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Risk assessment for stonecutting enterprises Accidental risks in the course of petroleum production and stone extraction

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Abstract. The paper is devoted to the assessment of accidental risks occurring at the works engaged in stone extracting and petroleum production. Two basic kinds of accidents common for stone extracting and petroleum production have been chosen to be discussed in the part under consideration. The most dangerous accidental situation characteristic for a stone milling line is an unsanctioned explosion, UE, of blasting agents used for the development of stone deposits. The analysis of a risk occurrence in certain accidental situations is to be carried out. With reference to petroleum extraction, a combustibles and lubricants (C & L) explosion is the most dangerous of characteristic accidental situations. To reveal the most probable causes of accidental situations to be realized, a graph of cause and effect relations has been constructed for each of the accidental situations most probable causes to real situation of an accident. Disasters of a natural origin are the most probable causes of unsanctioned explosions at the deposits of stone raw materials. Technology related natural disasters are the most probable causes of unsanctioned explosions to be realized at multiple well platforms engaged in petroleum production.

1. Introduction

An accidental risk is a risk of unwanted ecological after-effects technology-related in a production. As opposed to a constant risk, an accidental risk is connected with an uncertainty which is followed by different after-effects. The after-effects depend both on the character of the accident itself (transport accidents, fires, explosions, chemical or biological ones, radioactive emissions, building and construction collapses, hydrodynamics-related accidents, etc.) [1] and on the condition of the environment, climate, season and other factors.

There are plenty of accident and catastrophe causes, but the basic ones are as follows:

- non-observance of a workplace and technological discipline;
- design faults;
- building faults;
- equipment, buildings and constructions deterioration;
- the results of natural disasters.

The lines of petroleum production and stone extraction belong to geological branches, accident incidence rate being in their nature to the utmost due to dangerous natural raw materials (i.e. petroleum and accompanying gas) being extracted and harm full substances and materials (occupational dust, combustibles and lubricants, etc.) being stored [2].

The following kinds of accidents are characteristic for the lines of petroleum production and stone extraction:



- accidents of a natural origin (earthquakes, floods, landslides, mudflows, falls of ground, sloughs, avalanches, slope washes, storms, wilderness fires);
- technology-related accidents (fires, explosions, explosion threats, accidents followed by blowing-out (a threat of blowing-out) chemically hazardous accidental materials; unexpected collapse of buildings, constructions, failure of transport communication line elements).

2. Essence of survey

Two basic kinds of accidents common for stone extraction and petroleum production have been given consideration in the survey performed. In stone extraction, an unsanctioned explosion of the explosives used in the development of stone deposits (EM). In petroleum production, the explosion of combustibles and lubricants is the most common accidental situation. The analysis of these accidental situation risks was made in the course of works performed.

To begin with, stone extracting branch is to be given consideration to. Blasting operations are common in this production and are followed by extracting stone.

The methods of explosive works are as follows: using deep-hole charges (being the most common one for modern open-pits), chambering charges (being used for exploding great solid rock formations with the aim of blowing-out, faulting or fragmenting), using outer and blast hole charges. In the open pits, the last two methods mentioned are not used frequently and, as a rule, they are intended for fragmenting oversized blocks.

The method of breaking with deep-hole charges is the basic one in the open pits. Deep-hole charges are usually located vertically in the rock formation, sometimes they are in an oblique position, whereas their horizontal position can be observed almost never. The main parameters of blast hole drilling, the blast hole being located vertically, are as follows: the diameter of a deep hole, the height of the scarp, the interval between charges, the interval between series, the length of sub drilling, the least resistance line, the tamping height, a charge quantity and its construction [3].

The use of a charge construction characterized by the availability of free-air spaces is an advanced method of an explosion controlling (see Figure 1). It contributes to a higher intensity and evenness of fragmenting (the size of an average piece becomes smaller by a factor of 1.5 – 3, the yield of oversize material becomes several times smaller), a reduced volume of tamping works makes the explosive ratio smaller by 10...30 % simultaneously increasing the yield of broken material, balm stones into the depth of the solid and the seismic effect of the explosion becoming smaller.

A better fragmenting of subsurface rocks as a result of blasting out charges containing air gaps is achieved due to energy rearrangement occurring in an explosion-generated pulse (causing a reduced incidental pressure in the initial period and a longer explosion effect), choking the explosion of the upper charge with light end explosion products.

