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# **HSE Management System Criteria Ranking to Evaluate Contractors Prequalification Using the Analytical Hierarchy Process in the Fifth Refinery of South Pars Gas Complex**

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## **Abstract**

According to the International Association of Oil and Gas Producers (OGP) statistics, the number of oil and gas industries contractors has had a rising trend; on the other hand, there has been a considerable increase in both the frequency of the time wasted due to the injuries and the risk exposure ratio, based on the contractors statistics. South Pars Gas Complex (SPGC), like other large companies, uses the capabilities of numerous organizations as contractors to execute its programs. Based on the studies and internal audits, these contractors only few of which hold the regulated and modern system of the health, safety and environment (HSE) are responsible for approximately 85% of the incidents occurred in SPGC. The lack of adequacy and efficiency of the criteria presented in contractors HSE prequalification checklist prior to signing the contract as well as improperly prioritizing these criteria regarding the company's structure and management system are referred to in this analysis. In the current study, a questionnaire containing 34 criteria based on the different instructions of international gas and oil companies was prepared.

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To verify the reliability and validity of the criteria, thirty professional HSE experts of the complex revised these criteria using SPSS to cross out the ones not highly related to the assessment. The final criteria both ranked and prioritized using the analytical hierarchy process (AHP) can be used in an HSE prequalification checklist by the complex to evaluate the contractors.

**Keywords:** HSE; the analytical hierarchy process (AHP); South Pars Gas Complex (SPGC).

## **1. Introduction**

Various studies about the instructions present in international organizations and companies especially in the field of oil and gas including NORSOK (Norway), TOTAL (France), ENI (Italy), SHELL (Shell HSE handbook, 2011), Abu Dhabi National Oil Company (ADNOK, 2004), HAUNDAI (South Korea) and domestic companies such as National Iranian Oil and Gas Company as well as various books and references were conducted to determine the criteria regarding the goal of the current research. The questionnaire consisting of these criteria was revised by 30 professional HSE experts of the complex. Using SPSS and the results of the nine-point Likert scale questionnaire, they removed the criteria not highly related to the goal and reducing the reliability of the questionnaire (Cronbach's alpha) below 0.7. Seven HSE experts determined the final criteria hierarchy diagram. Finally, the location of each pairwise comparison was calculated and entered into EXPERT CHOICE Software by those thirty experts to prioritize the criteria.

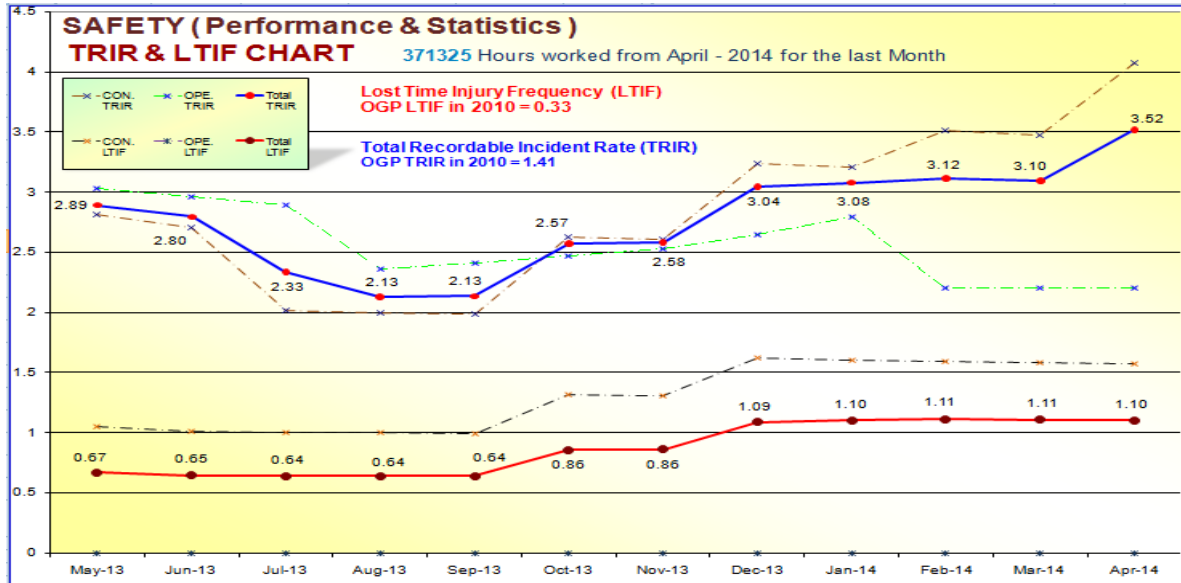
## **2. Problem Statement**

- It seems really necessary to rank HSE criteria in the fifth refinery of SPGC due to the lack of comprehensive, specific and integrated criteria to evaluate the contractors prequalification. According to the tender application forms, holding international certificates is the only criterion considered by the fifth refinery to score the contractors. As HSE experts believe, SPGC is not comprehensive enough to evaluate the contractors prequalification.
- Due to the differences between the organizational structure, management system and environmental and regional conditions of this refinery and those of international companies, the ranking of criteria established by international oil and gas companies need to be reconsidered.

