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REVIEW OF METHODS FOR ASSESSING THE QUALITY OF GAS INFLOW STIMULATION WORKS AT THE FINAL STAGE OF FIELD DEVELOPMENT TO IMPROVE THE EFFICIENCY OF THE CONSTRUCTION PROCESS

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Abstract

The current state of Russia's gas industry (in particular, in the north of the West Siberian region, where there are numerous deposits) is characterized by depreciation of the technical base of enterprises, depletion of the largest old fields, reduction of gas inflow intensification, and the appearance of many hard-to-recover reserves. All this requires an assessment of the quality of drilling operations during well construction, which should also consider the stages of field development.
The purpose of the work is to review the methods of quality assessment of gas inflow stimulation works at the final stage of field development to improve the efficiency of the construction process.
Based on the conducted review, the authors propose their integrated approach to the quality assessment of inflow stimulation works, which provides interrelated performance assessments. Regional socio-economic risks of field development completion at the final stage are outlined.

Keywords: Wells, Management, Drilling works, Development, Economy.

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INTRODUCTION

One of the new terms that have recently entered science and society is the concept of quality of life used, in particular, by specialists of the United Nations to assess the population's standard of living in various countries (Kozhabayev et al., 2023). This indicator reflects the

relationship between the spiritual development of society and the sphere of material production in the context of quality of life (Bykov, 1999; Kotlyarova et al., 2023). From the point of the application of gas inflow stimulation methods at the final stage of field development, the quality of drilling works affects not only the economic component of the concept of quality but also directly influences the social sphere and the preservation of human potential (Loseva et al., 2023). In other words, conducting works and applying technologies at the old fields will yield the effect of preservation and development of the northern cities, where gas-producing enterprises are town-forming ones (Busakhin, 2023; Kenzhin et al., 2021).

Quality improvement equivalent to an increase in the number of constructed wells is a source of rational and efficient use of gas resources on a global scale (Bezpalov et al., 2023). A contradiction in the economic form of the relationship between the categories of quantity and quality is the fact that quality improvement causes a rise in costs, as it requires increased investment (Kiseleva et al., 2023b; Tolmachev et al., 2020). The search for an optimal ratio between the quality of the constructed well, the number of wells, and their cost (which is considered a negative characteristic from the point of view of the drilling company and the production organization) (Glichev, 2001) is an important issue.

The contradiction between the costs of quality provision and its required level is the source of dialectical development of quality management systems (Kiseleva et al., 2023a, 2023c). Its resolution has passed through the following stages:

- rejection (control of all stages of well construction, considering that many processes take place deep in the ground, which complicates the control process);
- quality management (mathematical statistics methods, while currently there are no approbated methods for determining the quality of gas well construction, especially at the fields in the final stage of development);
- quality planning (the most relevant approach, yet there is no approbation of planning methodology for well construction at the moment);
- environmental and social safety (a drilling company has to not only build the well with high quality and carry out drilling operations per the requirements of the production company but also consider the environmental component and obtain a social effect in the form of preserving the organization's labor potential) (Figure 1).

The concept of quality in the construction of wells in the gas production complex includes a set of technical, technological, human, natural, environmental, geological, social, organizational, and other factors affecting the performance of the drilling enterprise.

