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Comparison HOR and AHP Methods in Risk Mitigation of Line Pipe Procurement

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Abstract *- OCTG (Oil Country Tubular Goods) is a type of pipe used for oil and gas exploration activities. To meet the demands for the fulfillment of Line Pipe material needs at PT Pertamina EP. The results of the analysis and identification of risk factors from 3 Subjet Matter Expert (SME) in Line Pipe material procurement activities. From 13 Process Activities, 16 Risk Events (Ei) and 35 Risk Agents (Aj) were obtained. In House of Risk (HOR) 1, the results of the calculation of the Aggregate Risk Potentials (ARPj) value of 35 Risk Agents (Aj), the highest Aggregate Risk Potentials (ARPj) with a value of 810. In House of Risk (HOR) 2, the results of the calculation of the Effectiveness to Difficulty ratio (ETDk) value of 4 Preventive Action (PAk), the highest Effectiveness to Difficulty ratio (ETDk) value with a value of 4860. In the Analytic Hierarchy Process (AHP), the results of the calculation of the Consistency Ratio value of 5 Criteria Weight the highest Criteria value with a percentage of 45.4% and the Consistency Ratio of 4 Alternatives the highest Alternative value with a percentage value of 44.06%. The best alternative solution in the selection of mitigation strategies for contract type selection is "TFC (Technical Framework Contract)" with the highest percentage and value. The TFC (Technical Framework Contract) contract type is in accordance with the PTK-007 Revision 5 Chapter IV Contract guidelines.*

Keywords: *Analytical Hierarchy Process (AHP); House of Risk (HOR); Line Pipe*

I. INTRODUCTION

In oil and gas production operations, the first process is the lifting of crude oil from production wells to the surface. This stage involves Artificial Lift, a method of artificial lift used to increase oil or gas production from wells with low natural pressure at the desired level (Saurabh & Chouhan, 2015). Examples of Artificial Lift Equipment such as Sucker Rod Pump (SRP), ESP (Electric Submersible Pump), Gas lift, and Jet Pump to provide additional boost to the well. The use of pumping technology and equipment in accordance with the characteristics of production wells can increase the efficiency and productivity of oil and gas production operations (Al-Mutaz et. al, 2017).

In this study, to avoid potential problems that will occur, the House of Risk (HOR) method is applied to the decision-making support model, the Risk Agent in the House of Risk (HOR) is selected based on the high Aggregate Risk Potentials (ARP) value, meaning that it has a high probability of occurrence and causes many Risk Events with severe impacts (Rukmi, 2022). And the Analytical Hierarchy Process (AHP) method was developed by Thomas Lorie Saaty to find the priority order of various alternatives in a problem solving (Saaty T. L., 2008).

Data collection using non-probability method (Purposive Sampling). Purposive Sampling is a sampling unit that is selected based on certain considerations, this technique is used especially when there are only a few people who have expertise in the field being studied.

The objectives of the research is to Analyzing and identifying risk factors that occur in Line Pipe material procurement activities, Measuring the value of the highest

risk factors that occur in Line Pipe material procurement activities, Determining effective and efficient contract type selection mitigation strategies to overcome the highest risk factors in Line Pipe material procurement activities, and Determining the best alternative solutions for contract type selection mitigation strategies in overcoming risk factors that occur in Line Pipe material procurement activities.

The results of the comparison of the use of the House of Risk (HOR) method and the Analytical Hierarchy Process (AHP) method in this study are expected to identify risk factors and determine the best alternative solutions for mitigation strategies for selecting contract types in Line Pipe material procurement activities. The most effective and efficient alternative solutions are used to reduce risk factors that may occur in the procurement of goods and services, so that in the future it can better predict risks and choose mitigation strategies.for risk mitigation strategies in future Line Pipe material procurement activities better.

II. METHODS

Data collection using non-probability method (Purposive Sampling). Purposive Sampling is a sampling unit that is selected based on certain considerations, this technique is used especially when there are only a few people who have expertise in the field being studied.

