RISK IDENTIFICATION AND EVALUATION FOR MAJOR NATURAL GAS STORAGE FACILITIES

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1. Introduction

Natural gases extracted from oil fields are increasingly used to meet energy needs. Gas production doesn`t fulfill the market`s fluctuant demand, therefore gases are stored in underground deposits.

The storage of compressed natural gases underground, in natural reservoirs of oil and gas, is used as an effective common technology since 1915 to adjust the gas supply in order to fulfill the market`s demand.

For underground storage, natural gases are injected in underground oil and gases reservoirs, when the market`s demand falls beneath the supply sources, and are extracted from these deposits to increase their delivery capacity in order to meet the required level when demand exceeds the production.

The primary function of an underground gas deposit is to regulate supply and demand for the consumption seasonal variations. Besides this, the storage facilities can ensure gas delivery from the safety reserves, in case interruptions appear in the normal supply rate, and can also help in conserving the energy by using associated gases that otherwise would be sent to flare.

In order to build an underground deposit, companies use wells that establish a controlled connection between surface facilities and deposit. These wells used to inject and extract natural gases are called exploitation wells. In addition to these exploitation wells, (pressure) observation wells can also be used.

The construction and the operation of the deposits must be made in such a manner, that the preservation`s integrity is safely maintained. The underground installation must be designed, built and exploited without involving any risks in the personnel and exploitation reliability.

2. Considerations regarding the increase of natural gases underground storage

In Romania, natural gases are one of the subsurface natural reserves with a major importance, if we are to consider the relative sizeable reserves, the production, the energetic share and the long history of exploitation.

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In our country, we extract high purity methane gas with a methane content of 98-99,7% and a calorific value of 42 MJ/m^{3}N, as well as the associated or well gas from the oil structures.

Methane gas, which forms the vast majority of the Romanian reserves, is quartered in geomorphological structures in the shape of a cupola, vaultings called domes in the Transylvanian Plateau. In this area, from the 67 gas fields, 54 where identified after 1948. In the Transylvanian Plateau, extraction proceeds only in a few areas.

Underground storage is a vital part of the natural gas industry.

The possibility of natural gas storage offers certainty in delivery through the high demand periods by increasing supplies when necessary, and represents a safety precaution in case the current production is interrupted.

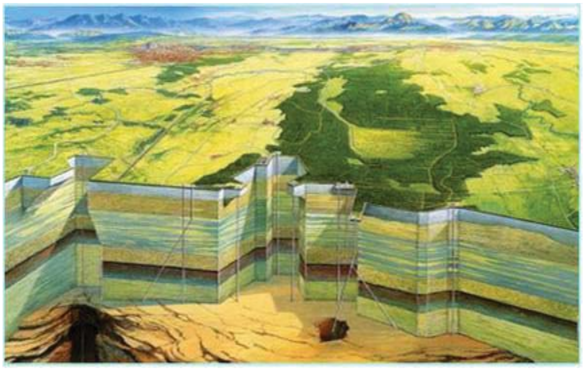

Fig. 1. **Overview Picture - underground gas-storage reservoir developed in depleted fields**

The National System for Natural Gases (SNGN) acts to increase the natural gases underground storage capacities, to absorb consumption peaks during the cold season, as well as to increase the safety degree of gas delivery to the consumers. The measures and actions taken by SNGN pursue to increase the safety coefficient when gas is delivered and to absorb the unbalance peaks, at values as close as possible to the ones that are applied in the countries from the European Community.

In order to successfully fulfill gas market future evolutions and to realize the sources (supplies) - demand balance, SNGN acts, from the subsurface storage point of view, in three different ways:

1) develops current deposits by increasing the storage capacity and the daily quantities that will be extracted;

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2) increases performance and operational flexibility in the existing deposits;

3) identifies new fields that can be converted in subsurface deposits.

The main elements that constitute a natural gas deposit are:

1. a standalone field with the right characteristics for gas storage;

2. a number of wells connected to a piping system;

3. compression and drying stations;

4. a main station that ensures both the gas supply for injection, as well as the distribution to the consumers.

To these main elements, are added: individual heaters for wells; observation wells; individual or collective separators; a collecting system for residual water; measure devices and pressure regulators; a methanol injection system.

Although in the last two years the storage capacity has had a significant increase, the ratio of the consumed gas at national scale and the ones extracted from the deposit is approximately 11%, which represents a reduced safety degree in providing gas to the consumers, under the values obtained in the western European countries (>25%).

New deposits are programmed to be realized in semi-depleted fields that are strategically located in the deficit areas, with gas sources that, especially, cover the consumption in areas with daily and seasonal fluctuations. Placing these new deposits will be possible after a transport capacity analysis by The National Transportation Society and some pre-feasibility and feasibility studies of various depleted fields located nearest to big consumers and areas with high consumption variations that can be seasonal, daily and/or hourly.