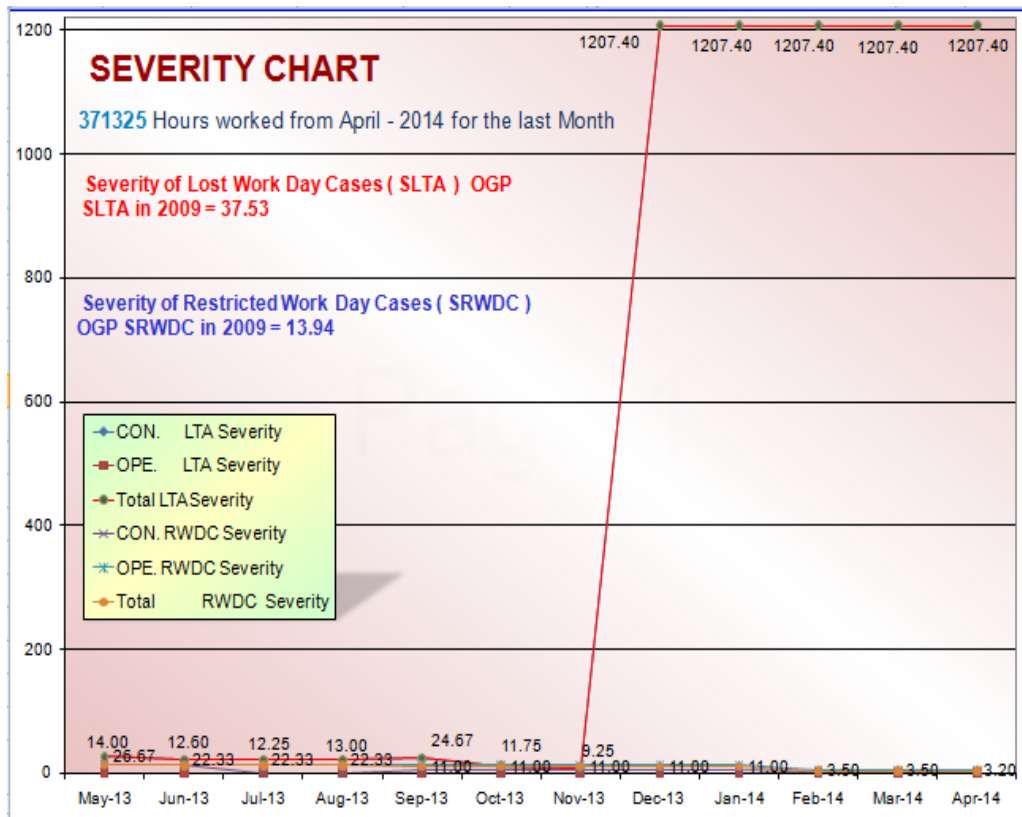
## **3. Research necessity and importance**

Environments in which work is carried out by contractors bear high potentials of human, equipment and environmental accidents due to work diversity, various working groups and contractors unfamiliarity with the environment and conditions. A leading gas refining company and beneficiary employer, the fifth refinery of SPGC (South Pars Gas Company) is provided with the services of at least 20 contractors per annum. Based on the analysis of the accidents bank, although SPGC has been granted the certificates of HSE-MS, OHSAS 18001 and ISO 14001 regarding health and environment and has made numerous efforts to improve HSE system, it has failed to improve the incidents indexes against OGP standards. As the end-of-April 2014 analysis indicated, the indexes of total recordable incident rate (TRIR), lost time incident frequency (LTIF) and severity lost time accident (SLTA) against OGP standards are 3.52 to 1.41, 1.10 to .033 (Diagram 1) and 1207 to 37.53,

respectively showing the considerable differences of the rate and severity of incidents between this company and OGP international standards (Diagram 2).

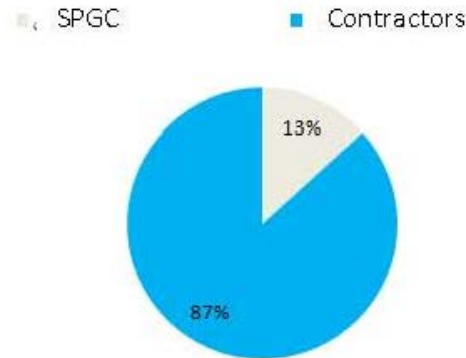


**Diagram 1:** The comparison of TRIR and LTIF between the fifth refinery and OGP Association



**Diagram 2:** The comparison of SLTA between the fifth refinery and OGP Association

One hundred seventy out of one hundred ninety six incidents caused by contracting companies between 2010 and 2013 show these companies effect on the incidents (Figure 1).