2.1 House of Risk Model

House of Risk (HOR) is divided into two phases, namely House of Risk (HOR) phase 1 and House of Risk (HOR) phase 2 (Pribadi, Cahyani, & Baihaqi, 2016). House of Risk (HOR) phase 1 is developed through the following stages:

- Identify the procurement process through activity mapping and systematic grouping to identify possible Risk Events (Ei) and Risk Agents (Aj).
- Estimate the severity of the Risk Event (Ei) on a scale of 1-10, where a 10 risk results in dangerous disruption.
- Identify the Risk Agent (Aj) through the Risk Event (Ei) on a scale of 1-0, where a weight of 10 the occurrence of the risk cause always occurs.
- Determining the correlation relationship between Risk Event and Risk Agent (Rij) with a rating scale of (0, 1, 3, 9) where 0 means there is no correlation and 1, 3, and 9 indicate low, medium, and high correlation.
- Calculate the Aggregate Risk Potentials (ARPj) value based on the severity of the Risk Event (Si), the impact of the event on the Risk Agent (Oj) and the correlation between the Risk Event and the Risk Agent (Rij).
- Determine the priority ranking (Pj) based on the results of the calculation of Aggregate Risk Potentials (ARPj) by sorting from large to small.

$$ARP_j = O_j \sum_j S_j R_{ij} \quad \text{..... (2.1)}$$

The House of Risk (HOR) phase 2 was developed through the following steps:

- Prioritized Risk Agents (Aj) are selected through pareto diagram analysis.
- Identify and make consideration of Preventive Measures (PAk).
- Determine the correlation relationship between the Preventive Measures and the prioritized Risk Agents (Ejk) on a scale of (0, 1, 3, 9) where 0 means no correlation and 1, 3, and 9 indicate low, medium, and high correlation.
- Calculate the Total Effectiveness of Measures (TEk) value based on the Aggregate Risk Potentials (ARPj) value and the correlation between Preventive Measures and Risk Agents (Ejk).

$$TE_k = \sum_j ARP_j E_{jk} \quad \text{..... (2.2)}$$

- Determine the value of the Degree of Difficulty of Performing the Action (Dk) with a Likert scale of 3 (Easy to implement), 4 (Somewhat difficult to implement), and 5 (Difficult to implement).
- Calculate the Effectiveness to Difficulty ratio (ETDk) based on the Total Effectiveness of Actions (TEk) value divided by the Degree of Difficulty of Performing Actions (Dk) value. In stage 7, determine the priority ranking (Rj) based on the calculation results of the Effectiveness to Difficulty ratio (ETDk) by sorting from large to small.

$$ETD_k = TE_k / D_k \quad \text{..... (2.3)}$$

2.2 Analytical Hierarchy Process (AHP) Model

Analytical Hierarchy Process (AHP) to find the priority order of various alternative solutions in a case in problem solving. Analytical Hierarchy Process (AHP) is developed through the following stages:

- Determination of objectives and hierarchical preparation of Preventive Action (PAk) strategies based on the final results of the analysis of the calculation of the House of Risk (HOR) method. The purpose of preparing a hierarchy of criteria and sub-criteria is to determine the weighting of the indicators of the Preventive Action (PAk) strategy to be selected.
- Create a Pairwise Comparison Matrix by comparing each criterion element with other criteria to produce a priority vector value.
- Synthesis of priority, conducting eigenvector calculations looking for the eigenvalue of the vector to get local priorities. eigenvector calculations can be done with the help of matlab software, online AHP calculators and manual calculations (Microsoft excel).
- The consistency test is carried out by proving the Consitency Ratio (CR) value ≤ 0.1. The first thing in consistency testing is to calculate the Consistency Index (CI) through equation 2.4. After calculating the Consistency Index (CI) followed by calculating the Consitency Ratio (CR) through equation 2.5. The Random Index (RI) value is determined based on the number of criteria. From the results of the calculation of the Consitency Ratio (CR), if the Consitency Ratio (CR) value ≤ 0.1, the AHP calculation results are declared valid (Hafiyusholeh & & Asyhar, 2016).

III. RESULT AND DISCUSSIONS

The results of data collection were carried out by brainstorming Line Pipe procurement activities, distributing questionnaires, and interviews. Branstroming is done to identify the process and activities of Line Pipe procurement activities to get Risk Event (Ei), Risk Agent (Aj) and Preventive Action (PAk). Interviews and questionnaires were conducted to obtain an assessment of the Severity (Si) of the Risk Event, Occurrence (Oj) of the Risk Agent, Correlation between Risk Event and Risk Agent (Rij), Correlation between Priority Risk Agent and Preventive Action (Ejk), and Degree of Difficulty (Dk). Experts who act as Subject Matter Expert (SME) are people who have competency certification issued by SKK MIGAS or LSP-HULU MIGAS.