Moreover, the volume for the gas cushion afferent to each deposit will be reconsidered, to increase flexibility for storage capacities and to better respond to the requirements (normal, high, crisis, daily and hourly peaks consumption), as well as storage cost optimization.

Experience gathered in the last years taught us that natural gas deposits have a sufficient storage capacity to sustain the winter consumption, but not enough extraction capacity for high consumption periods. Decreasing storage capacities leads to lower pressures in the deposits, resulting in a lower extraction capacity, leading to unbalance when demand reaches high peaks.

In this context, security and continuity of gas supply is a strategic objective. For now, existing deposits could supply the natural gas, following an unforeseen accident, for a period of about 45 days, which is quite less compared to countries like France or Germany (105 days), which should give us food for thought in the context in which our only external source to date is the Russian Federation. Therefore, our country requires increasing the number of underground storage facilities, which involves special investment.

In conclusion, storage capacities are confronted with a lack of flexibility which should be resolved by transforming seasonal deposits into multicycle deposits, or by increasing the storage activity efficiency through an intelligent pricing policy.

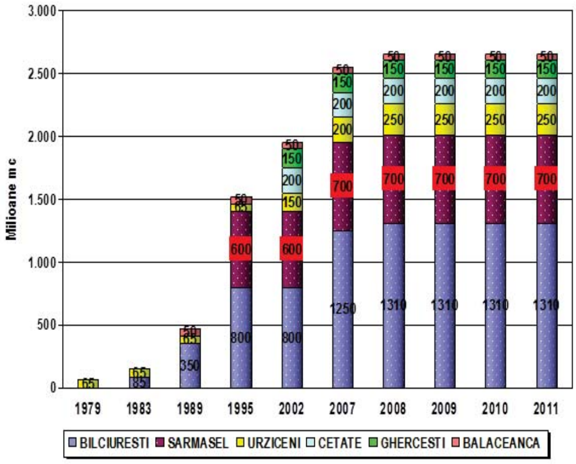

Fig. 2. **The evolution of natural gas storage capacities in the 1979 – 2011 period**

***Observations*:**

1) Investments regarding compression stations are efficient in optimizing the technological process of natural gas storage, owed to the fact that, as the gas quantity from the deposit decreases, field energy also drops, so a surface supplementary mechanical energy is needed to facilitate natural gas extraction, transport and distribution.

Thus, necessary technological procedures are realized by means of compression. This helps increasing well flows and the natural gas delivery pressure from the well to the National Transportation System and further to the consumers.

Obviously, compression stations determine the highest recovery factor value of the fields` hydro-carbides.

2) A particularly complex aspect, with important influences in achieving the investment plan, focuses on promoting investments that regard the achievement of certificates, agreements and authorizations needed when working on private locations.

To solve these, SNGN permanently bonds with the state institutions to simplify and shorten the procedures that apply to obtain the necessary approvals.

3. Identifying risks during technological processes

The procedures for hazard identification, risk quantification and determining risk acceptability and risk reduction, are all part of risk management.

Generally, to identify hazards, specific techniques are required, [3]:

- analysis techniques through sorting called *Screening Analysis;*
- verification lists *Checklists;*
- hazards preliminary analysis;
- scenarios analysis *What if* (what happens if);
- analysis of modes and effects of failure *FMEA (Failure Modes and Effects Analysis)*;
- functionality Studies without danger *HAZOP (Hazard and Operability Studies)*;
- audit while operating etc.

Risk estimation

The concept of risk comprises two components:

- serious consequences;
- the probability of events.

If we assign a risk level of severity and probability (see figure 3). We get the same level of risk for different couples: gravity (y) - probability (x).

The probability is expressed as number of events produced per unit of time (year).

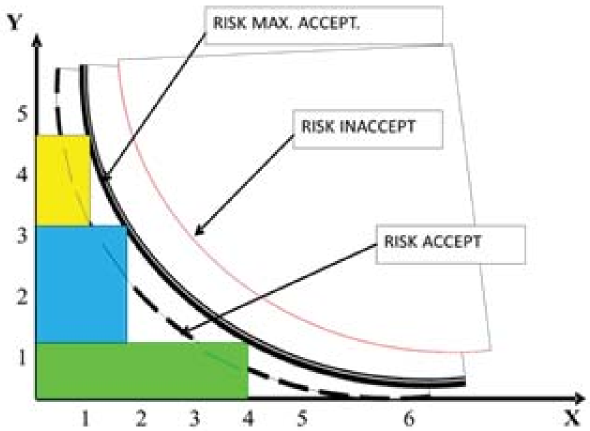

Fig. 3. **The risk curves: y - gravity , x – probability**

4. The centralized monitoring and control over natural gas storing facilities

Underground gas storage is a vital part of the natural gas industry. The possibility of storing gas underground provides certainty of supply during periods of high demand by increasing supplies and is a safety measure in case of interruption of current production.

