

**Root cause analysis for external
interference incidents**

1. INTRODUCTION

Root cause analysis (RCA) is an approach for identifying the underlying causes of an incident. It is a tool to help identify what, how, and why an event occurred so that the most effective solutions can be identified and implemented to prevent future occurrences. The RCA process involves data collecting, causal factor charting, root cause identification, and recommendation generation and implementation.

The term "root cause" doesn't mean only one main cause is to be identified. Focusing on a single cause can limit the outcome of the exercise, resulting in the exclusion of viable solutions.

2. WHAT ARE WE COVERING?

This document includes all incidents related to external interference on pipelines. Causes include but are not limited to excavation, piling, groundworks and ploughing but also the use of explosives (e.g. quarries), demolition activities or construction works near the pipeline that lead to vibrations damaging the pipeline.

All incidents involving own operator's personnel (often referred to as "first party" excavation damage) or the operator's contractor (often referred to as "second party" excavation damage) or people or contractors not associated with the operator (often referred to as "third party" excavation damage) are included.

An incident may or may not lead to an unwanted release of gas or failure of the pipeline and could be the result of a previous damage due to external interference. The proposed method is less appropriate for situations where not sufficient reliable data can be collected or the timeline cannot be reconstructed (time gap between the moment damage occurred, if known, and moment of detection of the damage too large).

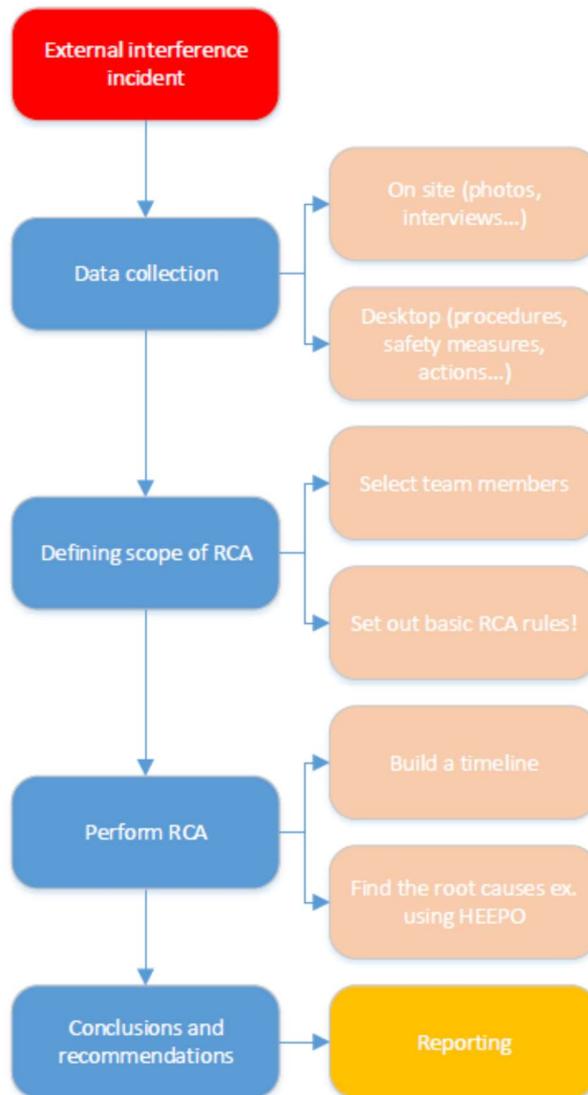
It is important that not only incidents that resulted in an unwanted release of gas or failure of the pipeline are investigated, but also all damages and even near-miss events.

Damages from causes other than external interference like natural hazards, corrosion, material defects or construction errors, which results in a release of gas, are not covered in this document.

3. METHODOLOGY

3.1 Flowchart

The major phases of the analysis are shown in the next figure.



3.2 Which data to collect?

Enough data about the incident has to be available before starting the RCA. It's important that the data are objective and free of personal opinion. Pictures and schematic drawings can be helpful. The incident scene may be accessible only for a limited time after the incident (i.e. private land owner, traffic disturbance) and the scene can quickly change due to weather conditions or repairing activities. Therefore, it is necessary to focus in the first moments (hours) after the incident on the data that otherwise will be lost.

