VIBRATION MONITORING AND DIAGNOSIS AT THE IEA-R1 NUCLEAR RESEARCH REACTOR

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Introduction

- At the beginning: reactor used mainly for research and training

- Since 1996: industrial applications (radioisotopes production)

- Power increased to 5MW, upgrades and ageing management

- Continuos Vibration Monitoring System (CVMS)

Objective

A diagnostic and vibration monitoring strategy for the pumps of the reactor primary cooling loop:

- Transducers position and orientation
- Measurements periodicity
- Defects to be observed
- Vibration analysis techniques
- Alarm limits

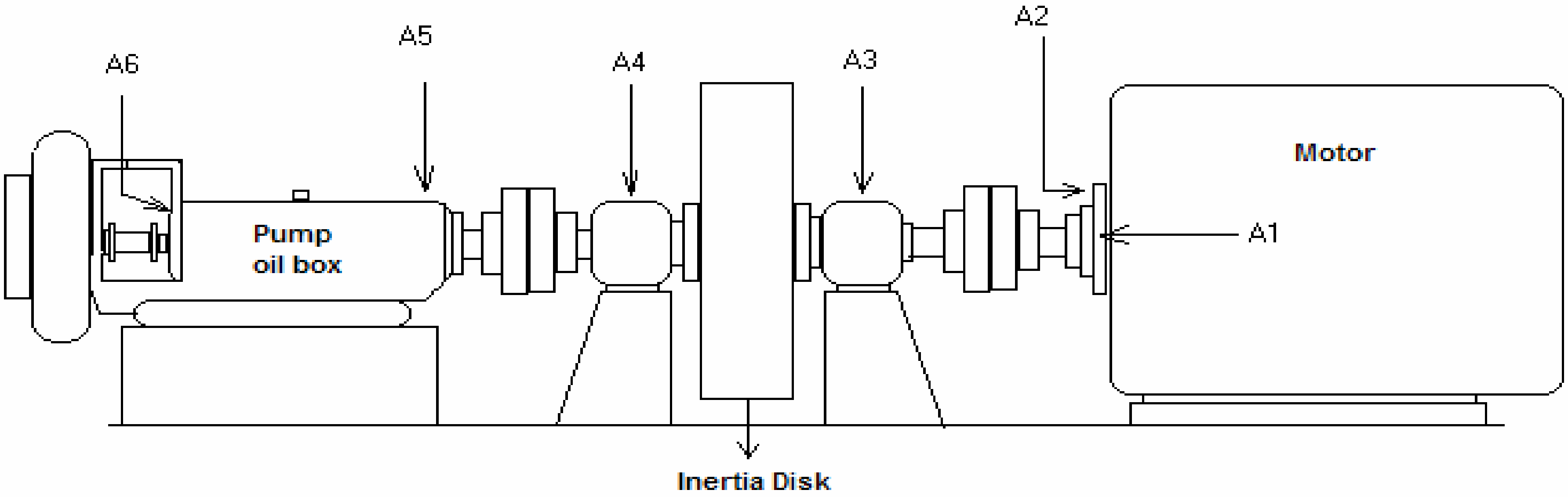
Methodology

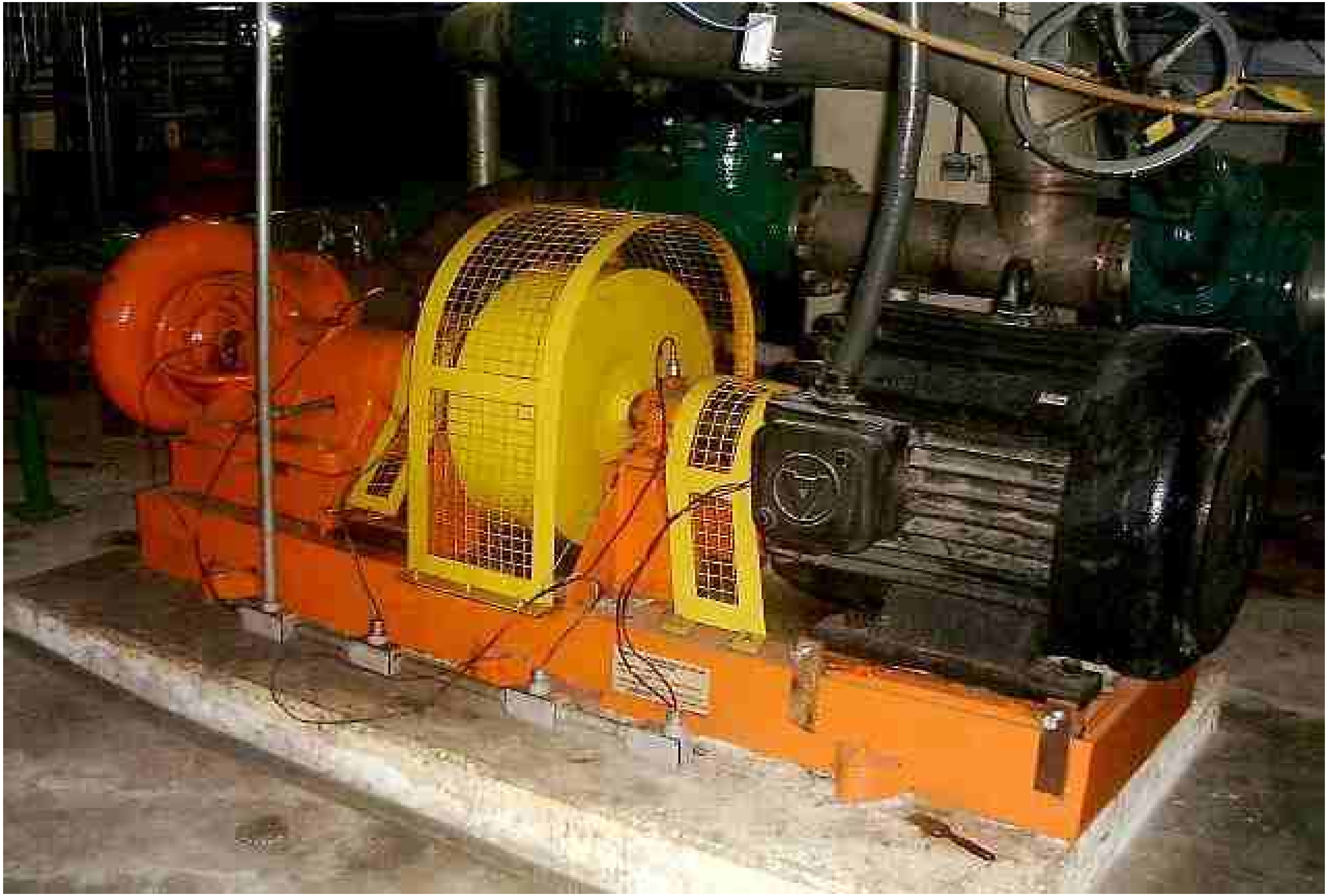
- The literature: books, manuals, standards and papers

- Historical monitoring of the pumps

- Results with a Mechanical Defects Simulation Machine (MDSM)

