

Application of the Analytical Hierarchy Process for Maintenance Vendor Selection in Gas Processing Operations

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Abstract

Maintenance vendor selection in gas processing operations must consider procurement risks that affect equipment reliability, particularly delayed delivery, limited technical assistance, and nonconforming spare parts. This study applies the Analytical Hierarchy Process as a quantitative ranking procedure to select vendors for manifold valve procurement at the Naphtha Gas Processing Unit. The decision hierarchy comprises four main criteria, twelve sub-criteria, and four active vendors. Primary data were obtained from five expert respondents through pairwise-comparison questionnaires, while the final ranking was cross-checked against GEP SMART vendor performance metrics. The main-criteria matrix produced a Consistency Ratio of 0.0481, confirming acceptable judgment consistency. The criterion weights indicate that Service is the most influential factor, with a weight of 0.5578, followed by Delivery 0.2603, Quality 0.1249, and Cost 0.0570. Global priority synthesis placed CV Thania Mandiri in the first rank with a score of 0.3712, followed by CV Jaya Mudita 0.2850, PT Atlas Sembawang 0.1779, and JNK Heaters 0.1660. A $\pm 10\%$ sensitivity test produced no ranking reversal, showing that the priority order remained stable under moderate changes in criterion weights. These findings provide a measurable decision basis for maintenance vendor selection in gas processing procurement.

Keywords: Analytical Hierarchy Process, Gas Processing, Maintenance Vendor Selection, Manifold Valve, Pairwise Comparison.

Abstrak

Pemilihan vendor maintenance pada operasi pengolahan gas perlu mempertimbangkan risiko pengadaan yang mempengaruhi keandalan peralatan, terutama keterlambatan pengiriman, keterbatasan dukungan teknis, dan ketidaksesuaian suku cadang. Penelitian ini menerapkan Analytical Hierarchy Process sebagai prosedur pemeringkatan kuantitatif untuk memilih vendor pengadaan manifold valve pada Unit Naphtha Gas Processing. Struktur keputusan terdiri atas empat kriteria utama, dua belas subkriteria, dan empat vendor aktif. Data primer diperoleh

dari lima responden ahli melalui kuesioner perbandingan berpasangan, sedangkan peringkat akhir dicocokkan dengan metrik kinerja vendor pada GEP SMART. Matriks kriteria utama menghasilkan Consistency Ratio sebesar 0,0481, sehingga konsistensi penilaian dinyatakan dapat diterima. Bobot kriteria menunjukkan bahwa Service menjadi faktor paling berpengaruh dengan bobot 0,5578, diikuti Delivery 0,2603, Quality 0,1249, dan Cost 0,0570. Sintesis prioritas global menempatkan CV Thania Mandiri pada peringkat pertama dengan skor 0,3712, diikuti CV Jaya Mudita 0,2850, PT Atlas Sembawang 0,1779, dan JNK Heaters 0,1660. Uji sensitivitas $\pm 10\%$ tidak menghasilkan perubahan peringkat, sehingga urutan prioritas tetap stabil terhadap perubahan moderat pada bobot kriteria. Temuan ini menyediakan dasar keputusan terukur untuk pemilihan vendor maintenance dalam pengadaan operasi pengolahan gas.

Keywords: *Analytical Hierarchy Process, Pemilihan Vendor Maintenance, Manifold Valve, Pengolahan Gas, Perbandingan Berpasangan.*

1. Introduction

Gas processing operations require continuous equipment availability, reliable maintenance execution, and timely material support. Maintenance items such as valves, seals, gaskets, instrumentation parts, and other replacement components are directly connected to process equipment readiness. In this operating environment, vendor performance cannot be treated only as a purchasing matter because delayed delivery, limited technical assistance, and nonconforming spare parts can disrupt maintenance schedules and reduce equipment reliability. Supplier evaluation in the gas and oil industry has been positioned as a structured decision problem because supplier performance affects operational continuity, delivery reliability, and procurement effectiveness [1]–[4]. Supplier selection in oil and gas also involves operational risk because delays in extraction and refinement activities may negatively affect industrial performance [5], [6]. Therefore, maintenance vendor selection in gas processing operations requires a quantitative decision procedure that can evaluate Cost, Quality, Delivery, and Service criteria in a consistent and traceable manner.