3.1 House of Risk (HOR)

In House of Risk (HOR) 1 to find out the value of Aggregate Risk Potentials (ARPj). In Table I Activities Process each activity has its own risks, but risk control will ultimately cover the entire system that builds a process. Based on Line Pipe procurement activities, 13 activities were identified in which there are 16 Risk Events (Ei) and 35 Risk Agents (Aj) shown in Table II Risk Event (Ei) and Table III Risk Agent (Aj).

Table I. Activities Process

Process	Activity
Plan	Market and demand analysis of Line Pipes
	Line Pipe material procurement planning
Source	Evaluation & Selection of suppliers
	Price negotiation
	Agreement/contract
Make	Purchase of Hot Rolled Coil (HRC) raw materials
	Material Production Line Pipe
Delivery	Inventory management
	On-time delivery
Receiving & Performance Review	Material inspection comes
	Line Pipe material acceptance
	Warranty & Guarantee
	Supplier performance evaluation

Table II. Risk Event (Ei)

Code	Risk Event (Ei)	Severity (Si)
E1	Price fluctuations of Hot Rolled Coil (HRC) raw materials	9
E2	Increased demand for Line Pipes	7
E3	Needs planning is done out of the blue	9
E4	Line Pipe supplier limitations	6
E5	Material specifications are less clear	5
E6	The negotiation process lasted a long time	5
E7	The contract creation process takes a long time	4
E8	Difficulty obtaining Hot Rolled Coil (HRC) raw materials	9
E9	The production process lasts a long time	8
E10	Line Pipe material availability	9
E11	Delay in delivery of Line Pipe material	9
E12	Increased Transportation & Logistics costs	6
E13	The implementation of the inspection process lasts a long time	6
E14	Material receiving process in warehouse	6
E15	Difficulty in making warranty claims	5
E16	Supplier performance does not meet requirements	5

Table III. Risk Agent (Aj)

Code	Risk Agent (Aj)	Occurrence (Oj)
A1	World crude oil price fluctuations	10
A2	Changes in global economic conditions	7
A3	Procurement of new work programs	6
A4	There is a leak in the existing Line Pipe	7
A5	The procurement budget has not yet been approved	4
A6	Procurment function lacks Human Resources (HR) in the field of Planning Strategy	5
A7	Regulation of the Inland Content Level (TKDN) regulation on the supply of goods	4
A8	The supporting data documents provided by the supplier are incomplete	3
A9	Inaccurate HPS/OE calculation data and bid price	4
A10	Supplier bid price above HPS/OE value	8
A11	There is a contract clause that the supplier did not agree to	3
A12	Legal Function lacks Human Resources (HR) in the field of Contract Management	4
A13	The contract's office is being serviced/off	5
A14	Minimum requirements for purchasing Hot Rolled Coil (HRC) raw materials	7
A15	Stock availability of domestic Hot Rolled Coil (HRC) raw materials is small	8
A16	Hot Rolled Coil (HRC) raw material demand increases	9
A17	Limited number of operational production machines	8
A18	Breakdown of production operational machinery	5
A19	Stock of Line Pipe material in the warehouse is small	7
A20	Warehouse inventory management is not good	4
A21	Line Pipe preparation arrangement is not according to specifications	5
A22	Natural disasters	3
A23	Climate Events/Changes	3
A24	Disruption to the management of Disability & Imports	8
A25	Limited number of transporter companies	4
A26	Fuel Price Increase & Travel Operations	6

A27	HSSE function lacks Human Resources (HR) Inspector section	7
A28	Limitations of inspection equipment	6
A29	The large number of pipes inspected	8
A30	Incomplete admission supporting documents	6
A31	The official in charge of the document is on duty/leave	5
A32	Unlawful use of authority in the contract	3
A33	The explanation of the warranty claim clause is unclear	3
A34	The goods received do not match the specifications in the contract	5
A35	Problems in the implementation of contract work in other units	4

From the results of the data input above, calculations can be made for the Aggregate Risk Potentials (ARPj) value.

