Southern California Edison Company

23 PARKER STREET

IRVINE, CALIFORNIA 92718

R. M. ROSENBLUM
MANAGER OF
NUCLEAR REGULATORY AFFAIRS

TELEPHONE
(714) 587-5420

January 17, 1990

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Subject: Docket No. 50-206
Final Acceptance Criteria for the
Thermal Shield Monitoring Program
San Onofre Nuclear Generating Station
Unit 1

The enclosure to this letter provides the final acceptance criteria for the reactor vessel thermal shield monitoring program in accordance with Provisional Operating License DPR-13 License Condition 3.M, "Cycle X Thermal Shield Monitoring Program." Interim acceptance criteria were previously provided to the NRC by letter dated September 6, 1989. On October 4, 1989 SCE received a telecopy of the staff's Safety Evaluation of the interim acceptance criteria which included six recommendations to be incorporated in the final acceptance criteria. This Safety Evaluation was later transmitted to us by letter dated November 3, 1989. These recommendations have been included in the final criteria.

The thermal shield monitoring program in conjunction with the enclosed acceptance criteria will provide sufficient indication of the thermal shield condition to assure the safe operation of Unit 1.

If you have any questions or desire further information, please contact me.

Very truly yours,

RM Rosenblum

Enclosure:
cc: J. B. Martin, Regional Administrator, NRC Region V
C. Caldwell, NRC Senior Resident Inspector, San Onofre Units 1, 2 and 3

2nd Dist
A001
1/1
See 12/4/90 Note from Dorin Foster
A001
1/1

Enclosure

THERMAL SHIELD MONITORING FINAL ACCEPTANCE CRITERIA

Monitoring of the San Onofre Unit 1 reactor vessel thermal shield consists of Neutron Noise Monitoring and Loose Parts Monitoring. The two methods are used in order to have two independent systems provide early information in the unlikely event of thermal shield degradation.

Neutron Noise Monitoring Methodology

The ex-core detector electrical current signals are recorded on an FM tape recorder or directly on a personal computer. At least three neutron noise inputs are monitored for at least twenty minutes once a week in accordance with License Condition 3.M, Section 3.b. The recordings are analyzed using Power Spectral Densities (PSD's), Cross Power Spectral Densities (CPSD's), and Coherence and Phase functions to provide thermal shield frequency and amplitude data for comparison with base line information. In addition in-phase and out-of-phase PSD's are performed to enhance signal analysis.

The processed data are provided to Westinghouse for review and evaluation. To ensure the data are analyzed as expediently as possible, the data are transmitted to Westinghouse via telephone modem. Floppy disks containing the data and hardcopies of the plots are mailed as a backup when necessary.

Neutron Noise Final Acceptance Criteria

After establishing the interim acceptance criteria, seventeen (17) sets of data were acquired from July 1, 1989 to September 4, 1989 over the power range of 85% to 92%. The data were analyzed by Westinghouse and the final acceptance criteria for the neutron noise monitoring program were established based on the cumulative increases or decreases in neutron noise PSD levels and/or changes in the center frequency of spectral peaks.

Curves have been established to envelope the PSD of the signals of each of the eight ex-core power range detectors for the seventeen neutron noise data sets. The signals used to generate the PSD's have been processed using a high pass filter with a center frequency of 0.8 Hz. Figures A through H show the base line PSD levels (Curves 1 and 4) and PSD levels for monitoring (Curves 2, 3, 5 and 6) for all eight of the ex-core power range detectors.

Curve 1 is the upper base line curve generated directly by connecting the maximum envelop points of the base line data.

Curve 2 has been established at a level which is 80% above base line (Curve 1) and represents the noise level at which analysis and evaluation of the data for trends (Curve 1 level is 56% of Curve 2 level) would be initiated.