The Analytical Hierarchy Process (AHP) is a multi-criteria decision-making method that decomposes a complex decision problem into a hierarchy consisting of a goal, criteria, sub-criteria, and alternatives. AHP uses pairwise comparison to compare decision elements two at a time and then transforms expert judgments into numerical priority weights. The method also provides a consistency measurement to examine whether the judgments used in the comparison matrix are logically acceptable before the final ranking is interpreted. The development and wide application of AHP across decision-making problems have been documented in the AHP literature, including a review of AHP development from 1979 to 2017 [7]–[9]. In maintenance vendor selection, AHP is relevant because the decision cannot be reduced to price alone. Vendor

selection must also account for material conformity, delivery readiness, service responsiveness, and technical support. In this article, AHP is used to convert expert assessments from procurement, maintenance, reliability, and operation functions into measurable weights for Cost, Quality, Delivery, and Service, and then synthesize those weights into a global vendor ranking.

Recent studies confirm that AHP remains relevant for supplier and spare-parts vendor selection because it can combine qualitative expert judgment with quantitative selection. Sanni et al. [10] applied AHP to spare-parts supplier selection using procurement, quality, service, price, and payment criteria. Manik [4] used AHP to evaluate ten suppliers using cost, quality, delivery, flexibility, and communication criteria, showing that supplier alternatives can be ranked through measurable priority weights. Recent supplier-selection studies also show that vendor evaluation can be connected to recorded performance indicators through VPI and AHP-based assessment [11], [12]. In the gas and oil industry, Wang et al. [1] applied AHP as part of a structured supplier evaluation model, which confirms that criteria-based evaluation is necessary in this sector. These studies provide a methodological and sectoral basis for applying AHP to maintenance vendor selection in gas processing operations.

However, the existing literature still leaves a specific research gap. First, many AHP-based supplier-selection studies evaluate suppliers at the general supply-chain level, while maintenance-item procurement requires closer attention to equipment reliability, material conformity, technical support, and delivery readiness. Second, supplier-selection studies in oil and gas often address broader supplier evaluation, whereas this article focuses on maintenance vendor selection for manifold valve procurement at the operating-unit level. Third, several vendor-ranking studies stop at the final priority order, while maintenance procurement decisions require judgment consistency, global priority synthesis, ranking stability, and comparison with internal performance records [13], [14]. These gaps indicate that an applied AHP study is still needed for maintenance vendor selection in gas processing operations, especially when the decision must be quantitatively traceable and operationally interpretable.

The novelty of this study lies in the specific application of AHP to maintenance vendor selection for manifold valve procurement at the Naphtha Gas Processing Unit. The decision hierarchy is constructed using four main criteria (Cost, Quality, Delivery, and Service) which are decomposed into twelve operational sub-criteria and evaluated across four active vendors. Unlike general supplier-selection studies, this article links the AHP structure to maintenance procurement conditions by integrating expert pairwise comparison, Consistency Ratio testing, global priority synthesis, $\pm 10\%$ sensitivity testing, and comparison with GEP SMART vendor performance metrics. Thus, the novelty is not the invention of a new AHP variant, but the rigorous and traceable application of AHP to a specific maintenance-item procurement case in gas processing operations.

This study contributes to the field by providing a quantitative decision basis for maintenance vendor selection. The contribution is threefold. First, it translates Cost, Quality, Delivery, and Service into a hierarchical AHP structure suitable for maintenance-item procurement. Second, it produces measurable priority weights and global vendor scores that

support vendor ranking. Third, it examines the stability and interpretability of the ranking through sensitivity testing and comparison with recorded GEP SMART performance metrics. These contributions are important because maintenance procurement decisions in gas processing operations require a transparent method that links expert judgment, vendor performance, and equipment reliability requirements.

Accordingly, this manuscript addresses three research questions. First, how are the relative weights of Cost, Quality, Delivery, and Service determined using AHP for maintenance vendor selection in gas processing operations? Second, how does the AHP hierarchy generate global priority scores for active manifold valve vendors at the Naphtha Gas Processing Unit? Third, does the resulting vendor ranking remain stable under moderate criterion-weight changes and remain consistent with recorded GEP SMART vendor performance metrics? Answering these questions is important because gas processing maintenance requires vendor-selection decisions that are quantitatively traceable, operationally interpretable, and aligned with equipment reliability needs.