Pareto diagram is used to determine the Priority Risk of Agent (Pj) with the calculated value of Aggregate Risk Potentials (ARPj) of 35 Risk Agent (Aj) can be seen in Figure 1 Priority Rank of Agent (Pj). As an illustration by following equation 2.1 for Aggregate Risk Potentials (ARPj) as follows:

$$ARP_j = O_j \sum_j S_j R_{ij}$$

$$= 10 \text{ x } [\ 9\ (9)]$$

$$= 810$$

Table IV. Risk Agent Priority

Code	Risk Agent (Aj)	Aggregate risk potentials (ARPj)
A1	World crude oil price fluctuations	*810*
A16	Hot Rolled Coil (HRC) raw material demand increases	*729*
A15	Stock availability of domestic Hot Rolled Coil (HRC) raw materials is small	*648*
A17	Limited number of operational production machines	*576*
A2	Changes in global economic conditions	567

Based on the results of the pareto diagram analysis, the 5 priority Risk Agents (Aj) selected have a cumulative percentage of 47.43% of the total cumulative value of Aggregate Risk Potentials (ARPj). Can be seen in Table IV Risk Agent Priority is expected to be followed up.

Figure 1 Priority Rank of Agent (Pj)

In House of Risk (HOR) 2 to find out the Effectiveness to Difficulty ratio (ETDk) value. In Table V Preventive Action (PAk), the value of Degree of Difficulty (Dk) is known and to determine the value of Degree of Difficulty Performing Action (Dk) an interview was conducted with one of the Subject Matter Expert (SME) VP Supply Chain Management.

Table V. Preventive Action (PAk)

Code	Preventive Action (PAk)	Degree of Difficulty (Dk)
PA1	Spot Buying	5
PA2	LTC (Long Term Contract)	4
PA3	TFC (Technical Framework Contract)	3
PA4	MSA (Multi Standing Agreement)	5

From the results of the data input above, calculations can be made for the Total Effectiveness of Action (TEk) value. As an illustration by following equation 2.2 for Total Effectiveness of Action (TEk) as follows:

$$TE_k = \sum_j ARP_j E_{jk}$$

$$= 810\ (9) + 729\ (9) + 567\ (9)$$

$$= 14580$$

The results of Total Effectiveness of Actions (TEk) calculation are divided by 3 values of the Degree of Difficulty of Performing Actions (Dk) on Preventive Actions (PAk) by following equation 2.3 for the Effectiveness to Difficulty ratio (ETDk) as follows:

$$ETD_k = TE_k / D_k$$

$$= 14580/3$$

$$= 4860$$

Table VI Preventive Action Priority

Code	Preventive Action (PAk)	Effectiveness to Difficulty ratio (ETDk)
PA3	TFC (Technical Framework Contrac)	4860
PA4	MSA (Multi Standing Agreement)	1609,2
PA2	LTC (Long Term Contrac)	1404
PA1	Spot Buying	291,6

In Table VI Preventive Action Priority is the results of the calculation of the Effectiveness to Difficulty ratio (ETDk) value from 4 Preventive Action (PAk). The high Effectiveness to Difficulty ratio (ETDk) value indicates the effectiveness of Preventive Action (PAk) to reduce the Risk Agent (Aj), but if the Effectiveness to Difficulty ratio (ETDk) value is quite low, it can indicate that Preventive Action (PAk) is less effective.

3.2 Analytic Hierarchy Process (AHP)

The steps in the Analytic Hierarchy Process (AHP) can be described in Table VII AHP Framework. In Set Up Decision Hierarchy, previous sub-chapter has been discussed and determined that 5 criteria are taken based on Risk Agent (Aj) priorities and 4 alternative solutions to be used based on Preventive Action (PAk) to overcome the problem of procuring Line Pipe materials.

