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ORIGINAL ARTICLE

Assessing Safety Culture Maturity in Indonesia's Petrochemical Producer

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ABSTRACT

Introduction: Safety culture maturity is essential in high-risk industries, including the petrochemical sector, where maintaining workplace safety helps prevent accidents and improve operational efficiency. This study explores the maturity level of safety culture at the petrochemical company in Indonesia using Hudson's five stage maturity model as a framework for evaluation. The research aims to identify the correlation between safety culture maturity and five aspects of organizational factors. **Methods:** The questionnaire was completed using online survey-based research by the employees in a petrochemical company of 86 respondents selected through purposive sampling. Safety culture maturity served as the dependent variable, while the independent variables included five organizational factors: information, organizational learning, employee participation, communication, and commitment. The study considers safety culture maturity as the dependent variable, while the five organizational factors serve as independent variables. Data were analyzed using regression analysis Spearman's correlation to assess between these factors and the maturity level of safety culture. **Results:** The results from the framework demonstrating the safety culture maturity at the level of generative. The strongest correlations were found in commitment ($r = 0.712$, $p < 0.01$), followed by information, organizational learning, employee participation, and communication. Meanwhile, gender and education level did not significantly influence safety culture maturity. **Conclusion:** These findings highlight the importance of organizational commitment, effective communication, and continuous learning make the safety culture become the habit. The study recommended the petrochemical industries using the framework and revised the questionnaire align with the regulation for continuous improvement in safety culture.

Keywords: cultural maturity, health, petrochemical industry, safety culture

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INTRODUCTION

The petrochemical industry is recognized globally as a high-risk sector due to its reliance on complex processes. The process involves hazardous chemicals, elevated temperatures, and high pressures (Narayanan *et al.*, 2023). These operational characteristics significantly increase the likelihood of incidents such as fires, explosions, toxic chemical releases, and environmental pollution (Fassio *et al.*, 2022). Between 2018 and 2023, Indonesia recorded numerous major incidents in chemical and petrochemical facilities, including explosions and fires. These incidents resulted in at least 34 fatalities, dozens of injuries, and severe damage to production facilities, often halting operations and causing significant material losses.

In response to these risks, many petrochemical industries implement Health, Safety, and Environment (HSE) programs designed to manage operational hazards. It is through integrated policies, procedures, infrastructure, and safety management systems. For example, studies in China and India have shown that robust safety systems significantly reduce incident rates and improve regulatory compliance in petrochemical operations (Bai *et al.*,

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2023; Xu *et al.*, 2023). In Indonesia, the government mandates the implementation of safety management systems (e.g., SMK3), and many petrochemical firms adopt international standards such as ISO 45001. Despite existing regulatory frameworks and the implementation of safety systems, such recurrent accidents highlight a persistent gap between compliance with the actual health and safety performance in the field.

Despite these efforts, chemical-related accidents still frequently occur, signaling a gap between formal compliance and practical effectiveness (Wicaksono *et al.*, 2021; Widowati *et al.*, 2024). The key issue lies in the maturity of safety culture itself, not merely in the existence of safety programs. Research has shown that industries with mature safety culture tend to have fewer incidents and better operational resilience (Williams, Fugar and Adinyira, 2020). Although various high-risk industries such as oil and gas, aviation, and construction have used safety culture maturity models to assess and enhance safety culture, there is a lack of such practical and systematic application within Indonesia's petrochemical sector (Boskeljon-Horst, Sillem and Dekker, 2023). The problem is not the absence of regulations, but the limited evaluation of how deeply safety principles that embedded in organizational behavior, management practices, and worker perceptions.

The International Labour Organization (ILO) has established guidelines to prevent major accidents (Halonen and Liukkunen, 2021). The Code of Practice on Safety in the Use of Chemicals at Work, aimed at protecting workers from chemical hazards and preventing chemically induced illnesses and injuries (Dreval *et al.*, 2020). Indonesian government mandates the implementation of safety management systems, which have been widely adopted in many petrochemical industries. However, chemical incidents and accidents still frequently occur. Safety culture is the foundation for ensuring the reliability of safety management systems. One approach to understanding industrial safety culture is through the safety culture maturity model, which focuses on organizational characteristics.

