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Extended Abstract

The Comparative Study of Deviated and Multilateral Wells Drilling Risks for Use in Infill Drilling

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Abstract

Considering the importance of different sectors of the oil industry, especially the upstream sector and the drilling industry, risk assessment and risk management, as well as moving towards new methods and technologies, are inevitable for reducing costs and improving the profitability and credibility of the National Iranian Oil Company. The drilling industry is one of the most important upstream sectors, and its processes usually involve higher risks than many other activities in this industry. The main objective of this study is to compare the drilling risks associated with directional and multilateral wells for application in infill drilling. For this purpose, the relevant literature was first reviewed and the research gap was identified. Then, experts' opinions and drilling documents were used to identify the technical and non-technical risks. A pairwise comparison questionnaire was distributed among experts working in different sectors of the oil industry, and the Analytic Hierarchy Process (AHP) was used to rank the technical and non-technical risks. The results showed that formation-fluid influx into the well (Kick), which can lead to blowout if not controlled, and stuck pipe had higher priority than other technical risks. Therefore, the causes, control measures, and consequences of these risks were analyzed using Bow-Tie diagrams. In the non-technical section, a lack of specialists was identified and ranked as the most important risk.

1. Introduction

Due to the nature of activities in the oil industry, there have long been risks in the upstream, midstream, and downstream sectors. With the emergence of safety mechanisms, methods have been developed to identify, evaluate, and reduce the probability and impact of these risks [1]. The drilling industry, as a critical upstream sector, typically faces higher risks than many other activities; therefore, risk identification, evaluation, and mitigation in this sector are necessary. Implementing new drilling methods can also increase these risks and their potential impacts [2]. One method used for drilling and well redevelopment is multilateral drilling. The increasing use of this method worldwide indicates its effectiveness. After directional drilling, horizontal drilling, and sidetrack drilling, multilateral drilling was developed to the point that by 2006, about 8,000 multilateral wells had been drilled globally. This type of well drilling not only reduces development costs but can also improve oil production and increase the drainage area of the well [3]. Therefore, studying technical and non-technical risks in both directional and multilateral drilling can increase awareness and strengthen the safety culture within organizations. Conducting risk assessment by considering two different drilling methods and comparing their risks provides an estimation of the relative risk weights of these methods and can support managers in adopting innovative drilling technologies.

Given the complexity of directional and

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multilateral well drilling, risk assessment in these operations should not be limited to the identification of general drilling hazards. In such wells, factors such as well-path complexity, increased contact length between the drill string and the borehole wall, more difficult hole cleaning, higher sensitivity to formation-pressure control, the need for suitable downhole tools, and reliance on experienced personnel can increase the probability of both technical and non-technical risks. Therefore, this study identifies the effective risks in directional and multilateral drilling, ranks them using the Analytic Hierarchy Process, and then analyzes the highest-priority technical risks in terms of causes, control measures, and consequences using the Bow-Tie method. This approach clarifies the link between risk-ranking results and operational decision-making in infill drilling projects.

2. Materials and Methods

This applied study used historical data and questionnaires for data collection; therefore, it can be classifying as descriptive in terms of data collection methods.

Data Collection Tools and Methods

Data collection tools and methods include:

• Library studies (authentic articles, university theses, documents related to risks in various fields, and directional and multilateral wells(

• Reviewing and analyzing documents related to drilling directional wells in southern oil-rich areas (safety instructions, documents from the General Directorate of Safety, and daily drilling reports related to the research scope)

• Interviews with experts from the General Directorate of Drilling in Southern Oil-bearing Areas to identify non-technical risks, advantages, and disadvantages of the methods and limitations in implementing multilateral well technology in the Iranian oil industry

• Completing questionnaires to assess priority risks

The expert panel consisted of 13 specialists with direct experience in drilling engineering, well operations, drilling services, and drilling project management. The experts were selected based on their relevant work experience and familiarity with the technical and non-technical risks of directional and multilateral drilling. Their work experience ranged from 10 to 27 years; 12 participants held master's degrees and one participant held a bachelor's degree. The experts' judgments were given equal weight in the pairwise comparison analysis because all participants had relevant practical experience and expertise in the research area.