Table VII. AHP Framework

Step 1 Set Up Decision Hierarchy	Step 2 Make Pairwise Comparisons	Step 3 Synthesize the result to determine the best alternative
Difining the decision problem	Collecting Data from Expert	Estimating relative weight of element
Identifying the criteria		Calculating the Degree of Consistency
Developing Alternative Solution		Calculating Priority Ranking

Pairwise Comparisons Matrices (PCM) is the core stage of the Analytic Hierarchy Process (AHP) method, in this stage Subject Matter Expert (SME) assesses the criteria and alternative solutions. Subject Matter Experts (SME) conduct an assessment by filling out a set of pairwise comparison forms to produce a comparison matrix between criteria, sub-criteria, and alternatives. The numbers in the Pairwise Matrix are preferences from the intensity of importance scale. Table VIII Pairwise Comparative Matrix of Criteria to Table IX Pairwise Comparative Matrix of Alternatives for Subcriteria on Availability of Domestic Hot Rolled Coil (HRC) below is the result of Pairwise Comparison Matrix from one of the Subject Matter Expert (SME).

Table VIII. Pairwise Comparative Matrix of Criteria

Criteria	World crude oil price fluctuations	Changes in global economic conditions	Number of Operational Machines for Domestic Hot Rolled Coil (HRC) Production	Hot Rolled Coil (HRC) raw material demand increases	Stock availability of domestic Hot Rolled Coil (HRC) raw materials is small
World crude oil price fluctuations	**1,00**	7,00	3,00	4,00	5,00
Changes in global economic conditions	0,14	**1,00**	1,00	3,00	5,00
Number of Operational Machines for Domestic Hot Rolled Coil (HRC) Production	0,33	1,00	**1,00**	2,00	4,00
Hot Rolled Coil (HRC) raw material demand increases	0,25	0,33	0,50	**1,00**	3,00
Stock availability of domestic Hot Rolled Coil (HRC) raw materials is small	0,20	0,20	0,25	0,33	**1,00**

Table IX. Pairwise Comparative Matrix of Alternatives for Subcriteria on Stock availability of domestic Hot Rolled Coil (HRC) raw materials is small

Alternatives	Spot Buying	LTC (Long Term Contract)	TFC (Technical Framework Contract)	MSA (Multi Standing Agreement)
Spot Buying	**1,00**	0,20	0,11	3,00
LTC (Long Term Contract)	3,00	**1,00**	0,11	5,00
TFC (Technical Framework Contract)	9,00	7,00	**1,00**	7,00
MSA (Multi Standing Agreement)	0,33	0,14	0,11	**1,00**

From the weighting results of the Pairwise Comparisons Matrices (PCM) followed by the Synthesizing. Synthesizing is the process of estimating the relative weight of elements, calculating the consistency ratio, and prioritizing alternative solutions.

Table X. Mean priorities by Criterion

Criteria	%
World crude oil price fluctuations	45,35%
Changes in global economic conditions	19,18%
Number of Operational Machines for Domestic Hot Rolled Coil (HRC) Production	11,39%
Hot Rolled Coil (HRC) raw material demand increases	12,38%
Stock availability of domestic Hot Rolled Coil (HRC) raw materials is small	11,68%

Table XI. Mean priorities by alternatives

Alternatives	%
Spot Buying	13,31%
LTC (Long Term Contract)	32,78%
TFC (Technical Framework Contract)	44,06%
MSA (Multi Standing Agreement)	9,86%