The Primary Loop Pump

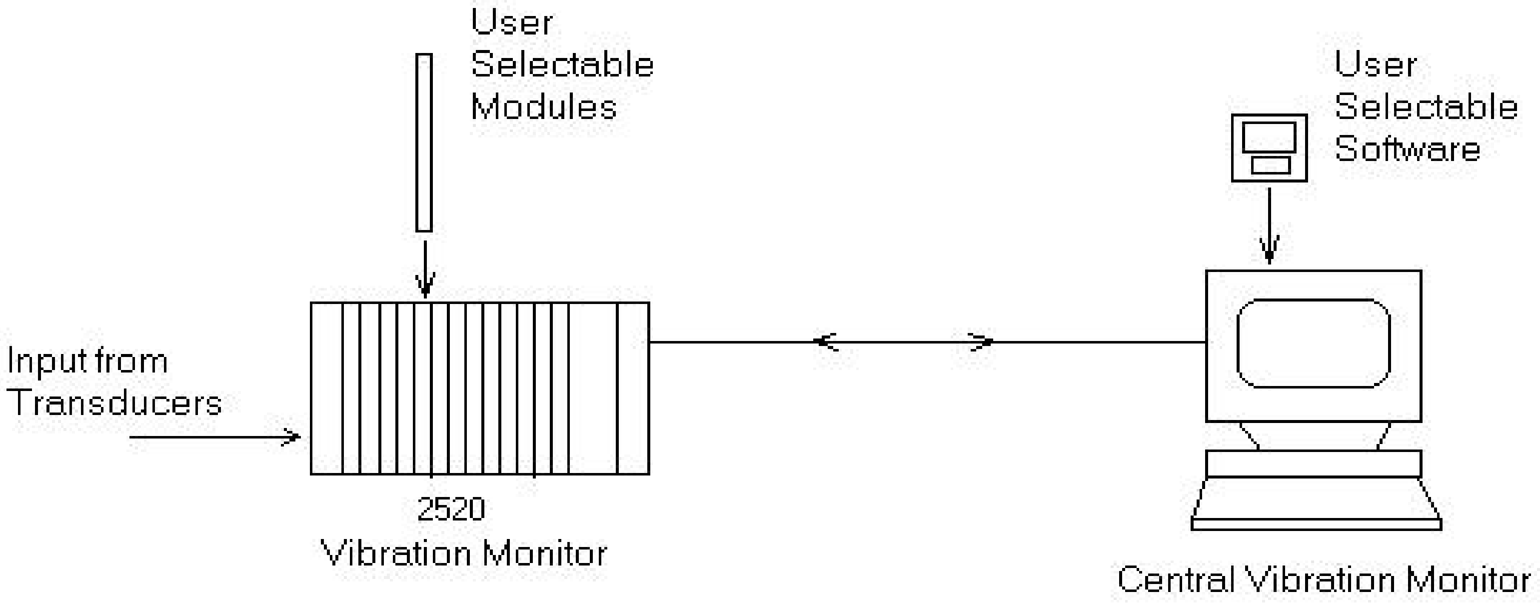




The B Pump

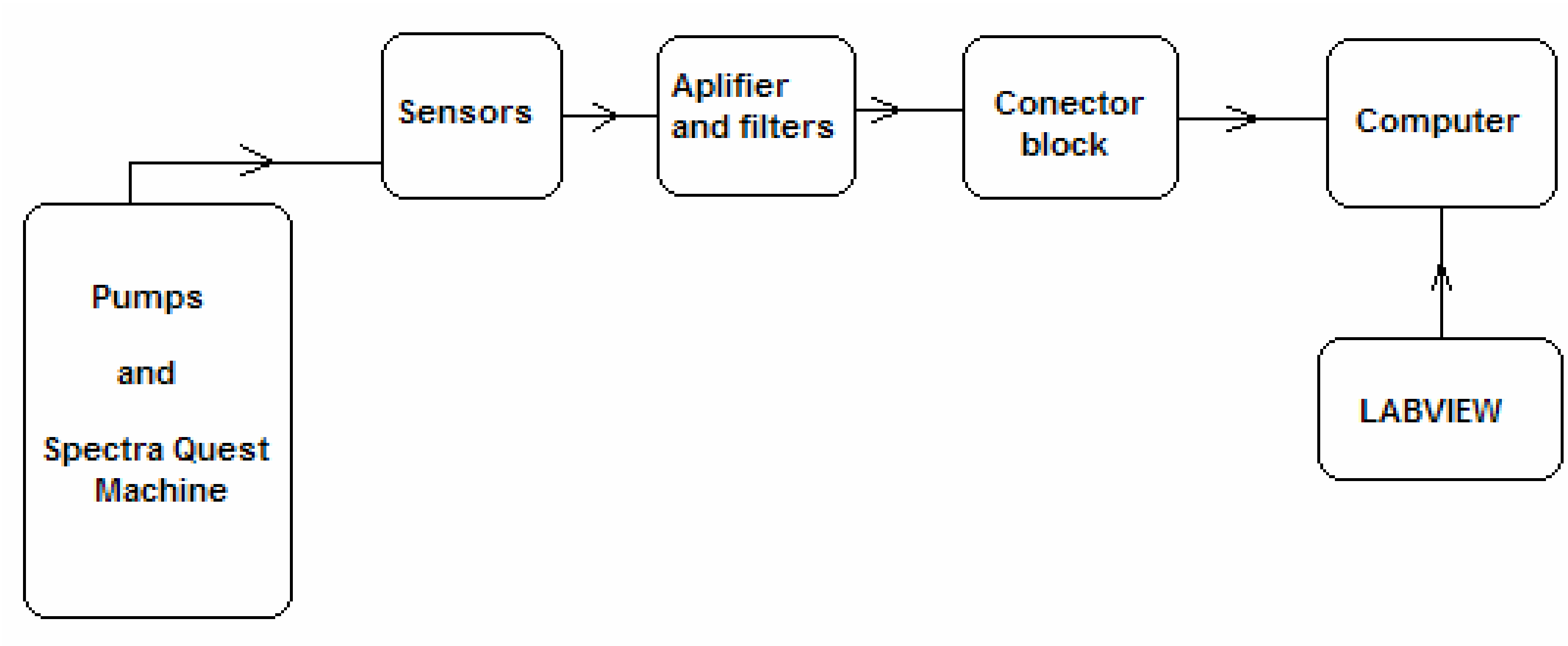
Bearings and accelerometers of the B Pump

