IDENTIFICATION, EVALUATION AND MINIMIZATION OF INDUSTRIAL RISKS RELATING TO OIL PIPELINES

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ABSTRACT

The security of the functioning systems represents, through the four specific components (security, availability, reliability and maintenance), a basic component of the processing requirement.

Monitoring of all specific intrinsic and operating parameters of oil and gas pipelines can be technically detected and diagnosed by:

- existing defects.
- rapid and effective intervention to eliminate the damage, if they occurred.

To establish the maintenance programs that can ensure the proper functioning of the oil pipelines, it is necessary to establish their technical status. The research done helps reduce the risk of oil pipeline damage.

Keywords: *Risk scenario, evaluation, oleoduct, probability, technical failure*

INTRODUCTION

The National Petroleum Transport System - SNT, represents the set of interconnected main pipelines, which ensures the collection of the oil extracted from the operating or import perimeters and its management from the points where it is delivered by the producers / importers to the processing units. [1] Pipelines transport natural gas, oil and petroleum products, water for population consumption, irrigation and waste water.

Figure 1. The connections between the operating, processing and consumption centers of the pipelines.[2]

Long pipelines networks are found in Europe and North America, and transport oil from the exploitation points to the processing centers, and between the processing center and the consumption centers (fig.1.). The processing center may be located in other country than the one from which is extracted. There are also pipelines that cross the Mediterranean, linking northern Africa with Europe. In Europe, the longest networks are in Russia, most of the pipes are in the Volga- Ural area, Moscow, Western and Central Europe, as shown in the figure 2.

In Romania is one of the longest pipeline networks in Europe (approx. 2500 km), Subcarpathians, Getic Plateau, Romanian Plain. [2]

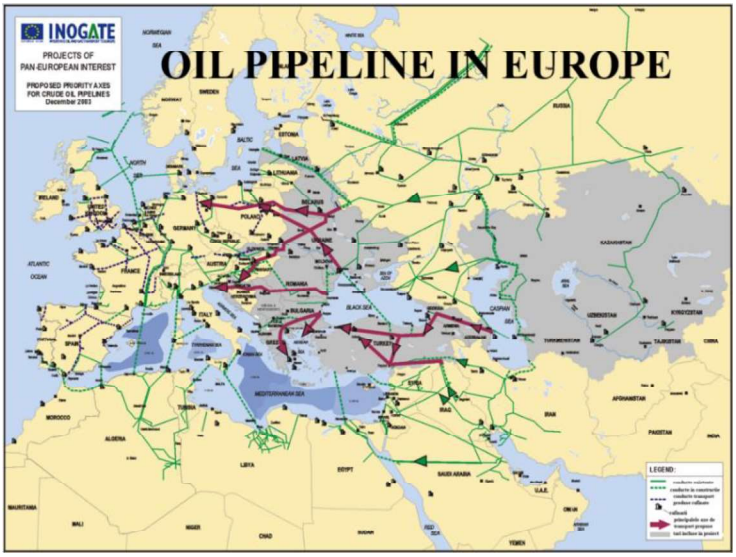

Figure 2. Oil pipelines in Europe. [2]

Oil pipelines safety

The security of the functioning systems represents, through the four specific components (security, availability, reliability and maintenance), a basic component of the processing requirement (fig. 3.). The common point between the security components of the system is the use of probalistic tools, as a technique for assessing the risks of the different operating states of the analyzed system. The efficient processing of the techological lines and systems implies their quasi- continuous operation, by substantially reducing stops duet o failures/ disposals. The implementation of the technological equipment useed in the process industries requires high levels of *reliability* and *technical security.*

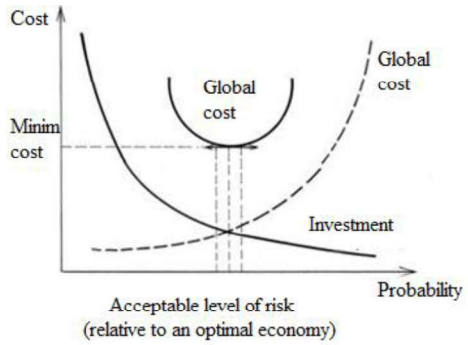

Figure 3. The principle of determining acceptable risk in relation to an optimal economy. [3], [4]

In the case of oil papelinesc, the fullfillment of this desideratum is essentially conditioned by the meeting of the following *mechanical criteria of technical safety:*