2. Method

This study used a quantitative decision-making approach based on the Analytical Hierarchy Process to select maintenance vendors for manifold valve procurement at the Naphtha Gas Processing Unit. AHP was selected because the vendor-selection problem involved several evaluation criteria that had to be assessed simultaneously and converted into numerical priority weights. The method follows the hierarchical decision structure, pairwise comparison mechanism, and consistency assessment developed in AHP, where expert judgments are transformed into priority vectors and examined through consistency indicators before the final ranking is interpreted [7], [15]. AHP is appropriate for this study because it allows Cost, Quality, Delivery, and Service to be evaluated as interrelated decision criteria rather than as independent administrative indicators

2.1 Research Design

The research was designed as an applied quantitative study. The unit of analysis was maintenance vendor selection for manifold valve procurement in gas processing operations. The evaluated alternatives consisted of four active vendors: CV Jaya Mudita, CV Thania Mandiri, PT Atlas Sembawang, and JNK Heaters. The decision variables were structured into four main criteria, namely Cost, Quality, Delivery, and Service. Each criterion was decomposed into three sub-criteria, resulting in twelve sub-criteria used in the AHP hierarchy.

The research design consisted of six sequential stages: constructing the AHP hierarchy, collecting expert judgments through pairwise-comparison questionnaires, aggregating expert judgments, calculating local priority weights, testing judgment consistency, synthesizing global vendor priorities, and examining ranking stability through sensitivity testing. The final AHP ranking was then compared with GEP SMART vendor performance metrics to support operational interpretation

2.2 Treating Liquid Waste using Distillation Membranes

The AHP hierarchy was constructed into four levels. The first level was the decision goal, namely selecting the most appropriate maintenance vendor for manifold valve procurement. The second level consisted of four main criteria: Cost, Quality, Delivery, and Service. The third level consisted of twelve sub-criteria derived from the four main criteria. The fourth level consisted of four vendor alternatives.

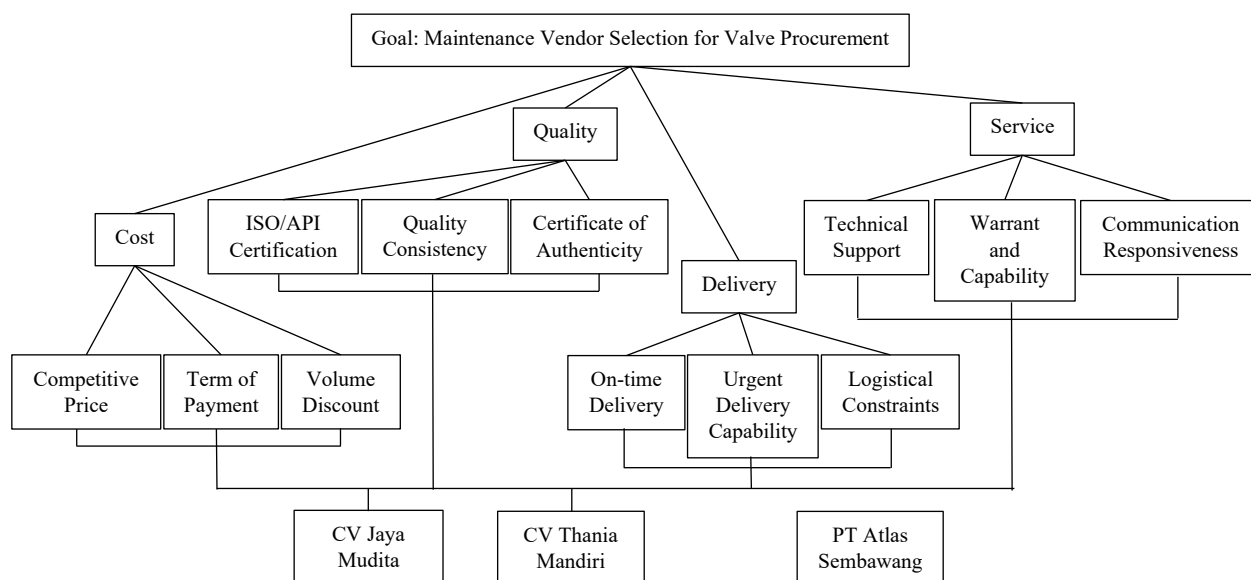


Figure 1. AHP Hierarchy Tree Diagram for Maintenance Vendor Selection

The Cost criterion represented the economic aspect of procurement. The Quality criterion represented material conformity and product reliability. The Delivery criterion represented the vendor's ability to provide the required item within the required time. The Service criterion represented technical support, warranty handling, and communication responsiveness during procurement and maintenance execution.