The Continuous Vibration Monitoring System

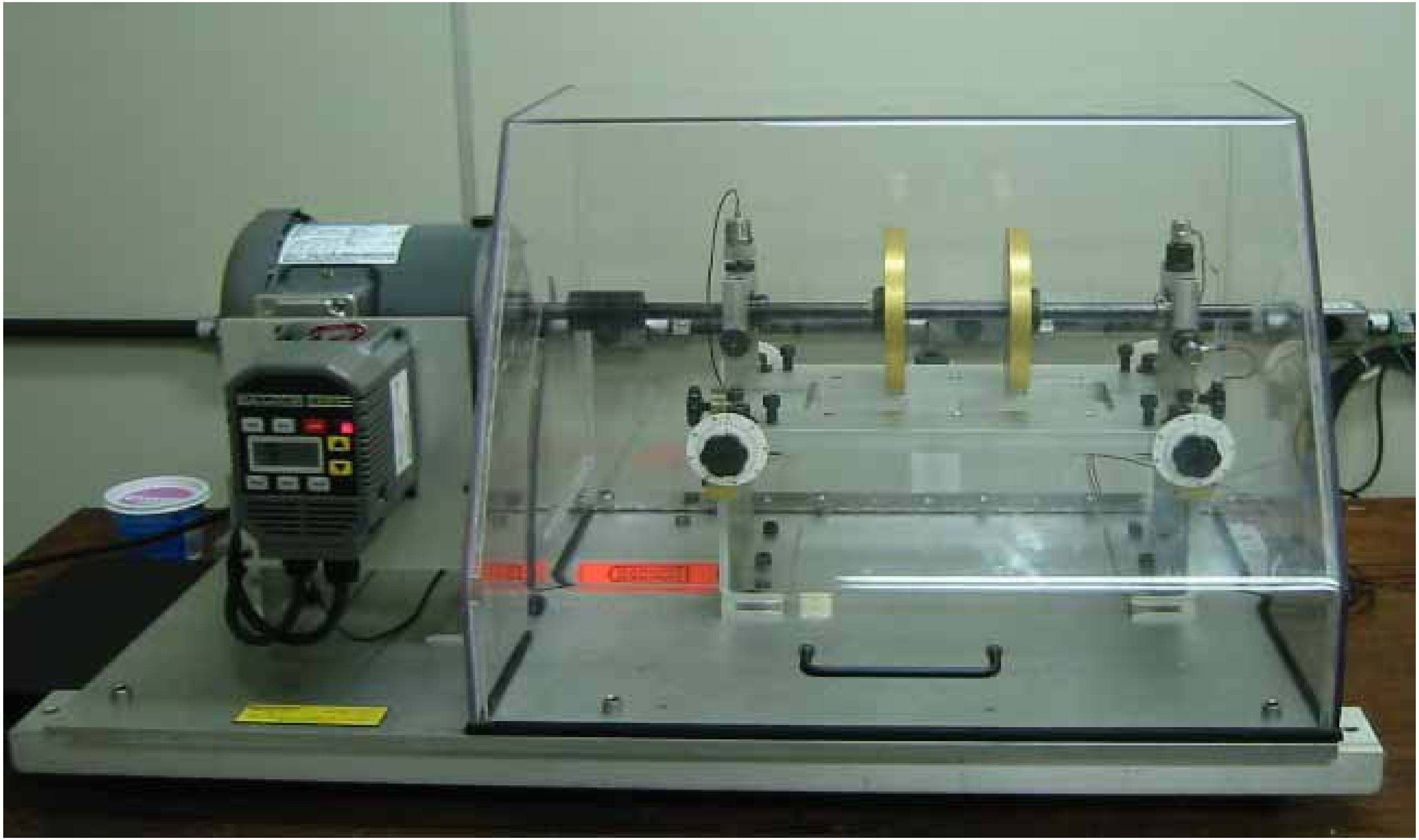


Some panels at the Control Room

The parallel signal acquisition equipment



- research
- complementar monitoring



The MDSM (Spectra Quest)