**Figure 1:** The comparison of SLTA between the fifth refinery and OPG Association

As the internal audits indicated, none of these contractors held a regulated system of HSE. The lack of adequacy and efficiency of the criteria presented in contractors HSE prequalification checklist prior to signing the contract as well as improperly prioritizing these criteria regarding the work conditions and environment are referred to in this analysis.

Today, the hazards are often of so profound variety, risk and consequences that compensating the impacts seems practically impossible. That is why a preventive approach taken regarding health, safety and environment issues is considered highly important to affecting HSE situation and ultimately reducing incidents in the area controlled by organizations. Therefore, it seems necessary to determine comprehensive and applied criteria in the prequalification stage regarding the management structure, workplace conditions and types of work.

The group AHP was implemented in this study to both determine and prioritize the criteria. Since this method can formulize the question in a hierarchy and consider both qualitative and quantitative criteria, it is regarded as one of the most comprehensive systems for multiple-criteria decision-making. Not only does AHP consider different alternatives in decision making and analyze the sensitivity to criteria and sub criteria but also is based on the pair wise comparison facilitating judgment and calculations. Of the unique advantages of AHP in multiple-criteria decision-making is that it shows the rate of the compatibility and incompatibility of the decision. It also holds a strong theoretical foundation and is based on obvious principles [1].

#### **4. Literature review**

##### **4.1. Introduction**

These days, oil, gas, petrochemical and auto manufacturing companies as well as municipalities along with other large companies streamline their practices through outsourcing. Using contractors from HSE organization having proper performance has considerably affected employers' projects and reduced the outsourced plans

costs. Thus, the interaction between employers, contractors and subcontractors HSE management system is of high importance.

According to the International Association of Oil and Gas Producers (OGP) statistics, the number of contractors in oil and gas industries has had a rising trend; on the other hand, there has been a considerable increase in both the frequency of the time wasted due to the injuries and the risk exposure ratio, based on the contractors statistics. Due to the fact that employers are required to cover the costs of incidents and illnesses occurring to contracting companies staff, some large employers have dedicated some articles of HSE management system requirements to this issue. HSE management systems in employers and contracting companies covered by employers have led to a decrease in job risks and incidents thus improved contractors HSE systems.

#### ***4.2. Literature review in international organizations and companies***

Having issued the guideline OGP report [2] titled HSE Management Guidelines for Working Together in a Contracting Environment, the International Association of Oil and Gas Producers took the first step regarding contractors HSE management system and its formal introduction to the oil industry in 1999. In that guideline, different stages of contractors HSE management have been developed focusing on the pre-execution phases while HSE indexes have been considered fitting contractors' situation.

NORSOK (Norsok Sökkels Konkuranseposisjon, The Norwegian Technology Center) standards established by Norway oil industry presents some indexes in the form of a questionnaire to evaluate contractors competency related to the post-contract stages based OGP Model 291[3].

Using the model presented by the International Association of Oil and Gas Producers, Abu Dhabi National Oil Company prepared a guideline similar to OPG 291 in 2009. Selecting qualified contractors regarding HSE prior to signing the contract has been highlighted in this guideline. According to that, the qualified contractors are selected through filling out the questionnaire and HSE specialized checklists in the form of balanced scorecards [4].

In 2010, a similar study conducted in Mahshahr Shahid Tondgooyan Petrochemical Company regarding the development of the evaluation method of petrochemical, oil and gas industries contractors/suppliers HSE performance aimed to rank them based on the performance in HSE management system in the phase of execution with the combination of the Deming cycle or the plan-do-check-act (PDCA) cycle and the seven-element OPG model. As the results suggested, the only index having a different score was management commitment in the section of staff contribution [5].

Tehran municipality prepared a three-step model to manage its contractors HSE in 2011. Numerous HSE indexes were considered in this model for the contractors HSE prequalification [6].

Of these models, the International Association of Oil and Gas producers Guideline No 291 has been based on one of the most comprehensive contractors HSE management system models in various related (and non-related) industries, i.e. the present methods of oil industry contractors HSE management are somehow an

adaptation of that model [7].

It is considered a necessity for each organization to develop and execute its contractors selection methods according to its own rules and regulation. One of the goals the present study pursues is to develop and rank the criteria used in contractors prequalification in SPGC.