2.3 Criteria and Sub-Criteria

The criteria and sub-criteria were defined to reflect maintenance procurement requirements in gas processing operations. Cost was represented by competitive price, term of payment, and volume discount. Quality was represented by ISO/API certification, quality consistency, and certificate of authenticity. Delivery was represented by on-time delivery, urgent delivery capability, and logistical constraints. Service was represented by technical support, warranty and return policy, and communication responsiveness.

Table 2. Criteria and Sub-Criteria Used in the AHP Model

Main Criteria	Code	Sub-Criteria	Code
Cost	C1	Competitive price	C1.1
Cost	C1	Term of payment	C1.2
Cost	C1	Volume discount	C1.3
Quality	C2	ISO/API certification	C2.1

Main Criteria	Code	Sub-Criteria	Code
Quality	C2	Quality consistency	C2.2
Quality	C2	Certificate of authenticity	C2.3
Delivery	C3	On-time delivery	C3.1
Delivery	C3	Urgent delivery capability	C3.2
Delivery	C3	Logistical constraints	C3.3
Service	C4	Technical support	C4.1
Service	C4	Warranty and return policy	C4.2
Service	C4	Communication responsiveness	C4.3

Source: Processed Data (2026)

This variable structure was used consistently in the pairwise-comparison questionnaire, local weighting, global priority synthesis, sensitivity testing, and final vendor-ranking interpretation.

2.4 Respondents and Data Sources

Primary data were obtained from five expert respondents selected through purposive sampling. The respondents were selected because they had direct knowledge of maintenance requirements, procurement procedures, vendor performance, and operational conditions at the Naphtha Gas Processing Unit. The expert group represented maintenance, procurement, process engineering, reliability engineering, and operation functions. This respondent structure was used to ensure that the pairwise judgments reflected both technical and procurement perspectives.

Secondary data were obtained from GEP SMART vendor performance metrics. These metrics were used to compare the final AHP ranking with recorded vendor performance indicators, including delivery performance, reject rate, and service rating. The comparison was not used to replace the AHP result but to support the operational interpretation of the final vendor ranking.

2.5 Pairwise-Comparison Procedure

Pairwise-comparison questionnaires were used to compare decision elements at the same hierarchy level. Each respondent compared the relative importance of criteria, sub-criteria, and vendor alternatives using Saaty's 1–9 scale. A value of 1 indicated equal importance, while values of 3, 5, 7, and 9 indicated increasing levels of importance. Intermediate values of 2, 4, 6, and 8 were used when the judgment fell between two adjacent levels. Reciprocal values were used when one element was less important than another element.

The pairwise-comparison matrix was expressed as:

$$A = [a_{ij}] \quad (1)$$

where a_{ij} represents the relative importance of element i compared with element j . The reciprocal property was applied as:

$$a_{ji} = \frac{1}{a_{ij}} \quad (2)$$

and each diagonal element was defined as:

$$a_{ii} = 1 \quad (3)$$

This structure ensured that every comparison matrix followed the reciprocal rule required in AHP.

2.6 Aggregation of Expert Judgments

Because the study involved five expert respondents, individual pairwise-comparison judgments were aggregated before priority-weight calculation. The aggregation was conducted using the geometric mean because pairwise-comparison values are ratio-scale judgments. For each matrix element, the aggregated judgment was calculated as:

$$\overline{a_{ij}} = \left(\prod_{k=1}^m a_{ij}^{(k)} \right)^{\frac{1}{m}} \quad (4)$$

where $\overline{a_{ij}}$ is the aggregated comparison value, $a_{ij}^{(k)}$ is the comparison value from respondent k , and m is the number of expert respondents. The aggregated matrix was then used as the basis for priority-weight calculation.

2.7 Priority-Weight Calculation

Priority weights were calculated for each comparison matrix. The normalized matrix approach was used to obtain the priority vector. Each matrix element was divided by the sum of its column, and the average value of each row was used as the local priority weight. The normalization was expressed as:

$$n_{ij} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}} \quad (5)$$

The local priority weight for each element was calculated as:

$$w_i = \frac{\sum_{j=1}^n n_{ij}}{n} \quad (6)$$

where w_i is the local priority weight of element i , n_{ij} is the normalized value of element i in column j , and n is the number of compared elements. The same procedure was applied to the main criteria, sub-criteria, and vendor alternatives.

