Perception Study of Safety Indicators in Nuclear Installations using Mann Withney Nonparametric Statistic Technique

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Abstract. A safety perception assessment of nuclear plants have been conducted. Factors to be considered in the assessment are demographic factors that illustrate the different job positions considered to affect the perception of safety indicators in the existing implementation. The study was conducted using nonparametric statistical techniques, especially Mann Whitney test techniques that emphasize the presence or absence of differences between two examples of independent or dependent populations. As a result, the perception pattern of safety indicator shows that there is no difference between the operational worker of the research reactor and the nuclear installation work unit. However, through internal grouping of a research reactor only based on position, education, and age groups, there is a difference in perception of safety indicators. In grouping based on the position structure of perception difference lies in all the characteristics whereas in the group based on education and age obtained there are two differences from the five characteristics considered. With a 4.05 scale likert scale, generally perceptions of safety considerations in accordance with their significance in both nuclear research reactor and nuclear installation work units can be considered good enough. When compared to other test techniques for each safety indicator it is found that almost all of the techniques employed result in acceptance of the null hypothesis which states that perceptions of the importance of safety do not differ between work units

Keywords: Nonparametric Satatistic, Mann-Whitney Test, Safety Performance, Safety Indicators

1. Introduction

Usually, safety performance is measured and monitored by recordable injury rate [1]. The use of safety indicators in the implementation of a safety management system needs to be done to understand how the implementation of safety is carried out. In addition, what is happening in the provision of safety and what has been done from the implementation of safety should be reviewed. To understand that the implementation of the safety indicator being used is considered to be efficient and effective it is necessary to conduct an overview of how to evaluate it and the techniques used in data collection with servei techniques.

The purpose of measurement of indicators and or safety characteristics is to obtain an objective measure that can be used to determine the proper prioritization of safety in addition to a statement of the importance of safety within the organization under consideration [2]. The reflection is that it can state the significance of each indicator and / or characteristic that has been placed to have appropriate
and appropriate safety considerations with the importance of safety itself and is then expected to help achieve the efficiency and effectiveness of the program related to the indicator or characteristic.

This paper presents an assessment and implementation of the study of indicators and / or safety characteristics [3]. The method of calculation performed based on nonparametric statistical techniques is Mann Whitney's test to test the hypothesis of the differences of two independent populations[4]. The hypothesis is intended to express the perception of the respondent to the meaning of each indicator and / or characteristic under consideration [5]. As a result, respondents' perception will be obtained from two different work units, or one unit with two groups of respondents in the implementation of the safety of their missions such as the structure of position, education, and age.

The result is the presentation of the significance of safety in the form of consideration of the characteristics and or indicators that describe the form of the implementation of safety in the installation.

2. Methodology
In conducting perception study activity on safety indicator between research reactor and nuclear installation methodology used is nonparametric statistic test and special use Mann Whitney test technique that enable can explain the existence of difference of perception between group of respondent to significance and meaning of a statement or what then called safety indicators [6], [7], [8]. In addition to the distinction between research reactor and nuclear installation can also be distinguished internally [9], [10] a nuclear reactor or a nuclear installation according to demographic factors in the questionnaire are:

a. Position  
b. Education  
c. Age / Age  
d. Field of Work

For subsequent work fields attributes are not considered more deeply on the grounds that the working group will be highly significant against each type of work performed in accordance with work descriptions set by the organization, including in accordance with the purposes of this study intended for differentiation between work units. An example of a data recapitulation used in collecting data is given in Table 1.

| No | Position | Education | Age     | Work Area | Score of Q1 u.t. Q37 |
|----|----------|-----------|---------|-----------|----------------------|
| 1  | STAF     | DIV/S1    | 41 - 50 THN | BTU       | 43                   |
| 2  | STAF     | SLTA      | 41 - 50 THN | BTU       | 65                   |
| 3  | STAF     | SLTA      | 41 - 50 THN | BTU       | 43                   |
| 4  | STAF     | SLTA      | 41 - 50 THN | BTU       | 43                   |
| 5  | STAF     | SLTA      | >50 THN   | BTU       | 65                   |
| 6  | STAF     | DIV/S1    | >50 THN   | BTU       | 65                   |
| ...| ...       | ...       | ...      | ...       | ...                  |
| 126| STAF     | DI/II/III | >50 THN   | BPR       | 65                   |
| 127| STAF     | DIV/S1    | 31 - 40 THN | BPR       | 43                   |
| 128| MANAJER  | SLTA      | >50 THN   | BPR       | 65                   |
| 129| MANAJER  | DIV/S1    | 41 - 50 THN | BPR       | 43                   |
| 130| MANAJER  | S2        | 41 - 50 THN | BPR       | 43                   |