#### **4.3. Contemporary researchers' studies review**

1. The first section of the study HSE Management Plan as a Tool for Contractors HSE Management by Dezhbankhan introduced the general overview regarding HSE management including contractors selection, management and evaluation; while the way to develop the HSE management plan as one of the criteria to select contractors was presented in the second section [8].
2. Khakbaz Abiane in 2012 [9] presented criteria in his study titled A Model to Select Oil Industry Subcontractors Based on the Balanced Scorecard and the Analytic Hierarchy Process to evaluate and rank subcontractors participating in the oil company's tenders. In addition to the financial aspect, three other aspects of the balanced scorecard were considered as criteria in the analytic hierarchy process to rank the alternatives, i.e. contractors [9].
3. Hemati in 2012 [10] conducted a study titled A New approach to Select Contractors using the Analytic Hierarchy Process and Fuzzy TOPSIS. Using the AHP method and fuzzy TOPSIS, he presented a new approach to evaluate contractors and help to choose the contractors best fitted to outsource companies' activities to regarding privatization [10].
4. Eslami in 2012 [11] carried out a study titled Hazard-based Risk Assessment Comparing the Analytic Hierarchy Process with Fuzzy TOPSIS. Having determined the hierarchy for all the hazards using fuzzy AHP method and the 5 risk factors, he ranked and evaluated the risk of each hazard. In the second method, he determined both the work breakdown structure (WBS) and priority between the 5 risk factors using AHP prior to ranking the hazards using the fuzzy TOPSIS model[11].

## **5. Methodology**

Various studies about the instructions present in international organizations and companies especially in the field of oil and gas including NORSEK (Norway), TOTAL (France), ENI (Italy), SHELL [12], Abu Dhabi National Oil Company (ADNOC, 2004), HYUNDAI (South Korea) , ISO [13] and OHSAS [14] standards domestic companies such as National Iranian Oil and Gas Company as well as various books and references were conducted to determine the criteria regarding the goal of the current research [15,16,17]. The questionnaire consisting of these criteria was revised by 30 professional HSE experts of the complex.

## **6. The questionnaire validity and reliability**

### **6.1. Validity**

The data needed for this study were included in a questionnaire developed by the ideas of the advisor, HSE experts and the instructions of the organizations and companies related to the oil and gas industries. The experts holding long work experience (the average of 12 years), relevant academic degrees (38% with Bachelor's, 60%

with Master's and 2% with PhD Degrees) and experience working with international companies such as TOTAL (France), ENI (Italy) and HYUNDAI (South Korea) confirmed the validity of the questionnaire.

### 6.2. Reliability

Initially, thirty four criteria were determined using the studies and experts' ideas. Each criterion, as a variable, was introduced to the software followed by registering each of the experts' ideas presented as a Likert 9-scale point in SPSS.

According to the results, Cronbach's alpha calculated was lower than the acceptable value (0.7). Thus, the criteria whose alternatives' mean was lower than the total mean were removed to increase the Cronbach's alpha (Figure 2).

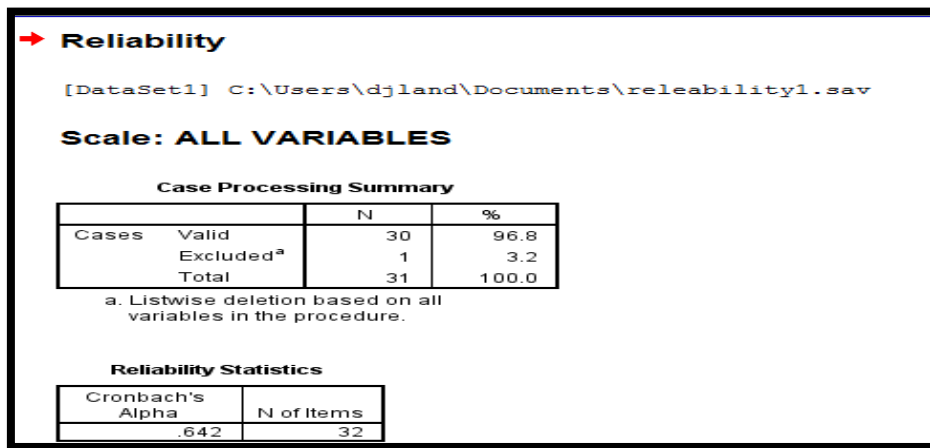


Figure 2: The questionnaire reliability in the first step

Once the 6 criteria were removed, the Cronbach's alpha increased to the acceptable value of 0.719 (Figure 3).