The following questions can serve as a guideline.

1. When did the incident occur? Ex. Date and day, time...
2. The events and actions that directly lead to the incident
 - Type of operator (contractor, farmer, developer, land owner...), other people directly involved (company, pipeline operator supervisor, ...)
 - Type of excavation equipment? (See for example EGIG¹ Definition List)
 - Type of works performed? (Depth, width, length, speed, power, normal working distance to pipeline....)
3. Where did the failure occur?
 - What was the land use at the place of the incident?
 - Are there any other uses nearby worthwhile considering (other pipelines, power lines, railroads...)?
 - Condition of the land (dry, wet, flat, slope, hard surface, levels in de underground)
4. Who identified the damage or failure? Who reported it to who?
5. What safety measures were in place?
 - Locating and/or marking of the pipeline or buried installation
 - Convention with pipeline operator
 - Was there a one-call system in place
 - Pipeline operator supervisor present on site
 - Mechanical protection (permanent, temporary)
6. What were the consequences?

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- Damage to pipeline (ex. metal, coating, dent, scratch, ...)
 - Economic consequences, direct and/or indirect (interruption of service)
 - Injuries and/or fatalities
7. What were the actions taken directly following the incident?
- How was the incident initially identified by the Operator?
 - What did the controller(s)/control room do after the incident? Were these actions a cause or a contributing factor to the consequences of the incident?
 - Are data collected and pictures taken as soon as possible?
8. Which information was exchanged before and during the works near the pipeline?
- Plans
 - Safety instructions
 - Written/verbal agreements

All this data aim at describing the facts and can be collected at the incident scene, in logging files or by interviewing people. One should be aware that not all data are equally accurate and reliable.

On the other hand, information is needed on the procedures and written work instructions that describes how the company deals with the process of "works in the vicinity of pipelines". As this type of information is less subject to changes, it can be collected at a later stage. In general, this information can be found in quality or safety manuals and operational manuals.

3.3 Defining the scope

Before starting the RCA, the team members that will perform the analysis must be designated. Ideally the RCA team is a mixture of people that are directly involved in the incident and some people that look at it more from a distance. The team shall also have a chairman who will lead the team through this process of incident analysis. Depending on the complexity a secretary can be appointed and experts shall be invited.

The scope of the analysis must be clear to all team members, i.e. it should focus on finding the underlying causes that resulted in a specific incident. The members must receive a brief explanation on the methodology used and on what will happen with the conclusions and recommendations.

The following basic rules for performing an RCA are applicable:

1. Use a check list to help what to collect and to document
2. Document only the facts and never opinions
3. Don't jump to conclusions, keep asking questions (why, how,...?)
4. Allow the evidence to steer the investigation, both incriminating and exonerating

3.4 Performing the RCA

On the basis of the collected data, a timeline of the event will be constructed. This shall be done in preparation of the first RCA team meeting. One of the first things that the team should do, is to complete the timeline, to fill in the time gaps and to indicate clearly the remaining gaps.

Chapter 4 gives some guidelines based on the **HEEPO method**. This process is supported by an excel-tool "root cause analysis". For every RCA performed, the identified root causes are marked in the excel-spreadsheet in a uniform way. When the information of multiple analysis is collected and put together, a statistical analysis of these data shall be performed.

3.5 Conclusions and recommendations

After identification of the root causes, the team shall put forward recommendations that makes more unlikely similar incidents to occur. The link between the identified root cause(s) and the recommendation(s) shall be clear.

The conclusions and recommendations are the result of RCA and shall be documented in a report. The collected data and the names of the team members will be part of the report.