The performance evaluation

$R=Vd/Vb$

where

Vd is the measured value of a vibration parameter in a defect condition

and

Vb is the reference value of the parameter

The parameter is suposed to be an *indicator* when R>=1.6

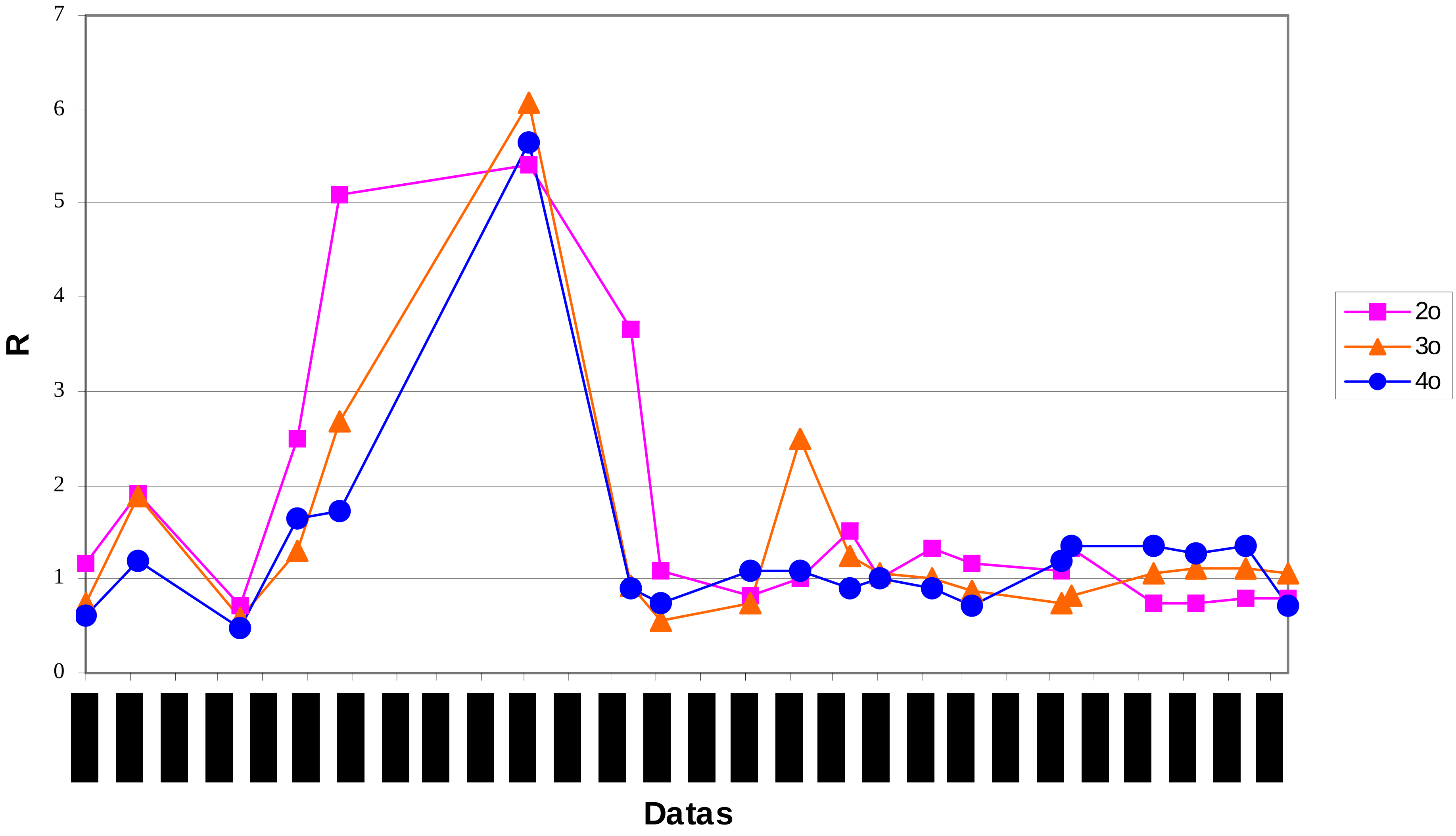
Results in the Pumps

Comparing the historical vibration signal

With the

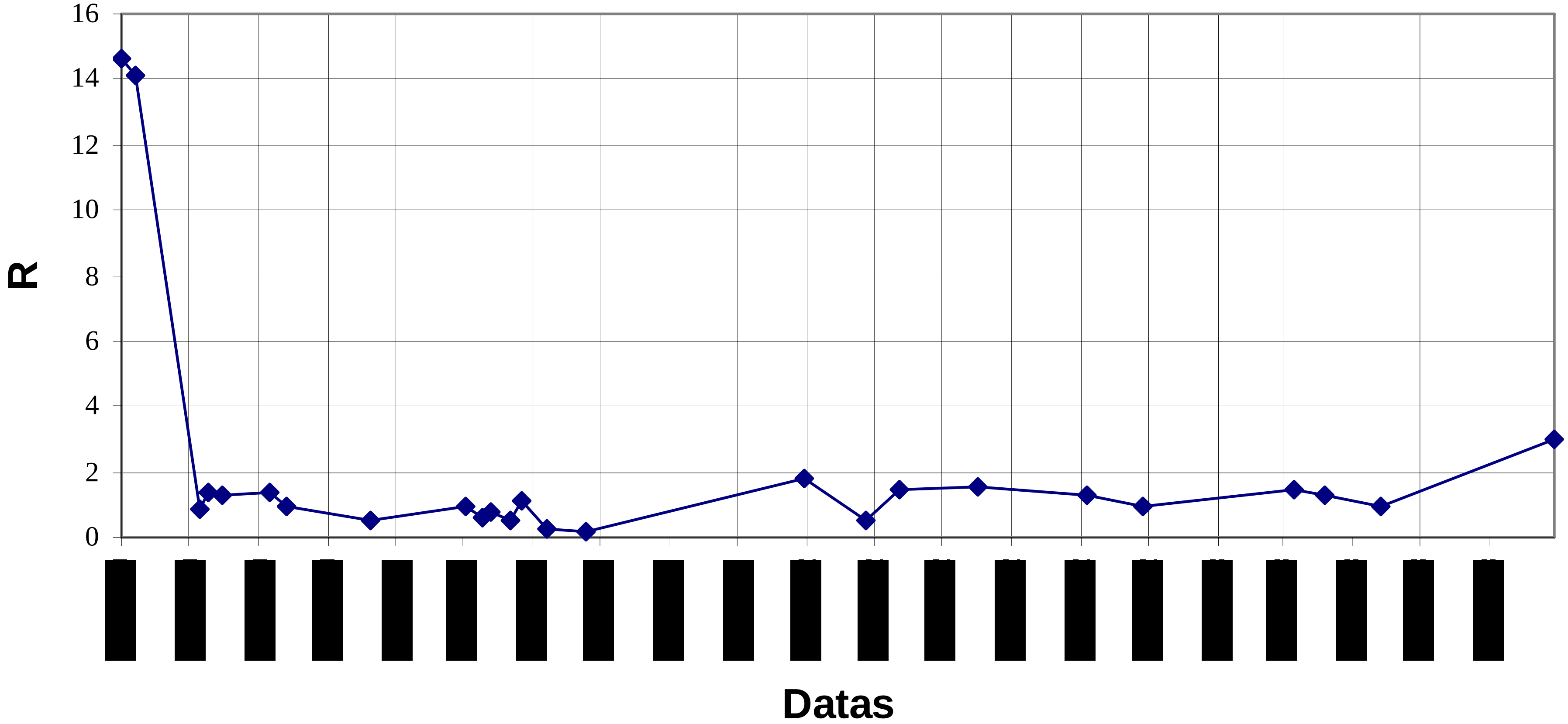
Events records

Looseness in the B Pump inertia disk bearing in May 2002



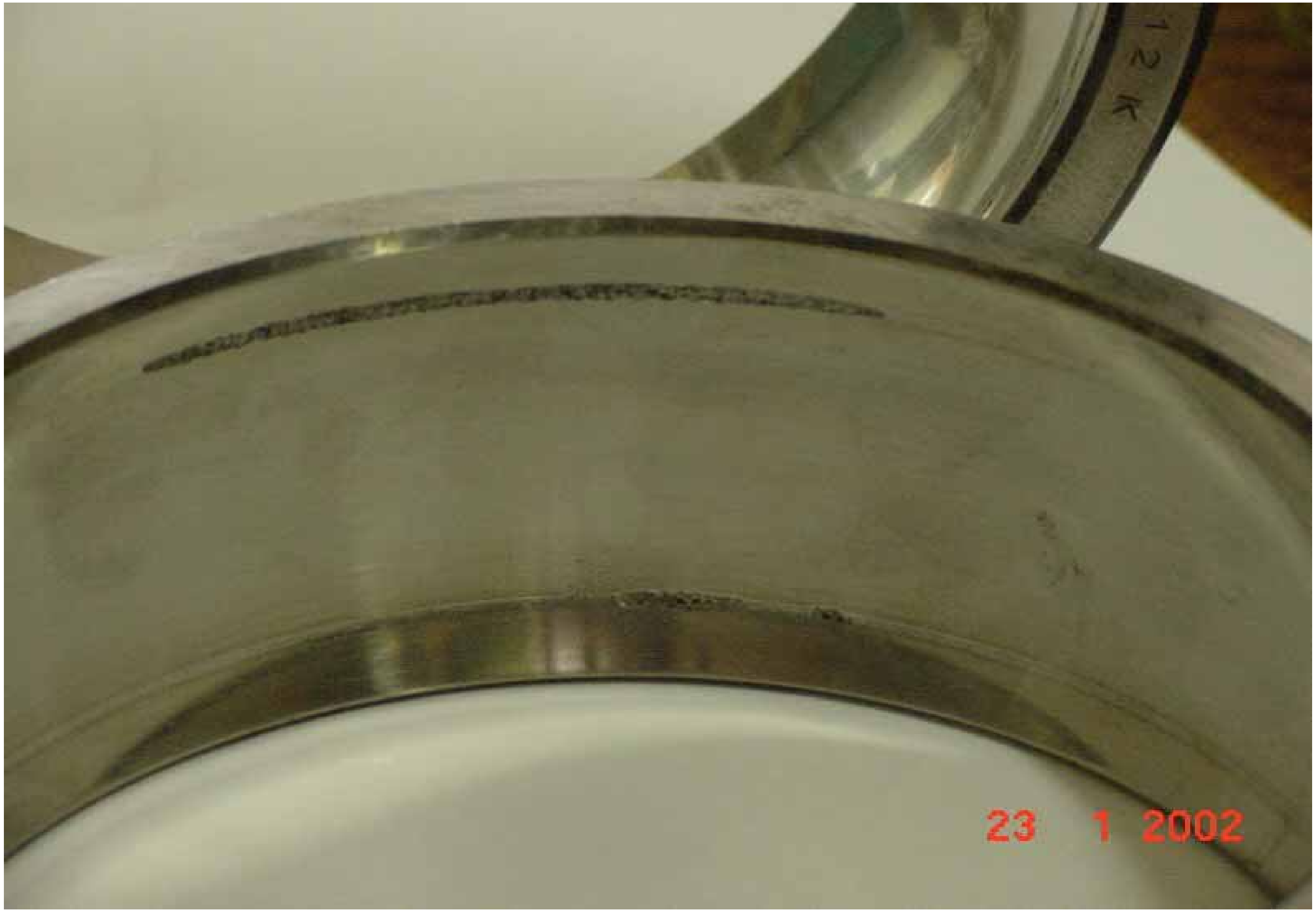
shaft speed inter-harmonics at A4 position