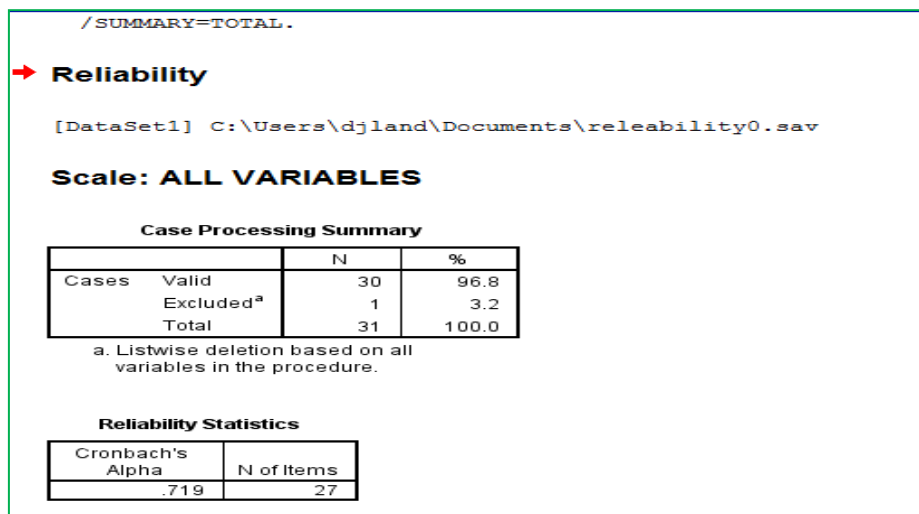
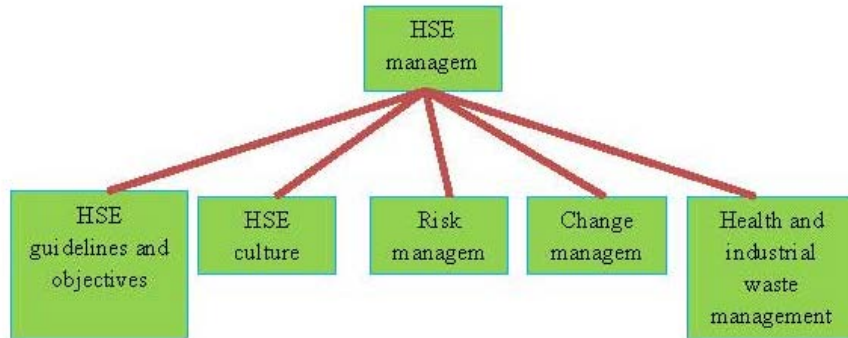


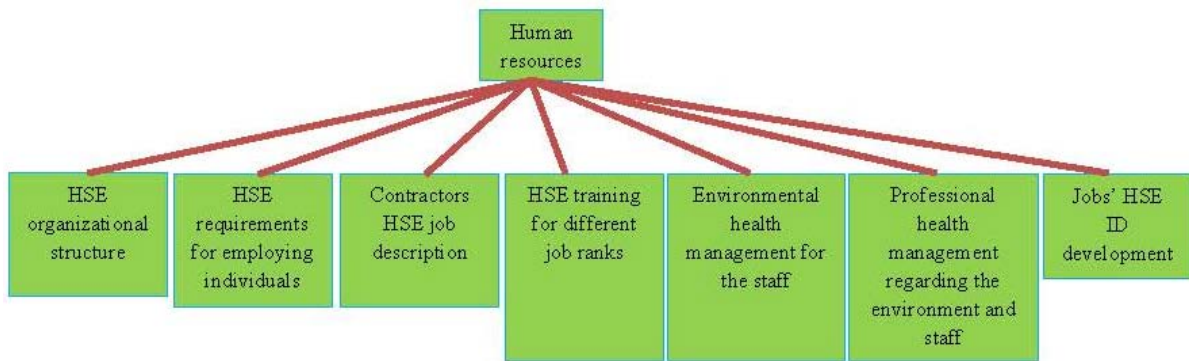
Figure 3: The Cronbach's alpha value after removing the items reducing the reliability

### 7. The hierarchical tree

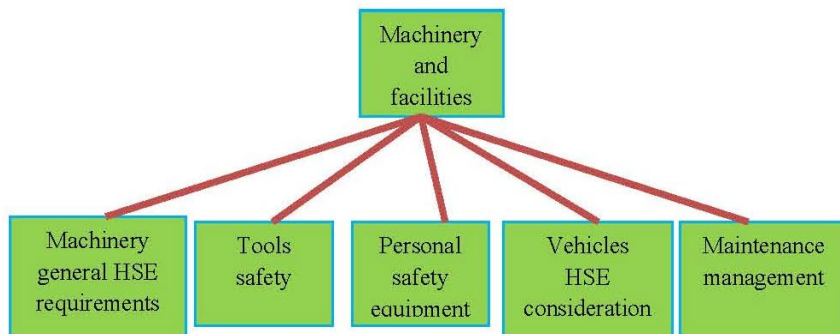
Once the final criteria were determined by seven HSE experts of the fifth refinery, their hierarchical tree was formed and the sub criteria were categorized under the 6 main criteria (Diagrams 1-4 to 5).