2.8 Consistency Test

A consistency test was conducted to examine the logical reliability of each pairwise-comparison matrix. Consistency testing is important in AHP because expert judgments should not be random or contradictory before the resulting priority weights are used for decision interpretation. Consistency evaluation in AHP is commonly performed using the maximum eigenvalue, Consistency Index, and Consistency Ratio.

The maximum eigenvalue was calculated from the weighted sum vector and priority vector. The Consistency Index was calculated as:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (7)$$

The Consistency Ratio was calculated as:

$$CR = \frac{CI}{RI} \quad (8)$$

where CI is the Consistency Index, λ_{max} is the maximum eigenvalue, n is the number of compared elements, and RI is the Random Index. The Random Index followed the standard AHP RI values, where $RI = 0.58$ for $n = 3$ and $RI = 0.90$ for $n = 4$. A pairwise-comparison matrix was considered acceptable when $CR < 0.10$. Matrices that met this threshold were used for global priority synthesis.

The consistency test was applied to the complete AHP matrix set, consisting of one main-criteria matrix, four sub-criteria matrices, and twelve vendor-alternative matrices under the sub-criteria. Each matrix was accepted only when the Consistency Ratio was below 0.10; matrices that failed this threshold were not used for global priority synthesis.

For the main-criteria matrix, λ_{max} was 4.1298 and CI was 0.0433. Because the matrix contained four criteria, the applied RI value was 0.90, resulting in a CR of 0.0481. This value indicates acceptable consistency because it is below 0.10.

2.9 Global Priority Synthesis

Global priority synthesis was conducted by multiplying the main-criteria weight, sub-criteria weight, and vendor local priority weight. The global score of each vendor was calculated as:

$$S_v = \sum_{i=1}^4 \sum_{j=1}^3 W_i \times W_{ij} \times W_{vij} \quad (9)$$

where S_v is the global priority score of vendor v , W_i is the weight of main criterion i , W_{ij} is the local weight of sub-criterion j under criterion i , and W_{vij} is the local priority weight of vendor v under sub-criterion j . The vendor with the highest global priority score was assigned the first rank.

2.10 Sensitivity Testing

Sensitivity testing was conducted to examine whether the vendor ranking remained stable under moderate changes in criterion weights. The test was performed by increasing and decreasing each main-criterion weight by 10%. After each adjustment, the global vendor scores were recalculated and the resulting vendor ranking was compared with the original ranking. The ranking was considered stable when no rank reversal occurred under the tested scenarios.

2.11 Comparison with GEP SMART Vendor Performance Metrics

The final AHP ranking was compared with GEP SMART vendor performance metrics to support the operational interpretation of the result. The comparison used vendor performance

indicators such as on-time delivery, reject rate, and service rating. This step was not intended as a separate model but as a cross-check to examine whether the AHP-based ranking was consistent with recorded procurement performance. A vendor ranking that remained aligned with GEP SMART metrics was interpreted as more operationally reasonable for maintenance procurement decision-making.

The GEP SMART data were taken from internal vendor performance records for manifold valve procurement during January-December 2025. OTD Rate was calculated as on-time deliveries divided by total deliveries, Reject Rate as rejected items divided by received items, and Service Rating as the arithmetic mean of recorded service evaluations on a 1-5 scale. GEP Rank was determined by ordering vendors according to the combined operational direction of higher OTD Rate, lower Reject Rate, and higher Service Rating.

3. Result and Discussion

The AHP analysis produced three main findings. First, Service became the dominant criterion in maintenance vendor selection for manifold valve procurement, followed by Delivery, Quality, and Cost. Second, CV Thania Mandiri obtained the highest global priority score and was selected as the first-ranked vendor. Third, the vendor ranking remained stable under $\pm 10\%$ criterion-weight changes and was aligned with GEP SMART vendor performance metrics. These findings indicate that maintenance vendor selection in gas processing operations is driven more strongly by service reliability and delivery readiness than by price alone.

