# FUZZY ASSESSMENT OF OIL SPILLS INTO THE ENVIRONMENT

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**Abstract**

*It is known that the amount of expected environmental damage with adverse effects is defined as the sum of the individual expected losses for different components of the environment. Estimation of damage caused by oil spills during tragic oil pipeline accidents is based on the existing normative documents and methodological guidance. The basis for developing priority measures to increase the safety of the main pipelines, which are considered a potential source of threat, is the risk assessment in the pipeline. Accidents are mainly associated with oil spills, which have a negative impact on the environment. Therefore, any section of the main oil pipelines should be assessed with certain risk parameters as it can cause accident.*

**Keywords:** risk, oil leakage, corrosion, environment, oil pipeline, fuzzy numbers scale, fuzzy analysis.

## I. Introduction

Typical scenarios of pipeline destruction consist of [1]:

- the formation of a persistent environment pollution due to oil blowout from the damaged pipeline;
- oil pool fire, leading to the thermal influences on the environment, material objects and people;
- the explosion of fuel-air compositions;
- the distribution of explosive fuel-air combination clouds with the wind, and possible explosion.

Accident risk assessment of main oil pipelines involves: [2-4]:

- Forecasting of oil leakage rates in the pipeline and estimation of the volume of spilled and lost oil (technological risk);
- Evaluation of the consequences of oil spills for various components of the natural environment;
- Carrying out the hazardous rank of the pipeline route based on risk assessment and prioritizing safety measures for ranging.

The oil pipeline leak prediction is generally based on the combined effects of the groups shown in Table 1.

The relative impact of each group of factors on the intensity of accident changes in the pipelines is considered with weight coefficient.

Each of these groups, based on statistical data on leakage statistics (influencing factors) in relation to accidents on main oil pipelines, has a specific weighting coefficient ("contribution"). It should be noted that weight coefficient are preliminary and can be determined as a rule, taking into account the opinion of specialists (experts).

**Table 1:** *Total statistics on accident stopping frequencies by factors (weight coefficients)*

| № | Name of groups | Shares of group factors |
|---|---|---|
| 1 | External anthropogenic influences (F1) | 0,20 |
| 2 | Corrosion (F2) | 0,10 |
| 3 | Quality of pipe production (F3) | 0,05 |
| 4 | Quality of construction and installation works (F4) | 0,10 |
| 5 | Constructive technological factors (F5) | 0,10 |
| 6 | Natural effects (F6) | 0,10 |
| 7 | Exploitation factors (F7) | 0,05 |
| 8 | Defects in pipe and weld seams (F8) | 0.30 |

## II. Methods

Taking into account of weight coefficients in order the assessment of effective parameters, the following ranking was held on a 5-point scale. (Table 2).

Then, the results of evaluating the factors that caused oil leakage from the pipelines to the environment by individual experts were examined. The research (opinions) conducted by three different experts on these factors are shown in Table 3. As can be seen in Table 3, linguistic assessments ("very low", "low", "medium", "high" and "very high") given by experts differ from each other and from the scale adopted so far. So if expert 1 exaggerates factor F8 (defects in pipes and welds) as the most influential factor, experts 2 and 3 focus on factors F7 (operational factors) and F2 (corrosion), respectively. If expert 1 chooses F3 (pipe production quality) and F7 (exploitation factors) as the least effective factor, expert 2 accepts factors F3 , F4 , F5 , F6 and 3rd expert accepts factors F4 and F5 .

**Table 2:** *Rank classification according to the weight coefficient of the factors by groups*

| Weight coefficient change range | Linguistic estimates | Rank |
|---|---|---|
| Less than 0,07 | “very low” | 1 |
| 0,7-0,13 | “low” | 2 |
| 0,14-0,20 | “medium” | 3 |
| 0,21-0,27 | “high” | 4 |
| More than 0,28 | “very high” | 5 |

Aggregation of expert opinions on the above 8 factors (Table 3) was carried out for oil leaks. Initially, the linguistic values shown in Table 3 were converted to fuzzy numbers on the scale in Figure. The final vector was determined based on the aggregation of fuzzy numerical vectors.