**Diagram 3:** The Five HSE management sub criteria

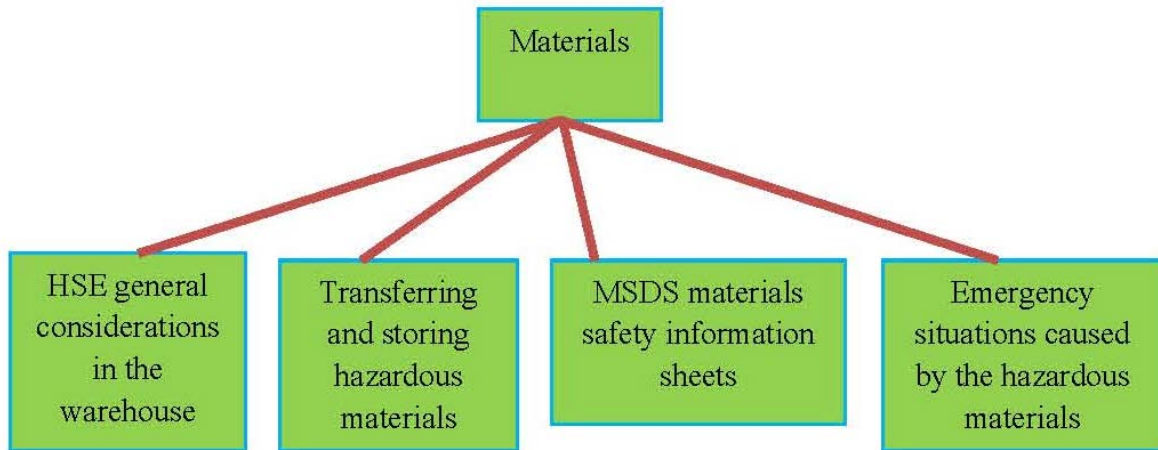


**Diagram 4:** Seven human resources sub criteria

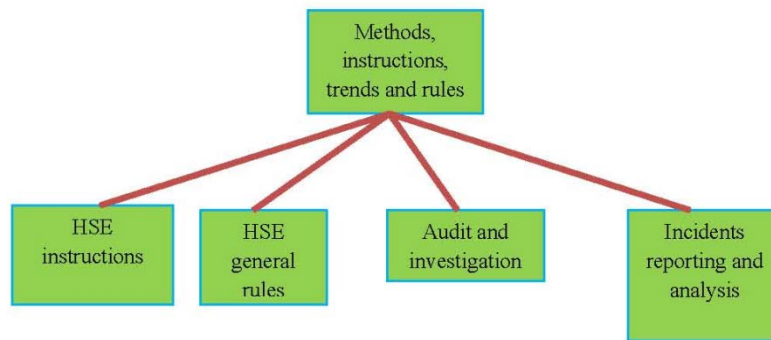


**Diagram 5:** Five machinery and facilities sub criteria

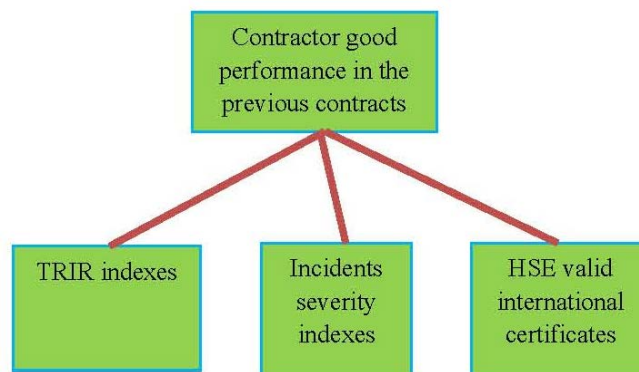




**Diagram 6:** Five materials sub criteria



**Diagram 7:** Four methods, instructions etc sub criteria



**Diagram 8:** Three HSE management sub criteria

## 8. Data analysis results using the software

### 8.1. Local priority

Once the hierarchical tree structure and experts' ideas regarding the pairwise comparisons were entered into Expert Choice, reliable software regarding the AHP method, the criteria were ranked as the following.

Moreover, the inconsistency rate calculated 0.06 (< 0.1) was acceptable. As indicated, HSE good performance in the previous contracts ranked top followed by the other criteria (Table 1).

