COMMISSIONING OF THE VIBRATION AND TEMPERATURE DATA ACQUISITION SYSTEM FOR THE PREDICTIVE CONTROL AND PROTECTION OF THE ROTATING COMPONENTS OF THE IEA-R1 REACTOR

Reynaldo Cavalcanti Serra* and Dorival Gonçalves Tecco*

*Instituto de Pesquisas Energéticas e Nucleares - IPEN-CNEN/SP
Caixa Postal 11049
05422-970, São Paulo, Brasil
e-mail: rcserra@net.ipen.br

ABSTRACT

This work gives a brief account of the commissioning activities for the vibration and monitoring systems which were installed in the primary and secondary circuits as well as in the emergency generator of the pool type research reactor IEA-R1 at IPEN. Vibration and temperature signatures are presented and compared. Contours for the alarm level throughout the frequency spans are suggested and the perspectives for the future activities are discussed.

I. INTRODUCTION

Vibration analysis and monitoring methods have been introduced for the control of components of the primary circuit, secondary circuit and the emergency generator as a safety measure for the operation of the IEA-R1 nuclear reactor at IPEN, in São Paulo, Brazil. One system based in the method presented in [1] is presently installed remotely in the reactor control room. Aside from allowing the continuous monitoring of the vibration and temperature signals from the most important cooling and emergency circuits, it also avoids the radiological control problems associated with in-situ inspections.

The components and the instrumentation are basically those described in [2]. It consists of a total of six thermocouples and eighteen accelerometers, which are distributed amongst the primary cooling circuit components, secondary cooling circuit components and the emergency generator components. The characteristics of the data acquisition and analysis equipment are also described in the same reference and will not be repeated in this document.

This work presents the general philosophy behind the commissioning activities, the data analysis and some captured signals. The evolution of some of the vibration signals is also discussed and comparisons with older historical data are made.

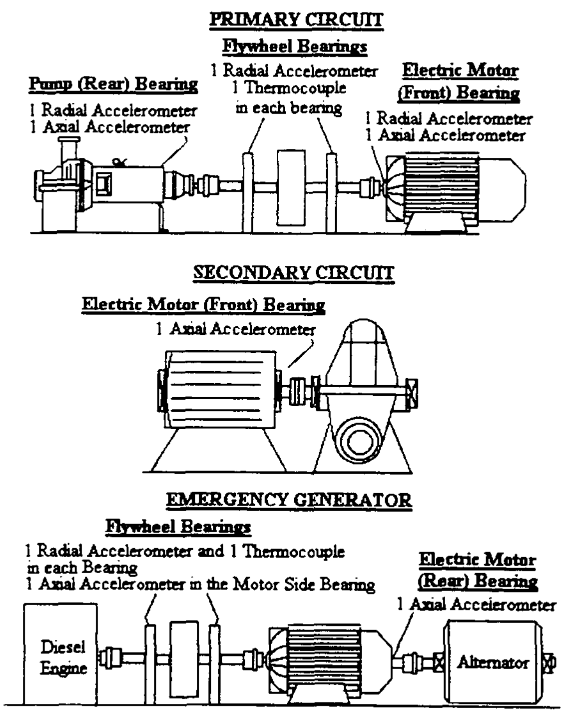

Fig. 1: Diagram with the Transducer Positions in the Cooling Circuits and the Emergency Generator System

II. COMMISSIONING OF THE DATA ACQUISITION SYSTEM

The commissioning of the data acquisition system was carried out mainly through the comparative analysis amongst the vibration and temperature data, bearing in mind that the transducers and the conditioning systems are calibrated individually.

The initial stages of the verification activities consisted of comparing the signals from each transducer amongst themselves and then the evolution of each transducer along the operation. The first signatures obtained with the system were also compared against historical data recorded with other laboratory instrumentation, e.g. as in [3]. In the case of the temperature analysis system, an additional verification is also made against the independent reading available in the control room.

The position and the discrimination of the accelerometers and thermocouples are shown in Fig. 1.