3.1 Main-Criteria Weighting and Consistency Test

The main-criteria weighting shows that Service obtained the highest priority weight, followed by Delivery, Quality, and Cost. The Consistency Ratio of the main-criteria matrix was 0.0481, which is below the maximum acceptable threshold of 0.10. This result indicates that the expert judgments used to compare the four criteria were consistent and suitable for further synthesis.

Table 3. Main-Criteria Weights and Consistency Test

Criterion	Weight	Rank
Service	0.5578	1
Delivery	0.2603	2
Quality	0.1249	3
Cost	0.0570	4

Source: Processed Data (2026)

To improve replicability, the aggregated main-criteria pairwise-comparison matrix and its normalized matrix are reported in Tables 4a and 4b. The comparison values are not necessarily integers because they represent geometric-mean aggregation of five expert judgments.

Table 4a. Aggregated Pairwise-Comparison Matrix of Main Criteria

Criterion	Cost	Quality	Delivery	Service
Cost	1.0000	0.3721	0.1989	0.1367
Quality	2.6875	1.0000	0.3322	0.2459

Criterion	Cost	Quality	Delivery	Service
Delivery	5.0265	3.0100	1.0000	0.2870
Service	7.3133	4.0659	3.4841	1.0000

Source: Processed Data (2026)

Table 4b. Normalized Main-Criteria Matrix and Priority Weights

Criterion	Cost column	Quality column	Delivery column	Service column	Priority weight
Cost	0.0624	0.0440	0.0397	0.0819	0.0570
Quality	0.1677	0.1184	0.0662	0.1473	0.1249
Delivery	0.3136	0.3563	0.1994	0.1719	0.2603
Service	0.4563	0.4813	0.6947	0.5989	0.5578

Source: Processed Data (2026)

Table 4c. Consistency-Test Recapitulation for the Full AHP Matrix Set

Matrix set	Number of matrices	Consistency information reported in the calculation file	Status
Main criteria	1	CR = 0.0481	Accepted
Sub-criteria under Cost, Quality, Delivery, and Service	4	Each sub-criteria matrix was screened using CR < 0.10 before synthesis	Accepted
Vendor alternatives under twelve sub-criteria	12	Each alternative matrix was screened using CR < 0.10 before global scoring	Accepted
Total matrix set	17	All matrices met the AHP consistency threshold used in this study	Accepted

Source: Processed Data (2026)

This recapitulation clarifies that the reported CR value for the main-criteria matrix was not the only consistency test performed. The same acceptance threshold was applied to the sub-criteria and vendor-alternative matrices before the final global priorities were interpreted.

Table 4d. Consistency Test for Main-Criteria Matrix

Parameter	Value	Description
λ_{max}	4.1298	Maximum eigenvalue
n	4	Number of compared criteria
CI	0.0433	Consistency Index
RI	0.90	Random Index for $n = 4$
CR	0.0481	Consistency Ratio
Status	Consistent	$CR < 0.10$

Source: Processed Data (2026)

Service became the most influential criterion because manifold valve procurement is closely related to maintenance execution. In gas processing operations, weak vendor service can delay technical clarification, warranty response, and operational support. The low weight of Cost does not mean that price was ignored; rather, it shows that price competitiveness was less dominant than service reliability and delivery readiness for maintenance items connected to equipment reliability. This interpretation is consistent with supplier-selection studies that treat cost, quality, delivery, and service as interrelated criteria rather than isolated purchasing indicators [1], [10], [16].

3.2 Sub-Criteria Weighting

The sub-criteria weighting explains which operational factors shaped the final vendor ranking. Under Cost, competitive price became the dominant sub-criterion. Under Quality, certificate of authenticity had the highest weight. Under Delivery, on-time delivery became the dominant sub-criterion. Under Service, communication responsiveness became the most influential sub-criterion.

Table 5. Sub-Criteria Weights

Main Criterion	Sub-Criterion	Local Weight	Global Weight	Rank
Cost	Competitive price	0.6324	0.0361	1
Cost	Term of payment	0.2609	0.0149	2
Cost	Volume discount	0.1066	0.0061	3
Quality	ISO/API certification	0.1062	0.0133	3
Quality	Quality consistency	0.2605	0.0325	2
Quality	Certificate of authenticity	0.6333	0.0791	1
Delivery	On-time delivery	0.6368	0.1658	1
Delivery	Urgent delivery capability	0.2541	0.0661	2
Delivery	Logistical constraints	0.1091	0.0284	3
Service	Technical support	0.2541	0.1417	2
Service	Warranty and return policy	0.1091	0.0609	3
Service	Communication responsiveness	0.6368	0.3552	1

Source: Processed Data (2026)

The largest global sub-criterion weight was Communication Responsiveness, with a value of 0.3552. This was followed by On-Time Delivery at 0.1658 and Technical Support at 0.1417. These three sub-criteria represent the operational side of maintenance procurement because they determine how quickly and reliably the vendor can support maintenance activities. This finding strengthens the argument that maintenance vendor selection is not a price-dominant decision. For manifold valve procurement, communication responsiveness and delivery reliability have stronger implications for maintenance readiness than price reduction alone.

