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Comparative Study of Working Culture for Safety Improvement between Operators and Users in ASEAN Research Reactors

Weerawat Pornroongruengchok

Thailand Institute of Nuclear Technology, Thailand. E-mail: weerawat@tint.or.th
Thailand Academy of Science (TAS), Thailand.
Mahidol University, Thailand. E-mail: weerawat.pon@student.mahidol.ac.th

Wasin Vechgama

Thailand Institute of Nuclear Technology, Thailand. E-mail: wasin@tint.or.th

Jinkyun Park

Korea Atomic Energy Research Institute, Republic of Korea. E-mail: kshpjk@kaeri.re.kr
University of Science and Technology (UST), Republic of Korea.

Previously, the concept of a homogeneous working culture was proposed to explain how similar cultural characteristics among nuclear research reactors in the Association of Southeast Asian Nations (ASEAN) could enhance safety and collaboration. This follow-up study turns that idea into practice through a regional survey of operators and users from seven facilities across Thailand, Malaysia, Indonesia, Vietnam, and the Philippines using Hofstede's model. The objective of this study is to extend the scope of safety improvement for ASEAN nuclear research reactors through the study of the homogenous cultures between users and operators. The results showed a common pattern across the region with high power distance and strong uncertainty avoidance, which emphasized respect for hierarchy and clear operational procedures as key elements supporting a safety-conscious environment. Differences appeared in individualism and long-term orientation, where users tended to value independent decision-making and future-oriented perspectives more than operators. These variations illustrated how cultural traits influence teamwork, communication, and human reliability in daily reactor operations. By integrating these comparative cultural profiles, the study provides the first empirical evidence of shared ASEAN tendencies in safety culture. The findings served as practical guidance for improving operator and user collaboration, reducing human error, and establishing a cohesive and sustainable safety framework for the ASEAN region's nuclear research facilities.

Keywords: Working culture, safety improvement, nuclear research reactors, Hofstede's model

1. Introduction

Safety culture has long been recognized as a fundamental element in ensuring the safe operation of nuclear facilities (Nascimento et al. 2017), particularly nuclear research reactors (Oliveira et al. 2003), where daily activities involve close interaction between reactor operators and users. While technical systems, regulations, and operational procedures provide the structural foundation for safety, human and organizational factors remain critical contributors to both safe performance and the occurrence of human error. Among these factors, working culture plays a significant role in shaping communication, decision-making, teamwork, and adherence to safety procedures. In the context of nuclear research reactors in the Association of Southeast Asian Nations (ASEAN), safety culture presents a unique regional dimension. ASEAN research reactors operate within diverse national, institutional, and

professional environments, yet they share similar regulatory frameworks, training practices, and collaborative research activities (ASEAN LNSN 2026), (ASEAN NPSR 2026), (Silva et al. 2021). Many facilities regularly host users from external institutions and neighboring countries, creating a working environment where operators and users with different roles, responsibilities, and perspectives must cooperate closely under strict safety requirements. This setting highlights the importance of understanding not only organizational safety culture within a single facility, but also the shared and differing cultural characteristics across the region.

Previous studies (Pornroongruengchok et al. 2025) have proposed the succession case in Thailand and concept of a homogeneous working culture to explain how common cultural traits among ASEAN research reactors may contribute to enhanced safety and regional collaboration. These studies suggested that shared values, such as respect for authority, strong procedural compliance, and collective responsibility, could support a stable and safety-conscious working environment. However, empirical evidence supporting this concept has remained limited, particularly with respect to how these cultural characteristics manifest differently between reactor operators and users.

Operators and users play distinct yet interdependent roles in research reactor operations. Operators are primarily responsible for reactor safety, compliance with operational limits, and adherence to established procedures, whereas users often focus on experimental objectives, research outcomes, and efficient use of reactor time. Differences in working culture between these two groups may influence communication effectiveness, coordination during experiments, and overall human reliability. Despite this, most safety culture studies in nuclear research reactors have focused on operators or organizational levels, with limited attention given to comparative cultural analysis between operators and users.