Curve 3 has been established at a level 200% above Curve 1 (Curve 1 level is 33% of Curve 3 level). This represents a level of neutron noise that would require NRC notification as indicated in License Condition 3.M, Section 4. The Curve 3 amplitude levels are well below the average levels inferred from analytical predictions for thermal shield Beam Modes for the postulated thermal shield worst credible degraded case (failure of the remaining flexure, failure of all of the support block bolts, and loosening of the dowel pins), and the levels inferred for the case of postulated failure of the intact flexure with three support blocks degraded.

Curve 4 is the lower base line curve generated directly by connecting the minimum envelop points of the base line data.

Curve 5 has been established at a level which is 56% of the lower base line Curve 4 and represents the noise level at which the data would be analyzed in detail and any trends in amplitude or frequency shift evaluated.

Curve 6 has been established at a level 33% of Curve 4. Curve 6 represents a level of neutron noise that would require NRC notification as indicated in License Condition 3.M, Section 4. Qualitative examination of the Curve 6 PSD levels for the 1206 and 1208 upper and lower detectors (see Figures C, D, G and H), where more pronounced resonance peaks were detected, indicate that if any predominant resonance peak was to decrease to a level giving a smooth transition between adjacent valleys, the Curve 6 level would be reached or surpassed.

Curves 5 and 6 represent a reduction in the neutron noise PSD levels corresponding to a postulated thermal shield degradation. Although specific degradations leading to lower PSD levels are not predicted by analysis, as a precaution, curves 5 and 6 are developed to detect and report reductions in the PSD levels in the event that they occur. As stated above, curves 5 and 6 are 56% and 33% of curve 4 respectively. This relationship is similar to curves 2 and 1 which are 56% and 33% of curve 3 respectively.

The following actions will be taken depending on the amplitudes of the data collected during ongoing neutron noise monitoring:

1. If Curve 2 or Curve 5 levels are reached at any frequency, detailed examination of the trends of amplitudes and center frequencies of dominant peaks will be performed. Accelerometer data will be reviewed, and analysis results and information from other plants will be used, as needed, to study the observations from the SONGS 1 data.

2. If Curve 3 or Curve 6 levels are reached at any frequency, the NRC will be informed within one day as indicated in License Condition 3.M, Section 4.a. Studies will be performed to establish the causes of the increase or decrease in neutron noise level. Within 14 days the conditions will be evaluated and a report provided to the NRC documenting future plans and actions per License Condition 3.M, Section 4.b.

Below 1.1 Hz, the lower criteria lines apply only to the spectrum peak. Increases in neutron noise signal levels have been attributed to core burnup and boron concentration changes in many plants. As a larger neutron noise data base is accumulated, the trends that are caused by changes in core burnup and/or boron concentration can be substantiated. Increases in neutron noise levels due to burnup and boron depletion are not uniform for all plant designs. Reference 1 notes that these effects can differ significantly depending on the fuel loading or design. Burnup effects should not cause changes in natural frequencies, although a shift in fuel assembly natural frequencies over the first fuel cycle was inferred from the data reported in References 1 and 2. As reported in Reference 1, an essentially linear increase in RMS signal levels occurred with "soluble boron concentration changes associated fuel burnup." Westinghouse experience is consistent with the above.

If Curve 2 levels are reached, the data will be initially reviewed for trends that are likely to be a result of burnup and boron depletion effects. If a trend indicative of the effects discussed above is found, the criteria will be adjusted to reflect the trend. The necessary adjustment will be established by calculating the trends of RMS levels over frequency bands established by review of the spectra. The observed changes will be assumed to be linear throughout the fuel cycle. The boron concentration and burnup at the time of data collection will be used as parameters and the trends will be compared with experience gained from other plants, i.e., the variations should have a rate consistent with values observed at other plants.

The base line PSD levels (Curves 1 and 4) and PSD levels for monitoring (Curves 2, 3, 5 and 6) will be adjusted for cycle burnup and boron concentration changes during the cycle.