4. DESCRIPTION OF POSSIBLE ROOT CAUSES TO BE CONSIDERED IN RCA

4.1 HEEPO Analysis

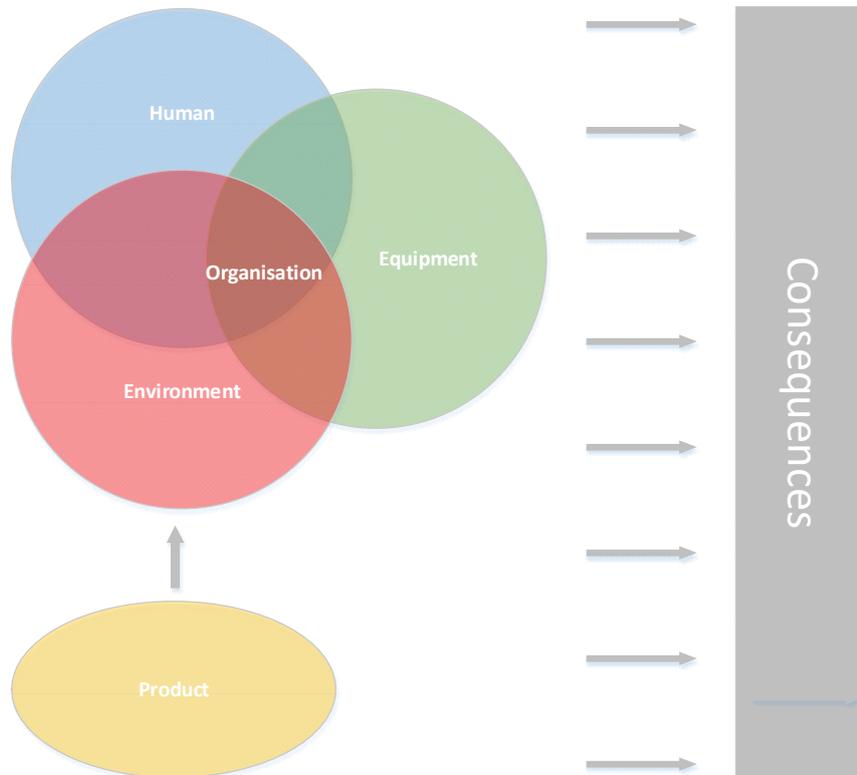
Although not formally required, it can be a good idea to structure the investigation according to the **HEEPO method**.

HEEPO, which stands for *human, equipment, environment, product and organisation*, can help with a risk assessment or an analysis of an incident or accident.

Hazards, risk factors and causes can be related (but not limited) to:

- **H**uman: lack of physical or mental capacity, lack of knowledge or skills, lack of right attitude or behaviour
- **E**quipment: workplace lay-out, machines, hand tools, protective equipments
- **E**nvironment: light, noise, climate, vibrations, air quality or dust
- **P**roduct: dangerous substances, heavy loads and sharp or warm objects
- **O**rganisation: tasks, working hours, breaks, shift systems, training, communication, team work, social support or autonomy.

In a graph form:



4.2 Safety barriers

A check list, structured according to consecutive safety barriers, can help **identifying the proper root cause**:

1. "One Call" notification practices and "One Call" notification errors
2. Convention between parties
3. Locating practices
4. Surveillance and patrolling
5. Excavation practices
6. Pipeline protection
7. Excavation operator practices

4.2.1 "One Call" notification practices and errors

- **No one call system implemented**
 - o No initiative
 - Legal framework [lack of]
 - Cost
 - ...
 - o Initiative started, not yet finished
 - Complexity of process
 - Project ownership [no pusher]
 - Cost
 - ...
 - o
- **No/no timely notification made to the one-call center at all.**
 - o Not known
 - Professionalism [lack of]
 - Not sufficient publicity
 - Target audience
 - Repetition frequency [too low]
 - Communication channel/style [not adapted/attractive]
 - ...
 - ...
 - o Assumed a call was not needed
 - Land is own property
 - Regulation allows misinterpretation
 - Appraisal of risk ("it was just a small job")
 - Because another pipeline operator notified (whose pipe is also near)
 - Did a notification for another job on same location some time ago?
 - ...
 - o Emergency situation (no time), unforeseen work
 - Procedure in this situation [lack of]
 - o Perception of the use of the one call center
 - User-friendliness
 - Response time [too long]
 - Cost
 - o Not all the information timely available to do the notification