The foundation of the model was introduced by Westrum, who classified safety culture into three levels: Pathological, Bureaucratic, and Generative. The model emphasizing the flow of information as a critical factor in organizational safety (Duarte *et al.*, 2023). Hudson later expanded Westrum's model into five stages such as pathological, reactive, calculative, proactive, and generative, which he termed the safety culture maturity ladder (Greeff, 2023). This model has been applied across various industries, including oil and gas, aviation, healthcare, and construction, to assess and enhance safety culture (Boskeljon-Horst, Sillem and Dekker, 2023). Hudson described the model as a continuous improvement journey rather than a framework focused solely on compliance. Organizations have found this model useful in identifying both strengths and weaknesses in their safety systems (Orlando, Lima and Abreu, 2019).

Additionally, the safety culture maturity ladder reflects both individual and organizational transformation in safety management (Al-Bayati, 2021). Instead of merely associating culture with safety outcomes, this model describes how organizations progress through different stages of change in their approach to safety and risk management (Williams, Fugar and Adinyira, 2020). The maturity level of an organization or facility is determined based on its maturity across these elements. Deciding the most appropriate level should be based on the average level achieved by the organization or facility being evaluated. One approach to understanding industrial safety culture is the safety culture maturity model which focuses on these organisational characteristics. To address the maturity level, this research purpose to evaluate safety culture maturity one of the largest producers of Petrochemical Industry in Indonesia.

In other countries, they used safety culture maturity models to assess and improve internal safety practices. Indonesian petrochemical companies have yet to systematically adopt this approach. Without understanding the maturity level of safety culture, it is difficult for organizations to identify weaknesses, align employee behavior with safety goals, or prioritize meaningful improvements. Given the recurring incidents and the strategic importance of the petrochemical industry to Indonesia's health and safety at work, this research seeks to answer the current maturity level of safety culture across key petrochemical industries in Indonesia. Evaluating safety culture maturity is essential to identify strengths and weaknesses beyond compliance and to guide long-term improvements in safety performance.

This study aims to assess the maturity of safety culture using the Safety Culture Maturity Model (SCMM). That focus on ten core elements: management commitment, communication, learning organization, employee involvement, trust, and

others. The study applies this framework to ten petrochemical companies in Indonesia, drawing comparisons based on company type and product line. This research contributes empirical evidence to support the development of tailored safety strategies for the Indonesian petrochemical sector and offers a foundation for future regulatory and managerial interventions. By identifying current maturity levels, this study provides strategic insights that can help industries strengthen their safety practices, reduce risk exposure, and improve overall performance in a high-hazard sector that is vital to national health and safety industry. This pattern further reinforces the importance of understand the maturity level of safety culture in Indonesian petrochemical industries as a foundation for meaningful improvement and accident prevention.

METHODS

The safety culture maturity model used in this study based on Hudson model. This model much more suitable for implementation in Indonesia compared to Fleming. The Fleming's criteria (e.g., an adequate safety management system, technical failures not being the main cause of accidents, and compliance with health and safety laws) limit its broader applicability. Additionally, the three stages of safety culture development proposed by International Atomic Energy Agency (IAEA) considered less comprehensive (Greeff, 2023). Hudson's model was slightly modified by renaming the calculative stage to the bureaucratic stage (as in Westrum's model) and the generative stage to the sustainable stage. These changes were made to make the terms easier to understand and more familiar for safety managers in Indonesia.

To assess the maturity level of safety culture, a structured questionnaire was developed based on the five dimensions of safety culture maturity. The number of questions for each dimension varied based on the number of elements in the framework. The dimensions examined included information, organizational learning, employee participation, communication, and commitment. The questionnaire consisted of a total of 22 elements with 5 criterias with total 110 questions. For each question, respondents were asked to select the element that best represented their company's position. Table 1 provides indicators for each variable of five elements related to the five maturity levels. Stratified simple random sampling techniques were used in selecting workers within the companies Each unit in the sample had an equal chance of being included in the survey.