Loose Parts Monitoring Methodology

The second method of detecting potential thermal shield problems is with the use of the Loose Parts Monitoring System. SCE has installed four (4) accelerometers for loose parts monitoring. These accelerometers are mounted at 90 degree intervals on the reactor vessel upper flange at approximately the same elevation as the core barrel seating flange. The License Condition 3.M, Section 3.a requires that a minimum of two (2) accelerometers be operable in Mode 1. The monitoring of each accelerometer consists of the following:

1. Spectral characteristics at normal background levels have been recorded to establish a base line for later comparison. This was initially done when the unit reached 85% power and will be used as a basis for comparison with subsequent spectral plots when the situation warrants, i.e., when alarm limits are exceeded or abnormal noise is noted.

2. RMS voltage values are recorded for a period of five minutes twice a day in accordance with License Condition 3.M, Section 3.a. The values are trended to detect any changes in noise level and are analyzed for possible loose parts activity. The trends will also be used to determine if there is any accelerometer signal degradation (see Figures J, K, L and M).

3. The recording of all loose parts monitoring activity, including RMS values and audio background noise levels, is performed twice daily. Once a week the cognizant engineer and a member from the Performance Monitoring Group (PMG) review the data for any anomalies.

4. Audio recordings have been collected at 15%, 30%, 70%, and 85% power to establish an audio background noise base line. If anomalies are noted, recordings will be compared to the base line recordings (see Loose Parts Monitoring System Final Acceptance Criteria below).

Accelerometer Impact Sensitivity

Essential to early loose part detection is the question of system sensitivity. Regulatory Guide 1.133 specifies the minimum sensitivity requirements for a Loose Parts Monitoring System. The requirement is that the system can detect a metallic loose part that impacts with a kinetic energy of 0.5 ft-lb on the inside surface of the reactor coolant pressure boundary within three feet of a sensor. On July 19, 1989, with the unit at normal operating pressure and temperature, testing was performed at a distance well in excess of the three feet requirement and also at a location which had a transmission path to the sensors which had several component interfaces. This path provided many sources of impact signal reflections and attenuation. Despite these conditions the impact signal is evident in Figure I as detectable well above the normal background level. The accelerometers and charge amplifiers are manufactured by Dytran Instruments and have a nominal total system sensitivity of 1 volt/g acceleration.

The results of this impact test clearly indicate that the Regulatory Guide sensitivity requirement is satisfied.

Loose Parts Monitoring System Final Acceptance Criteria

Impact test data collected in Modes 3 and 5 (used to determine accelerometer sensitivity) and data collected at 30% and 85% power were sent to Combustion Engineering (CE) for review and evaluation. The data were used to establish the basis for the following acceptance criteria:

> If the ratio of the peak to average RMS value exceeds four times the average RMS ratio during the 5 minute monitoring interval, then the monitoring interval will be extended to twenty minutes and an event count will be initiated which will count the number of peaks which exceed the four times average ratio. If the count rate exceeds one per ten minutes over a two week period, the NRC will be informed within 1 day as indicated in License Condition 3.M, Section 4.a. Within 14 days the condition will be evaluated and a report provided to the NRC documenting future plans and actions per License Condition 3.M, Section 4.b.

Based on the evaluation of the data collected it was determined that peak RMS signals two times the standard deviation of the average RMS values are normal activity due to the background noise.

Attached Figures J, K, L and M are examples of the recorded RMS peak to average ratio values from the four Loose Parts Monitoring System accelerometers. All of the recordings were made while the unit was operating in Mode 1. These recordings are plotted vs. time to establish a trend and to observe possible increases in the RMS values.

References

1. F. J Sweeny, J.Mach-Leuba and C. M. Smith, "Contribution of Fuel Vibrations to Ex-Core Neutron Noise During the First and Second Fuel Cycles of the Sequoia 1 Pressurized Water Reactor," Progress in Nuclear Energy, 1985, Vol. 15 pp 283-290.

2. F. J. Sweeny, "Sensitivity of Detecting In-Core Vibration and Boiling in Pressurized Water Reactors Using Ex-Core Neutron Detectors," NUREG/CR-2996 (ORNL/TM-8549), July 1984.

