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A Trend Analysis on the failure of Safety facilities in Nuclear Power Plants

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1. Introduction

In Korea, all nuclear power plant(NPP) operator have to write a failure report called "structure and system failure report" when a structure and system failure leaded to enter into the operation limiting condition for its maintenance, according to the standard operating procedure(2015A) of KHNP(Korea Hydraulic Nuclear Power). And the structure and system is related to safety function in NPPs.

Using above the report, Korea Institute of Nuclear Safety has been making the causes of failure (direct and root) and action details of each failure into the database since 2009.

This study is purposed to contribute to the safety operation of NPPs in the future by analyzing the trends of failures at Hanul 2 and 3.

2. Methods and Results

2.1 Methods

The difference between the number of failure per year and the average number of failure up to the previous year is defined as S. And the sum of S each year was defined as TS.

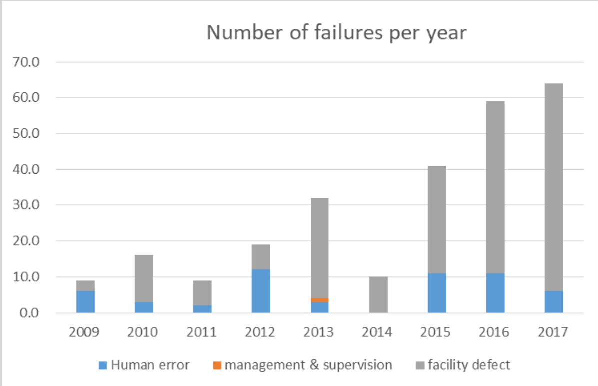
In other words, S having a (-) value means that the number of failures is lower than the existing average number of failure, and S having a (+) value means that the number of failures is higher than the existing average number of failure. Therefore, the larger the values of the TS, more likely the failure is to decrease or increase.

S = (N(Y)-A(2009~(Y-1))
N(Y) = number of failures at a year(Y)
A(2009~(Y-1)) = average number of failures up to previous year

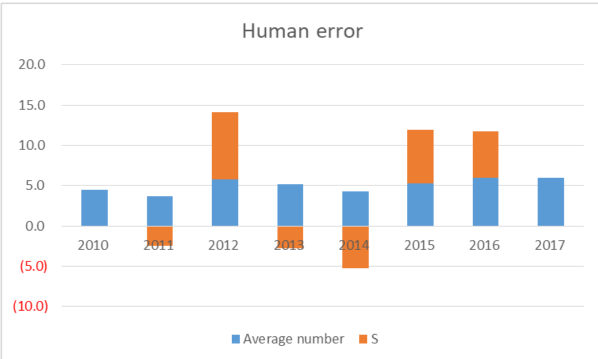
TS = SUM(S(2009~2017)

2.2 Review of Root cause

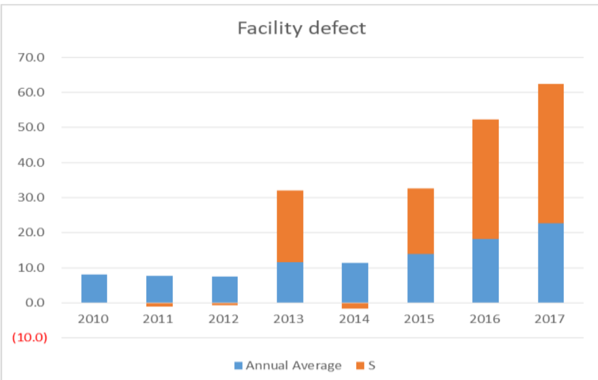
There were a total of 259 failures subject to the operation limiting condition from 2009 to 2017. The number of occurrences per year is shown in the figure below, indicating an increasing number of failures each year.



The following figure illustrates the calculation of S values of human causes and facility defects, ignoring management & supervision because of lack of data.



In human error, the cumulative mean for each year was similar, but the TS value was 10.3.



In facility defect, the cumulative annual average is rising slowly, but the TS value was 109.7 which is more than 10 times that of failures caused by human error.