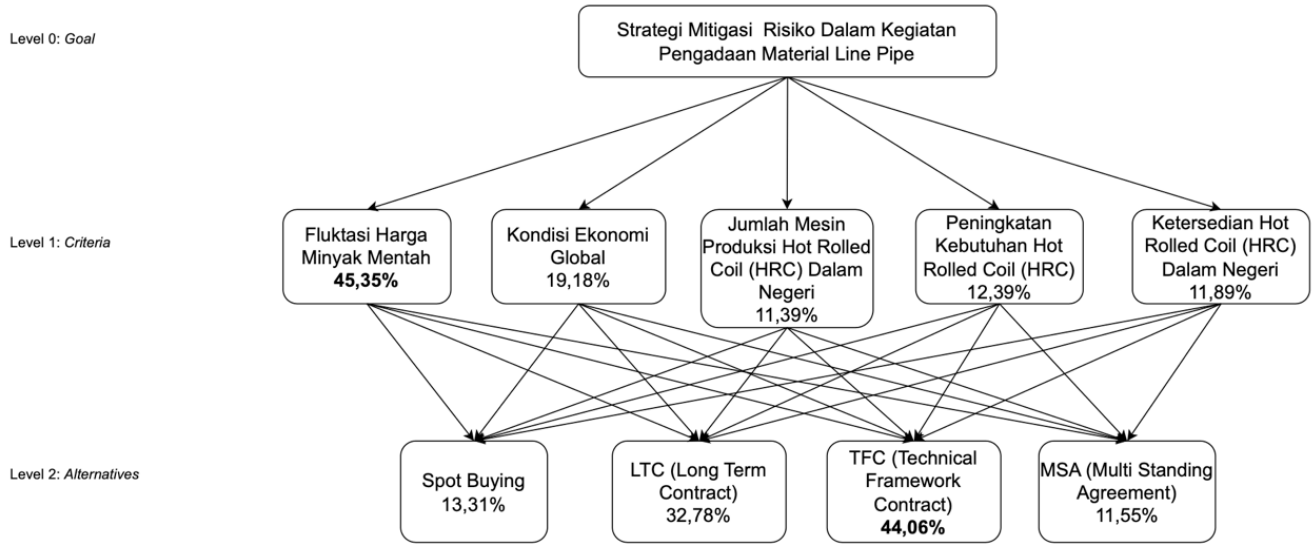

Figure 2. AHP Final Result

The results of the Synthesize calculation of the three SMEs in Table X Mean priorities by Criterion and Table XI Mean priorities by alternatives to Figure 2 AHP Final Result, the most prioritized criterion "Crude Oil Price Fluctuations" with a value of 40.97% and the best alternative solution "TFC (Technical Framework Contract)" with a value of 46.57%.

IV. CONCLUSION

Based on the results of research, discussion, and explanation of the previous chapters. Chapter 4 will contain conclusions from this research regarding the problems that occur in the activities of Line material procurement activities at PT Pertamina EP:

1. The results of the analysis and identification of risk factors from 3 Subjet Matter Expert (SME) in the activity of Line Pipe material procurement activities using the House of Risk (HOR) method. In House of Risk (HOR) 1, from 13 Process Activities, 16 Risk Events (Ei) and 35 Risk Agents (Aj) were obtained.
2. To measure the risk factors that have the highest risk value, we can use the House of Risk (HOR) and Analytic Hierarchy Process (AHP) methods. In House of Risk (HOR) 1 with the calculation of Aggregate Risk Potentials (ARPj). The results of the calculation of the Aggregate Risk Potentials (ARPj) value of 35 Risk Agents (Aj), the highest Aggregate Risk Potentials (ARPj) value "A1 Fluctuations in World Crude Oil Prices" with a value of 810. And the Analytic Hierarchy Process (AHP) with the calculation of the Consistency Ratio for Criteria Weight. The results of the calculation of the Consistency Ratio value of 5 Criteria Weight, the Cosistency Ratio value for the highest Criteria Weight "Crude Oil Price Fluctuations" with a percentage value of 45.4%.
3. Preventive Action (PAk) in determining mitigation strategies for selecting effective and efficient contract types to overcome the highest risk factors in Line Pipe material procurement activities. In the House of Risk (HOR) 2 method with the calculation of the Effectiveness to Difficulty ratio (ETDk). The results of the calculation of the Effectiveness to Difficulty ratio (ETDk) value of 4 Preventive Action (PAk), the highest Effectiveness to Difficulty ratio (ETDk) value "PA3 TFC (Technical Framework Contract)" with a value of 4860. And the Analytic Hierarchy Process (AHP) method with the calculation of Consistency Ratio for Alternative Solutions. The results of the calculation of the Consistency Ratio of 4 Alternative Solutions, the Consistency Ratio value for the highest Alternative Solutions "TFC (Technical Framework Contract)" with a percentage value of 44.06%.
4. Based on the results of the analysis using the House of Risk (HOR) and Analytic Hierarchy Process (AHP) methods. It can be concluded that the best alternative solution in determining the mitigation strategy for selecting the type of contract is "TFC (Technical Framework Contract)" with the highest percentage and value. The use of the TFC (Technical Framework Contract) contract type is in accordance with the PTK-007 Revision 5 Chapter IV Contract guidelines.

For further studies, in risk control company can conduct regular monitoring of the identified risk factors. Involving more Subject Matter Experts (SMEs) can ensure accurate risk identification.

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