Fig. 2 shows the velocity trace for the axial direction at the electric motor (front) bearing in the primary circuit. The Y and the X axes designate respectively the RMS velocity in mm/s and the frequency in Hz. Shown are the actual signature (dark patch), a reference trace and the two alarm levels. The trace legends are best revealed in Fig. 3 for convenience.

The main vertical cursor shows the fundamental frequency, which was equivalent to 30Hz for this particular pump. The reference trace corresponds to one data acquisition made at the earliest stages of the commisioning and had an amplitude of about 0.8mm/s at the fundamental frequency. The actual trace corresponded to one acquisition made about 60 days latter than the reference trace without any interference to the components. It shows a relative decrease in the amplitude at the fundamental frequency to 122.5μm and is not presently attributed to any improvements made to the components.

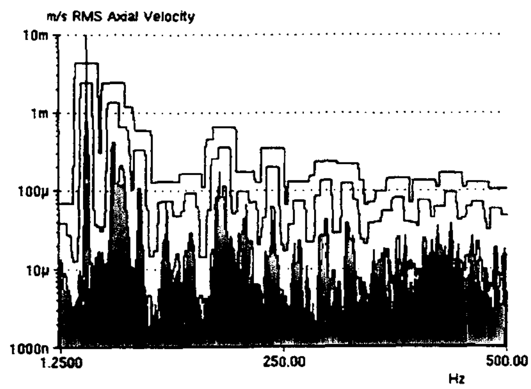

Fig. 2: Axial Velocity Reading from the Accelerometer at the Electric Motor (Front) Bearing, Primary Circuit

Note: The traces designations are shown in Fig. 3

The alarm levels were defined on a history basis, e.g. the misalignement problem shown in Figure 3 of [3] and also from the suggestions made by [4]. With the present system, the alarm and warning levels are defined in a set-up procedure in which a given increment is applied over the fundamental amplitude and then throughout the spectrum. Alternatively, the system also allows the division of the frequency span into 12 windows, i.e. the definition of band levels, however this was not the present case.

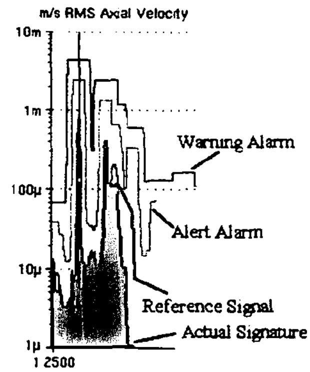

Fig. 3: Legend for the Traces Shown in Fig. 2

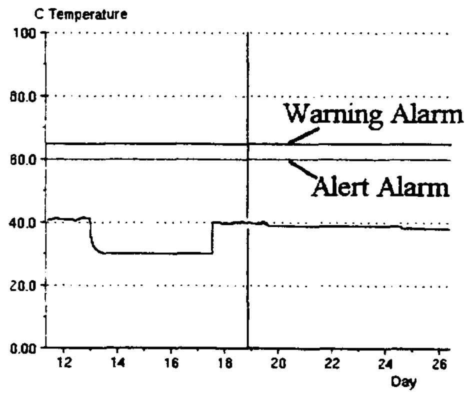

Fig. 4: Temperature Reading from the Thermocouple at the Flywheel Bearing, Pump Side, Primary Circuit

Fig. 4 corresponds to the temperature trace taken at the flywheel bearing, pump side in the primary circuit. The alarm and warning levels are defined respectively as 60°C and 70°C in view of the safety and design criteria for the component. The actual temperature trace exhibits one stage of relatively constant temperature up to about 13th, then a decrease to about 30°C as the circuit was switched off and then an increase to the operation temperature thereafter. These temperature values are in full agreement with the readings made in the control room, indicating a satisfactory system performance.