- ensuring the mechanical strength of the structural components. This means avoiding to reach the limit states- critical, or last.
- prevention of cracking and fracturing of materials.
- ensuring the mechanical stability, the rigidity of the structural components and maintaining the initial geometric shape of each component, during the service fife under load.
- ensuring the tightness of the technological enclosures. [3], [4]

METHODS

Technical failure of the oleoduct - the total / partial exit of the SNP function- Risk Scenario (National Petroleum Transport System)

AVARIE TEHNICĂ OLEODUCT:
SUCCESSION OF TECHNICAL INCIDENTS / WORK ACCIDENTS → PERSONAL EXPLOITATION ERRORS → TOTAL / PARTIAL OUTPUT OF SNP FUNCTIONS → ENERGY INSECURITY → ECONOMIC INSECURITY → DIFFICULTIES

The causes and effects of the Risk Scenario are described in table 1.[5]

Table 1. The causes and effects of the Risk Scenario

RISK SCENARIO: TECHNICAL FAILURE OLEODUCT → TOTAL / PARTIAL OUTPUT OF SNP FUNCTION	
Causes:	**Effects:**
-poor condition of oil pipelines and pumping stations. -lack of investments in oil pipelines and pumping stations. -lack of revisions to the equipment related to the oil pipelines and pumping stations. - non-technological renewal of oil pipelines and pumping stations. - the incorrect configuration of the pumping stations. - wrong pipeline configuration (thickness). - wrong maneuvers performed by the operating personnel. - lack of specialized and / or trained operating personnel. - poor communication or communication with the Central Oil Dispatcher - CDO. - CDO personnel not specialized in times of crisis. - lack of working procedures during times of crisis. - lack / failure to comply/ unawareness of national / European procedures in case of serious damage. - lack of training in the field of Risk Management.	-stop the oil (oil / gas) market between Romania, the EU, NATO or other partner countries. -oil refueling (oil / gasoline / ethane) a neighboring energy systems, from the EU, NATO or other partner countries. -non-supply with oil the major consumers and master oil pipelines within the SNP. - huge material damage resulting from the lack of oil. - huge material damage resulting from the interdependence of other systems compared to oil.

The calculation of the Risk Scenario presents the following steps:

- Methodology of establishing the probability:

Due to the effects caused by the causes of the technical failure of the pipeline (total / partial exit from the SNP function) we have adopted an average level for establishing the probability, the event having a significant probability of occurring.

For the establishing the probability was adopted the next probability scale: [5]

Table 2. Establishing the probability.

LEVEL/ ASSOCIATED SCORE		DEFINITION OF PROBABILITY	PERIOD
	1. Very low	It has a very low probability of occurring. Normal measures are required to monitor the evolution of the event.	**after 13 years**
	2. Low	The event has a low probability to occur. Efforts are needed to reduce the probability and / or attenuation the impact of the product.	**10 – 12 years**
X	**3. Medium**	The event has a significant probability of occurring. Significant efforts are required to reduce the probability and / or attenuation the impact of the product.	**7 – 9 years**
	4. High	The event is likely to occur. Priority efforts are needed to reduce the probability and / or attenuation the impact of the product.	**4 – 6 years**
	5. Very high	The event is considered imminent. Immediate and extreme measures are required to protect the target, evacuation to a safe location if the impact requires it.	**1 – 3 years**

- Determining the severity of the consequences of the proposed scenario:

The severity of the consequences is given by the unfavorable level of vulnerabilities and impact. The analysis of vulnerabilities and capabilities are presented in table 3.[5]

Table 3. Analysis of vulnerabilities and capabilities related to the Risk Scenario.

RISK SCENARIO: TECHNICAL FAILURE OLEDUCT-VULNERABILITIES AND CAPABILITIES	LEVEL
1. Lack of energy infrastructures (pumping stations and oil pipelines) in 17 counties of the country: • the lack of investments (new constructions of pumping stations and oil pipelines, non- refurbishment of existing pumping stations and pipelines - old). • unpredictability of the political system. • the possibility of an interruption of oil- regional or national, generating: • halting the oil market between Romania and EU/ NATO/ partener countries; • stopping the production of electricity from thermal power plants, • stopping the supply of oil to industrial and domestic consumers. • energy insecurity, generating economic insecurity. • generating national insecurity.	**Very low** **Low** **Medium** **High** **Very High**
2. Incorrect or precarious configuration of energy infrastructures: • the incorrect or precarious configuration of the pipelines (thickness). • the incorrect or precarious configuration of the pumping stations.	**Very low** **Low** **Medium** **High** **Very high**
3. The degree of specialization and periodic training of the personnel with the responsibilities of restoring the process of oil supply. • the operative personnel of the Central Oil Dispatcher - CDO. • operating personnel from pumping stations. • maintenance staff. • security personnel.	**Very low** **Low** **Medium** **High** **Very high**