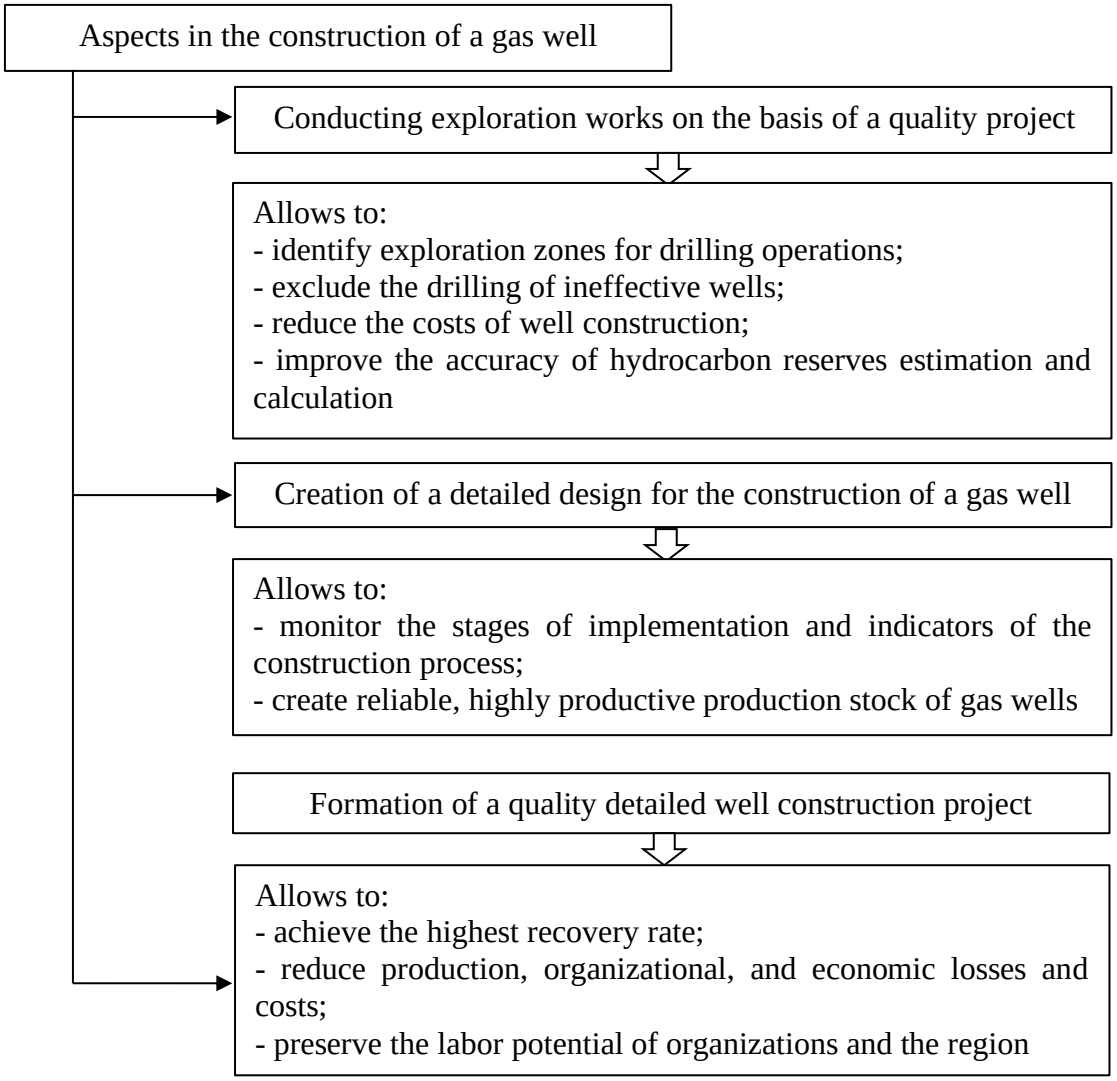

Figure 1. Aspects in the construction of a gas well

Planning and quality assessment of well construction

Planning and assessment of the performance of any enterprise is carried out by calculating and analyzing the system of technical, economic, production, organizational, and social parameters of its activities. Modern conditions of development of the real sector of the economy in the extractive industry dictate high requirements for all stages of well construction, associated with the need to improve the efficiency of production drilling (Panikarovskiy et al., 2021), increase the quality of well construction (Katanov et al., 2021), ensure the potential and real flow rate, and reduce the cost of drilling operations. All this overlaps with the emergence of fields at the final stage of development, which requires stimulating the flow of hydrocarbon raw materials. Therefore, an accurate, efficient, and realistic assessment of well construction quality, especially at the final stage of development (completion), is extremely important in drilling operations. Given the increasing complexity of geological production, technical, and

technological conditions associated with the final stage of field development and well construction, along with quantitative evaluation criteria (speed, excavation), the decisive role is played by indicators describing the quality of drilling operations performed (Fediukin et al., 2001; Novoselov et al., 2023).