The scale ranged in the statement from Pathological to Generative, reflecting the stages of safety culture in the petrochemical industry. The respondents were required to select one statement from a likert scale ranging from "Pathological" (lowest maturity) to "Generative" (highest maturity). This scale allowed respondents to indicate their agreement with statements representing different stages of safety culture maturity. Selecting a statement indicated that the respondent also agreed with all preceding statements. For example, if a respondent selected the proactive stage, it implied agreement with the pathological, reactive, and calculative stages as the company's safety culture evolved through these levels.

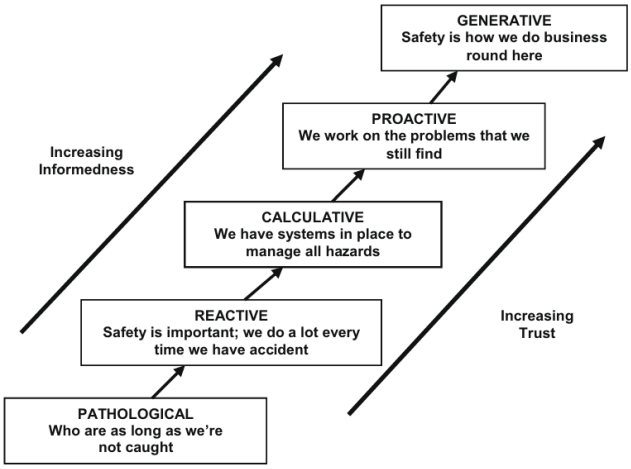

Figure 1. Safety Culture Model of Hudson (Hudson, 2009)

Table 1. Indicators for Each Dimensions

Variables	Indicators
Information (X1)	Reporting & recording
	HSE information
Organizational Learning (X2)	Incident investigation & analysis
Employee Participation (X3)	HSE involvement
Communication (X4)	HSE communication
Commitment (X5)	HSE planning
	Auditing
	Incentive schemes
	HSE training & Competence
	HSE appraisals

Each choice was scored from 1 (Pathological) to 5 (Generative). The average score was calculated for each respondent across all questionnaire items. These individual scores were then aggregated to determine the mean maturity score for the organization as a whole. The final average score was used to classify the organization's safety culture maturity level based on Hudson's model. A mean score closest to 5 indicated that the organization had reached the "Generative" stage of safety culture maturity.

The respondents were required to select only one statement from the scale, which was structured from the lowest to the highest level of safety culture maturity. This study employed a quantitative research design to assess the maturity level of safety culture in a petrochemical company conducted at Company X as one of the largest producers Petrochemical in Indonesia. The analysis focused on the cumulative scale. A construct table was developed to present respondents' choices for all items. The data were sorted so that respondents who selected higher maturity levels were listed at the top, while those selecting lower levels were at the bottom. The statements were then ranked to identify the most commonly agreed-upon stages of safety culture maturity.

Data collection was conducted in March 2024 using the structured questionnaire. This process ensured the clarity, relevance, and practical applicability of the instrument. Safety officers involved were professionals. With minimum supervisory level with strong knowledge of occupational and process safety standards and their implementation. The questionnaire was distributed online to ensure it was accessible to all relevant employees across the organization.

The population consisted of safety personnel across 27 petrochemical companies in Indonesia. The sample consisted of 86 respondents and was selected using purposive sampling. Ensuring the respondents had significant experience and involvement in direct involvement in safety management and operational safety practices. The study examined safety culture maturity (Y) as the dependent variable, while the independent variables included information (X1), organizational learning (X2), employee participation (X3), communication (X4), commitment (X5), gender, age, education, and work experience.

Data processing followed a quantitative research design. The collected data were analyzed using a cumulative scale, where respondent's choices were sorted from the highest to the lowest maturity levels. This process allowed for a ranking of the most commonly agreed-upon stages of safety culture maturity. The responses were categorized into five stages of safety culture maturity, and the analysis focused on identifying patterns in the responses related to the five key dimensions of safety culture. A construct table was created to present respondents' choices for all items. Furthermore, to deepen the analysis, we conducted correlation analysis to examine the relationship between independent variables (X1-X5) and the dependent variable (safety culture maturity).

The data organized to show the distribution of safety culture maturity levels among the respondets. To analyze the relationships between the five independent variables (information, organizational learning, employee participation, communication, and commitment) and the dependent variable (safety culture maturity). Spearman's rank correlation analysis was applied. This method was chosen based on maturity levels ranked from low to high of safety culture maturity scale. This research has received an ethical certificate from the ethics committee from The Research and Community Engagement Ethical Committee of Faculty of Public Health Universitas Indonesia and the number of the ethics certificate is Ket-65/UN2.F10.D11/PPM.00.02/ 2024.