The main hazards occurring in realization of unsanctioned explosion at the stone deposit are as follows: fragment injuries and injuries caused by spalls of mined rocks and crushable materials along with direct human exposure to shock-induced air waves and to detonating products of explosive charges.

Most accidents and cases resulting in injuries happen due to violation of safety measures. An unsatisfactory level of the personnel's workplace discipline, improper control, irresponsibility, negligence of business managers, inadequate control on the part of the Federal Service for Environmental, Technological and Nuclear Supervision authorities also serve as a background of accident occurring at the productions.

3. Technological aspect

Figure 1 shows a graph of cause and effect relations (a tree of experiences) dealing with accidents having happened in accordance with some probable scripts of event courses. The graph mentioned is related to the deposits given consideration in the given paper as the stone extraction there is performed opencast combined with blast hole drilling.

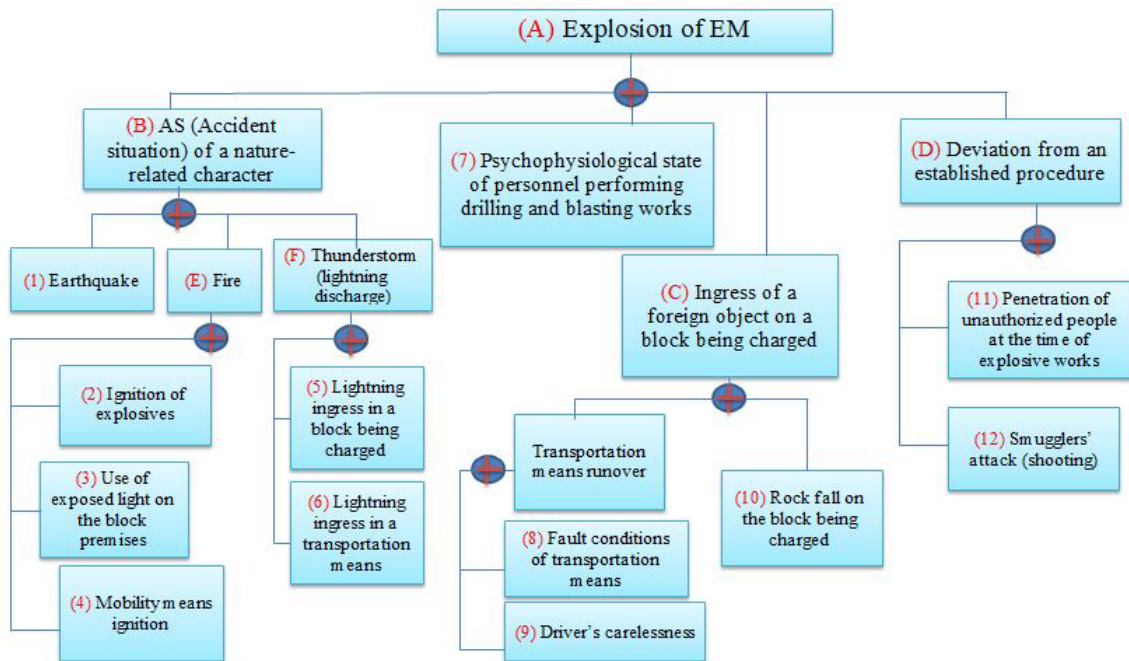


Figure 1. A graph of cause and effect relations (a tree of experiences) dealing with accidents that happen according to probable scripts of event development at stone extraction works.

From the causes of unsanctioned explosions of explosive materials in a block being charged which are represented in the tree, an analysis of static information has been made to reveal the probabilities of their occurrence.

Basing on the information obtained, a probability calculation of the main event, i.e. an unsanctioned explosion [3], was performed in accordance with the following Equation:

$$P(x) = 1 - (1 - P(i_1)) \cdot (1 - P(i_2)) \dots (1 - P(i_n)) \quad (1)$$

The calculations are indicative of the fact that the probability of an unsanctioned explosion in the site of explosive works is 1.72×10^{-4} . The background (B), namely, "Accident situation of a nature-related character" is the most important factor as concerns the most important event.

Consequently, nature-related disasters are the most probable causes of unsanctioned explosion realization in the deposits of stone raw materials.

Next, an accidental situation characteristic for the line of petroleum production is to be given some consideration, namely, an explosion of combustibles and lubricants. Combustible and lubricant warehouses are located on each multiple-well platform, in the immediate vicinity of other objects. There are such materials in them as petroleum products involving different kinds of combustibles and lubricants, fuels [4] (gasoline, diesel-fuel oil, liquefied-petroleum gas, pressurized natural gas, liquefied natural gas); lubricants (engine, transmission, and special oils, greases), subject-oriented liquids (brake fluids and coolants).