The issue of quality at the drilling enterprise when designing and constructing wells and interacting with the extraction organization acquires economic and social urgency precisely at the final stage of field development. Apart from the risk of great losses due to the low quality of performed drilling works, which is inherent in all capital-intensive industries (Klyuev et al., 2022), including the gas industry, an important and independent role is acquired by the risk of lost profit due to the strong influence of natural-geological, technical, and technological factors. This impact can be mitigated by careful attention to the quality of the materials and equipment used, the drilling method, and the project implementation processes.

The constant need to meet domestic demand for gas, as well as a certain dependence of the budget on gas exports, requires that gas production volumes be increased or maintained at an acceptable level.

The current situation in the gas industry calls for a qualitatively new approach to well construction in fields at the final stage of development. In this situation, great attention should be paid to reducing the rate of cost increase and improving the profitability of drilling operations. This cannot be achieved without considering the improvement of the quality of work throughout the entire cycle of well construction. It should also be borne in mind that gas production enterprises are town-forming enterprises and maintaining production rates will have a social effect in the form of preserving the labor potential of gas enterprises and small towns in the West Siberian region of Russia. Without measures at the final stage of field development, such as the stimulation of gas inflow, many towns and settlements will cease to exist. As a result, the region may face labor market tensions in the form of increased unemployment (Sekerin et al., 2022).

The specified problems currently faced by the gas industry cannot be solved by targeted intervention separately but require a comprehensive approach.

The need for this approach is justified by the performance of works at certain stages when it is necessary to apply the well-known method of quality management: "The performer of the next technological operation is your consumer". For example, low quality of geological exploration works leads to drilling the so-called dry wells and, as a result, to an increase in costs of the drilling enterprise.

In this connection, the present study aims to review the methods of quality assessment

of gas flow stimulation works at the final stage of field development to improve the efficiency of the construction process.

METHODS

To achieve the set goal, a study based on qualitative methods of information collection was carried out. In the course of the study, we systematized the methodological basis for quality assessment during well construction by drilling companies.

Proceeding from this, the study employed the document analysis method, which enabled us to collect data for analyzing the quality of drilling production during well construction, while considering the shortcomings of the existing methods and relying on the practical objectives of their application. The theoretical and methodological basis of the work was provided by scientific works on quality assessment and the specifics of drilling enterprises.

Analysis of the developed and utilized quality assessment methods demonstrates that the currently existing scientific and methodological approaches to the integral assessment of well construction and drilling works as a mining facility and an operating site do not provide a realistic assessment of the quality of each well due to the lack of definite, specific, and uniform quantitative criteria and indicators.

RESULTS AND DISCUSSION

Analysis of the stages and directions of well construction

The specifics of assessing the quality of well construction is that it must be carried out for all major stages of site exploration, well construction, and the production of hydrocarbons (Figure 2).

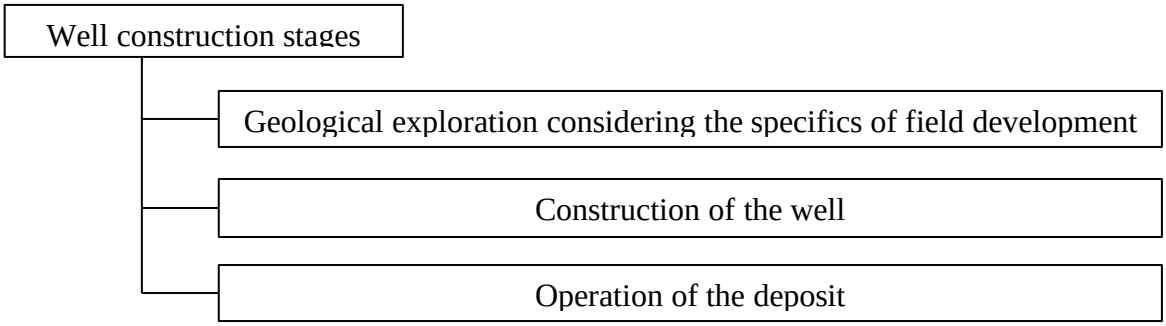

Figure 2. Stages of well construction

The process of building the quality of well construction as a technical product includes two stages: engineering its design itself considering all the features of the field and well

construction.