- ...
- **Wrong/not sufficient information provided by applicant:**
 - (last minute) Change in location or type of works
 - Exact location or type of works not known at time of notification
 - Exact time not known at time of notification
 - Ambiguity (ex. Streets/villages with almost the same name)
 - Application form not clear (definitions, units, ...)
 - Other party involved who does the notification
 - Miscommunication
 - ...
- **Pipeline operator reaction following notification:**
 - No or no timely reaction
 - Notification received not sufficiently in advance
 - Emergency situation (no time), unforeseen work
 - Procedure in this situation [lack of]
 - Overload
 - Professionalism/experience
 - ...
 - Wrong/not sufficient information provided
 - Based on incomplete/ uncertain information: Ask for more information
 - Appraisal of risk
 - Experience
 - Guidelines [lack of]
 - Training
 - Erroneous pipeline data
- **"One Call" notification system error**
 - Ticket transmission failures (failure to transmit the ticket to a facility operator that should have received it)
 - Wrong/outdated data
 - Geo-referencing error
 - Denial of service
 - ...

4.2.2 Convention between parties

- **No convention**
 - Procedure [not asked by]
 - Pipeline operator not informed (see no notification)
 - Because convention with another pipeline operator (whose pipe is also near)
 - Refusal
- **No written convention, only verbal**
 - Procedure
 - Appraisal of risk
 - Attitude (confidence / naivety)
 - Time constraint
 - Refusal
 - Registration tool (paper, electronic)
 - (temporarily) Not available
- **Incomplete/wrong convention**
 - Based on incomplete/ uncertain information
 - No additional information or investigations were asked (time and cost)
 - Change in type of works or location compared to start of works
 - Convention does not mention what to do when conditions change
 - Type of works "unconventional" to pipeline operator
 - Standard guidelines [not applicable]
 - "unconventional" aspect of the works not detected at notification
- **Convention not known by excavation operator**
 - Other people involved
 - Deemed not necessary to transmit information to excavation operator
 - Switch of excavation operator
 - Information handover
 - Communication
 - Language skills

4.2.3 Locating practices

- **Excavation activities started prior to locating facility**
 - o Convention [no/not respected]
 - Time constraint
 - Change of working schedule
- **Facility could not be located when performing detection**
 - o Type of facility, depth, interference
 - Detection technology
 - o Detection at wrong place
 - Incorrect/lack of facility records or maps
 - Technical archive
 - Change in technology over time (paper → digital)
 - Position of permanent markers inaccurate
- **Markings indicate facility at wrong location**
 - o Type of facility, depth, interference
 - Detection technology
 - o Misinterpretation of the markings
 - Not sufficient markers
 - Visibility of markers
 - o Sudden and unexpected change of the position of the facility
 - Incorrect/lack of facility records or maps
 - o Multiple facilities close to each other
 - Incorrect/lack of facility records or maps
- **Markings removed**
 - o Markings hinders the works
 - Type of markers
 - o By other party working on the site
 - o Temporarily but not put back
 - o Weather conditions
 - Type of markers
- **Pipeline depth of cover**
 - o Less than expected
 - Incorrect/lack of records or maps
 - Not to standard practice
 - Erroneous determination
 - Multiple pipelines close to each other
 - Limited number of points
 - Erroneous reference level

- Top soil removed
- Sudden and unexpected change of the depth of cover
 - Incorrect/lack of facility records or maps
 - Presence of a pipeline fitting
- Not checked prior to excavation activities

4.2.4 Surveillance and patrolling

- **Working activity not detected by patrolling**
 - Duration of work vs. patrolling frequency
 - Not visible to patrolling
- **Working activity detected by patrolling but**
 - Interpretation of the type of working activity and the risk it poses
 - Intervention too late/not possible
- **No surveillance on site**
 - Not in convention
 - Only during certain periods or (higher risk) activities
 - Change in working schedule
 - Absence (illness, late arrival, ...) of supervisor
 - No substitute
 - Multiple activities at multiple places to follow up
 - [No] Arrangement in case of absence supervisor
- **Surveillance but**
 - Multiple activities to follow up by supervisor
 - Not familiar with activities and risks
 - Substitute (not the regular supervisor)