To address this gap, this study conducts a comparative analysis of working culture between reactor operators and users across multiple ASEAN research reactor facilities. Using Hofstede's cultural dimensions framework, the study examines similarities and differences in key cultural traits, including power distance, uncertainty avoidance, individualism, masculinity, and long-term orientation (Shin et al. 2021). By surveying participants from seven research reactors in Thailand, Malaysia, Indonesia, Vietnam, and the Philippines, this work aims to identify common regional patterns as well as role-specific cultural variations. Accordingly, a comparative examination of working culture between operators and users is essential for understanding how cultural similarities and differences influence safety-related behavior in ASEAN nuclear research reactors. By positioning working culture as a contextual factor influencing human reliability and operational risk, this study aims to support more effective operator–user collaboration and risk-informed safety improvement at both facility and regional levels.

In this study, culture is defined as a set of shared values, beliefs, and behavioral norms that shape how individuals interact within their working environment. Safety culture refers to the collective commitment to prioritize safety through risk awareness, procedural compliance, and open communication. In nuclear research reactor environments, safety culture also emerges from interactions between operators and users, forming a critical interface where cultural differences may act as latent conditions influencing human reliability and safety performance.

2. Conceptual Framework

This study conceptualizes working culture as a latent contextual factor that indirectly influences

safety performance through its impact on safety-related behavior and human factor. Cultural characteristics, represented by Hofstede's dimensions, shape how individuals perceive authority, uncertainty, responsibility, and long-term consequences. These cultural orientations influence observable behaviors such as communication patterns, adherence to procedures, willingness to question decisions, and coordination between reactor operators and users.

Safety-related behaviors, in turn, affect human reliability by determining the likelihood of human error, the robustness of performance under non-routine conditions, and the effectiveness of responses to operational deviations. Human reliability is therefore treated not as an isolated attribute, but as an outcome shaped by cultural and behavioral contexts. Ultimately, variations in human reliability influence overall safety performance, including operational stability, defense-in-depth effectiveness, and incident prevention in nuclear research reactor operations. Within this framework, the operator–user interface represents a critical interaction point where differences in working culture may lead to divergent safety-related behaviors, potentially introducing latent vulnerabilities or, conversely, reinforcing safety through complementary roles. By empirically comparing cultural dimensions between operators and users across ASEAN research reactors, this study aims to clarify how homogeneous and divergent cultural traits propagate through behavior and reliability to influence safety outcomes. The Conceptual framework is shown in figure 1.

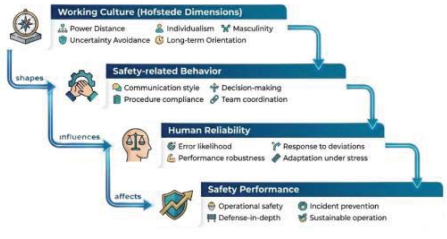

Fig.1. Conceptual framework illustrating the relationship between working culture, safety-related behavior, human reliability, and safety performance in ASEAN nuclear research reactors.

3. Methodology

3.1. *Study Design*

This study employed a cross-sectional survey design to examine and compare working culture between reactor operators and users in ASEAN nuclear research reactor (NRR) facilities. The study was framed by a conceptual model in which working culture is treated as a latent contextual factor influencing safety-related behavior and human reliability, and ultimately contributing to safety performance. A comparative approach was adopted to identify both shared regional characteristics and role-specific differences between operators and users.

3.2. *ASEAN Nuclear Research Reactor Facilities and Participants*

The study covered seven operational nuclear research reactor facilities across five ASEAN member states, including Thailand, Malaysia, Indonesia, the Philippines, and Vietnam. The participating facilities and corresponding number of participants are as follows:

- Thailand: TRR-1/M1 (1 MW, operational) – 11 operators and 11 users
- Malaysia: PUSPATI TRIGA Reactor (RTP) (1 MW, operational) – 16 operators and 11 users
- Indonesia (Facility 1): G.A. Siwabessy Multipurpose Reactor (RSG-GAS) (30 MW, operational) – 4 operators and 12 users
- Indonesia (Facility 2): Kartini Reactor (100 kW, operational) – 3 operators and 4 users
- Indonesia (Facility 3): TRIGA Bandung Reactor (TRIGA 2000) (2 MW, operational) – 3 operators and 4 users
- Philippines: Philippine Research Reactor-1 Subcritical Assembly for Training, Education, and Research (PRR-1-SATER) (subcritical, operational) – 3 operators and 3 users
- Vietnam: Dalat Nuclear Research Reactor (DNRR) (500 kW, operational) – 7 operators and 3 users

In total, 95 participants were included in this study, comprising 47 operators and 48 users across the seven facilities. This distribution reflects differences in operational structure and user engagement levels among the participating reactors, while ensuring that both operator and user perspectives were represented at each facility. Participants were categorized into two groups based on their functional roles. The operator group included licensed reactor operators, reactor supervisors, and technical staff directly responsible for reactor operation and safety. The user group consisted of researchers, experimenters, and technical personnel utilizing the reactor for research, education, and irradiation activities.