Repair of the A Pump in July 2000

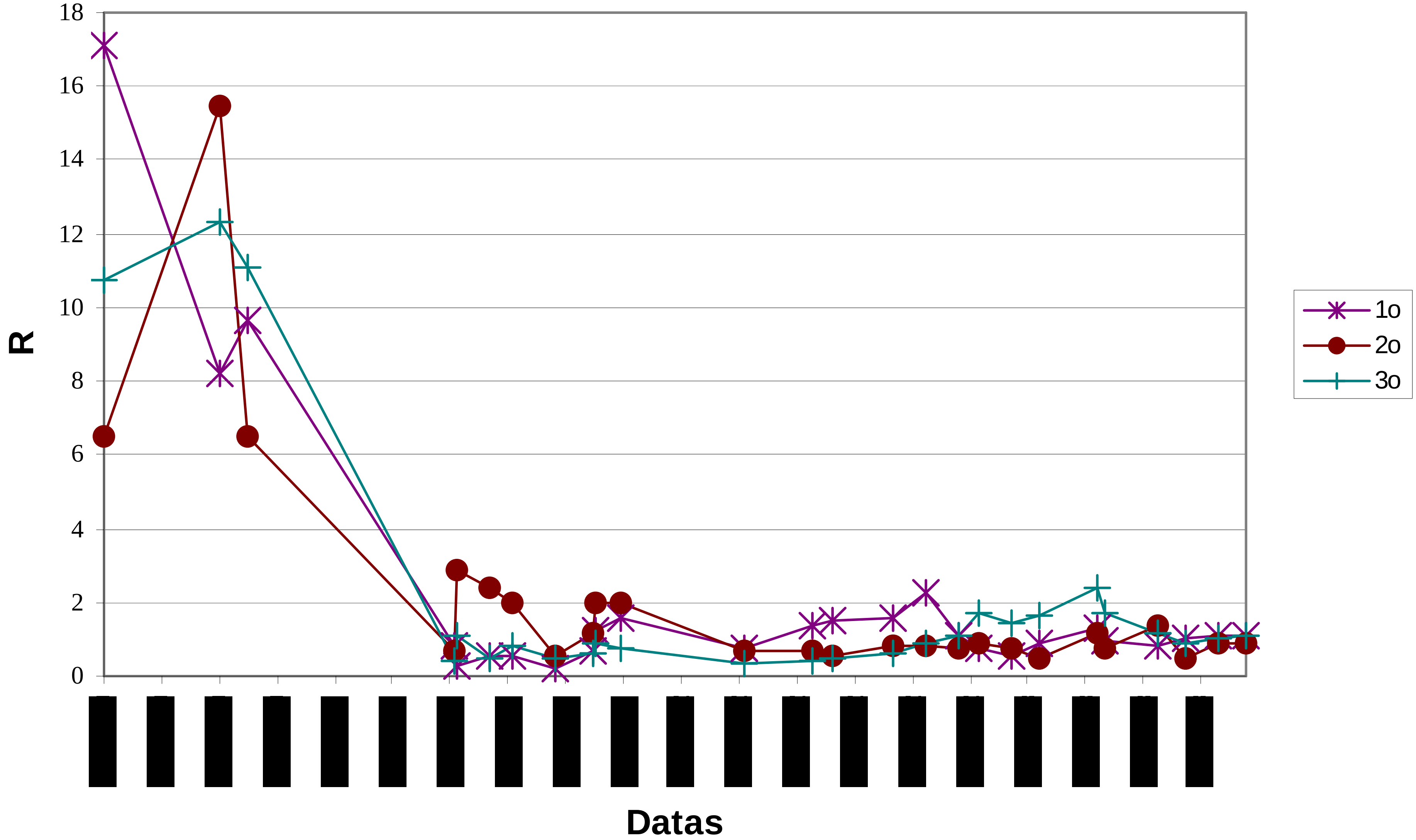


2nd harmonic of the blade pass frequency at A6 position

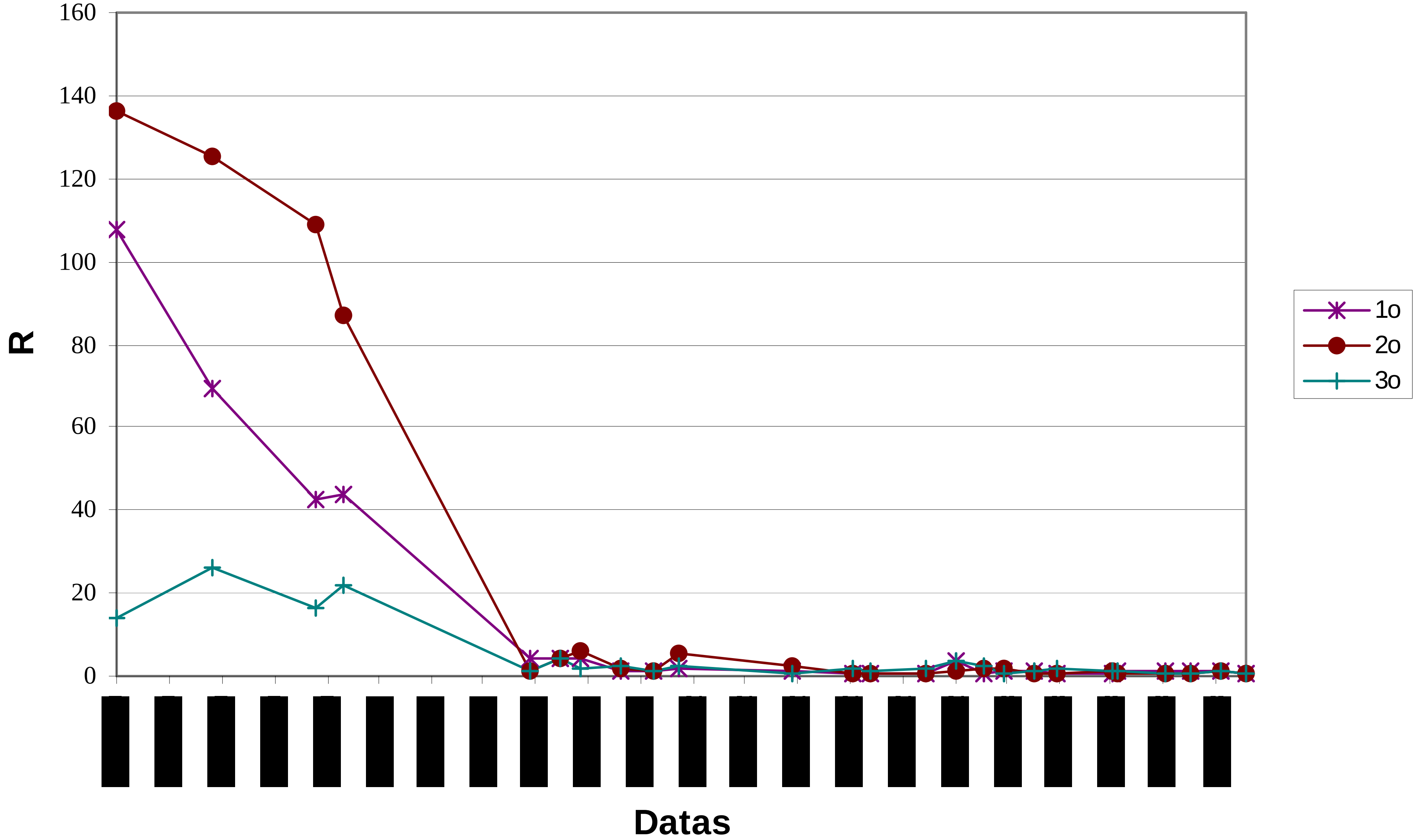
Repair of the B Pump in June 2001



rolling bearing of the inertia disk