4.2.5 Excavation practices

- The machine operator did not follow the correct procedures when excavating near a facility.
 - No specific "digging near gas facility" working procedure
 - Procedure is only for "standard" situations
 - Working according to procedure regarded as annoying
 - Slows down the work
 - Procedure not (sufficiently) known by machine operator
 - Education, training
 - Certificate
- Failure to maintain clearance with powered equipment

- Type of machine not adapted to type of work
- [No] Physical barrier between machine and pipeline / facility
- [No] clear view
- Misunderstanding between machine operator and ground worker
 - Language
 - [No] Clear view
 - Communication tools
- Hastiness
 - Workload
- Equipment failure
 - [Lack of] Maintenance
 - [No/expired] Certification
 - Improper use
- Failure to support exposed facilities: Facility failed due to lack of support in accordance with generally accepted engineering practices or instructions provided by the facility operator.
- Failure to use hand tools where required.
- Failure to verify location by test digging.
- Improper backfilling: damage caused by improper materials (ex: large/sharp rocks) in the backfill or improper compaction of the backfill.
- Use of different type of tools/ machines than in convention
 - Conventional tool / machine not available
 - Change in working schedule
 - Machine breakdown
 - Maintenance [lack of]
- Conditions changed over time
 - Weather
 - Ground conditions different than what expected
 - Ground sampling

4.2.6 Pipeline protection

This includes all issues where the (mechanical) protection measures, if any, fail to prevent pipeline damage.

- **No protection**
- **Protection removed**
 - o Protection hinders the works
 - o By other party working on the site
 - o Temporarily but not put back
- **The barrier fails**
 - o To prevent lateral encroachment
 - o To highlight the pipeline presence and/or location
 - o The machine is able to breach the barrier
 - Other type of machine
 - o Degraded over time (not sustainable for the period of work)

4.2.7 Excavation operator practices

- Operator fails to notice the barrier due to type or size of the machine
- Operator ignores the presence of a pipeline. This event accounts for human error in continuing excavation work despite knowledge of the pipeline's presence.
 - o Operator was not aware or ignored the risks and hazards related to the works near the pipeline or underground installation
- Operator fails to stop activity given that pipeline presence is unknown. This event accounts for the fact that the machine operator may stop the activity on making contact with the barrier despite the fact the pipeline presence is unknown.
- Conditions changed over time
 - o Visibility
 - Rain, fog
 - Sun
- Not physically or mentally fit
 - o Drugs, alcohol, medicine
 - o Sleep
 - o Emotional problems
 - o Hearing and vision
 - o ...
- Working hours

- Overtime
- Shifts
- ...

4.3 Other factors

Other factors can play a role in the occurrence of the incident that are not covered above.

4.3.1 Abandoned facility

An event caused by an abandoned facility issue.

- A nearby abandoned facility has been located instead of the active facility.
- A facility may have been located as abandoned, but found active after the excavation exposed the facility.

4.3.2 Deteriorated facility

Situations in which an excavation disrupts the soil around a facility resulting in damage, failure or interruption of service. However, the facility was deteriorated (i.e. corroded, graphitized, etc.) to the extent that the deterioration and not the excavation activity caused the facility issue.

4.3.3 Previous damage

A significant period of time can have passed between the failure or the discovery of the damage and the moment the actual damage occurred, making evidence harder to collect and a root cause difficult to identify.

5. AFTERWORD

According to the latest EGIG statistics², external interference, especially caused by “third parties”, remains a principal cause of failure of underground gas transportation pipelines. Although in recent decades a significant reduction in the external interference failure frequency is achieved.

In order to keep the external interference failure frequency decreasing, a more profound understanding of the underlying causes of these incidents is of primary interest.

This document offers an approach for identifying the underlying causes of an incident, i.e. how to perform a Root Cause Analysis (RCA). It is a guideline to help identifying what, how, and why an event occurred so that the most effective solutions can be identified and implemented to prevent future occurrences. The extended list of questions in chapter 4 proves that an external interference incident can have multiple possible causes. A structured approach will help to identify and avoid omitting the relevant ones.

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² www.egig.eu