The importance of the first stage owes to the fact that the construction of a well reproduces the content of a previously developed design, demonstrating its uniqueness. For example, for us, work on gas flow stimulation must be carried out at the final stage of field development. Low quality of project development will cause the mining company to receive a result that does not meet their demand, i.e., a production well. Later, it will be difficult to organize the production process of well construction, which will entail increased costs of new wells and a reduced economic effect (Syromiatnikov & Andreev, 1991). Negligence and cost savings at this stage lead to great economic and social losses in the further construction and operation of wells, as well as a reduction of the production well stock. The social consequences consist, first and foremost, in personnel losing competencies and, potentially, in staff reductions in the future.

Comprehensive influence on the quality of the developed well construction project should be carried out in two directions (Figure 3).

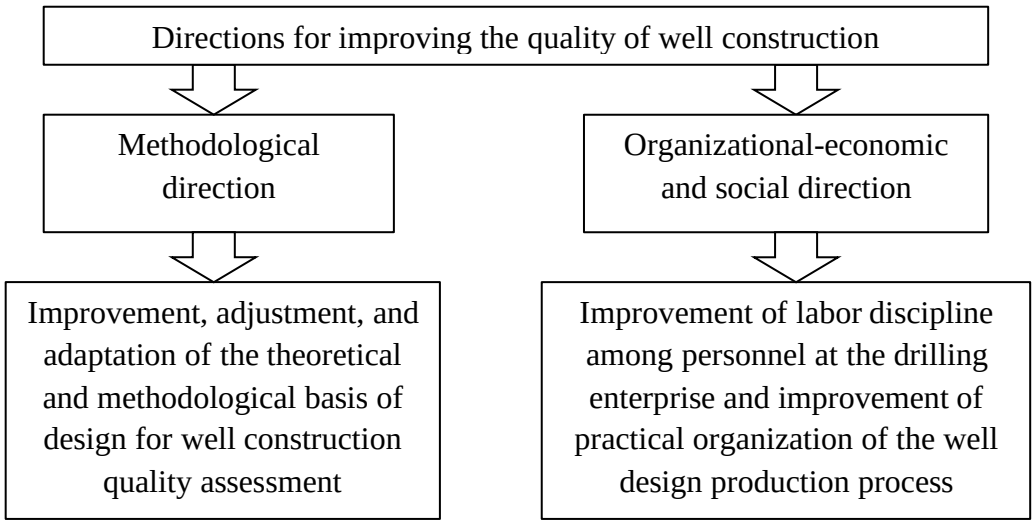

Figure 3. Directions to improve the quality of well construction

To increase the quality of both project development and the construction of wells, it is important to establish close interaction and cooperation between participants in design and construction: the client (mining enterprise), the designer (project institute, research institute, etc.), and the executor (drilling enterprise). Only well-organized interaction will enable efficient and prompt response to the necessary changes both in the design and the construction of the well. This interaction is vital not only at the stage of construction design but throughout the life cycle of the well, which will further allow designing new wells to account for the specifics of the field.

Today's situation in the sphere of development and performance of design works in the gas industry is marked by a multitude of drawbacks, and sometimes there are gross violations (Chejmatova & Vaganov, 2022). For instance, the use of group projects in development is limited by the requirements of the technical and technological, geological, and socio-economic criteria of the deposit, as well as the purpose of the wells and the goals of drilling works, which is a negative practice in construction, as individual structures are essentially erected following the same scheme. This approach fails to account for the specifics of the field, which is particularly important at the final stage of its development (Syromiatnikov & Andreev, 1991).

To solve this problem, it is recommended to introduce a multivariant design of well structures, drilling technology, materials used, and the competencies of drilling company employees using modern software. This will markedly accelerate the design process, reduce its labor intensity, and ultimately improve the quality of its results. In addition, this will provide the opportunity to account for specific features, such as the performance of works at the final stage of field development. Further on, it will be necessary to conduct a comparative analysis of the factually obtained parameters after the construction and commissioning of the well and the project estimates to create a unified industrial methodology. This will eliminate any subjectivity in the relationships between the client, the contractor, and the executor. The conformity of the project indicators with the actual results obtained in the construction should be the basis for assessing the quality of the construction of wells and its connection with the economic and social efficiency of the project.