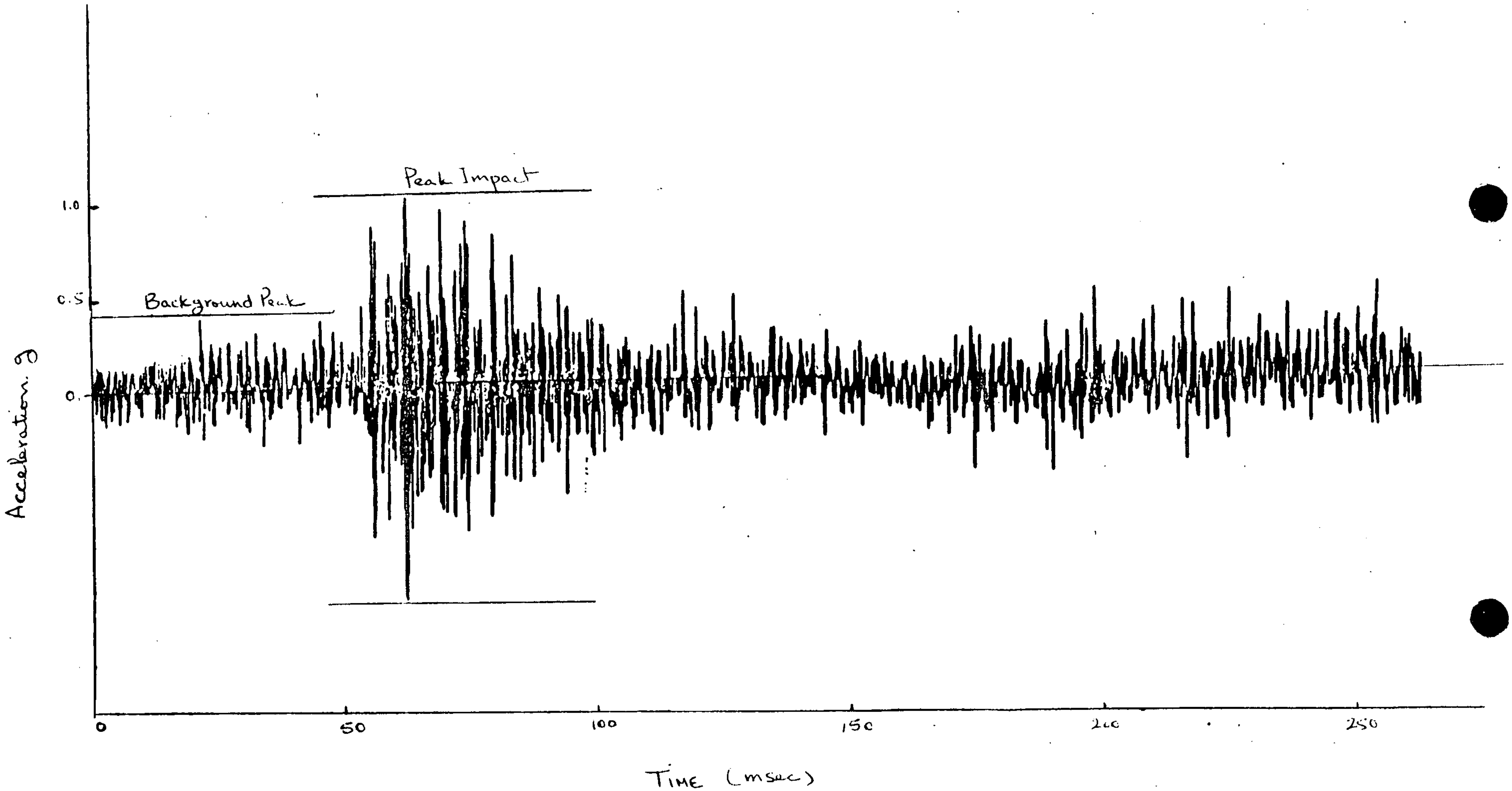