3.3 Global Priority Synthesis and Vendor Ranking

Global priority synthesis was conducted by multiplying the main-criteria weight, sub-criteria weight, and vendor local priority weight. The resulting values were summed to obtain the final global score for each vendor.

Table 6. Final Vendor Ranking Based on AHP Global Priority

Rank	Vendor	Global Score	Percentage
1	CV Thania Mandiri	0.3712	37.12%
2	CV Jaya Mudita	0.2850	28.50%
3	PT Atlas Sembawang	0.1779	17.79%
4	JNK Heaters	0.1660	16.60%

Source: Processed Data (2026)

CV Thania Mandiri obtained the highest global priority score of 0.3712. Its first-rank position was mainly supported by strong performance in high-weight sub-criteria, particularly Communication Responsiveness, Technical Support, and Certificate of Authenticity. CV Jaya Mudita ranked second with a score of 0.2850. Although this vendor performed strongly in cost-related sub-criteria, its lower contribution in the dominant service-related sub-criteria reduced its final position.

PT Atlas Sembawang ranked third with a score of 0.1779, supported mainly by its strength in On-Time Delivery. JNK Heaters ranked fourth with a score of 0.1660. The final ranking confirms that AHP selects the best vendor through weighted performance across all hierarchy levels, not through dominance in a single criterion. This result is consistent with the logic of AHP, where the final priority depends on the interaction between criterion weight, sub-criterion weight, and vendor local priority [7].

3.4 Sensitivity Analysis

Sensitivity analysis was conducted to examine whether the vendor ranking remained stable under moderate changes in criterion weights. Each main criterion was increased and decreased by 10%, and the global scores were recalculated for each scenario. The result showed no rank reversal across all tested scenarios.

Table 7. Sensitivity Analysis under $\pm 10\%$ Criterion-Weight Changes

Scenario	Rank 1	Rank 2	Rank 3	Rank 4	Status
Original weight	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Reference
Cost +10%	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Stable
Cost -10%	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Stable
Quality +10%	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Stable
Quality -10%	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Stable
Delivery +10%	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Stable
Delivery -10%	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Stable
Service +10%	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Stable
Service -10%	CV Thania Mandiri	CV Jaya Mudita	PT Atlas Sembawang	JNK Heaters	Stable

Source: Processed Data (2026)

The absence of rank reversal indicates that the final priority order was stable under moderate criterion-weight changes. This is important because AHP relies on expert judgment, and small changes in criterion weights may occur when different experts or operational conditions are involved. The stable first-rank position of CV Thania Mandiri indicates that its advantage was not caused by one unstable criterion, but by its weighted performance in high-impact sub-criteria.

3.5 Cross-Check with GEP SMART Vendor Performance Metrics

The final AHP ranking was cross-checked against GEP SMART vendor performance metrics. This comparison used On-Time Delivery, Reject Rate, and Service Rating. The purpose of this step was to support the operational interpretation of the AHP result, not to

replace the AHP calculation. The metric direction was defined before comparison: a higher OTD Rate indicates stronger delivery performance, a lower Reject Rate indicates better material conformity, and a higher Service Rating indicates stronger service performance. The GEP Rank was assigned by ordering vendors according to the combined direction of these three indicators for the January-December 2025 evaluation period.