**Table 1:** Main criteria ranking

Criteria	Rank
HSE good performance in the previous contracts	0.443
HSE management	0.237
Human resources	0.135
Methods and instructions	0.107
Machinery and facilities	0.042
Materials management	0.037

Table 2 contains the information regarding the HSE management sub criteria including HSE guidelines and objectives, risk management, HSE culture, health and industrial waste management and change management. According to the results, HSE guidelines and objectives attained the first rank while change management was placed the last in the list.

**Table 2:** HSE management sub criteria ranking

The HSE management sub criteria	Rank
HSE guidelines and objectives	0.434
HSE culture	0.289
Risk management	0.152
Health and industrial waste management	0.084
Change management	0.041

Human resources sub criteria ranking is shown in Table 3. The inconsistency rate was calculated as much as 0.07 and acceptable.

**Table 3:** Human resources sub criteria ranking

The human resources sub criteria	Rank
HSE organizational structure	0.244
HSE training for different job ranks	0.194
HSE requirements for employing individuals	0.168
Jobs' HSE ID development	0.112
Contractors HSE job description	0.089
Professional health management regarding the environment and staff	0.087
Environmental health management for the staff	0.087

The results of prioritizing the machinery and facilities sub criteria using the pairwise comparisons table are presented in Table 4.

**Table 4:** Machinery and facilities sub criteria ranking

The machinery and facilities sub criteria	Rank
Maintenance management	0.60
Machinery general HSE requirements	0.10
Tools safety	0.10
Personal safety equipment	0.10
Vehicles HSE considerations	0.10

Table 5 contains the information regarding the pairwise comparisons of materials sub criteria including HSE general considerations in the warehouse, transferring and storing hazardous materials, MSDS materials safety information sheets and emergency situations caused by the hazardous materials. The results revealed that the emergency situations caused by the hazardous materials ranked at the top followed by the three other sub criteria all of which attaining the second place.

**Table 5:** Materials sub criteria ranking

The materials sub criteria	Rank
Emergency situations caused by the hazardous materials	0.40
HSE general considerations in the warehouse	0.20
Transferring and storing hazardous materials	0.20
MSDS materials safety information sheets	0.20

Table 6 shows the results from comparing the methods and instructions sub criteria.

**Table 6:** Methods and instructions sub criteria ranking

The methods and instructions sub criteria	Rank
Audit and investigation	0.553
Incidents reporting and analysis	0.313
HSE general rules	0.067
Incidents reporting and analysis	0.067

Finally, the good performance sub criteria of the contracting companies were compared. The results and the sub criteria local priorities are shown in Table 7.

**Table 7:** Contractors good performance in the previous contracts sub criteria ranking

The contractors good performance in the previous contracts sub criteria	Rank
Incidents severity indexes	0.414
HSE valid international certificates	0.248
TRIR indexes	0.117

**8.2. Overall priority**

Determining the priority in the AHP is performed in two parts:

- Local priority
- Overall priority

Local priority is determined using the pairwise comparison matrix while the final rank of each item is regarded as its overall priority calculated synthesizing the local priorities [1:40].

Once the pairwise comparison and local priorities of the alternatives and criteria were performed, the local priorities were synthesized in the software to determine the overall priorities. The results are shown in Table 8.

**Table 8:** The 28 criteria final ranking

1	Incidents severity indexes	0.208
2	HSE guidelines and objectives	0.111
3	HSE valid international certificates	0.091
4	HSE culture	0.074
5	HSE organizational structure	0.063
6	Audit and investigation	0.050
7	HSE training for different job ranks	0.046
8	HSE requirements for employing individuals	0.040
9	TRIR rate	0.040
10	Risk management	0.039
11	Incidents reporting and analysis	0.029
12	Jobs’ HSE ID development	0.027
13	Health and industrial waste management	0.021
14	Contractors HSE job description	0.021
15	Professional health management regarding the environment and staff	0.021
17	Environmental health management for the staff	0.021
18	Maintenance management	0.020
19	Emergency situations caused by the hazardous materials	0.017
20	Change management	0.010
21	HSE general considerations in the warehouse	0.009
22	Transferring and storing hazardous materials	0.009
23	MSDS materials safety information sheets	0.009
24	HSE instructions	0.006
25	HSE general rules	0.006
26	Machinery general HSE requirements	0.003
27	Tools safety	0.003
28	Personal safety equipment	0.003

## **9. Limitation**

The purpose of using AHP is obtaining the opinion of experts and specialists, however, non-fuzzy AHP not reflect correctly the way of human thinking, because in this method, paired comparison use exact numbers. one other cases that non-fuzzy AHP criticized is included: existing scale of unbalanced judgments, uncertainties and inaccurate paired comparisons .because of fuzzy natures(uncertainty) of these judgment ,decision makers often are unable to announce exactly their priorities. For this reason they offer a range number rather than fixed number in their judgment. in spite of fuzzy AHP advantages rather than non –fuzzy AHP ,It was necessary to use relevant software because of avoiding complicated calculation .but there was not comprehensive software for fuzzy AHP like expert choice in non-fuzzy AHP that enable analyze many criteria in several levels and provide sensivity analysis, various graphical diagram to better understanding .and also in this study has been used 30 expert judgments that this can reduce the advantage of hierarchical fuzzy compared to non- fuzzy. For these reasons we used non-fuzzy AHP. but if there was comprehensive software for fuzzy AHP it was better used AHP fuzzy method instead of non –fuzzy AHP method to achieve better results in this study.