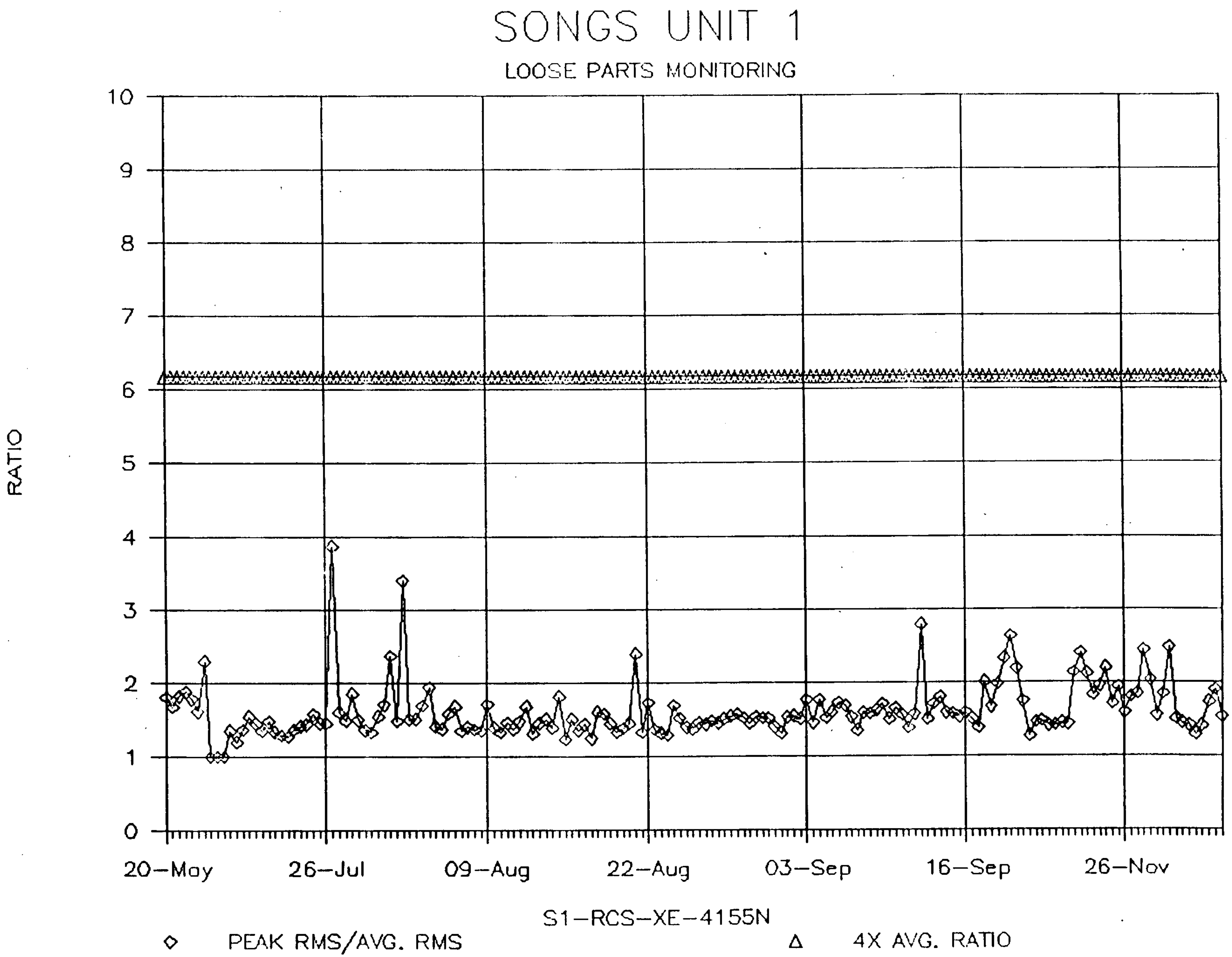