At the stage of project implementation, there are the technological, geological, and environmental aspects in the quality of well construction. The geological aspect characterizes the collection of information from the well based on the study of cores from underexplored fields, conducting the necessary set of industrial and geophysical research and testing all potentially gas-bearing horizons and promising intervals (Ugolev, 1979).

The technological aspect in the quality of construction points to the reliability and longevity of the constructed well and its effect as an engineering structure according to its intended purpose for further operation.

The environmental aspect covers the provided protection of the subsoil and the environment during the construction and operation of facilities at the deposit (Zaretskaya, 2022). The objectives of all three aspects are closely interrelated and are addressed in the process of well construction.

The construction involves four primary stages, which shape the quality of the well:

1) preparatory work for drilling and derrick installation at the field;

2) drilling the borehole with consideration of stimulating the inflow of hydrocarbon raw material;

3) casing the borehole;

4) opening the productive formation and developing the well at the final stage of field development.

The presence of a quality design, proper execution of all technical and technological operations, the project executor having the required competencies and discipline, and the use of quality materials and modern equipment in the process of construction are the factors that significantly raise the probability of obtaining a high performance well. In the design and construction of a well, it is critical to account for the natural geological phenomena present in the field, as they are unpredictable and affect the construction process with a significant negative impact on the quality of the future production well. Therefore, a high level of quality of the finished well cannot be guaranteed by the drilling enterprise until the end of construction. For this reason, all participants in the construction process need to conduct continuous monitoring of the factual compliance of each constructed well with the established criteria.

Important factors in the quality of the final stage of upstream works, which largely define the end output of formations and the technological and economic efficiency of hydrocarbon extraction (along with the geophysical characteristics of productive layers) are the level and justification of project solutions regarding the development system and the degree of their practical realization in field drilling and operation. In addition to the quality of the constructed wells, the efficiency of field operation is strongly affected by such factors as the chosen development scheme, the quality of production infrastructure objects, the choice of appropriate equipment and control of its trouble-free operation, the quality of well repairs, carrying out geological and technical measures to increase the output of formations, and qualifications of the involved personnel.

A considerable role in this process belongs to the observation of environmental safety and the implementation of environmental protection measures. In addition, it is important to consider the social effect of further work in fields in the final stage of development, as well as the preservation of labor potential and personnel competencies.

The methods of increasing output should be recognized as a powerful tool to raise the quality of field development since their application increases the recoverable reserves of hydrocarbon raw materials at the final stage of field development and affects the primary quality indicators of field development throughout its period of operation.

Requirements to the methodology for assessing and achieving the quality of well construction

As a result of our research, the requirements to be met by the quality assessment methodology have been systematized (Figure 4).