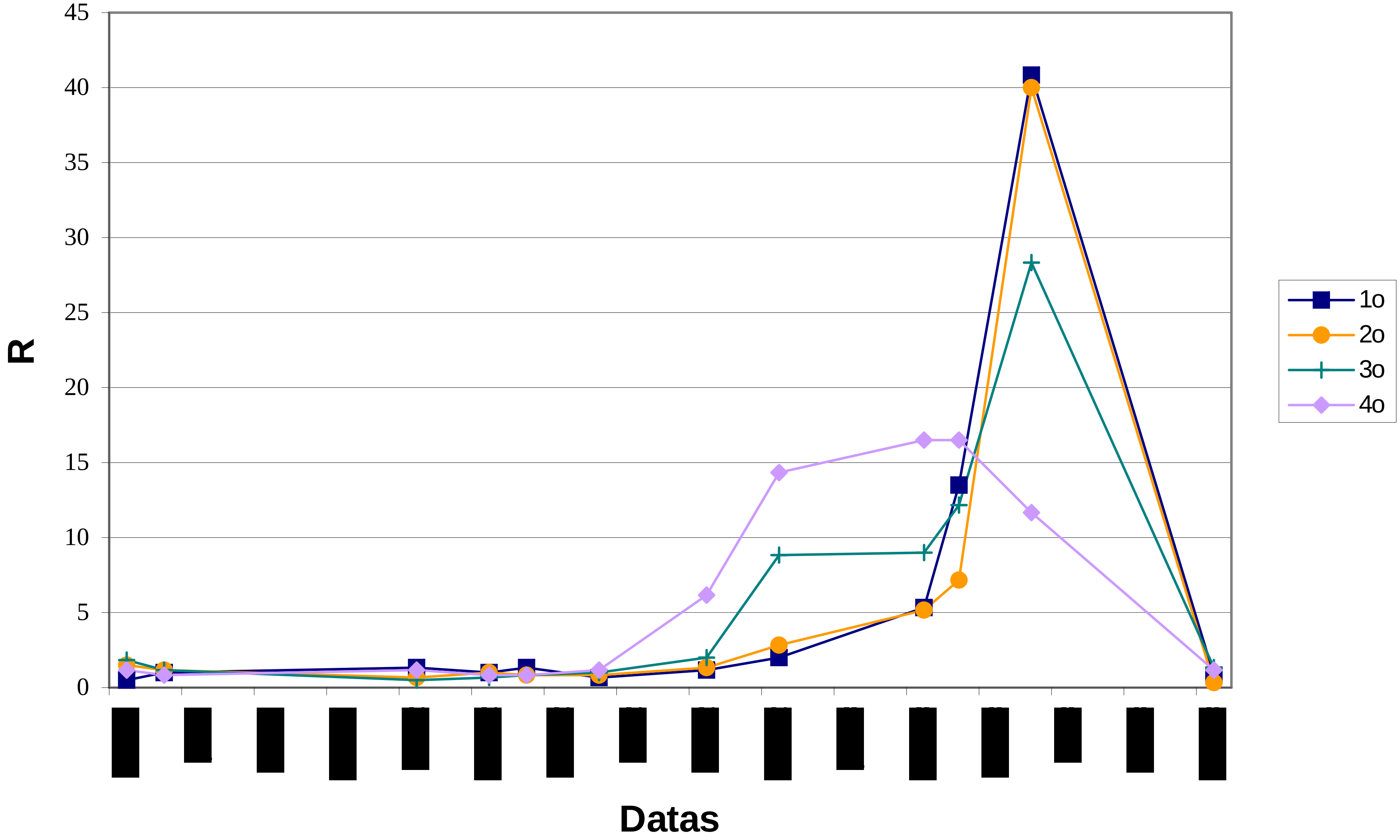
harmonics of the outer race defect frequency in the velocity spectrum (fo_v) at A3 position



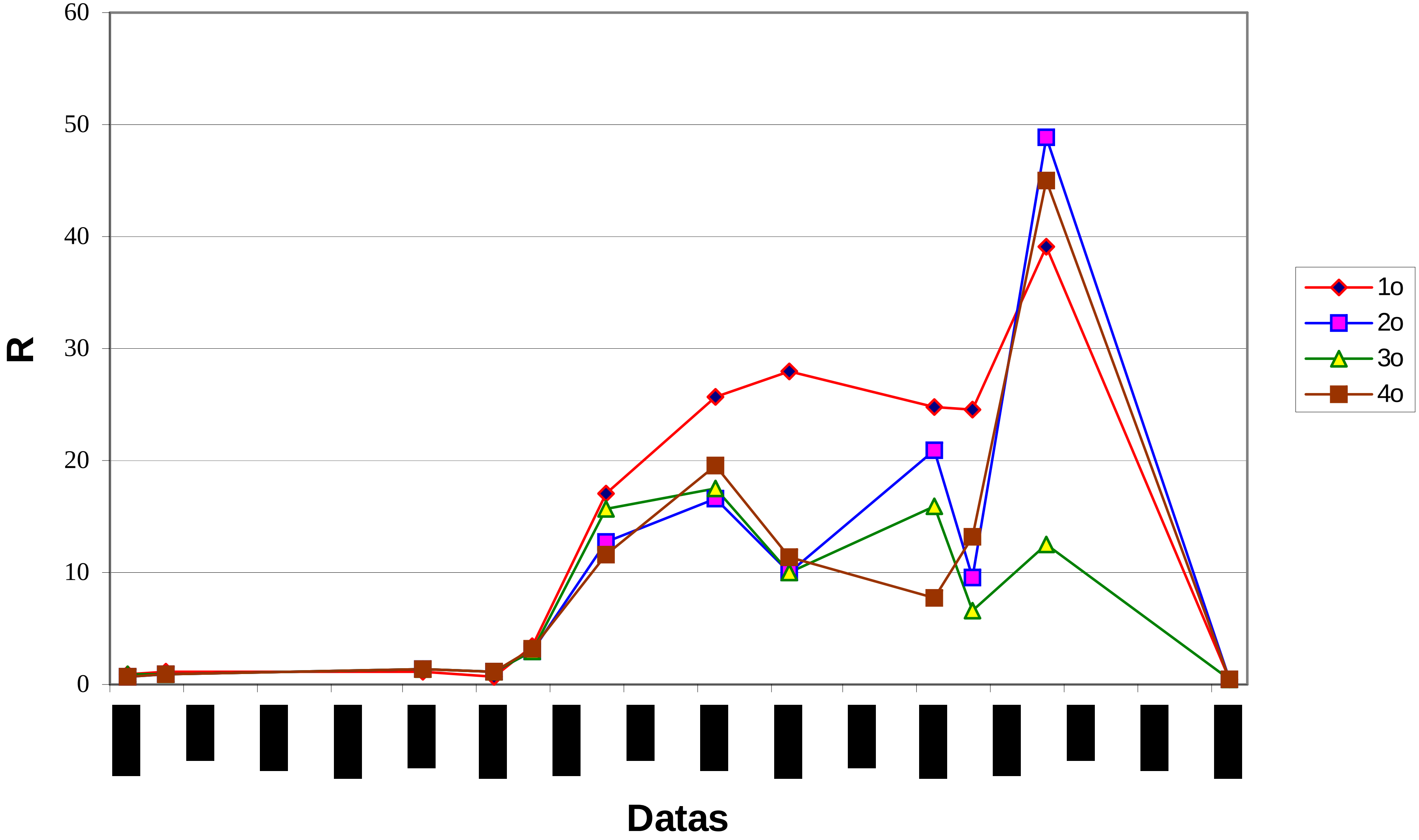
harmonics of the outer race defect frequency in the velocity Spectrum (fo_v) at A4 position

