operator intervention (response to first alarms)	$1x10^{-1}$ (more often than once in 10 years)
SIL System 1	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
SIL System 2	$1x10^{-2}$ to $1x10^{-3}$ (1x per 100 –1,000 years)
SIL System 3	$1x10^{-3}$ to $1x10^{-4}$ (1x in 1,000–10,000 years)
Explosion suppression system	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
MOV/ROV (remote isolating valves)	$1x10^{-1}$ to $1x10^{-2}$ (1x in 10–100 years)
Depressurisation system (flares, holding tanks, adsorption apparatus, scrubbers,…)	$1x10^{-1}$ (more often than once in 10 years)
Emergency cooling system	$1x10^{-1}$ (more often than once in 10 years)
Sprinkler system	$1x10^{-1}$ (more often than once in 10 years)
Fire and gas detection	$1x10^{-3}$ to $1x10^{-4}$ (1x in 1,000–10,000 years)
Hydrant monitors	$1x10^{-1}$ (more often than once in 10 years)
Walls	$1x10^{-2}$ to $1x10^{-3}$ (1x per 100 –1,000 years)
Oiled sewer, drainage system	$1x10^{-2}$ to $1x10^{-3}$ (1x per 100 –1,000 years)
Fire protection of structures	$1x10^{-2}$ to $1x10^{-3}$ (1x per 100 –1,000 years)
Fire and explosion protection (walls, shelters)	$1x10^{-2}$ to $1x10^{-3}$ (1x per 100 –1,000 years)
Flame arresters	$1x10^{-1}$ to $1x10^{-3}$ (1x per 10 –1,000 years)

Appendix B

Appendix B.1 Example of the Minimum Structure when Defining a Node

Information about the specified node can be listed separately or at the beginning of the node. This list must be provided in advance to the study participants for comments and additions before the start of the work meetings.

Node number	Description and design condition	Background documents	Equipment	Realized
4. Pyrogas compression GB-201 (1./2./3. stage)	GB-201 provides compression of pyrogas prior to separation. Pyrolysed gas cooled after water separator DA-103 to 25-35 °C (max 45°C) and with overpressure 30-60 kPa continua to separator FA-201. In FA-201 are separated remainings of the liquid before first stage of compressor suction of GB-201. GB-201 has 5 compression stages and final pressure is approximately 3,5 MPa. The minimal flow is set on 141 t/h on third stage of compressor discharge. The compression heats gas and it must be cooled in heat exchangers. Maximal temperature on any stage discharge is 110°C. Polymers formation is rising with rising temperature. Some amount of gas condensate after compression and cooling. The liquid is separate in separator prior next stage of compression. FA-201 – p=0,263 MPa; T=200°C FA-212 – p = 3,8 MPa; T=150°C EA-203A/B/C – shell: p = 0,39 MPa; T=120°C; tubes: p=0,9 MPa; T=60°C FA-202 – p = 0,39 MPa; T=120°C FA-203 – p = 0,65 MPa; T=120°C EA-204A/B – shell: p=0,65MPa; T=120°C tubes: p=0,9MPa; T=60°C GA-207/R – p=0,49 MPa; dp=0,197MPa; Q=15m3/h GT-201X – p=10MPa; T=500°C; Q=215t/h	PID-E7638-6F-0; HAZOP-2016-Doc No: &AE-S-RX 1002 (EN); HAZOP-2011-Příloha 2.1; TR-EJ	FA-201 FA-212 EA-203A/B/C FA-202/FA-203 EA-204A/B GA-207/R GT-201X GB-201 (1°) GA-202/R GB-201 (2° a 3°)	7/12/2020

	GB-201 (1°) – p=3,64 MPa, dp=3,6MPa; Q=166800m3/h GA-202/R - p=0,66MPa; dp=0,15MPa; Q=45m3/h GB-201 (2°a 3°) – p=3,64 MPa; dp=3,6 MPa; Q=166800m3/h			

Appendix B.2 Example of the Minimum Worksheet Structure

The deviation column must always contain all three parts of which it composed – property, guide word and element, see example. Any software can be used, but the output must meet the minima given in the example.
For the identified cause, prefer to record the effects in one cell with one risk assessment according to the worst effect category (Cat.). In the case of a large number of effects with significantly different risks, divide the effects into two or more cells and also perform the appropriate risk classification for all cells/effects. Then classify the risks by determining the frequency – F (classification according to probability – P or likelihood – L can also be used) and consequence – C – (severity – S can also be used). The classification is performed by the entire team that conducts the HAZOP study.
Category (Cat.): P – People; C – Citizens; E – Environment; A – Assets; R – Reputation

Node n. 4. Compression of pyrogas GB-201 (1./2./3. stage)/ Stripper DA-201															
N	Deviation	Cause	Consequence	Risk				Current safeguards	Reduced risks				n	Recommendation	Comment
				Kat	F	K	R		Kat	F	K	RR			
1	Pressure lower GB-201	1. Compressor surge	1. potential damage of the machine	A	2	3	TNA	1. Internal vibration monitoring at GB-201	A	3	3	TNA	46.	Install a low pressure trip at the inlet of GB-201 to trip GB-201	
							–	2. Monitoring of rotor displacement				–			
		2. Closed inlet to GB-201	Potential for formation of vacuum at the suction side, potential for damage of upstream equipment leading to loos of containment	P	3	4	TNA		P	3	4	TNA	46.	Install a low pressure trip at the inlet of GB-201 to trip GB-201	

							–		P	3	4	TNA	47.	Perform a SIL allocation for this low pressure trip	

Appendix B.3 Example of the Minimum Structure of the List of Recommendations

The responsible person and the deadline for completion are not filled in by the team conducting the study, but after completion by the Client with the responsible manager.

Node n. 4. Compression of pyrogas GB-201 (1./2./3. stage)/ Stripper DA-201									
Č	Reduced risks				Č	Recommendation	Comment	Responsible person	Deadline
	Cat	F	K	RR					
1	A	3	3	TNA	46.	Install a low pressure trip at the inlet of GB-201 to trip GB-201			
	P	3	4	TNA	46.	Install a low pressure trip at the inlet of GB-201 to trip GB-201			
	P	3	4	TNA	47.	Perform a SIL allocation for this low pressure trip			

Appendix C

Appendix C1 Example of the Completed HAZOP Study Assignment

Formulář zadání studie HAZOP EN vy

Appendix C2 HAZOP Study Assignment Form

Formulář zadání studie HAZOP EN.dc

Appendix C3 Example of the Worksheet Structure

Pracovní list HAZOP 1 EN.xlsx

Appendix D

Appendix D1 Schedule of the HAZOP Study – Mandatory Steps

The assignment is generally concerned with maintaining the continuity of the necessary steps. The following illustration shows a basic idea of which steps can be carried out simultaneously for larger projects and which must follow after the completion of the previous steps.

Timeline for HAZOP coordination									
HAZOP Request									Preparation
	HAZOP Assignment								
		Check of Assignment							
			Selection of supplier						
			Check with Supplier						
				Realization					Realization
				Revision					
					Acceptance				
						Distribution			Use
							Recommendation management		
								Implementation	