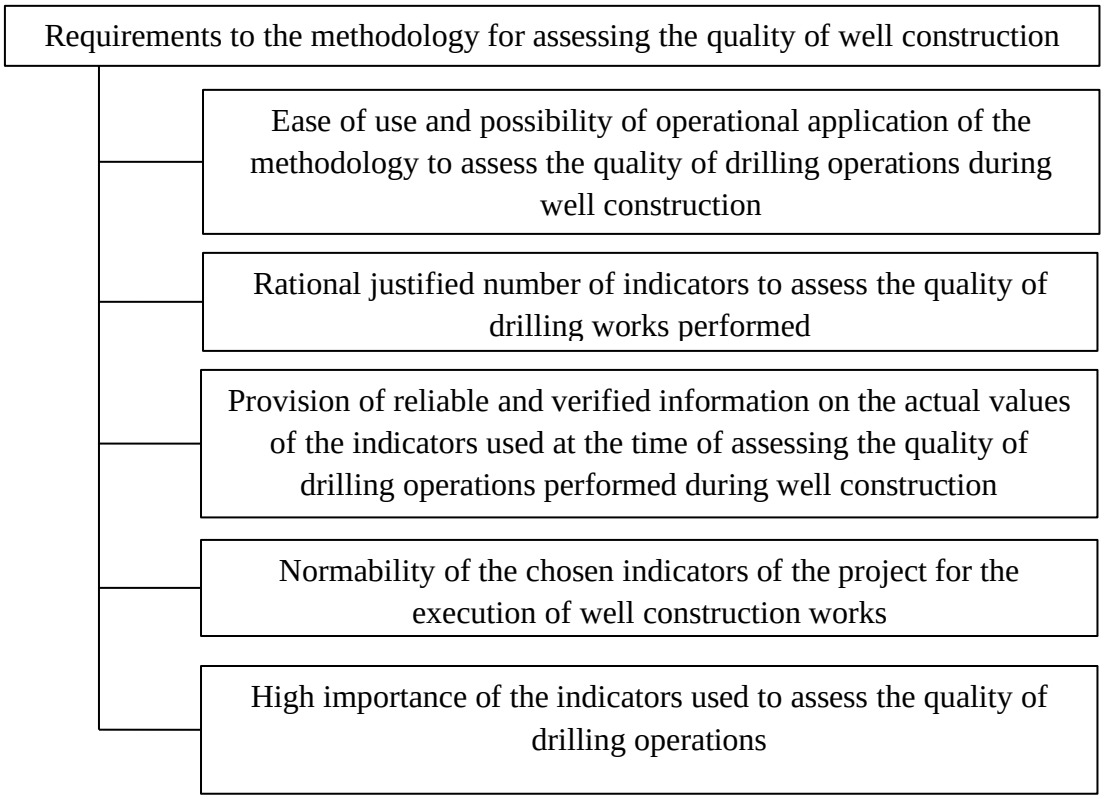

Figure 4. Requirements to the methodology for assessing the quality of well construction

A well, as a technical structure, has several quantitative and qualitative characteristics, deviation from which results in a decrease in the economic efficiency of its operation. The establishment and maintenance of qualitative characteristics occur consecutively in the process of drilling the well to the roof of productive deposits and well completion operations – primary penetration of productive strata, casing and zonal isolation of fluid-saturated gas reservoirs, secondary penetration of productive strata, especially for fields at the final stage of development, and well development and commissioning (Sereda & Solovev, 1988).

The main quality criterion of the constructed well is the fulfillment by the drilling company of all conditions of the project, which is developed upon the assignment of the producing company and should ensure maximum preservation of the reservoir properties of the productive formation, compliance with the requirements for the protection of subsoil, the environment, and personnel safety and social conditions.

The key requirements for achieving the well-construction quality indicators established by the project and applicable regulations of the producing organization are presented in Figure 5.