## **10. Recommendations**

1. The first proposal for a correct evaluation of contractors is necessary research on how to measure these criteria .In this study, the criteria that can identify qualified contractors were found and As well as the importance and rank the criteria was determined However, further research is needed to measure these criteria.
2. In this study, one method was used for ranking criteria but in future research can use other multi decision making method such as TOPSIS,VIKORE... and results can compare with results of this study.

## **11. conclusions**

- 1- The first question posed was as the following; what fundamental and applied criteria need to be considered to evaluate the contractors prequalification in order to achieve the final objective, i.e. an increase in the incidents caused by the contracting companies in SPGC? The instructions of the international oil and gas companies and organizations were comprehensively studied followed by relevant library studies to determine the primary criteria. The experts revised these criteria in the form of a questionnaire using SPSS. Eventually, 6 main criteria containing 28 sub criteria were determined.
- 2- The next question referred to ranking and prioritizing these criteria. The hierarchical tree was drawn in which the 6 main criteria were place at the first level and the 28 sub criteria were regarded at the second level. Criteria local and overall priorities were determined using Expert Choice.
- 3- Once these criteria and their priorities are determined, contractors prequalification checklist can be designed.

## References

- [1] H. Ghodsipoor. *The analytic hierarchy process*. Tehran, Iran: Amirkabir Industrial University, 2013, p.5
- [2] OGP producers. "HSE management-Guidelines for working together in a contract environment Report." Country where patent is registered. no.6.64/291, Sep 1999
- [3] NORSOK"HSE-Evaluation of Contractors."Norway. Standard(S-006), Rev.1, October, 2000
- [4] Abu Dhabi National Oil Company(ANDOK)"Guidelines on management of contractor HSE"Abudabi.ANDOK-COPV1-04,2004
- [5] M.Abbaspoor,MTutunchian,Mroayaei." A strategic management model to evaluate health, safety and environment". *Environmental Assessment and Monitoring*,vol.18,2011
- [6] Tehran municipality." Contractors HSE management system guidelines." Iran., 2011
- [7] Jafari, and M.Mapar. "Determining contractors HSE prequalification and qualification indexes in contract requirements based on the contract type, "Presented at 9<sup>nd</sup> Conf. Tunneling Symposium,Teharan,Iran,2011.
- [8] F. Dezhbankhan. "management plan as a tool for contractors HSE management," presented at the 1<sup>nd</sup> Int. Conf. HSE in Oil and Gas Industries, Teheran, Iran, 2008.
- [9] A.Khakbaz Abiane, M. Sajadi and M. Zamanisade." A Model to select oil industry subcontractors based on the balanced scorecard and the analytic hierarchy process, "presented at the 3<sup>nd</sup> Int.Conf in Industrial Engineering, South Tehran, Iran, April. 2012.
- [10]M.Hemati,R. Babaei and M.Hasanabadi." A new approach to select contractors using the analytic hierarchy process and fuzzy TOPSIS,"presented at 1<sup>nd</sup> Int.Conf in Privatization,Tehran, Iran, May 2011.
- [11]A.A.Eslami Baladeh, M. Fatemi." Hazard-based risk assessment comparing two approaches of AHP and fuzzy TOPSIS,"presented at 9<sup>nd</sup> Int.Conf in Industrial Engineering, Tehran, Iran, Jan. 2013.
- [12]Shell Company "Guidelines on management of contractor HSE"England. Volume1 HSE Management System,handbook,2011.
- [13]International Standard Organization "Quality Management System Requirements", ISO 9001:2000
- [14]OHSAS Ogranization"Safety Reference manual Contractors Insurance Group"England, Safety Management Occupational Health Safety Assessment Series, OHSAS 18001:1999
- [15]J. Asgharpoor. *Multi-criteria decision-making process*. Tehran University, Iran: Tehran, 2012.
- [16]A.Azar. *MADM approach applied decision makings*. Negah Danesh,Iran:Tehran,2011
- [17]M.Ateaei. *Fuzzy multi-criteria decision-making* . Shahrood Industrial University,Iran:shahrood,2000