RESULT

The demographic profile shows in this company was predominantly male, mid-career, moderately educated workforce. Total of 86 workers answered the questionnaire, the majority of respondents were male (97.7%), while only 2.3% were female. The most represented age group was 30–39 years (38.4%), while the lowest percentage was in the 40–49 age group (11.6%). In terms of education, most respondents (77.9%) had a high school qualification, while 22.1% held a bachelor's degree (S1). Regarding work experience, the majority had 11–20 years of experience (36.0%), while the fewest respondents had less than one year of experience (8.1%) (Table 2).

The correlation analysis in this study examines the relationship between each independent variable and the dependent variable (Maturity Level). The correlation analysis results indicate a significant relationship between Information (X1), Organizational Learning (X2), Employee Participation (X3), Communication (X4), Commitment (X5), Age, and Work Experience with

Maturity (Y). However, Gender and Education do not show a significant correlation with Maturity (Y). While age ($r = 0.282$, $p < 0.01$) and work experience ($r = 0.246$, $p < 0.05$) were positively correlated with safety maturity, their lower correlation values suggest that demographic factors have a weaker influence compared to organizational practices (Table 3). The correlation analysis revealed that commitment ($r = 0.712$, $p < 0.01$) had the strongest positive relationship with safety culture maturity, highlighting the critical role of leadership commitment in fostering a mature safety culture. Information ($r = 0.603$, $p < 0.01$) and communication ($r = 0.557$, $p < 0.01$) also showed strong correlations, emphasizing the importance of transparent information-sharing and effective communication in improving safety practices. Organizational learning ($r = 0.523$, $p < 0.01$) and employee participation ($r = 0.481$, $p < 0.01$) were significantly correlated with maturity level, indicating that continuous learning and employee involvement contribute to safety culture development.

Diagnosis of Safety Maturity Culture

A descriptive breakdown of the maturity scores revealed differences across the five key dimensions. The average score for communication and organizational learning was the highest at 4.88, reflecting strong leadership involvement and consistent integration of safety in planning and evaluations. Commitment and employee participation followed with scores of 4.87 and 4.85, suggesting effective safety briefings, feedback mechanisms, and regular incident-based learning practices. Information scored 4.79, indicating moderate engagement in information as safety

Table 2. Demographic Characteristics of Respondents (n=86)

Demographic	Category	n	Percentage (%)
Gender	Male	84	97.7
	Female	2	2.3
Age	20-29 years	22	25.6
	30-39 years	33	38.4
	40-49 years	10	11.6
	50-59 years	21	24.4
Education	High School	67	77.9
	Bachelor's degree	19	22.1
Work Experience	<1 year	7	8.1
	1-10 years	17	19.8
	11-20 years	31	36.0
	21-30 years	21	24.4
	31-40 years	10	11.6
Total		86	100.0

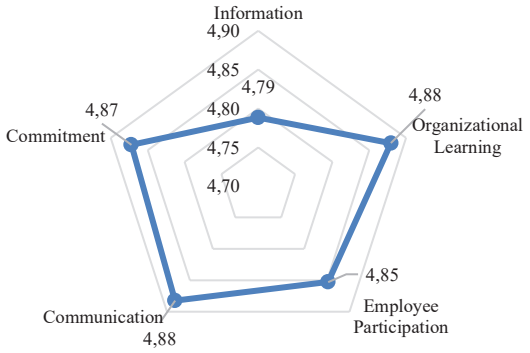

Figure 2. Key Elements of Maturity Level PT. X in Petrochemical Industry

Table 3. Correlation Between Organizational and Demographic Factors and Safety Culture Maturity (Spearman's Rank Correlation Coefficient)

Independent Variable	Correlation with Safety Culture Maturity	Spearman's r	p- value
Information (X1)	Positive correlation	0.603	**
Organizational Learning (X2)	Positive correlation	0.523	**
Employee Participation (X3)	Positive correlation	0.481	**
Communication (X4)	Positive correlation	0.557	**
Commitment (X5)	Strongest positive correlation	0.712	**
Gender	No significant correlation	-0.031	NS
Age	Weak positive correlation	0.282	**
Education	No significant correlation	0.225	NS
Work Experience	Weak positive correlation	0.246	*

(**. Correlation is significant at the 0.01 level; *. Correlation is significant at the 0.05)

decision-making, though with potential for improvement. This gap in information flow signals a need for better document control, more responsive reporting systems, and improved dissemination of safety protocols.