The quantification made is to use the Mann-Whitney test which will provide an explanation as to whether an indicator will be accepted to be used to describe the performance of the safety organization.
for each demographic factors of the questionnaire or corresponding statement. The Mann Withney test technique is included in the nonparametric test, which is considered to be an alternative to the parametric t-test which will provide better results in the interval scale study. In comparison, the Walt-Wolfowitz, Kolmogorov-Smirnov, Kruskal-Wallis, Moses test were used to obtain the results of two independent samples that did not bind each other. The formulas adapted for the quantification stage in the Mann-Whitney test are:

For Sample A

\[ U_A = n_A n_B + \frac{n_A(n_A+1)}{2} - \sum R_A \]  

For Sample B

\[ U_B = n_A n_B + \frac{n_B(n_B+1)}{2} - \sum R_B \]  

By using SPSS on the worksheet in the Data View the RSG research reactor is used as group 1 and the PTLR nuclear installation is subjected to group 2. For internal evaluation purposes, especially within the RSG-GAS research reactor the independent variables can be adjusted to the position parameters between the structural and staff, parameter of education between high school, DIII, DIV / S1 and S2, also on age parameter with group under 31, 31 up to 40, 40 up to 50, and> 50.

With the above analysis is charged with the Analyze menu → Nonparametric Tests → Legacy Dialogs → 2 Independent Sampels and then OK

Specifically for internal research reactor RSG-GAS with 4 groups of education and also 4 working age group hence Willis crew test can be done in working order Analyze → Nonparametric Tests → Legacy Dialogs → 2 Independent Sampels and then OK.

3. Results and Discussion

As a general description of the results of the reliability test data obtained that the Cronbah coefficient for the data is equal to 0.958 which is much greater than 0.5 and thus the data is reliable and further analysis can be done, Table 2.

| Cronbach's Alpha Based on | Standardized Items | N of Items |
|---------------------------|--------------------|------------|
| 0.958                     | 0.958              | 37         |

Along with the above reliability test, it was found that ANOVA test with Tukeys test for nonadditivity, and Hottelings quadratic test, and interclass correlation coefficient obtained that the data used is significant enough to be subjected to analysis, Tables 3, 4, and 5. And for each indicator mean, the preferred frequency can be seen in Table 6.
Grand Mean $= 4.0494$

a. Tukey's estimate of power to which observations must be raised to achieve additivity $= 2.355$. 

**Table 4. Hotelling’s T-Squared Test**

| Hotelling’s T-Squared | F  | df1 | df2 | Sig  |
|-----------------------|----|-----|-----|------|
| 150.425               | 3.436 | 36 | 162 | 0.000 |

**Table 5. Intraclass Correlation Coefficient**

| Intraclass Correlation | F Test with True Value 0 |
|------------------------|--------------------------|
|                        | Lower Bound | Upper Bound | Value | df1 | df2 | Sig  |
| Single Measures        | 0.381       | 0.335       | 0.434 | 23.768 | 197 | 7092 | 0.000 |
| Average Measures       | 0.958       | 0.949       | 0.966 | 23.768 | 197 | 7092 | 0.000 |

Two-way mixed effects model where people effects are random and measures effects are fixed.
a. The estimator is the same, whether the interaction effect is present or not.
b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

The hypothetical test results of the Mann-Whitney test technique summarized from the SPSS output as illustrated in Table 7 indicate whether or not the acceptability of the indicator and or the characteristics of the safety performance is indicated, Table 6. This Mann-Whitney test technique when compared to other tests such as Wald-Wolfowitz Test, Kolmogorov Smirnov, Kruskal-Wallis and Moses which can be seen in Table 5, will be more comprehensive data reliability. This hypothesis test illustrates for the acceptance level of the null hypothesis that when a significance greater than 0.05 is acceptable and means that the magna statement contained in each corresponding indicator does not differ in the two groups being compared.