There is a real necessity for planning in the short, medium and long drive to develop scenarios for demand and resources.

In order to cover the peak seasonal consumption the following solutions are used:

-gas storage in oil or gas deposits which were depleted partially or totally (76.8%) of the total;

-natural gas storage in aquifers (14.8%);

-natural gas storage into the cavities made in the salt rocks (7.9%);

-storage of liquefied natural gas (LNG) or liquefied petroleum gas (LPG) in saline deposits or other watertight deposits such as mines (0.5%);

Storing natural gas underground is a practice aimed at balancing the gas supply and demand given that it is considered complex system consisting of:

-domestic production;

-imports;

-existing transmission capacity;

-variable applications (seasonal, daily, hourly) which operate under the influence of weather and economic and social factors.

The centralized monitoring and control of a natural gas transportation technological node is a modern and complex system designed for the automatic supervision of technological nodes in networks of natural gas transportation equipped with valves powered by electric, pneumatic or hydro pneumatic means. The system contains both HARDWARE and SOFTWARE, integrated into a flexible control and data acquisition system (S.C.A.D.A.), which provides the possibility of automatic management of all processes carried out at a natural gas transportation technology node.

The implementation of this system ensures the monitoring and the local centralized control as well as the complete automation of the technological devices existing in a knot of natural gas transportation such as: sectioning valves (taps on / off) control valves, air-fresheners, pig launchers/ receivers, methanol injectors, gas heaters, etc. The system also ensures the acquisition, the numerical processing and the storing of process parameters (pressure, temperature, flow) facilitating the possibility of integrating these stations in SCADA systems

The main characteristics and control and monitoring possibilities offered by the program are:

- The graphic interface under the form of three-dimensional synoptic diagram (see Fig. 4)
- Information about the position and state of valves powered electrically and pneumatically
- Same screen viewing of all the necessary information for the control of a technology node (see Fig. 5)
- The valves which are closed, open or in an intermediate position have different symbols. (see Fig. 4).

Fig. 4. **Synoptic scheme of a storage facility**

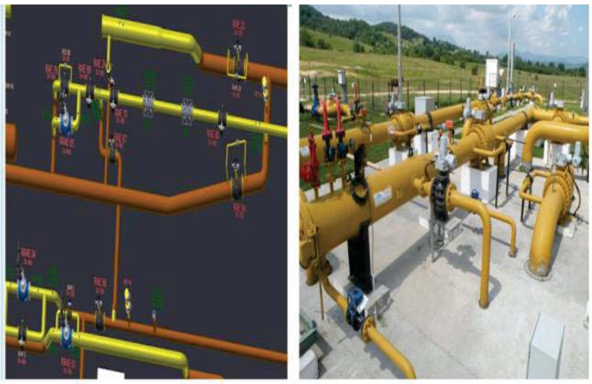

*Fig. 5***. The SCADA scheme**

The technological parameters of a technological node (p, T, Q, etc.) and their change `time can be represented graphically over time intervals chosen by the beneficiary.

5. Conclusions

The author proposes that the method should also be applied for the other risk identification procedures for natural gas storage facilities taking into account their characteristics. The paper presents three structural models of risk analysis for a natural gas storage facility.

* The underground gas storage is is used as an effective common technology since 1915 to adjust the gas supply to meet demand.

* For underground storage, natural gases are injected into underground reservoirs of oil and gas when the market demand falls below the production and are extracted from storage to supplement delivery at the required level when demand exceeds the production.

* The primary function of an underground gas deposit is to regulate supply and demand for seasonal variations in consumption. In addition, the storage facilities can supply the safety gas reserves in case of failure of the normal supply and can help conserve energy by using associate gases that otherwise would be sent to flare.

* To build an underground deposit, companies use controlled wells to establish a connection between the reservoir and the surface. These wells used to inject and extract natural gasses wells are called exploitation wells. In addition to these exploitation wells, (pressure) observation boreholes (standpipes) can also be used.

* The construction and the operation should be such as to maintain the integrity of preservation.

* The storage facility must be designed, constructed and operated so as not to present any risk for the sexploitation and for the personnel.

The main contribution this article makes is the introduction of structural models in the risk identification methods for the major natural gas storage facilities.

In order to carry out some comparative analyses of finding the optimal operating mode, the designer may choose his own values for simulation so that he could decide which of the operating modes leads to a convenient value of risk according to the number of elements taken into account and their grouping modality.

References

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