The results of the average maturity score indicate that the overall safety culture maturity falls within the "Generative" category, suggesting a well-developed and proactive safety culture within the organization. Among the five measured factors, organizational learning and communication recorded the highest scores, highlighting the company's strong emphasis on continuous learning, knowledge sharing, and effective communication in promoting safety. These findings suggest that employees actively engage in learning from past incidents and communicate safety-related concerns effectively. However, information received the lowest score. The organization has a well-established safety culture, with leadership commitment, employee involvement, and structured learning playing key roles in maintaining high maturity levels.

DISCUSSION

The demographic profile in this study reflects a typical workforce in the petrochemical sector predominantly male, mid-career, and moderately educated. The high proportion of male workers (97.7%) aligns with previous research suggesting gender imbalance remains common in industrial operations (Perks and Schulz, 2020). However, gender did not significantly affect safety culture maturity in this study, supporting findings by Çakıt *et al.* (2019) that gender differences may not impact safety attitudes in male-dominated industries. Most respondents had 11–20 years of work experience, and this variable was positively correlated with maturity, indicating that experience contributes to safety awareness, a finding also supported by Melberg and Gressgård (2023) In contrast, Amirah *et al.* (2024) emphasized the role of higher education in promoting safety behavior, which contradicts our result where education level showed no significant influence. This suggests that in high-risk industries like petrochemicals, practical experience and organizational safety culture may matter more than formal education.

The correlation analysis identified significant positive relationships between information (X1), organizational learning (X2), employee participation (X3), communication (X4), commitment (X5), age, and work experience with safety maturity level (Y). This infers that focusing on these elements can contribute to the growth of safety culture within the organization. Conversely, Gender and Education did not produce correlations with Maturity Level, depicting the reality that population characteristics have less impact than organizational and experiential factors (Çakıt *et al.*, 2019; Kunt *et al.*, 2024). The correlation between Information and Maturity Level appears to be strong and significant, which means that information flow is an important factor towards the development of robust safety culture. Organizations that foster a culture of free flow of safety information tend to have higher safety culture maturity (Pei *et al.*, 2023; Rahim *et al.*, 2024). A significant consequence concerns the level of information available to the organization and the need to raise it.

The descriptive maturity shows lower score in the information factor indicates that employees may not possess some critical safety-related information when they need it. To solve this issue, organizations need to improve their document systems and provide timely updates on safety procedures and knowledge management systems (Shinkevich *et al.*, 2019; Vashishth *et al.*, 2024) . Digital platform can be used, the easiest to carry like mobile applications. The dashboards, or interactive training modules can facilitate better dissemination of safety information and education interactive for the employees (Jule, 2020; Baldelovar and Kumar, 2022). There was a strong positive correlation between Organizational Learning and Maturity Level. This indicates that facilities that focus on continuous learning, sharing knowledge, and experience-based improvement are more likely to have a strong safety culture.

The diagnosis with strength in commitment and employee participation further supports this classification, showing that leadership visibly prioritizes safety and encourages frontline involvement in decision-making. These findings align with Pei *et al.* (2023), who found that mature safety cultures are characterized by integration of safety into leadership priorities and workforce engagement. Although the information dimension ranked slightly lower than others, it was still within a high-performance range, suggesting that safety documentation and data systems exist but may require enhancements in accessibility or real time updates. In contrast, some studies such as Knode (2020) argue that high scores alone may not fully represent maturity unless supported by behavioral

consistency and leadership accountability. Therefore, while the maturity scores support a generative classification, sustaining this level will require continuous investment in digital systems, leadership modeling, and inclusive safety practices to maintain long term performance.