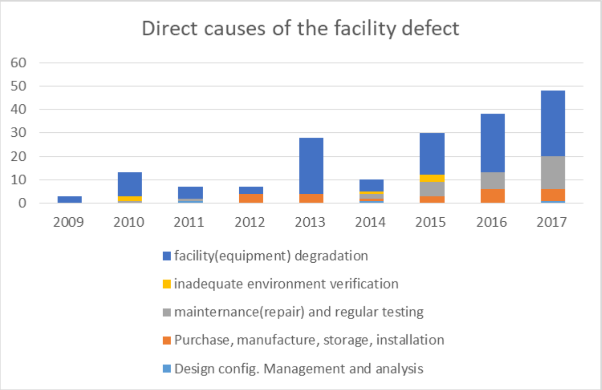
In order words, the facility defect leaded to increasing the total number of failure.

2.1 Review of direct cause

Based on the results of the root cause review, the most important direct causes of the facility defect were analyzed.

Direct causes for the facility defect from 2009 to 2017 were 1) design configuration management and analysis, 2) purchase, manufacture, storage, installation, 3) maintenance (repair) and regular equipment testing, 4) inadequate environment verification , 5) facility (equipment) degradation 6) other factors.

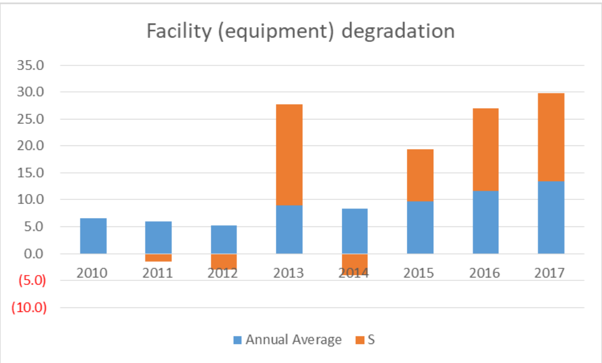
The number of annual occurrences for each cause is shown in the figure below, and the other factors were ignored because that they have not yet been classified as occupational causes.



Among direct causes of the facility defect, 121 degradation occurs from 2009 to 2017, which is 59.3% of the total 204 facility defects. The inadequate environment verification and the design configuration management and analysis, were ignored in conducting a trend analysis because that they are less than 5 percent of the total cases.

According to the above trend analysis, TS values for 1) purchase, manufacture, storage, installation, 2) maintenance (repair) and regular equipment testing and 3) facility (equipment) degradation were 14.9, 23.7 and 51.6 respectively.

The above result shows that the facility (equipment) degradation is the dominant factor of increasing failures by the facility defect.



The facility (equipment) degradation is classified as 1) computer hardware fault, 2) response error, signal loss, signal failure, 3) low voltage, discharge/other, 4) wear, abrasion, lubrication trouble, 5) contact fault and shorted, 7) circuit defect(failure), circuit breaker open, 8) deformation, distortion, position movement, malfunction, loose, loss of equipment, 9) overvoltage and other electric failure, 10) setting and variable variation, 11) corrosion, erosion, dirt, 12) vibration control, 13) other mechanical defects, 14) fatigue, 15) blockage, restriction, obstruction, restraint, foreign material and etc.

Among them, 2) response errors, signal loss and signal failure accounted for the largest portion with 41.3 percent, followed by computer hardware defects with 12.4 percent.

Analysis of the most significant measure of 2) response error, signal loss and signal failure found that replacement of electronic cards and related components accounted for 94 percent.

3. Conclusions

Analysis of failure trends in Hanul 3 and 4 NPPs shows that failures due to facilities defects due to longer operating periods are mainly caused and will likely take up more weight in the future. Facility failure analysis showed 65.3% had computer hardware defects, response errors, signal loss, misconnections and other electrical faults due to light age degradation, and 41% of them were changed by electronic cards and related components.

Since NPP entering frequently into the operation limiting condition has a negative effect on safety operation of the plant, the operators of the Hanul need to conduct a detailed cause analysis of the “response errors, signal loss and signal failure”.

This study shows that the proposed trend analysis methodology can be used to predict the safety weak point of the plant. As Nuclear power industry has accumulated more than 40 years of operation experience, this trend analysis methodology can be expected to contribute for efficient operation of NPPs.

REFERENCES

[1] RTRACER(rtracer.kins.re.kr), Corrective Action Tracking system(web system), developed by KINS, 2010.

[2] Regulation for reporting accident and event of nuclear facilities, Notice No.2018-3, NSSC

[3] Guideline for regular inspection of nuclear power plants and related facilities, GI-N01, rev 3, KINS, 2015.12.