**Table 6. Summary of hypothesis testing across positions, across education and across ages.**

| Indikator | Hypotesis Test |
|-----------|---------------|
|           | Mann Whitney  | Wald-Wolfowitz | Kolmogorov Smirnov | Kruskal-Wallis | Moses |
| BKA01     | Reject        | Retain         | Reject             | Reject         | Reject |
| BKA02     | Reject        | Retain         | Reject             | Reject         | Reject |
| BKA03     | Reject        | Retain         | Reject             | Reject         | Reject |
| BKA04     | Reject        | Retain         | Reject             | Reject         | Reject |
| BKA05     | Reject        | Retain         | Reject             | Reject         | Reject |
| BKA06     | Reject        | Retain         | Reject             | Reject         | Reject |
| BKB01     | Reject        | Retain         | Reject             | Reject         | Reject |
| BKB02     | Retain        | Retain         | Retain             | Reject         | Reject |
| BKB03     | Retain        | Retain         | Retain             | Reject         | Reject |
| BKB04     | Retain        | Retain         | Retain             | Reject         | Reject |
| BKB05     | Retain        | Retain         | Retain             | Retain         | Reject |
| BKB06     | Retain        | Retain         | Retain             | Reject         | Reject |
Table 7. Hypothesis test Summary

| No. | Null Hypothesis                                                                 | Test                                      | Sig.   | Decision             |
|-----|---------------------------------------------------------------------------------|-------------------------------------------|--------|----------------------|
| 1   | The distribution of BKA01 is the same across categories of Position             | Independent-Samples Wald-Wolfowitz Runs Test | 0.909^2| Retain the null hypothesis |
| 2   | The distribution of BKA01 is the same across categories of Position             | Independent-Samples Median Test           | 0.748  | Retain the null hypothesis |
| 3   | The distribution of BKA01 is the same across categories of Position             | Independent-Samples Moses Test of Extrems Reaction Runs Test | 0.000^1| Reject the null hypothesis |
| 4   | The distribution of BKA01 is the same across categories of Position             | Independent-Samples Mann-Whitney U Test   | 0.515  | Retain the null hypothesis |
| 5   | The distribution of BKA01 is the same across categories of Position             | Independent-Samples Kolmogorov Smirnov Test | 1.000  | Retain the null hypothesis |
| 6   | The distribution of BKA01 is the same across categories of Position             | Independent-Samples Kruskal-Wallis Test   | 0.515^2| Retain the null hypothesis |

For internal analysis only one work unit, in this case is imposed only on PRSG work units only, with a demographic-based grouping of data acquisition questionnaires. Examples of statistical tests...
showing the significance and magnitude of the Z factor can be seen in Figure 3abc. As a summary of the results it can be stated that the hypothetical zero for all indicators is acceptable which means that the perception of the significance of the statement in each indicator is equaled by different groups between structural and staff, by educational differences, and by age difference. This implies that the statement of salvation has been considered to correspond with its importance.

Table 8. Mann-Whitney test results on internal work unit of research reactor with variable of position group

| Indicators | BKA01 | BKA02 | BKA03 | BKA04 | BKA05 | BKA06 |
|------------|-------|-------|-------|-------|-------|-------|
| Mann-Whitney U | 648.000 | 663.000 | 539.500 | 456.500 | 597.500 | 424.500 |
| Wilcoxon W | 6753.000 | 6768.000 | 6644.500 | 6561.500 | 6702.500 | 6529.500 |
| Z | -0.651 | -0.557 | -1.929 | -2.682 | -1.224 | -2.853 |
| Asymp. Sig. (2-tailed) | 0.515 | 0.577 | 0.004 | 0.007 | 0.221 | 0.004 |
| Monte Carlo Sig. (2-tailed) | 0.563 | 0.676 | 0.068 | 0.005 | 0.250 | 0.005 |
| 99% Confidence Interval Lower Bound | 0.550 | 0.664 | 0.062 | 0.009 | 0.244 | 0.003 |
| Upper Bound | 0.576 | 0.688 | 0.075 | 0.015 | 0.267 | 0.007 |

Table 9. Result Mann-Whitney test results on internal work unit of research reactor with variable of education group

| Indicators | BKA01 | BKA02 | BKA03 | BKA04 | BKA05 | BKA06 |
|------------|-------|-------|-------|-------|-------|-------|
| Mann-Whitney U | 1770.000 | 1652.000 | 1778.500 | 1723.000 | 1826.000 | 1794.500 |
| Wilcoxon W | 4255.000 | 4137.000 | 6263.500 | 4208.000 | 3257.000 | 4279.500 |
| Z | -0.512 | -1.350 | -0.522 | -0.850 | -0.187 | -0.369 |
| Asymp. Sig. (2-tailed) | 0.608 | 0.177 | 0.800 | 0.395 | 0.851 | 0.712 |
| Monte Carlo Sig. (2-tailed) | 0.636 | 0.174 | 0.627 | 0.403 | 0.846 | 0.666 |
| 99% Confidence Interval Lower Bound | 0.624 | 0.164 | 0.614 | 0.390 | 0.837 | 0.653 |
| Upper Bound | 0.648 | 0.184 | 0.639 | 0.415 | 0.856 | 0.678 |