The values of these final vectors according to factors are given in Table 3. These prices are the general price vector of the group of experts.

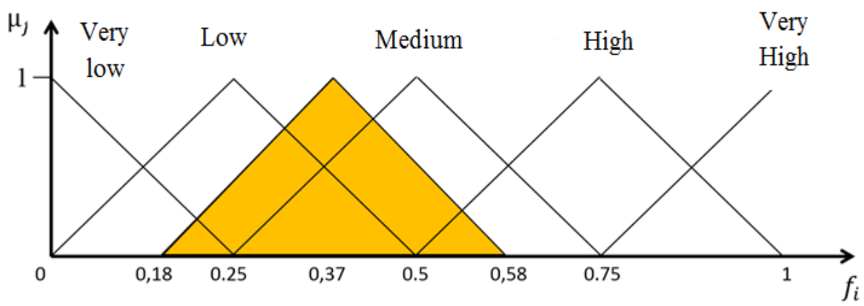


**Fig 1:** *Fuzzy numbers scale*

**Table 3:** *Possible risk factors for infield pipeline failures*

| Values of factors and risk factors | 1st expert score | | | | | 2nd expert score | | | | | 3rd expert score | | | | | Fuzzy numerical final estimate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| External anthropogenic influences – $F_1$ | | | ● | | | | | ● | | | | ● | | | | 0.17, 0.42, 0.75 |
| Corrosion – $F_2$ | | ● | | | | | ● | | | | | | | | ● | 0.25, 0.5, 0.67 |
| Quality of pipe production – $F_3$ | ● | | | | | ● | | | | | | ● | | | | 0, 0.17, 0.42 |
| Quality of construction and installation works – $F_4$ | | ● | | | | ● | | | | | ● | | | | | 0, 0.17, 0.42 |
| Constructive-technological factors – $F_5$ | | ● | | | | ● | | | | | ● | | | | | 0, 0.08, 0.33 |
| Natural influence – $F_6$ | | | | ● | | ● | | | | | | | ● | | | 0.25, 0.41, 0.67 |
| Exploitation factors – $F_7$ | ● | | | | | | | | | ● | | ● | | | | 0.25, 0.42, 0.58 |
| Defects in pipes and weld seams – $F_8$ | | | | | ● | | | | ● | | | | | ● | | 0.58, 0.75, 1 |

## III. Results

Then, according to the method [5], the distance to the highest value vector (in other words, to the “very high” risk factor) of this vector and the sum vectors of the individual experts were calculated. The distances obtained are shown in Table 4. As can be seen from Table 4, these distances were 5.90, 6.39, 5.92 and 5.90, respectively, for the generalized vector of individual experts and the expert group. If we take into account that the distance between the “very weak” indicator and the “very high” indicator is 13.75 and convert the above-mentioned distances to the scale [0, 1], we get the following: 42, 46, 43, 43%.

These estimates indicate the percentage of accident risks far from the "very high" risk, taking into account the opinion of individual experts and expert groups.

**Table 4:** *Results of fuzzy assessment*

| Values of factors and risk factors | Sum values of fuzzy vectors | Distance from "very high" risk | Diverge "too high" risk, % |
|---|---|---|---|
| 1st expert score | 0.18, 0.37, 0.59 | 5.90 | 42 |
| 2nd expert score | 0.18, 0.31, 0.53 | 6.39 | 46 |
| 3rd expert score | 0.18, 0.37, 0.59 | 5.92 | 43 |
| Fuzzy numerical final estimate | 0.18, 0.36, 0.58 | 5.90 | 43 |

## IV. Discussion

Finally, the final assessment was based on the final vector calculated for individual expert meetings and the expert group. The results were [0.18, 0.37, 0.59], [0.18, 0.31, 0.53], [0.18, 0.37, 0.59] and [0.18, 0.36, 0.58], respectively (Table 4). As can be seen, these indicators do not differ much from each other and can be assessed as “weak” by 0.52 degrees and “moderate” by 0.48 degrees on the scale [0,1] (Figure 1).

Therefore, despite the diversity of initial assessments by experts, the level of technological risk resulting from oil spills for oil pipelines is not very high, mainly can be assessed "weak" risks.

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