Repair of the A Pump in June 2003

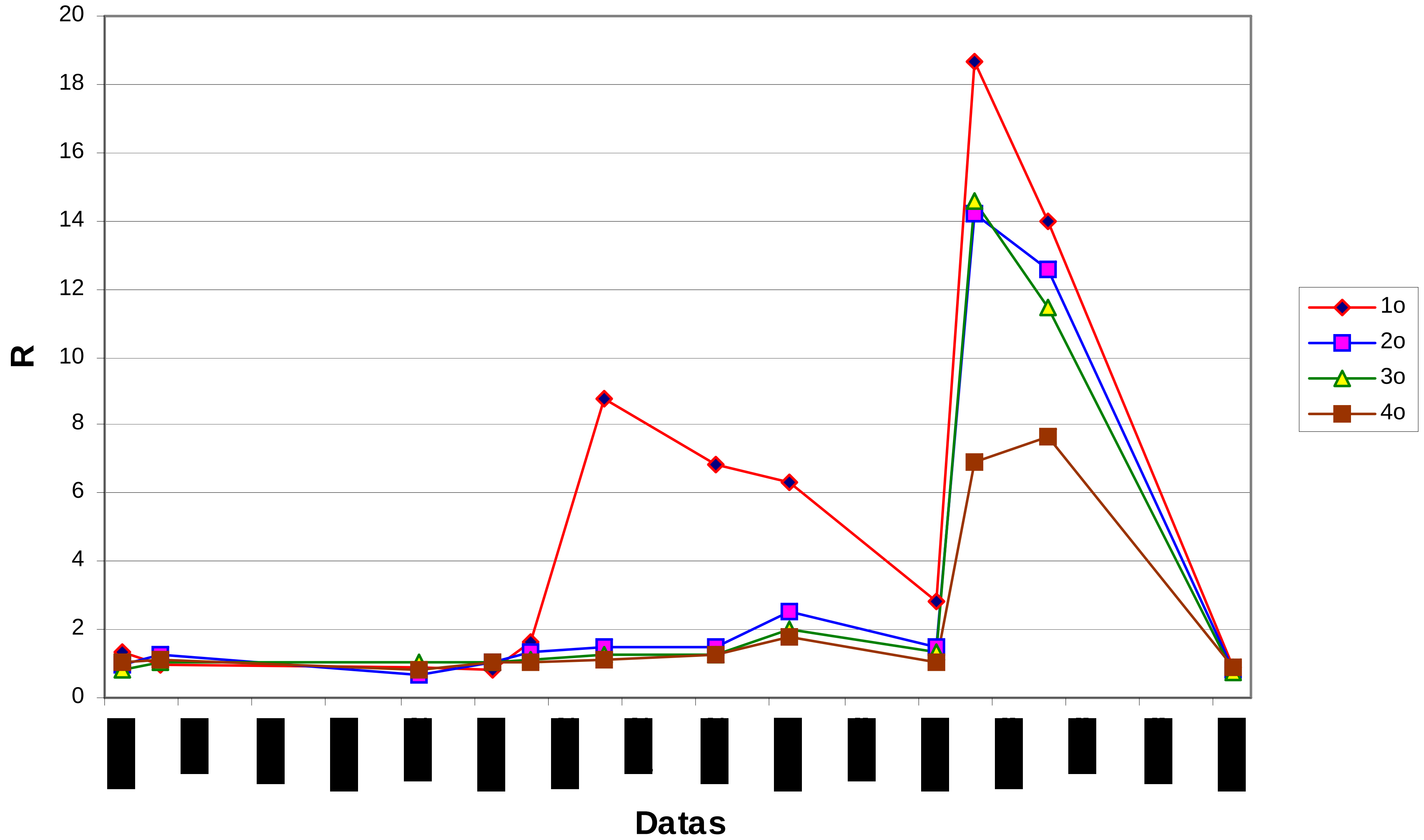
rolling bearing of the pump oil box



harmonics of the inner race defect frequency in the velocity spectrum (fi_v) at A5 position