Figure I. Time History of Impact Test Signal



igure J. Typical RMS Peak to Average Ratio, Loose Parts Monitoring System, Accelerometer No. 4155N.

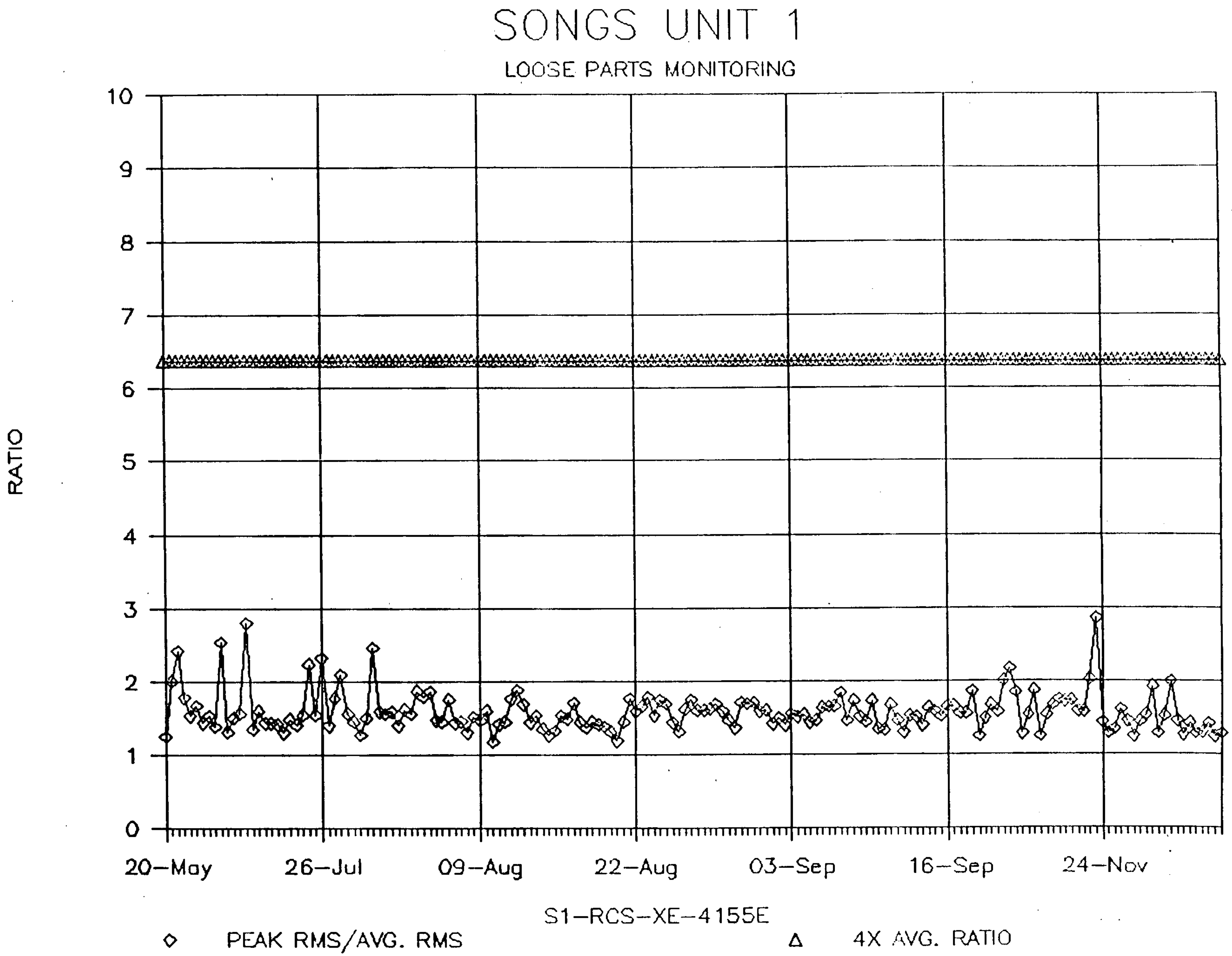


Figure K. Typical RMS Peak to Average Ratio, Loose Parts Monitoring System, Accelerometer No. 415[illegible]E.