A number of causes, such as a fire, high temperatures, fuel or other combustibles and lubricants leakage, electric equipment failure, faulty transportation facilities, etc. can provoke an explosion in a combustible and lubricant warehouse. Cause and effect relations (a tree of experiences) that are responsible for an accident (explosion of combustible and lubricant materials) are represented in Figure 2 in accordance with a probable script of the event development.

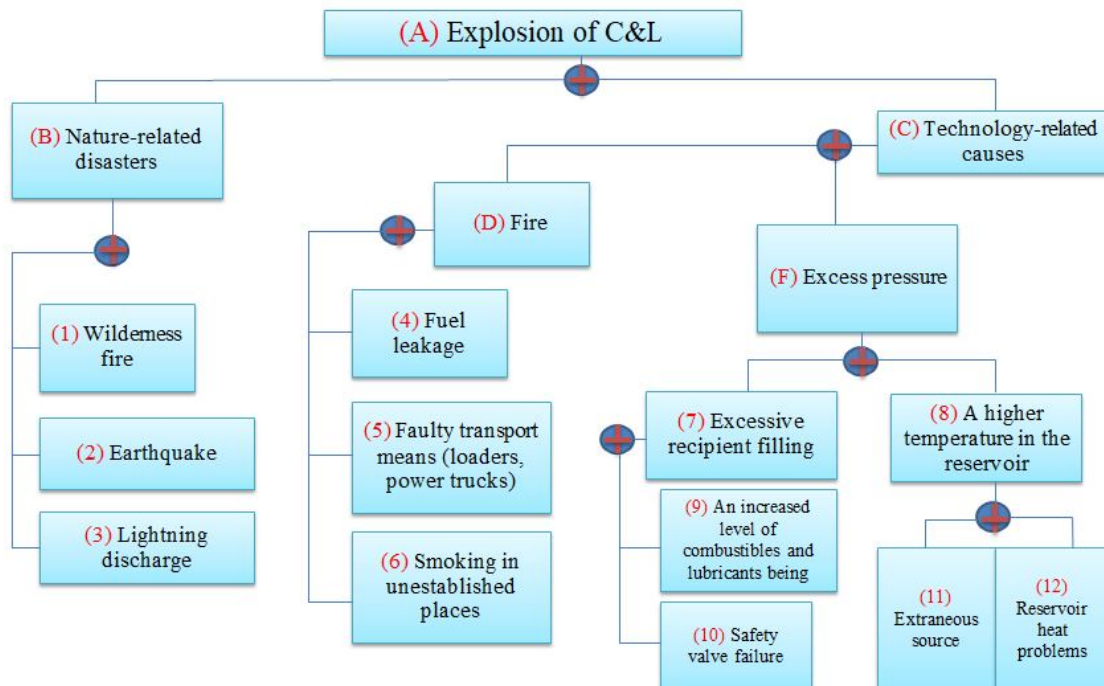


Figure 2. A graph of cause and effect relations (a tree of experiences) inducing accidents in accordance with probable scripts of developing events in petroleum production.

Basing on the causes of an unsanctioned combustible and lubricant explosion that has happened on a multiple-well platform and is represented in the tree of experiences, an analysis of statistical information was made to reveal the probabilities of their appearance.

The probability calculation with regard to the most important event [5], i.e. a combustible and lubricant explosion (Equation 1), results from the information obtained. It follows therefrom that the probability of unsanctioned combustible and lubricant explosion occurrence on a multiple-well platform makes up 6.7×10^{-5} . The background (C) of “Technology-related causes” is most important for the assessment of the main event probability. It follows therefrom that technology-related natural disasters are the most probable cause of realizing unsanctioned explosions on multiple-well platforms intended for petroleum production.

4. Economic disbenefit calculations

If events under consideration get realized at stone extraction and petroleum production works, economic disbenefit follow them resulting from facility accidents. Disbenefit was calculated following realization of accident situations occurring in the both lines and given consideration in the given paper to be compared [6].

An economic disbenefit following an accident at a stone deposit (an unsanctioned blast of explosives in the course of drilling and blasting operations) accounts for 25 mln 959 thou. 311 roubles. The disbenefit following an accident at the multiple-well platform of a petroleum production (combustible and lubricant materials explosion) accounts for 48 mln 613 thou 528 roubles.

