Case Study: Dealing with Reliability and Availability on Refurbishments

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Summary

During the project for refurbishment of the Sambeek & Belfeld locks we faced the challenge to verify the reliability and availability demands of parts of the current the lock construction, which will be re-used after refurbishment. The current construction of these locks was build in the 1920's. Therefore the (construction)data of the locks form that period was limited. Also historical maintenance data over the years was partial available. This case study shows, how we dealt with the process of verifying the reliability and availability demands by a combination of using inspection results and analysis techniques like FMECA and FTA.

Keywords: lock; reliability; availability; case study; failure mode effect and criticality analysis (FMECA); fault tree analysis (FTA).

1. Introduction

The Sambeek & Belfeld lock project is roughly divided into refurbishing and reconditioning the east, west and intermediate locks of both complexes. In addition to all lock gates, operating mechanisms and gears of the east locks, the lock gates and operating buildings with controls. The outer basins and lock chambers will largely be modernised and the intermediate gate will be removed. These measures meet the availability requirements of the 'Maasroute' project.

2. The situation at hand

Reliability and Availability (R&A) of structures is vital, as unavailability could result in damage to the economy and to the area's reputation. During the refurbishment of the Belfeld & Sambeek locks, our company faced demands to verify R&A. These demands applied to parts of both the old and the new structure. The issue was to prove that the lock elements that would continue operating in the current situation during renovations would still meet the demand.

The east locks must be available 24 hours a day, 7 days a week for ships to pass through the locks. Underlying requirements primarily focus on plannable and non-plannable unavailability. These underlying requirements are:

- Unplannable unavailability of the East Locks for ship passage should be a maximum of 24 hours per year.
- Plannable unavailability of the East Locks should be a maximum of 24 hours a year on average. Short plannable maintenance can be scheduled for the guard locks and their gears of the Gates, but the duration may not exceed 2 hours.

3. Method

The followed method was used in this case study to determine the availability and reliability of the lock elements to be renovated:

1. (Quick) FMECA to identify critical parts of the structure;
2. Set up inspection programme for critical parts;
3. Convert inspection results into failure data;
4. Use failure data in the Fault Tree Analysis to determine the effect on the design;
5. Adjust the design until R&A demands are met.

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3.1 FMECA

In the FMECA, failure mechanisms, effects and consequences are identified and linked to a component or element in the design. The consequences are ranked in order to identify the critical components. For the re-used locks elements is probability data not available. To gather that data and inspection programme is put in place.

3.2 Inspection programme

An inspection programme was launched to provide data on the probability that the re-used lock elements would fail. The inspection programme consists of:

- Measurements;
- Visual inspection based on non-destructive testing;
- Analysis of historic malfunction data.

The data gathered by this inspection programme is used to conduct the Fault Tree Analysis (FTA).

3.3 Fault Tree Analysis (FTA)

The purpose of the FTA is to assess whether the design meets the requirements for reliability and availability. The FMECA is the basis of the FTA. The FTA determines how the unavailability of the components of the lock would contribute.

The contract states that the east locks must be available 24 hours a day, 7 days a week for ships to pass through the locks. Underlying requirements primarily focus on plannable and non-plannable unavailability. These underlying requirements are:

- Unplannable unavailability of the guard locks and their operating mechanisms and gears for the lock passage process may not exceed a maximum of 24 hours a year.
- The number of lock cycles used as the basis for the design and for this Fault Tree Analysis is 30 per day.

The probability that the re-used concrete lock elements (lock gates, outer basins and chamber walls) will fail has been set at 0. Calculations show that the probability that the re-used concrete lock elements will fail is so small that it is an acceptable risk.

4. Conclusion

In this case study, the method described above was effective because the re-used elements of the structure were of such high quality that they could in fact be re-used. It was not necessary to adapt the design in order to meet requirements for reliability and availability.

If the calculations had shown that the reliability and availability requirements could not be met, it would have been possible that the elements would have had to be replaced, which would have led to delays in the project.

Re-using elements did pose certain risks. At the start of the project, these risks must be considered acceptable.

The failure probability analysis shows that the design met the availability requirement for unplanned unavailability. The reliability analysis shows that the contribution to the unplannable unavailability is primarily determined by the moving parts in the lock structure. The re-used civil constructions make no contribution.

The re-used civil structures do not influence plannable unavailability. Inspections can be conducted in parallel to maintenance work on the gears and operating mechanisms.