3.3. *Survey Instrument*

Working culture was assessed using Hofstede's cultural dimensions framework, which has been widely applied in organizational and safety-related studies in high-reliability industries. The survey instrument consisted of 18 items representing five cultural dimensions: power distance, uncertainty avoidance, individualism, masculinity, and long-term orientation (Park J. et al. 2015).

The questionnaire comprised three sections:

(i) Demographic information, including professional role, years of experience, and institutional affiliation.
(ii) Nuclear research reactor experience, covering operational involvement and frequency of reactor use.
(iii) Cultural characteristics, measured using the Hofstede-based items adapted from previous research to ensure consistency with earlier studies conducted at the Thai Research Reactor.

Using the same cultural instrument across all facilities enabled direct comparison between operators and users and supported regional-level analysis of cultural patterns.

Participation rates varied slightly across facilities due to differences in operational schedules, personnel availability, and local coordination constraints. In some facilities, particularly those with limited staffing or ongoing operational commitments, full participation of all eligible personnel was not always feasible.

Despite this, all participating facilities provided responses from both operator and user groups, ensuring representation of the key functional roles required for comparative analysis. Variability between facilities was further examined using descriptive statistics and graphical methods (e.g., boxplots), allowing identification of both regional trends and facility-specific dispersion in cultural dimensions.

These variations were considered during interpretation and were not expected to significantly affect the overall conclusions, as the analysis focused on consistent cross-facility patterns rather than individual facility dominance.

3.4. *Data Collection*

Data were collected through a combination of structured questionnaires and facilitated discussions coordinated via the ASEAN NPSR. Collaboration with key representatives at each facility ensured appropriate dissemination of the survey and contextual understanding of local operational practices. Participation was voluntary, and responses were anonymized to encourage candid reporting of cultural perceptions. The questionnaire used in this study was previously applied in a national-level assessment at the Thai Research Reactor in 2025. Its extension to ASEAN research reactors enabled evaluation of cultural homogeneity and role-specific differences at a regional scale.

3.5. *Data Analysis*

Descriptive statistics were used to characterize the cultural profiles of operators and users at both

facility and regional levels. Comparative analyses were conducted to examine differences between the two groups across the five cultural dimensions.

The degree of agreement and similarity between operator and user cultural profiles was assessed using the intraclass correlation coefficient (ICC) and Pearson correlation coefficient (r), enabling evaluation of both consistency and directional relationships. The analysis focused on identifying patterns that are meaningful from a safety perspective rather than solely on statistical significance. Cultural similarities were interpreted as indicators of a homogeneous working culture, while systematic differences were examined in relation to their potential influence on safety-related behavior and human reliability in research reactor operations.

All participating facilities were treated with equal weight in the analysis, regardless of differences in sample size. This approach was adopted to ensure comparability across facilities and to prevent disproportionate influence from larger participant groups. As the primary objective was to identify consistent cross-facility patterns rather than to estimate population-level parameters, equal weighting was considered appropriate for capturing regional trends while preserving the contribution of each facility.

This approach is consistent with the exploratory and comparative nature of the study, where emphasis is placed on understanding both shared and divergent cultural characteristics across ASEAN research reactor environments.

4. Results and Discussion

4.1. *Cultural Profiles of Users across ASEAN Research Reactor Facilities*

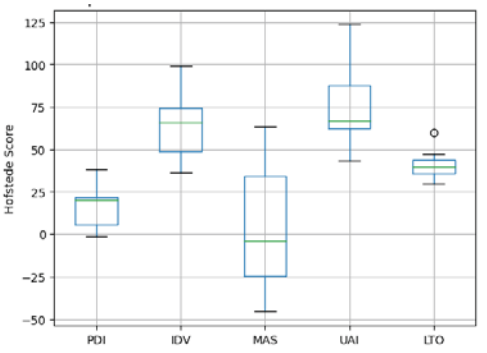

Fig.2. Boxplots of Hofstede cultural dimension scores for nuclear research reactor users across ASEAN facilities.