A comparative graph of an economic disbenefit following the accident situations realized at petroleum production and stone extraction works is represented in Figure 3.

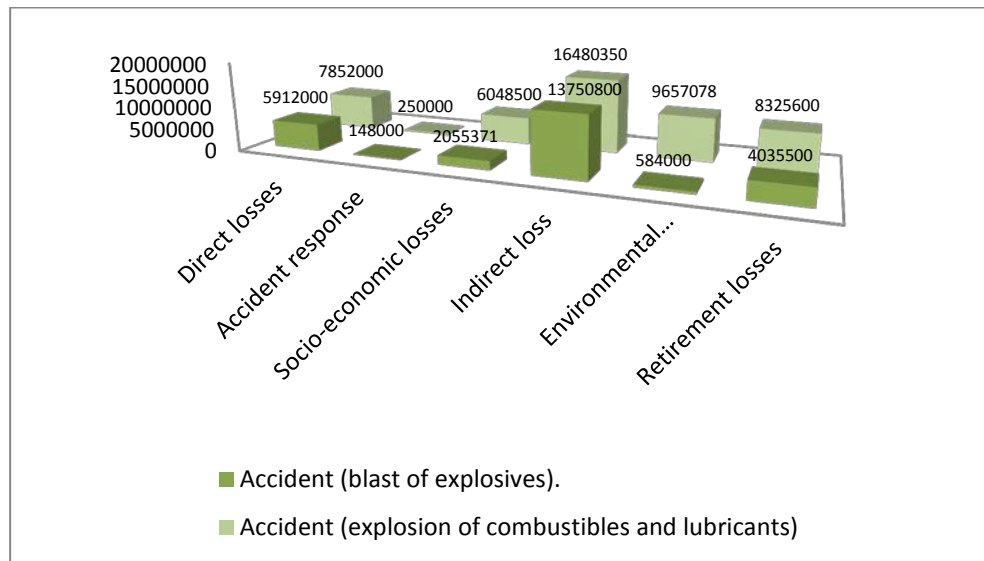


Figure 3. A comparative graph of an economic disbenefit following accident situations realized on production platforms of works under consideration.

5. Practical recommendations concerning making lower accidental risks

To make accidental risks lower in the conditions of stone extraction the following items should be anticipated:

- to arrange the possibility to study regulations and data messaging dealing with blasting work for the personnel performing drilling and blasting operations and employees responsible for a blasting work area;
- to control the knowledge of fire safety regulations;
- to conduct the instructions dealing with explosives transportation from the primary warehouse to work areas for the people performing the transportation;
- to limit the group of people having access to explosives on a need-to-know basis;
- to conduct instructions with drivers, fillers, and securities;
- to control the personnel compliance with fire safety regulations, trucking rules using autotruck transportation, rules of establishment and safe exploitation of production locations in addition to engine-driven primary mining for explosives being used in the services performing explosive works;
- to revise the labor system management in correspondence with the amendments made in the labor legislation.

To make an accidental risk smaller in the conditions of petroleum production the following items should be anticipated:

- to organize regulations and documentary data messaging study dealing with the rules of storing combustibles and lubricants for the personnel responsible for a proper combustible and lubricant storing and for the specialists engaged in work production in the area;
- to control the awareness of fire safety regulations on a regular basis;
- to conduct instructions for people engaged in transportation on the delivery of flammable materials from the primary warehouse to the sites of work performance;
- to limit the group of people having access to combustible and lubricant warehouses on a need-to-have –access basis;
- to conduct instructions with the personnel handling multiple-well platforms for petroleum production;
- to control the personnel observance of fire safety regulations, the rules of freight lift by autotruck transportation, rules of establishing and safe service of production sites in addition to a power-driven

preparation for application of flammable materials in the services performing petroleum production works;

– to revise the system of labor safety management and arrange it in correspondence with the amendments made in the labor legislation.

6. Summary

Accidental situations are common for most productions, petroleum production and stone extraction including. The mentioned productions being compared following accidents realized in the production areas, it is evident that the disbenefit resulting from the explosion of combustibles and lubricants is by far greater than the one resulting from explosive materials blast. Most probably this fact is connected with different kinds of the exploding materials and discharge components. Salaries attached to positions and wage pools are also of a considerable significance in this connection. The result of calculations proves that the disbenefit caused by explosion of combustibles and lubricants in a petroleum production area is by the factor of 1.8 greater than the similar index calculated for the blast of explosives.

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