3. Results and Conclusions

Reports related to problems encountered during the drilling of wells in three fields, together with experts' opinions and library sources, were used to identify and rank the technical and non-technical risks.

Technical risks' ranking

The results of ranking the technical risks using the AHP method and Expert Choice software are presented in Table 1.

Table 1. Results of ranking technical risks in Expert Choice software (source: research findings)

Criteria	Sub-Criteria	Risk Rate	Options	Weight
Technical Risk	Formation-Fluid Influx (Kick)	0.126	Single Lateral	0.339
			Multilateral	0.661
	Stuck	0.099	Single Lateral	0.384
			Multilateral	0.616
	Twisted Off	0.099	Single Lateral	0.44
			Multilateral	0.56
	Pack Off	0.094	Single Lateral	0.386
			Multilateral	0.614
	Cementing Problems	0.075	Single Lateral	0.35
			Multilateral	0.65
	Drilling in	0.074	Single Lateral	0.392

	Wrong Deviation		Multilateral	0.608
	Failure to achieve the main target point	0.073	Single Lateral	0.371
			Multilateral	0.629
	Disconnecting or Error the various modules of the downhole navigation tools	0.071	Single Lateral	0.339
			Multilateral	0.661
	Mud Lost	0.069	Single Lateral	0.384
			Multilateral	0.616
	Disconnecting or Error the various modules of the in-well navigation tools	0.057	Single Lateral	0.486
			Multilateral	0.514
	Mechanical Failure	0.055	Single Lateral	0.457
			Multilateral	0.543
	Gas Cut Mud	0.053	Single Lateral	0.448
			Multilateral	0.552
		0.053	Single Lateral	0.406
	Cutting Accumulation		Multilateral	0.594

As shown in Table 1, formation-fluid influx into the well (Kick), which may lead to blowout if it is not controlled in time, received the highest priority among the technical risks. This result is operationally reasonable because well-pressure control and early detection of influx are among the most critical aspects of drilling safety. Stuck pipe was ranked as the second most important technical risk. Its high priority is especially important in directional and multilateral wells, where increased inclination, complex well trajectories, greater drill-string contact with the borehole wall, and more difficult hole cleaning can increase the probability of this risk. Therefore, well-control planning, appropriate mud-weight design, continuous monitoring of pressure and mud volume, effective hole cleaning, torque-and-drag control, and proper selection of downhole tools should be emphasized in drilling risk management.

Non-technical risks' ranking

The results of ranking the non-technical risks using the AHP method and Expert Choice software are presented in Table 2.

Table 2. Results of ranking non-technical risks in Expert Choice software (source: research findings)

Criteria	Sub-Criteria	Risk Rate
Non-Technical Risk	Lack of Specialist	0.134
	Inexperienced or untrained personnel	0.129
	Improper project planning and budgeting	0.094
	Inadequate tendering price & Claim in Contract	0.091
	Material unsuitability & defects; Fabrication defects	0.09
	Lack of proper tools (proper Bit, downhole tools, etc.)	0.08
	Lack of financial resources	0.08
	Lack of new methods & new machinery	0.066

	Dependency to Abroad for some Equipment and Material	0.065
	Late material delivery	0.061
	Lower Oil Price	0.059
	Lack of Spare & material availability	0.051

The results indicate that risk management in directional and multilateral drilling should not be limited to technical controls alone. In addition to the high-priority technical risks of formation-fluid influx (Kick) and stuck pipe, non-technical factors such as lack of specialists, inexperienced or untrained personnel, and improper planning and budgeting can increase the probability or severity of technical failures. Accordingly, managers should consider human resources, training, equipment supply, operational planning, well-control procedures, mud programs, and preventive measures together when preparing for directional and multilateral drilling projects.

4. References

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