The overall assessment indicates that the organization has achieved a generative safety culture. Marked by proactive and embedded safety practices across multiple dimensions will lead to organizations striving for incident investigations with safety training practice and reflective learning (Behari, 2019; Alshemeri and Bugawa, 2023). However, other conflicting studies suggest that learning plays a role in safety culture maturity, but the effect of learning may be indirect, through the channel of leaders' time and effort (Bentoy *et al.*, 2022; Trinh and Feng, 2022). The relationship between Employee Participation and Maturity Level is moderate yet statistically significant, suggesting that directly engaging employees in decisions related to safety will increase safety culture maturity. Organizations that enable their employees to report hazards, contribute ideas to improving safety, and be involved in safety committees generally report higher maturity levels (Coelho *et al.*, 2023; Amirah *et al.*, 2024). This finding aligns with literature indicating that an inclusive safety culture contributes to higher compliance, lower accident rates, and proactive safety behavior (Tetzlaff *et al.*, 2021; Xu *et al.*, 2023). Other research challenges this and claims that employee participation does not guarantee maturity without effective leadership saying that pacing, changes to productivity, and other additional communication facilitates are necessary (Knode, 2020; Magalhães, Jordão and Costa, 2022).

Communication is shown to have a strong and statistically significant relationship with Maturity Level. These findings reinforce that an effective and sustainable safety culture is reliant on communicated mechanisms that are clear, consistent, and consciously open. Organizations will achieve higher maturity levels when there are effective channels of communication, regular safety briefings or information sessions, and active feedback (Yeshitila, Kitaw and Jilcha, 2021). Research has previously established the role of effective and clear communication channels regarding raising awareness and decision making in safety (Todaro *et al.*, 2023). Factors salient to the impacts of safety culture included management commitment to safety, employees' personal attitudes towards safety, coworkers' espousals of safety, pressure of work systems, the safety management system (Çakıt *et al.*, 2019).

Among all the various factors, commitment produced the greatest correlation, solely emphasizing the important role that leadership and organizational commitment have on developing a mature safety culture (Zara, Nordin and Isha, 2023). The results accomplish two things at one time. First, the results highlight the leadership commitment that fosters a mature safety culture. Second, the positive significant correlation to commitment proves that organizations should focus on cultivating leadership commitment to safety. Maturity culture can be fostered through incorporating safety performance within leadership evaluation processes, providing consistent safety leadership training for all levels of leaders, and maintaining status of safety as a core organizational value in making decisions (Syaifullah, 2024). Strengthening commitment at all levels of the organization will further enhance the effectiveness of safety programs and policies(Todaro *et al.*, 2023).

This study shows work experience was significantly correlated with safety maturity and learning based on experience is valuable. Organizations can use this to develop and execute specific mentoring programs where seasoned employees can assist newer employees in adopting best practices of safety (Melberg and Gressgård, 2023). Organizations can also help mitigation by developing knowledge transfer initiatives to structure on-the-job training around cases that foster experience and recognize that knowledge transference is preserved and improved in real time through every generation of employees (Dreval *et al.*, 2020; Rahim *et al.*, 2024). These findings highlight the organizational leadership commitment, structured learning, communication, and employee involvement is necessary for achieving and sustaining a generative safety culture within the petrochemical industry. This work has several limitations that need to be fully considered when interpreting the conclusions drawn from it.

CONCLUSION

The findings showed that the organization had reached the "Generative" stage, indicating a strong and proactive safety culture. Among the five organizational factors, commitment had the strongest correlation with safety culture maturity, followed by communication, information, learning, and employee

participation. While demographic factors such as age and work experience showed weak but significant correlations, formal education and gender were not influential. These results confirm that leadership, communication, and organizational learning are key drivers of safety culture maturity. These findings demonstrate that the Safety Culture Maturity is effective in identifying key factors influencing safety culture in the Indonesian petrochemical context. Future research should explore other contextual factors across different sites or sectors to support broader improvements in workplace safety performance.

CONFLICT OF INTEREST

The authors declare that there is no significant competing financial, professional, or personal interests that might have affected the performance.

AUTHORS' CONTRIBUTION

PNA: Conceptualization, Methodology, Data curation and Writing-Original draft preparation. ZD: Investigation, Reviewing, and Validation. AA:, Visualization, Software, Writing- Reviewing and Editing

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