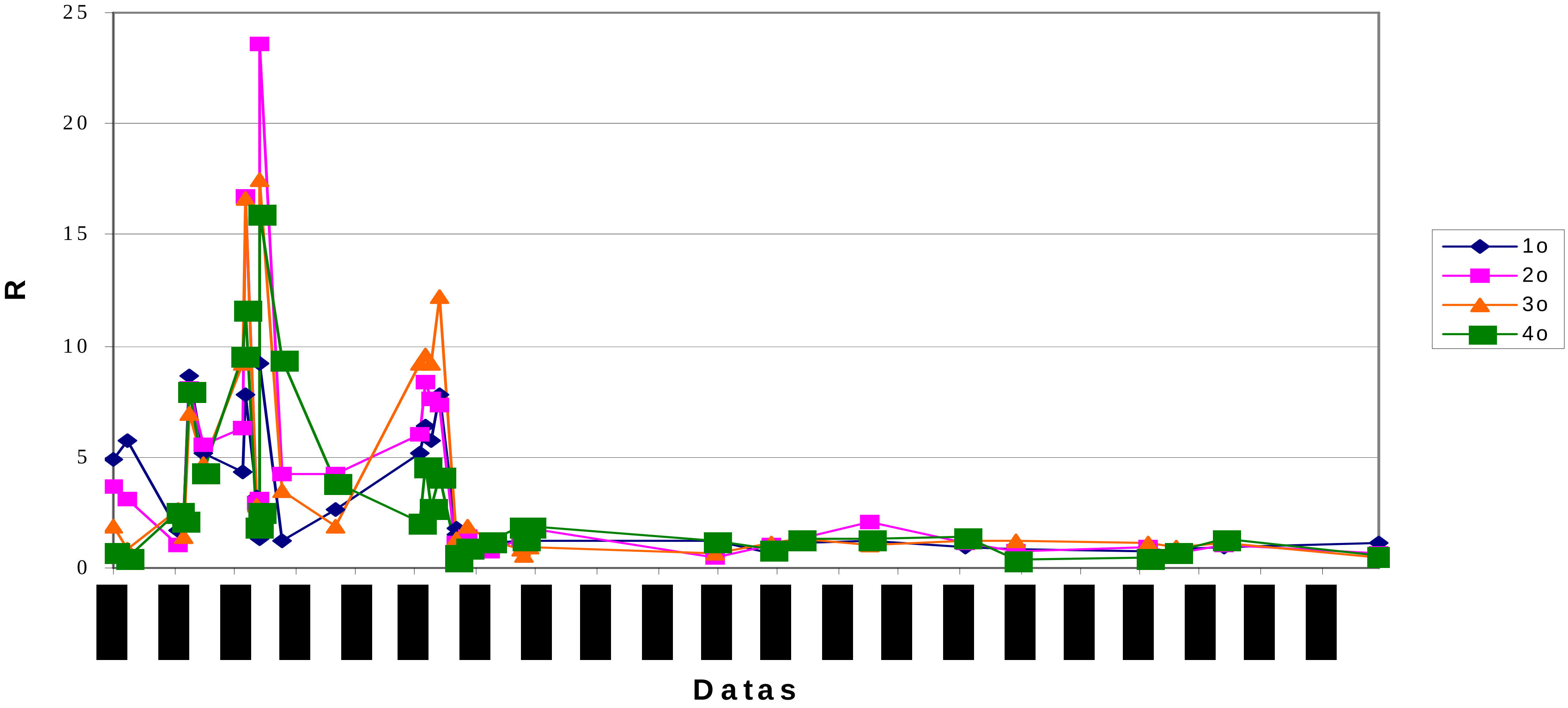


harmonics of the inner race defect frequency in the envelope spectrum (fi_e) at A5 position

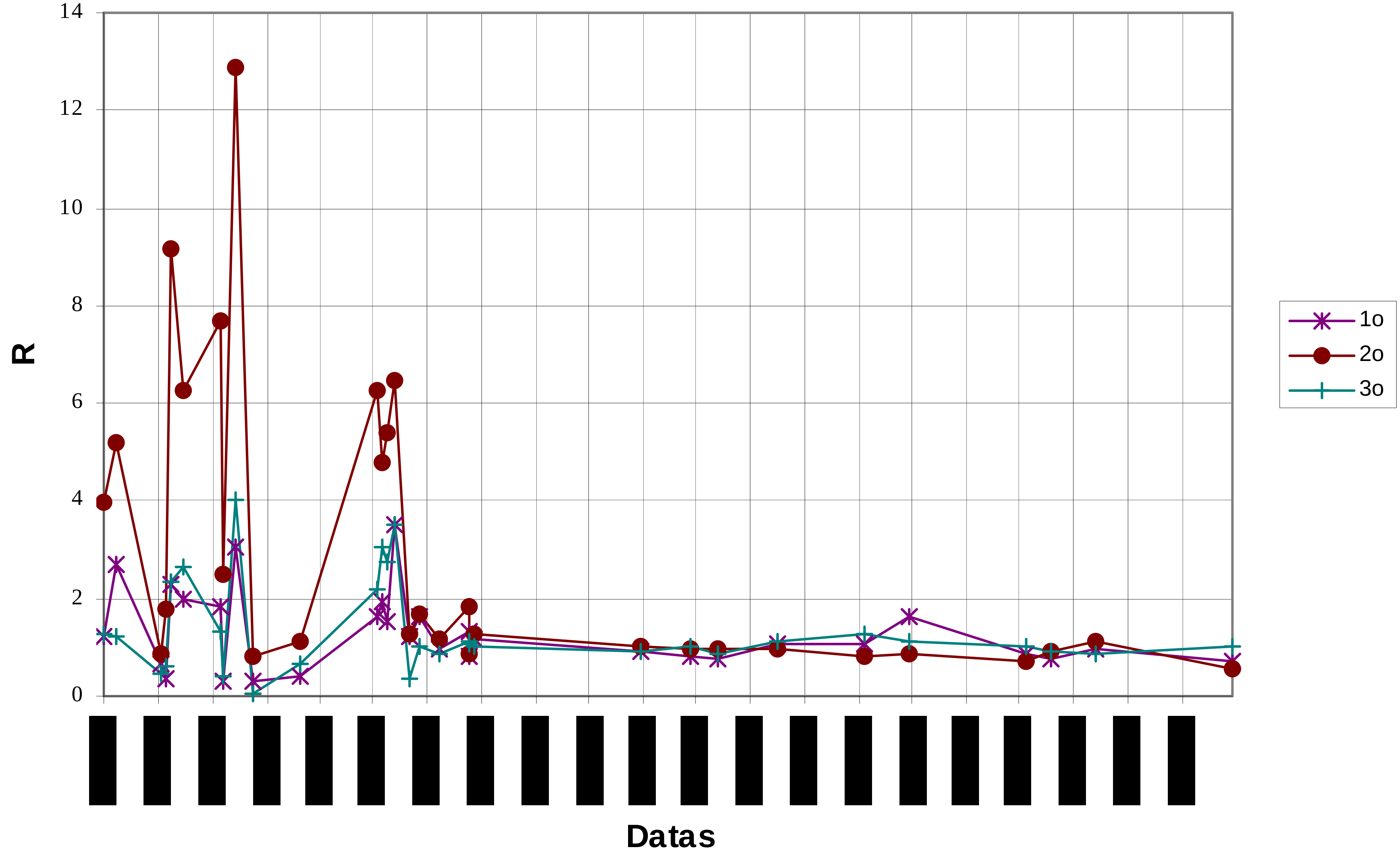


harmonics of the balls defect frequency in the envelope spectrum (fb_e) at A5 position

Lubrication problem in the A Pump until May 2001



shaft speed harmonics at A3 position



harmonics of the outer race defect frequency in the velocity spectrum (fo_v) at A3 position

Results in the MDSM

defect	common indicators	best direction	best parameters
imbalance	1h	H	1h
misalignmet			2h
looseness		H	2h,3h,4h
outer race	$fo_e(1,2,4)$, $Peak_a$	H	$fo_e(1,2,4)$
inner race	$fi_e(1,2,3,4)$, $fi_v(1,2,4)$, RMS_a, $Peak_a$, RMS_v	H	$fi_e(1,2,3,4)$
balls	$fb_e(1,2,3,4)$, $fb_v(3,4)$, RMS_a, $Peak_a$	V	$fb_e(1,2,3,4)$
cage	RMS_a, $Peak_a$	H	$Peak_a$
lubrication	$fo_v(1)$	V	$fo_v(1)$

The monitoring strategy

- imbalance, misalignment, mechanical looseness and rolling bearings faults

- the accelerometers positions on the pumps were confirmed

- continuous monitoring by CVMS and monthly parallel analysis

- the CVMS alarm limits were established based on the ISO10816 standard (R=2 for the alert limits)

Vibration parameters for the primary pumps monitoring

imbalance	misalignment	mechanical looseness	rolling bearing localized defects (**rbld**)	lubrication problems in rolling bearings
1h,2h, RMSv	2h,4h,RMSv	1h,2h,3h,4h 2nd,3th and 4th shaft speed inter-harmonics blade pass harmonics RMSv	four harmonics of the defect frequencies, in velocity and envelope spectrum RMS_a, $Peak_a$, RMSv	all parameters of **rbld** plus 1h,2h,3h,4h

Conclusions

- CVMS has been able to detect all mechanical defects

- additional analysis, such as the envelope, increases the safety and speed on the detection of defects

- vibration monitoring is complex and many parameters must be observed simultaneously

- tests in a concrete machine (MDSM) adds information and feeling that help to elaborate a monitoring strategy and to train people

- it is advisable: direct access to the raw data / analysis in a more flexible way

- vibration monitoring has been done with more efficiency, safety and confidence by the reactor operation staff