ELFORSK
THE SWEDISH ELECTRICAL UTILITIES' R&D COMPANY - ELFORSK AB

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Program area Nuclear
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Strategy plan

Vibrations

- Elforsk vibrations in nuclear applications program

Period: 2014-01-01 to 2015-12-31

Summary

Vibrations is a research program addressing vibration problems in the nuclear industry. The three focus areas of the program are computation, requirement/verification and components. Information from the program will assist the nuclear industry in addressing vibration issues with maintained safety and promoting a low life cycle cost. Participation of a mix of junior and senior participants in the program is encouraged to facilitate knowledge transfer.

1 Vision

The vision of the vibrations research within Elforsk is that the activities should contribute to an increased knowledge that in time should lead to less vibration related problems.

The results will be used in the decision making process to choose most favourable verification techniques when new equipment is to be installed or replaced.

The program should also constitute an arena for discussion on nuclear vibration issues for plant owners, authorities, vendors and researchers. It should also address the issue of knowledge transfer between senior and junior participants in suitable projects.

2 Background

Vibration problems are often complex and cause long periods of shut down or reduced power leading to large losses of income. Especially during power uprate projects there have been large vibration problems at the nuclear power plants. For instance at Oskarshamn Unit 3 there have been vibration problems in the steam lines caused by the new MSIV (Main Steam Isolation Valves). Moreover Forsmark 2 had vibration problems when changing HPT (High Pressure Turbine) inlet valves some years ago. Ringhals 3 encountered high vibration levels in the steam lines due to the design of the steam generator outlet nozzle. The problems at Ringhals 3 were not related to a power increase but due to a planned change of the steam generators.

The vibration experts at the nuclear power plants have expressed a desire to increase the in-house knowledge on how to calculate and dimension the various components especially for systems with rotating parts such as turbines and pumps. When buying a new component calculations are normally not handed over from the supplier to the clients. Suppliers sometimes even consider the data of the component a trade, especially when split contracts are used. This makes it hard to make calculations of the overall system performance. There is also a lack of standards when it comes to requirements when new equipment is acquired.

There are only a few experts within the field, especially when it comes to rotor dynamics, and many of them are close to retirement. The situation is the same at the nuclear power plants, at the suppliers and at consultancy companies, which makes it hard to solve the problem by recruitment. Instead new candidates must be educated in the field of vibrations.

3 Focus areas

The program was originally intended to focus on rotor dynamics, but was widened to vibrations in general by the steering group. Competence building activities are also included in the program. Many of those who work with vibration issues in the nuclear industry are to be retired within a few years, so there is a need for skills transfer. Because of this the research program will promote, on all levels, a mix of senior and more junior participants.

The activities are financed by Swedish and Finnish nuclear power plant owners. A steering group consisting of representatives from the financiers has been appointed, and they are responsible for the individual project decisions and follow up. Additional expert groups, for example reference groups, can be appointed when needed.

This program is focused on research and knowledge transfer rather than exchanging practical experience between the plants. Knowledge transfer is handled in a separate forum bilaterally between the plants, but several of the steering group members are participating in both groups.

Activities and projects initiated can result in:

- Reports
- Guides
- Seminars
- Knowledge databases

- Mapping of ongoing research

depending on the need.

The steering group has identified the following three focus areas for the program:

3.1 Computation

3.1.1 Introduction

Normally when new components are to be designed or when there are some vibration related problem at the plant different numerical methods are used. In the design process of larger components, experimental techniques are often used together with computations, hence the numerical techniques are compared and in some sense validated with experiments. However in many cases there are no measurement results available and the numerical method employed must be verified to give correct results for the problem to be analysed.

3.1.2 Objective

Obtain understanding of which methods that are suitable for attacking different vibration related problems. The objective is also to gain insight on how to integrate results from vibration measurements at the plants into structural analysis programs.

3.1.3 Activities

a. Comparison of different rotor dynamics software, could take the OL sea water pump as an example
b. Transform results of vibration measurements into structural analysis
c. Validation studies comparing Computational Fluid Dynamics (CFD) with experiments
d. Literature survey in the vibration area related to experiments and numerical analysis

3.2 Requirement/verification

3.2.1 Introduction

When exchanging components in nuclear power plants their performance have to be verified. This is normally done first at the factory FAT (Factory Acceptance Test) and then later at site SAT (Site Acceptance Test). However when the components are purchased, correct and relevant requirements have to be specified. Sometimes there are suitable international standards to be used for specifying the requirements regarding vibration levels. On the other hand, in some cases there are several standards with different requirements, thus leading to discussions with the manufacturer on what to fulfil and to verify at the FAT and SAT. On the contrary, for some components there is a lack of standards to be used to specify relevant vibration requirements.

There is also an issue related to the operation of the plants regarding allowable vibration levels. Systems, parts of systems and components have different allowable levels regarding vibrations. Experience and knowledge on

measuring and monitoring to assure a safe and reliable operation related to vibration issues is crucial.

3.2.2 Objective

Obtain common understanding and agreement on requirements to be specified and verified when exchanging components. The objective is also to define suitable vibration levels during long term operation together with appropriate methods for measuring/verifying and monitoring.

3.2.3 Activities

e. Diesel engines - requirements and design

f. Component requirements to system performance (acoustics, flow induced, mechanical)

g. Measuring/monitoring vibrations

h. General requirements regarding vibration levels and frequency content

3.3 Components

3.3.1 Introduction

Vibration problems in nuclear power plants can originate from different sources. For instance pipe vibrations can be induced by flow along surfaces or around discontinuities, acoustic resonance or by some mechanical excitation. There are even fluid structure interaction phenomena where vibrations of structures influence the vibrations of adjacent structures by vibration induced pressure waves through the medium.

Vibration problems in other components can be caused by other phenomena like unbalance, bearing instability, rub or other. On the other hand vibrations problems occurring at one location in the plant can give problem to other components, downstream in the same pipe system or mounted at the same foundation. For instance having an unfavourable flow situation upstream of a pump can cause high vibration levels in the pump giving raise to wear and future problems with operation availability.

Thus, in order to minimize the risk for vibration problems, it is vital to have an understanding of what type of problems may occur for different components and how it might affect the components. Apart from understanding the problems, it is of course very important to know how to avoid problems or mitigate them in order to have a safe and reliable long term operation.

3.3.2 Objectives

The objective is to increase the knowledge on vibration related problems for different components in order to avoid them or recognize and mitigate them in such a way that safe and reliable long term operation is ensured.

3.3.3 Activities

i. Pump analysis, for instance sea water pumps

j. Pipe vibrations, flow induced vibrations and mechanical vibrations during power uprate

k. Valve/components vibrations

l. Periodic vibrations (turbines 10-15 h), understanding the phenomena, list of causes

m. Fluttering of turbine blades, understanding the phenomena

n. Electrical engines and fans (ventilation safety systems)

4 Tentative budget

The overall budget for the program is 1 300 kSEK for 2014 and 1 300 kSEK for 2015.

5 Steering group

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Heikki Haapaniemi, Fortum

Inge Pierre, Svensk Energi

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