- Impact study:

Impact study is the management analysis at certain levels that identifies the impact of the loss of the resources of a European critical infrastructure (pumping station/ oil pipeline of national importance). The severity of all the impacts of the scenario will be taken into account and then the level of severity of the consequences of the hazard/ threat from the considered scenario will be established. The highest level will be chosen from the severity levels related to the impacts, according to table 4.

Table 4. Analysis of the impact of the Risk Scenario.

IMPACT	LEVEL	
Huge damage caused by lack of oil	**1.Very low**	temporary
	2.Low	significant damages
	3.Medium	medium damages
	4.High	big damages
	5.Very high	very big damages
Huge damage caused by the interdependence of the other systems with the oil	**1.Very low**	0 – 10% of VCI
	2.Low	11 – 20% of VCI
	3.Medium	21 – 30% of VCI
	4.High	31 – 40% of VCI
	5.Very high	peste 41% of VCI
Potential environmental damage	**1.Very low**	0 – 20%
	2.Low	21 – 40%
	3.Medium	41 – 60%
	4.High	61 – 80%
	5.Very high	peste 81%
Strong social impacts	**1.Very low**	0 – 10% of IP
	2.Low	11 – 20% of IP
	3.Medium	21 – 30% of IP
	4.High	31 – 40% of IP
	5.Very high	peste 41% of IP
VCI - Volume of Invested Capital; CP - Confidence of the population.		

- Calculation of severity of consequences:

Due to the strong impacts, we have chosen a very high level, which can cause immense damage, and the consequences can be catastrophic, leading to serious injuries and deaths, major losses of equipment, installations and suspending the service provision.

The calculation of the severity of the consequences is shown in table 5.[5]

Table 5. Gravity of consequences

LEVEL/ ASSOCIATED SCORE		GRAVITY OF CONSEQUENCES
	1. Very low	The event causes a minor disturbance in the activity, without material damage
	2. Low	The event causes minor material damage and limited activity disruption
	3. Medium	Personal injury, and / or loss of equipment, utilities and delays in service provision.
	4. High	Serious personnel injuries, significant losses of equipment and facilities equipment, delays and / or interruption of service provision.
X	**5. Very high**	The consequences are catastrophic resulting in serious personnel deaths and injuries, major losses of equipment, installations and facilities and the cessation of service provision.

- Calculation of risk level:

The calculation of the risk level is given by the product between establishing the probability and calculating the severity of the consequences, which is described in table 6.

Table 6. Calculation of risk level.

PROBABILITY						
	Very high 5					
	High 4					
	Medium 3					**Scenario DAMAGE**
	Low 2					
	Very low 1					
	0	**Very low 1**	**Low 2**	**Medium 3**	**High 4**	**Very high 5**
				GRAVITY/ CONSEQUENCES		

Note: The risk is given by the result of the probability of producing a hazard / threat and the severity of its consequences.

The result of the risk of producing the chosen scenario is the following:

The calculated risk has the value 15 (probability 3 x gravity 5), therefore there is a HIGH RISK to produce the script chosen.

CALCULATED RISK LEVEL	
LEVEL	**SCORE**
Very low	**1 – 3**
Low	**4 – 6**
Medium	**7 – 12**
High	**13 – 16**
Very high	**17 – 25**

- Risk management:

To reduce the risk, measures are required to reduce the following vulnerabilities and / or improve the following capabilities, according to table 7.[5]

Table 7. Risk treatment for the Risk scenario.