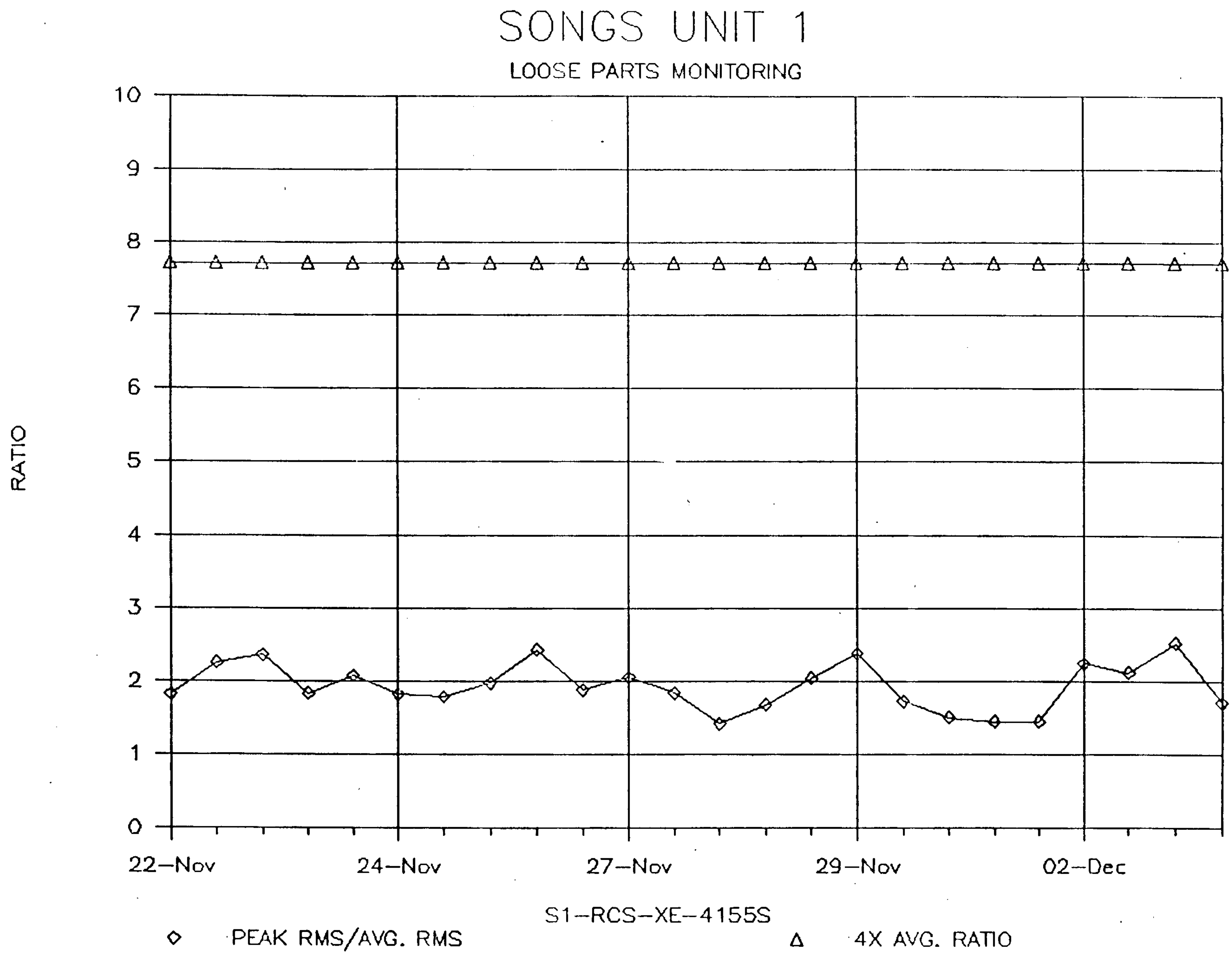


Figure L. Typical RMS Peak to Average Ratio, Loose Parts Monitoring System, Accelerometer No. 4155S.