Fig. 5 and Fig. 6 show the velocity traces for the radial accelerometers at the flywheel bearing, pump side. and the pump bearing in the primary circuit. The amplitudes at the fundamentals are respectively 96.8μm/s and 75.3μm/s, which are essentially consistent. The criterion for the alarm definition is the same as that applied in Fig. 2, i.e. a constant increment over the amplitudes.

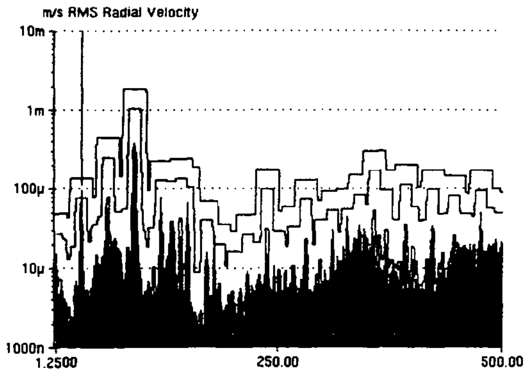

Fig. 5: Radial Velocity Reading from the Accelerometer at the Flywheel Bearing, Pump Side, Primary Circuit

Note: The traces designations are shown in Fig. 3

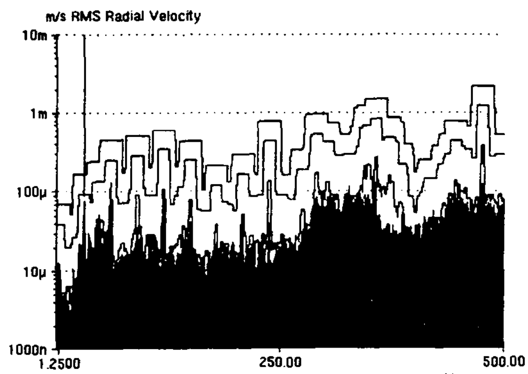

Fig. 6: Radial Velocity Reading from the Accelerometer at the Pump (Rear) Bearing, Primary Circuit

Note: The traces designations are shown in Fig. 3

Other traces have already been obtained for the secondary circuit and the emergency generator. Similar analysis procedures and presentation methods apply to these other signals, which shall therefore not be displayed in the present work for simplicity.

III. CONCLUSIONS

The vibration analysis and monitoring system for the control of the cooling circuit components has been commissioned and a data bank is being built from the initial signatures gathered in the process.

The objective thereafter will be to implement and maintain the data bank, so that any eventual abnormalities that may develop can be traced back to its earliest stages and the correlations can be carried out to define its nature. It is also expected that the alarm levels contours will be best adjusted to suit the actual component, rejecting unnecessary alarm events and/or restricting the increment over certain frequency spans if needed.

IV. ACKNOWLEDGEMENTS

The authors wish to acknowledge Associate Researcher support given by CNPq to D.G.Tecco.

V. REFERENCES

[1] Serra, R.C., Tecco. D.G., 1995, "**Shaft Crack Detection on Centrifugal Pumps by Vibration Analysis**", Proceedings of SMiRT 13, Porto Alegre, RS. Brasil, pp.315-317.

[2] Serra. R.C., Tecco, D.G., 1996, "**Aquisição de Dados, Monitoramento e Diagnóstico para Controle Preditivo e Proteção de Componentes Rotativos de Alta Responsabilidade do Reator IEA-R1 por Análise de Vibração**", Proceedings of the VI CGEN, Rio de Janeiro, RJ, Brasil (in CD format).

[3] Serra, R.C., Tecco, D.G., 1993, "**Perspectives to Introduction of Noise Analysis Techniques for Systematical Predictive Control of High Responsibility Rotative Equipment**", IEV93, Conf. Int. sobre Avaliação de Integrid. e Extensão de Vida de Equip. Ind., Pouso Alto-MG, Brasil, pp.75-77, ABCM.

[4] Berry, J.E., 1990, "**Proven Method for Specifying Spectral Band Alarm Levels and Frequencies Using Today's Predictive Maintenance Software Systems**", Sound and Vibration, Vol. 24, nº 9, pp. 16-28