Table 8. Cross-Check between AHP Ranking and GEP SMART Metrics

Vendor	AHP Score	AHP Rank	OTD Rate	Reject Rate	Service Rating	GEP Rank
CV Thania Mandiri	0.3712	1	94.2%	1.8%	4.3/5	1
CV Jaya Mudita	0.2850	2	91.5%	2.3%	4.1/5	2
PT Atlas Sembawang	0.1779	3	88.7%	3.1%	3.8/5	3
JNK Heaters	0.1660	4	85.3%	4.2%	3.5/5	4

Source: GEP SMART internal vendor performance record, January-December 2025; processed data (2026)

The comparison shows that the AHP ranking was aligned with the GEP SMART vendor performance order. CV Thania Mandiri had the highest AHP score and also showed the strongest recorded performance, with the highest OTD Rate, the lowest Reject Rate, and the highest Service Rating among the evaluated vendors. This alignment strengthens the operational interpretation of the AHP result because the first-ranked vendor was supported by both expert-based weighting and recorded performance metrics.

The GEP SMART cross-check also supports the importance of Service and Delivery in the AHP structure. Vendors with stronger delivery and service performance obtained better rankings, which confirms that the AHP result follows the operational logic of maintenance procurement. This finding is consistent with supplier-selection literature that emphasizes criteria-based evaluation and the use of vendor performance indicators when procurement performance affects operational continuity [1], [10], [12].

3.6 Engineering Interpretation

The result of this study indicates that maintenance vendor selection for manifold valve procurement is primarily driven by service capability and delivery reliability. Service obtained the largest criterion weight, and Communication Responsiveness became the most influential sub-criterion in the global hierarchy. This pattern is technically reasonable because manifold valve procurement requires fast clarification, reliable documentation, after-sales support, and responsive communication when maintenance execution faces operational constraints.

The final ranking also shows that the best vendor is not necessarily the vendor with the strongest cost performance. CV Jaya Mudita had strong cost-related priorities, but CV Thania Mandiri achieved the highest global score because it performed better in high-weight service and quality-related sub-criteria. This confirms that the AHP result reflects the operational logic of maintenance procurement rather than a price-dominant purchasing decision.

Overall, the AHP application provides a quantitative and traceable decision basis for maintenance vendor selection in gas processing procurement. The combination of consistent pairwise judgments, global priority synthesis, sensitivity testing, and GEP SMART cross-check

makes the final ranking more defensible for engineering and procurement decision-making. The result supports the selection of CV Thania Mandiri as the preferred vendor for manifold valve procurement, while CV Jaya Mudita can be considered as a secondary vendor to maintain procurement flexibility and supply continuity.

4. Conclusion

This study applied the Analytical Hierarchy Process for maintenance vendor selection in gas processing operations, using manifold valve procurement at the Naphtha Gas Processing Unit as the evaluated case. The AHP hierarchy was structured using four main criteria, twelve sub-criteria, and four active vendors. The consistency test showed that the main-criteria matrix was acceptable, with a Consistency Ratio of 0.0481, indicating that the expert judgments were sufficiently consistent for priority synthesis.

The result showed that Service was the most influential criterion, with a weight of 0.5578, followed by Delivery 0.2603, Quality 0.1249, and Cost 0.0570. This finding indicates that maintenance vendor selection for gas processing operations is not primarily driven by price, but by the vendor's ability to provide responsive communication, technical support, delivery reliability, and material conformity. Among the sub-criteria, Communication Responsiveness had the largest global influence, followed by On-Time Delivery and Technical Support. These findings confirm that maintenance procurement decisions must reflect operational reliability requirements, not only purchasing efficiency.

The global priority synthesis ranked CV Thania Mandiri first with a score of 0.3712, followed by CV Jaya Mudita 0.2850, PT Atlas Sembawang 0.1779, and JNK Heaters 0.1660. The $\pm 10\%$ sensitivity test showed no rank reversal, indicating that the vendor priority order remained stable under moderate changes in criterion weights. The cross-check with GEP SMART performance metrics also showed alignment between the AHP ranking and recorded vendor performance. This supports the operational interpretability of the result and strengthens the use of AHP as a quantitative decision basis for maintenance vendor selection.

The significance of this study lies in its application of AHP to a specific maintenance-item procurement case in gas processing operations. The study contributes by providing a traceable procedure that connects expert judgment, criterion weighting, global vendor scoring, ranking stability, and recorded performance metrics. The novelty is not in proposing a new AHP variant, but in applying AHP rigorously to manifold valve vendor selection at the operating-unit level, where procurement decisions are directly linked to maintenance execution and equipment reliability. The result can support engineering and procurement teams in selecting the preferred vendor while maintaining CV Jaya Mudita as a secondary vendor to preserve procurement flexibility and supply continuity.

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