Figure 2 presents boxplots of Hofstede cultural dimensions for nuclear research reactor users across ASEAN facilities. Uncertainty avoidance exhibits relatively high median values with a narrower interquartile range compared with other dimensions, indicating a shared preference for rule-oriented and risk-averse working behavior. In contrast, masculinity shows the widest dispersion, ranging from strongly negative to strongly positive values, reflecting substantial variation in task orientation and competitiveness among user groups. Individualism also demonstrates considerable variability, while power distance and long-term orientation remain comparatively moderate.

Based on the Hofstede cultural dimension scores obtained from seven research reactor facilities across five ASEAN countries; the user group exhibits a coherent regional cultural pattern with distinct variability in autonomy- and task-orientation-related dimensions. This pattern is particularly relevant to safety-related behavior, as it suggests a shared procedural and risk-averse mindset coexisting with facility-specific differences in interaction style and decision autonomy. Uncertainty Avoidance (UAI) emerges as the most prominent and consistent dimension among users. Across facilities, UAI values range from moderate to very high, with particularly high levels observed in Thailand and

the Philippines. This indicates that users generally prefer clearly defined procedures, explicit safety rules, and predictable operating conditions when conducting experiments at research reactors. From a safety perspective, such a preference supports conservative decision-making and reduces tolerance for ambiguity during reactor use.

Power Distance (PDI) among users is generally low to moderate across facilities. This suggests that while users acknowledge the authority of reactor operators and institutional safety structures, they do not operate under rigid hierarchical constraints. This cultural characteristic facilitates interaction and dialogue between users and operators, which is essential in research reactor environments where experimental activities require coordination and clarification beyond routine operations.

In contrast, Individualism (IDV) shows substantial variation across facilities. Users in some reactors (e.g., Malaysia and the Philippines) demonstrate high individualism, reflecting greater autonomy and independent decision-making in experimental work. In other facilities, lower IDV values suggest a stronger emphasis on collective coordination. These differences indicate that user behavior is strongly influenced by local institutional and research contexts rather than regional norms alone.

Similarly, Masculinity (MAS) exhibits wide dispersion, ranging from strongly negative to strongly positive values. This suggests that some user groups operate in cooperative, non-competitive environments, while others emphasize task orientation, assertiveness, and performance achievement. Such variation implies that user working styles differ considerably across facilities, potentially affecting communication tone, pressure handling, and teamwork during experimental activities.

Finally, Long-Term Orientation (LTO) among users is generally moderate. This reflects a balance between short-term experimental objectives (e.g., beamtime utilization and project deadlines) and longer-term research planning. The relative consistency of LTO suggests that sustainability of reactor use is recognized, although the emphasis placed on long-term planning varies by facility.

Overall, the user cultural profiles indicate the presence of a shared safety oriented backbone characterized by high uncertainty avoidance and moderate power distance combined with facility-specific variation in autonomy- and task-related dimensions.

4.2. *Comparison between Users and Operators: Dimension by Dimension Analysis*

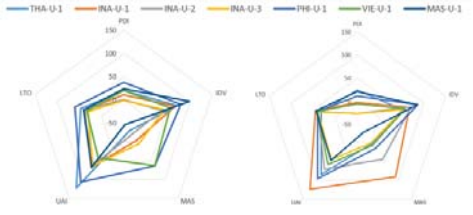

Fig.3. Radar chart illustrating Hofstede cultural dimension profiles of nuclear research reactor users (left) and operators (right) across ASEAN facilities.

When user cultural profiles are compared with those of operators at the same facilities, clear patterns of alignment and divergence emerge as shown in figure 3.

Strong alignment is observed in Power Distance (PDI). Correlation analysis indicates a high positive association between user and operator PDI values. This suggests that both groups share similar perceptions of authority and decision hierarchy, reinforcing clear command structures essential for safe reactor operation.

A moderate level of alignment is also observed in Uncertainty Avoidance (UAI). Both users and operators demonstrate a preference for rule-based and risk-averse behavior, although operators tend to exhibit more consistent UAI values across facilities. This reflects the influence of licensing

requirements, regulatory oversight, and standardized operating procedures on operator culture.