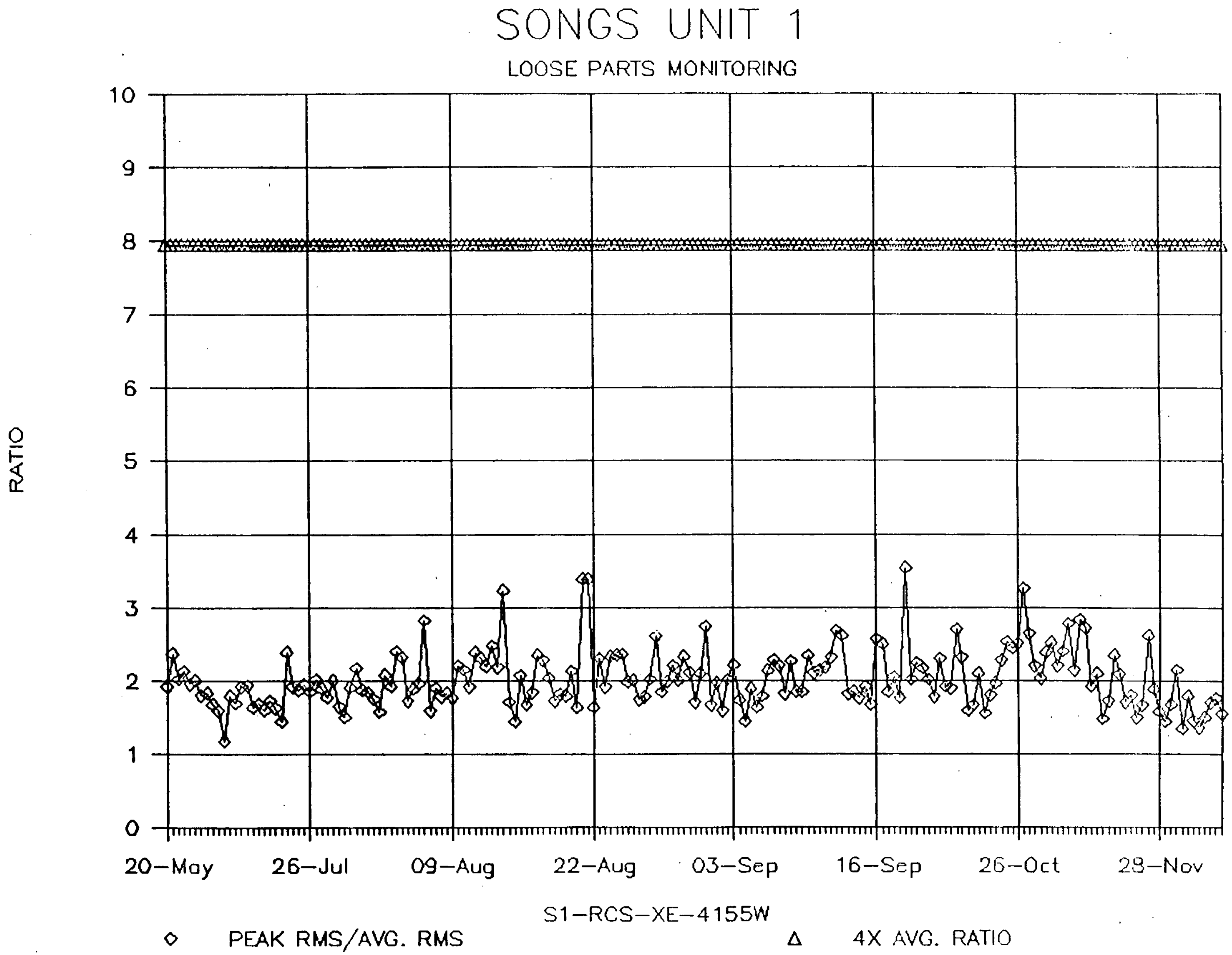


Figure M. Typical RMS Peak to Average Ratio, Loose Parts Monitoring System, Accelerometer No. 4155W.