VULNERABILITY AND / OR CAPABILITY	PROPOSED MEASURES
1. Lack of energy infrastructures (pumping stations and oil pipelines) in 17 counties of the country: • lack of investments (new constructions of pumping stations and oil pipelines, non-refurbishment of existing pumping stations and pipelines - old ones). • unpredictability of the political system. • the possibility of an interruption of oil- regional or national, generating the halting the oil market between Romania and EU/ NATO/ partener countries; • stopping the production of electricity from thermal power plants, • stopping the supply of oil to industrial and domestic consumers. • energy insecurity, generating economic insecurity. • generating national insecurity	Major investments in energy infrastructure: • new oil pipelines. • new pumping stations. • refurbishment of existing oil pipelines and pumping stations - old. • predictability (security) of the political system. • accessing European funds for securing European critical energy infrastructures.
2. Incorrect or poor configuration of energy infrastructures: • the incorrect or precarious configuration of the pipelines (thickness). • the incorrect or precarious configuration of the pumping stations.	• technical evaluations (technical expertise) on the thickness suitable for the pipelines in order to operate at normal parameters.
3. The level of specialization and periodic training of the personnel with the responsibilities of restoring the process of oil supply: • operating personnel from the Central Oil Dispatcher CDO. • operating personnel from pumping stations. • maintenance staff. • security personnel.	• training and training courses for operating personnel (CDO / pumping stations), maintenance and security. • analysis of technical events, technical incidents and accidents at work, etc. • the control of the installations on line of operation and the performing of the preventive maintenance.

After applying the risk reduction measures related to the risk scenario, results:

Table 8. Measures after risk treatment related to the Risk Scenario.

RISK SCENARIO: TECHNICAL FAILURE OLEODUCT VULNERABILITY	IDENTIFIED	AFTER THE APPLICATION OF THE MEASURES
1. Lack of energy infrastructures (pumping stations and oil pipelines) in 17 counties of the country. **2. Incorrect or poor configuration of energy infrastructures.** **3. The level of specialization and periodic training of the personnel with the responsibilities of restoring the process of oil supply.**	**1.Very low**	**1.Very low**
	2.Low	**2.Low**
	3.Medium	**3.Medium**
	4.High	**4.High**
	5.Very high	**5.Very high**

- Recalculation of severity of consequences:

After treating the risk through the measures proposed for the vulnerabilities and / or the capabilities of the risk scenario 1, we reduced the level associated with the severity of the consequences from the medium to the low level, according to table 9. [5]

Table 9. Recalculation of severity of consequences.

NIVEL / PUNCTAJ ASOCIAT		GRAVITATEA CONSECINȚELOR
	1.Very low	The event causes a minor disturbance in the activity, without material damage.
X	**2.Low**	The event causes minor material damage and limited activity disruption.
	3.Medium	Personal injury, and / or loss of equipment, utilities and delays in service provision.
	4.High	Serious personnel injuries, significant losses of equipment and facilities, delays and / or interruption of service provision.
	5.Very high	The consequences are catastrophic resulting in serious personnel deaths and injuries, major losses of equipment, facilities and the cessation of service provision.

- Discussion of calculation of the risk level after the reduction measures are applied:

Following the diminution of the risk and the recalculation of the severity of the consequences, the level of risk of producing the scenario was reduced, the value of the risk level after the application of the reduction measures is shown in table 10.

Table 10. Risk level.

PROBABILITY						
	Very high 5					
	High 4					
	Medium 3		**Scenario DAMAGE**			
	Low 2					
	Very low 1					
	0	**Very low 1**	**Low 2**	**Medium 3**	**High 4**	**Very high 5**
			GRAVITY/ CONSEQUENCES			

Note: The risk is given by the result of the probability of producing a hazard / threat and the severity of its consequences.

The result of the risk of producing the chosen scenario is the following:[5]

The calculated risk has the value 6 (probability 3 x gravity 2), therefore there is a LOW RISK to produce the script chosen.

CALCULATED RISK LEVEL	
LEVEL	**SCORE**
Very low	**1 – 3**
Low	**4 – 6**
Medium	**7 – 12**
High	**13 – 16**
Very high	**17 – 25**

CONCLUSION

1. Monitoring of all specific intrinsic and operating parameters of oil and gas pipelines can be technically detected and diagnosed by:

- existing defects.
- rapid and effective intervention to eliminate the damage, if they occurred.

2. In order to establish the maintenance programs that can ensure the proper functioning of the oil pipelines, it is necessary to establish their technical status. Preventive and predictive maintenance systems that significantly reduce the risk of damage occurring, can be applied after finding out the technical status of the oil pipelines.

3. The establishment of the maintenance plan for the oil pipelines is done as follows:

- identification of the limit state for the intervention.
- the probability of reaching the limit state.
- the volume of fluid (gas or oil) that can be released following an incident.

- number of population in the incident area.

4. Investigations for the identification, evaluation and minimization of industrial risks relating to oil pipelines involve high costs, approved equipment and authorized personnel. Research results can also be used in similar cases.

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