In contrast, weaker alignment is found in Individualism (IDV) and Masculinity (MAS). Users often display greater variability in autonomy and task orientation compared with operators, whose roles are more tightly constrained by formal responsibilities. These differences highlight the operator user interface as a zone where divergent working styles must be actively managed to maintain effective communication and coordination.

The weakest alignment is observed in Long-Term Orientation (LTO), where user and operator perspectives may diverge due to differing priorities. Users tend to focus on research outcomes and project timelines, while operators prioritize long-term operational continuity and safety margins.

4.3. *Operator–User Agreement: ICC and Correlation Analysis*

Table 1. Operator–User Agreement across Hofstede Cultural Dimensions

Dimen-sion	ICC	Spearman	Level of Alignment	Safety Interpretation
PDI	Moderate–High (~0.52)	0.75	Strong	Shared perception of authority supports clear command structure
IDV	Moderate (~0.57)	0.39	Low–Moderate	Differences in autonomy influence initiative and coordination
MAS	Low (~0.08)	0.34	Low	Task orientation varies by role and facility
UAI	Moderate (~0.44)	0.57	Moderate	Shared rule-oriented and risk-averse behavior
LTO	Poor (~−0.22)	−0.29	Low	Different planning horizons between users and operators

To quantitatively examine the degree of alignment between users and operators, paired statistical analyses were conducted across seven research reactor facilities using intraclass correlation coefficients (ICC) and Spearman's rank correlation. The calculated results are presented in Table 1. These analyses aimed to assess the extent to which cultural dimensions are shared between the two groups at the facility level, thereby providing empirical support for the concept of homogeneous working culture and its implications for safety-related behavior.

4.3.1. *Intraclass Correlation (ICC)*

The ICC results indicate moderate agreement between users and operators in selected cultural dimensions. Power distance exhibits moderate agreement, suggesting that both groups share similar perceptions of authority structures and hierarchical relationships within reactor operations. Individualism and uncertainty avoidance also show moderate levels of agreement, reflecting a shared orientation toward responsibility distribution and rule-based, risk-averse working practices.

In contrast, masculinity demonstrates low agreement, while long-term orientation shows poor agreement between users and operators. These findings indicate that task orientation, competitiveness, and planning horizons differ

substantially between the two groups and are more strongly influenced by role-specific responsibilities than by shared organizational or national culture.

Overall, the ICC analysis suggests that agreement between users and operators is strongest in dimensions directly related to authority and procedural safety, while dimensions associated with work style and future orientation exhibit greater divergence.

4.3.2. *Spearman Correlation Analysis*

Spearman correlation analysis further clarifies the relationship between user and operator cultural profiles at the facility level. A strong positive correlation is observed for power distance ($r \approx 0.75$), indicating that facilities with higher user acceptance of authority tend to exhibit similar patterns among operators. Uncertainty avoidance shows a moderate positive correlation ($r \approx 0.57$), supporting the presence of a shared rule-oriented and risk-averse safety mindset across both groups.

Lower correlations are observed for individualism ($r \approx 0.39$) and masculinity ($r \approx 0.34$), suggesting that autonomy and task-orientation-related behaviors vary between users and operators depending on their functional roles. Long-term orientation shows a weak and slightly negative correlation ($r \approx -0.29$), indicating differing planning perspectives between experimental users and operational staff.

These results reinforce the interpretation that cultural alignment between users and operators is dimension-specific rather than uniform across all aspects of working culture.

4.3.3. *Implications for Safety and Human Reliability*

From a safety perspective, the moderate to strong alignment in power distance and uncertainty avoidance represents a shared safety-oriented cultural backbone across ASEAN research reactors. This alignment supports procedural compliance, respect for operational authority, and predictable behavior during routine activities, thereby strengthening human reliability and existing safety barriers.

Conversely, weaker alignment in masculinity and long-term orientation highlights the operator–user interface as a critical area where differences in work style, pressure tolerance, and planning horizons may influence communication and coordination. These differences do not constitute direct safety deficiencies; rather, they function as latent conditions that can shape safety-related behavior, particularly during non-routine, time-constrained, or experiment-driven operations.

Taken together, the ICC and correlation results provide empirical evidence that ASEAN research reactor users and operators share core safety-relevant cultural characteristics while maintaining role-dependent differences. This combination supports regional safety harmonization while underscoring the need for structured interaction mechanisms such as standardized briefings, clear decision authority, and shared expectations to enhance human reliability at the operator–user interface.