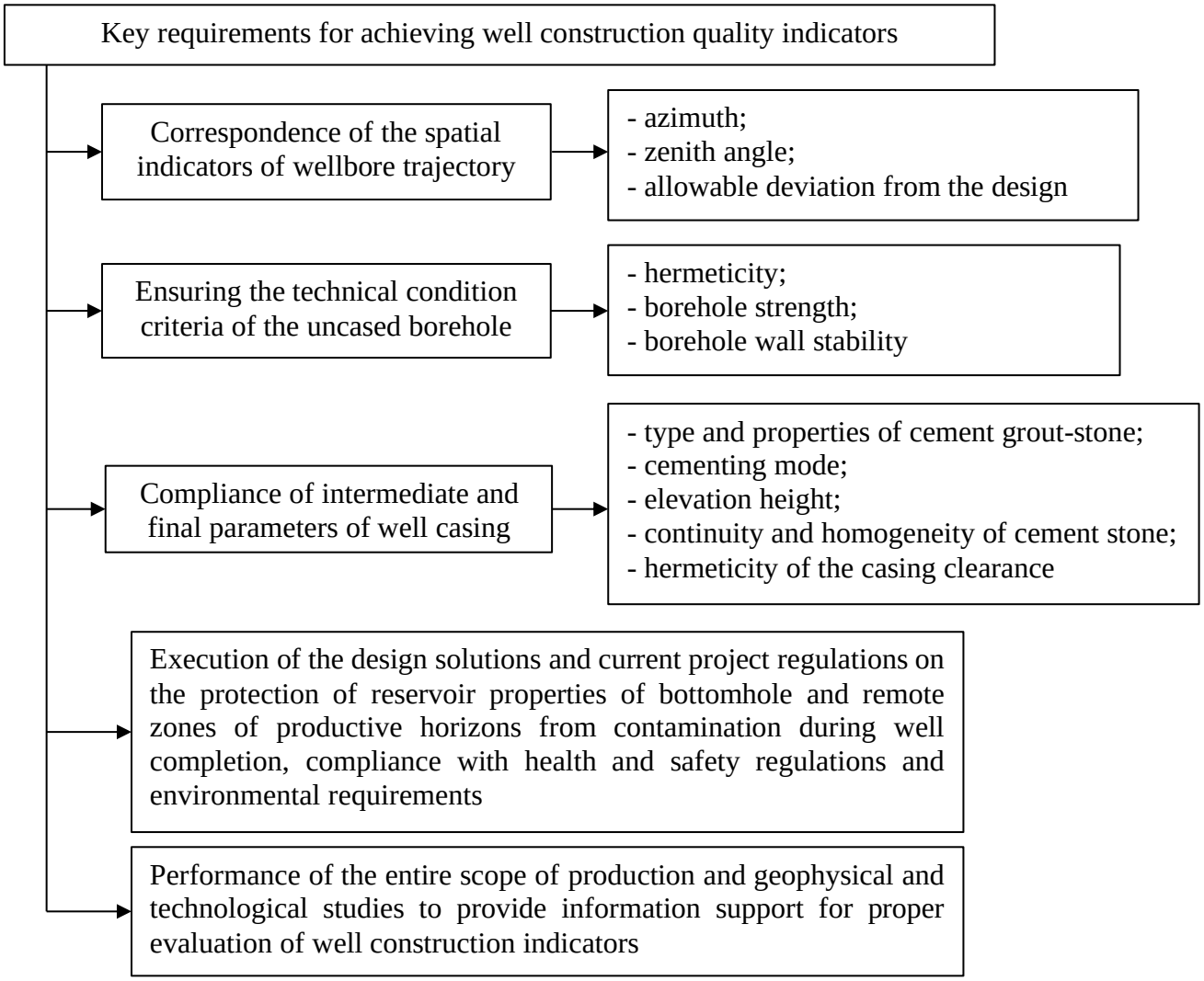

Figure 5. Key requirements for achieving well construction quality indicators

Therefore, the main indicators characterizing the quality of well construction are:

- compliance with the requirements for the specified wellbore trajectory;
- fulfillment of the volume of geological and geophysical surveys planned in the project;
- ensuring the specified quality of equipment fastening during well construction;
- ensuring the required quality of penetration and potential productivity of hydrocarbon reservoirs.

The listed group indicators include individual (n) indicators described by certain criteria. The quality of individual indicators is assessed by the value of the K_n coefficient. At K_n=1, the

fulfillment of this parameter is fully compliant with the project requirements (Sereda & Solovev, 1988).

It is essential to bear in mind the social assessment of well construction quality, especially in fields at the final stage of development, such as preserving labor potential at the meso- and micro-level and preventing social tension in the producing region.

CONCLUSIONS

The foundation of the proposed method of assessing the quality of the well considering its key characteristics is quite methodologically sound. The quality of a gas well is assured by the fulfillment of the following requirements imposed on it:

- fitting into the allowable deviation of the well trajectory from the plan at the final stage of field development;

- compliance with permissible limits of gas wellbore curvature;

- secure hermetization of the casing along its entire length (strong contact of the cement ring with the casing and rocks, no overflows in the casing clearance);

- correspondence of the gas well perforation interval to the productive section of the formation at the final stage of field development;

- ensuring that the obtained flow rate complies with the design flow rate or is higher (ensuring high permeability of the bottomhole zone) with consideration of the performed gas inflow stimulation works.

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