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2 Seas Mers Zeeën
MET-CERTIFIED
European Regional Development Fund

Development of International Standards and Certification schemes for Marine Energy Technologies

Deliverable D.1.6.2

Reliability testing appraisal

Project No. 2S01-020

With the financial support of

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Revision history

REVISION	DATE	AUTHOR	ORGANISATION	DESCRIPTION
V1.0	30/06/2017	JG	EMEC	

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1. Introduction

The subject of this document is the observed performance of 5 x Tocardo T2 turbines installed at Section (Roompot) 8 of the Oosterschelde Storm Barrier in the Netherlands, shown in Fig 1 below.

FIGURE 1 - T2 TURBINES INSTALLED IN ROOMPOT 8

The commissioning period revealed a number of faults that were remedied before the commencement of the operational test proper. After this the system was in operation for 17 weeks which was monitored for all loss of production. It should be noted that the turbine array has to be lifted under strict regulation by the Netherlands flood control authority. This reduces the energy developed by the turbines although this reduction is not caused by the unavailability of the turbines. These comments therefore relate to the operational period post-commissioning.

2. References

/1/ Massaro, G, "OTP2 Oosterscheldt Tidal Power Plant Roompot 8 – 2016 Operations Summary with energy yield performance", (2017)

/2/ EMEC, "Guidelines for Reliability, Maintainability and Survivability of Marine Energy Conversion Systems ", (2009)

3. Methodology

Start-up and commissioning of the Tocardo T2 turbines took place in Q4 2015. In this period two faults were noted viz:

- Bi-blade drift problems due to friction in the hub areas resulting from production tolerance errors
- Loss of brake fluid on one turbine, then on a second turbine.

Both issues were identified by observation of the instrumentation outputs during commissioning.

Following commissioning, all blades were removed and refurbished under guarantee and the system returned to work. The turbines functioned with 100% availability over the 17 week period of operation remaining in 2016.

4. Test Procedures

Records were kept of availability of the turbines, and the power production system. Use of the dam as a test bed site means that operations to limit changes in tidal height are regulated in line with the flood authority's requirements. That reduced the overall availability of the power production system but is not ascribable to the turbines. The turbines were kept on automatic but the lift system to meet regulations was a manual operation as that control system was not deemed suitable for automatic operation.

During the operation period turbine alarms were shown for a total period of 0.53 hrs in the 17 weeks of operation equating to 0.019% downtime.

5. Technical requirements

5.1. List of contents

Much of the recommended practice in the EMEC Reliability guide (see ref /2/) is not fully relevant to this test however the following on sources of evidence and outputs is useful:

EMEC Guide (section 10.6)	Comment on Oosterschelde Test
Data should originate from stable operation period (give consideration to start-up)	Fulfilled in terms of stability, start up problems not reliability issues
Data should come from equipment exposed to common operating conditions	Fulfilled in this case
Basis of data should be sufficiently extensive	17 weeks is too short a period
Number of data points (events) should be large enough to minimise influence of "outliers"	Not enough data gathered in this respect
Population data should be indicated to reflect statistical significance	Not enough data for this purpose
Repair and downtime data should reflect site specific conditions	Would need to explain limitations of access at the dam site
Data sources should be quoted	Given in report and could be expanded
EMEC Guide (section 10.9)	
Written prediction of reliability target based on design studies (FMECA etc)	Not given here but could be available or prepared for further test

TABLE 1 - - COMMENTS AGAINST POINTS FROM EMEC RELIABILITY GUIDE

6. Main observations and recommendations

Considering the comments in Table 1, the main comments and recommendations are presented below.

- The main discussion point is the assignment of the faults uncovered in commissioning being assigned to production faults rather than reliability. This is not contentious in the case of the friction experienced in the bi-blade hub bearings which proved to be a manufacturing quality matter – not disputed by the manufacturer who replaced all blades under warranty. In the case of hydraulic seal failures there is a bit more doubt as these could have resulted from a factory fault in assembly or some storage or handling procedure that allowed ingress of dirt particles which embedded sufficiently to cut through the seals on two machines. As these occurred in the commissioning period, it is reasonable to conclude that it could be related to factory, storage or handling issues.
- The only faults occurring during the 17 week long reliability run were minor alarm faults which created very little downtime.
- The OREDA Offshore Reliability Data volume 2 (5th Edition) 2015 suggests total failure for topside hydraulic power units (all failure) types is 75.41 failures per 10^6 operating hours. This equates to a failure (per device) every 1.5 years or for 5 systems a failure every 0.3 years. The lack of such a failure in the 17 weeks of operation is therefore not very surprising.
- It is difficult to compare any published data for the alarms as the report does not give a list of sensors so no calculation is possible, although it could be done in future.
- Overall, the period of actual operation after the remedial works to the factory-based faults is too short to draw much conclusion. The main recommendation would be to carry out a longer test, say, 8000 hours with careful recording of all turbine downtimes and their causes.
- The EMEC Guide was a very preliminary document written as a high-level expression of good practice. A Technical Spec. or standard would need to have a more contained and well-defined scope and suggest explicit methods for assessing reliability as well as suggesting rules for assigning commissioning failures to manufacturing or installation.