4.4. *Suitability and Limitations of Hofstede's Cultural Dimensions*

While Hofstede's cultural dimensions provide a structured and widely validated framework for comparing cultural characteristics, their application in high-reliability organizations such as nuclear research reactors requires careful consideration.

First, Hofstede's model was originally developed to describe national-level cultural differences. Its application to role-based groups, such as operators and users within the same organizational and regulatory environment, may not fully capture the complexity of professional subcultures. In nuclear research reactors, working culture is also shaped by formal training, licensing requirements, and strict operational

procedures, which may moderate or override broader cultural tendencies.

Second, the framework does not explicitly account for situational and operational factors that are critical in safety-critical systems, such as task complexity, time pressure, and risk levels. These factors can significantly influence human performance and decision-making beyond underlying cultural orientations.

Third, cultural dimensions should be interpreted as contextual tendencies rather than deterministic predictors of behavior. The observed differences between operators and users therefore reflect general patterns that may influence, but do not solely determine, safety-related actions.

Despite these limitations, Hofstede's framework remains a useful tool for identifying latent cultural patterns that influence communication, authority perception, and decision-making. When applied alongside human reliability perspectives, it provides valuable insights into how cultural context may shape safety-related behavior at the operator–user interface.

4.5. *Implications for Human Reliability Analysis (HRA)*

The observed cultural dimensions can be interpreted in relation to performance shaping factors (PSFs) commonly used in human reliability analysis (HRA), providing a bridge between cultural context and human error mechanisms.

High power distance (PDI) may influence authority gradients within reactor operations. While a clear hierarchical structure supports decision-making and operational control, it may also reduce upward communication, increasing the likelihood of communication-related errors, particularly in situations where users hesitate to question operator decisions.

Strong uncertainty avoidance (UAI) reflects a preference for rule-based and risk-averse behavior. This characteristic supports procedural compliance and reduces ambiguity during routine operations. However, it may limit flexibility and adaptive responses in non-routine or unexpected conditions, which are critical in safety-critical environments.

Differences in individualism (IDV) between users and operators may affect coordination and teamwork. Higher individualism among users may lead to more independent decision-making during experimental activities, which, if not well-coordinated with operators, could introduce misalignment in task execution. This relates to PSFs such as team communication, coordination quality, and shared situational awareness.

Variability in masculinity (MAS) suggests differences in task orientation and performance pressure. In some contexts, higher task orientation may enhance efficiency, while in others it may increase stress and risk-taking behavior, particularly under time constraints. These aspects are associated with PSFs related to workload, stress, and performance pressure.

Finally, divergence in long-term orientation (LTO) reflects differing planning horizons between operators and users. Operators tend to prioritize long-term operational safety and system stability, while users may focus on short-term experimental outcomes. This difference may influence decision-making under competing priorities and aligns with PSFs related to goal conflict and organizational priorities.

Overall, these findings suggest that cultural dimensions act as underlying contextual factors shaping PSFs, which in turn influence human reliability and potential error pathways. Understanding these relationships can support the development of targeted interventions, such as structured communication protocols, joint briefings, and shared safety expectations, to enhance coordination at the operator–user interface.

5. Conclusion

This study examined working culture differences and similarities between reactor operators and users across seven nuclear research reactor facilities in five ASEAN countries using Hofstede's cultural dimensions. By framing working culture as a latent factor influencing safety-related behavior and human reliability, the study provides empirical support for the concept of a homogeneous working culture at the regional level.

The results show that operators and users share a common safety-oriented cultural foundation, particularly in moderate power distance and strong uncertainty avoidance. These shared characteristics support procedural compliance, respect for operational authority, and conservative decision-making, which are essential for safe research reactor operation. At the same time, differences in autonomy-, task-orientation-, and planning-related dimensions reflect role-specific responsibilities rather than conflicting safety values.

From a safety perspective, these differences act as latent conditions shaping communication and coordination at the operator–user interface, especially during non-routine experimental activities. At the ASEAN level, the presence of shared cultural traits supports regional safety harmonization, while recognition of role-dependent variation highlights the need for structured interaction mechanisms. Overall, the findings offer practical guidance for strengthening operator–user collaboration and enhancing sustainable safety practices in ASEAN nuclear research reactors.

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