Table 10. Mann-Whitney test results on internal work unit of research reactor with variable age group

| Indicators | BKA01 | BKA02 | BKA03 | BKA04 | BKA05 | BKA06 |
|------------|-------|-------|-------|-------|-------|-------|
| Mann-Whitney U | 855.000 | 874.000 | 841.500 | 846.000 | 972.000 | 909.500 |
| Wilcoxon W | 1086.000 | 1105.000 | 1072.500 | 1077.000 | 1203.000 | 1140.500 |
| Z | -1.714 | -1.725 | -2.061 | -1.908 | -0.842 | -1.296 |
| Asymp. Sig. (2-tailed) | 0.079 | 0.085 | 0.039 | 0.056 | 0.400 | 0.195 |
| Monte Carlo Sig. (2-tailed) | 0.089 | 0.091 | 0.038 | 0.047 | 0.453 | 0.205 |
| 99% Confidence Interval Lower Bound | 0.097 | 0.084 | 0.033 | 0.042 | 0.440 | 0.195 |
| Upper Bound | 0.104 | 0.099 | 0.042 | 0.053 | 0.466 | 0.216 |

With an average value for all indicators of 4.02 Likert scale which means that the implementation of safety culture is good enough, Figure 1. Statement of indicators in the form of characteristics, namely safety characteristics as a recognized value, safety leadership, safety accountability, safety integrity into every form of organizational activity, and safety is used as a driving force for learning. The unity of the indicator in the characteristic form is subject to hypothesis testing by Mann-Whitney test technique and the results are expressed in Table 11. These results illustrate that not all null hypotheses are acceptable for all characteristics. For grouping by title it turns out that all the
characteristic zero hypotheses are rejected which means that there is a difference between structural and staff perceptions in the understanding of the organization of safety. In education-based clustering there is a difference in understanding of the organization of safety between non-graduate educated and undergraduate, particularly on the characteristics of safety accountability and safety as the driving force of learning. While grouping of respondents by age is younger than 40 years and older than 40 years of rejection of the null hypothesis on safety characteristics as a recognized value and safety leadership, who may already be able to receive safety with an awareness.

Table 11. Hypothesis Test Summary for intern reactor research only

| Karakteristik          | Uji Hipotesis dengan Teknik Uji Mann-Whitney |
|------------------------|---------------------------------------------|
|                        | Position | Education | Age             |
| Safety is a value      | 0,010; Reject | 0,341; Retain | 0,025; Reject |
| Safety Leadership      | 0,000; Reject | 0,150; Retain | 0,011; Reject |
| Safety Accountability  | 0,047; Reject | 0,032; Reject | 0,161; Retain |
| Safety is integrated   | 0,003; Reject | 0,088; Retain | 0,096; Retain |
| Safety is learning driven | 0,017; Reject | 0,029; Reject | 0,129; Retain |

Table 12. Safety characteristics profile

|             | TOTAL | PRSG | PTLR |
|-------------|-------|------|------|
| Safety is a value   | 4.02  | 4.13 | 3.84 |
| Safety Leadership   | 4.02  | 4.03 | 4.02 |
| Safety Accountability | 4.06  | 4.04 | 4.09 |
| Safety is integrated | 4.04  | 3.98 | 4.14 |
| Safety is learning driven | 4.12  | 4.05 | 4.23 |
| Average            | 4.05  | 4.05 | 4.06 |

Figure 1. Safety characteristics profile

4. Conclusion

From the above discussion we can conclude that:

a. The characteristics profile of safety indicators is generally good at all organizational levels with a 4.05 likert scale. By using internal grouping only one work unit based on position structure, education and working age, it is found that there is a difference of perception on the safety
indicator. In grouping based on the structure of position, the difference of perception lies in all the characteristics whereas in the group based on education and age there are two differences of the five characteristics considered.

b. The reliability of the data used is 0.968 coefficient of cronham and the significance level of 0.000 which states very significant and the data can be used for analytical purposes. Taken as a whole consider safety as its significance based on the research reactor unit and the nuclear installation provided by the corresponding likert scale of approximately 4.05 and 4.06, respectively. When compared to other test techniques for each safety indicator it is found that almost all the techniques employed result in the receiver to the null hypothesis that the perception of the importance of safety does not differ between work units.

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