Transport Roads & Maritime Services

NSW GOVERNMENT

Test method T182

Road roughness testing

OCTOBER 2012

Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary Added	D.Dash	May 1999
		Date on Test Method Revised to Agree with Date on Revision	D.Dash	Feb 2001
Ed 2/ Rev 0		Reformatted RMS template	J Friedrich	October 2012

Note that Roads and Maritime Services is hereafter referred to as 'RMS'.

The most recent revision to Test method T182 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T182

Road roughness testing

1. Scope

This test method defines the procedure for measuring ride quality determined from a response-type road roughness measuring system (RTRRMS). The NAASRA Roughness Meter is a conventional motor vehicle instrumented and calibrated against a repeatable profile-based measuring system which is stable with time. An electronic data acquisition system should normally be installed.

2. Definition

Roughness is a measure of the riding quality of pavement surfaces in response to longitudinal road profile. The NAASRA meter measures the total accrued vertical axle-to-body displacement in the upward (return) direction between the differential housing and body of the vehicle in which the meter is fitted, while travelling at any specified speed

The amount of movement being measured on any particular pavement depends on speed of travel and suspension characteristics of the vehicle. Special procedures are necessary to establish correlations between vehicles and to ensure that the measurements are related to a standard both initially and over a period of time.

Roughness is recorded at standard, constant speeds against distance travelled and reported in counts per kilometre where a single count is equivalent to a displacement of 15.2 mm.

The AUSTROADS Pavement Design Guide gives values for suggested terminal roughness values for different road classes generalised here as follows:

Type of Road	Counts per km
High Standard Roads (Highways)	110
Country Main Roads	150
Minor Urban Roads	175

3. Apparatus

3.1 Family-sized station wagon, preferably consistent with ARRB and other current State Road Authority vehicles fitted with the following:

(a) Odometer with reading accuracy 0.1 kilometres

(b) High uniformity radial ply tyres;

(c) KONI adjustable rear shock absorbers;

(d) High uniformity rear coil springs;

(e) Cruise control (optional)

(f) NAASRA Roughness meter

(g) Ballast of 100kg secured within the vehicle equally distributed over the back axle. Ballast to be adjusted to maintain 100kg if luggage or extra load is carried

(h) Data Acquisition system capable of capturing roughness counts for each 100m interval and recording to an IBM compatible lap-top computer

(i) No roof bars, luggage racks or signs should be installed in a manner causing wind to influence roughness measurement. Appropriate warning devices such as magnetic signs should be provided

4. Procedure

4.1 Pre-Test Checking

(a) Only two people should be in the vehicle during testing and both should occupy the front seats.

4.1.2 Apparatus

(a) Tyre inflation as per Appendix 1

(b) Safety/Warning devices are fitted

(c) Computer and cables are installed and all test apparatus is operating correctly

(d) Start computer data acquisition program

(e) Approach start of test lane at appropriate test speed (2.1 below)

(f) Check data is being recorded and corresponds with distance measured and features observed

4.2 Driving:

4.2.1 Speed

The response to different types of road deformation is dependent on speed so that a constant, standard speed must be maintained during testing as follows:

(a) Urban: 50 kmph Non Urban: 80 kmph

(b) In some circumstances these speeds may not be safe so that the maximum safe speed must be adopted that is below the standard speed and within the prevailing speed limits

(c) Results should be rejected where speed deviations of more than 10 kmph occur and the section should be tested again

4.2.2 Technique

Acceleration and braking will be recorded as roughness. Errors arising in the testing will be small if these activities are done smoothly and consistent with safety so as to reduce axle-body movement not attributable to the road surface.

(a) Overtaking is permitted where it can be carried out smoothly and provided that each lane is of similar roughness so that no significant error will arise. A note should be made of all such events that may influence roughness measurements

(b) The vehicle must be driven in the centre of the test lane which will generally be along the usually trafficked wheel paths. The wheelpath through curves and corners is not always central to the lane and it may then be preferable to follow the wheel paths to allow safer vehicle handling

4.2.3 Road Surface conditions

No attempt should be made to consciously avoid or encounter obvious pavement defects unless it could be expected to damage the vehicle, affect calibration or that some other risk may ensue.Such defects that influence the roughness count or were consciously avoided must be noted. Bridges, railway crossings, culverts, trenches etc should be noted. Construction and maintenance operations should be noted by "end of seal", and "start of seal" comments.

(a) Testing should be terminated when roughness counts above 200 counts per kilometre are being sustained. Care should then be taken to travel so as to avoid potential damage or risk until testing can be recommenced. The corresponding report for that length should indicate roughness above 200 counts per kilometre and that testing was terminated.

4.2.4 Test Lane

The lane tested shall be that used by the majority of traffic, generally the slow (kerb) lane in a multi lane rural situation and the median lane in the urban situation where the kerb lane is generally obstructed by parked vehicles. Any exception to this should be noted.

4.2.5 Wind

The effect of strength and direction of wind may have some bearing on the roughness recorded. Testing should generally be avoided if the wind velocity is greater than 25 kmph. Testing should also be abandoned during sustained heavy rain.

4.3 Recording of Data

The roughness value in counts/km is determined by dividing the roughness count over a given length by that length, (e.g. for 0.5 km, roughness count = 40, Roughness = 40/0.5 = 80 raw counts/km).
Raw values must be substituted into the calibration equation which is current for the corresponding vehicle and test speed.

At each interval where roughness is recorded the following data is essential:

(i) NAASRA count

(ii) Odometer reading

(iii) Any variation from test speed

The following data should be recorded for each test section:

(a) Test vehicle identification number

(b) Vehicle registration number

(c) Driver and operator's name

(d) Weather conditions (temperature, wet etc)

(e) Date

(f) Front and rear tyre pressures

(g) Test speed (50 or 80 kmph)

(h) Road number (e.g. MR184, SH10)

(i) Start, and end ROADLOC reference (CP or RP)

(j) Intermediate features and ROADLOC references

(k) NAASRA Roughness counts at 0.1 km intervals for a survey and for construction control etc

4.4 Reference points

All data is to be collected with reference to the Road Authority's accepted road referencing system such as the "ROADLOC" system.

4.5 Manual recording

Roughness results can be measured by reading and manually recording successive readings shown on the mechanical recording device against distance recorded from the vehicle odometer, or a separate calibrated distance measuring device.

4.6 General

In the event that the rear of the car is to be jacked the roughness linkage cable must first be disconnected from the differential housing.

5. Calibration

The calibration procedure is set out in Appendix 3. Calibration involves three phases as follows:

- Preparation of vehicle and equipment;
- Measurement of reference sections;
- Correlation of vehicle to reference measurements

5.1 Component calibration and installation

The general principle to be followed during installation of a roughness testing vehicle is to establish a condition that can be maintained during the life of the vehicle by minimising faults or imbalances that would induce roughness counts. Calibration of a vehicle can best be maintained if all components, including replacement parts, can be made to conform to a reproducible and measurable state or condition. Calibration between vehicles is important as reference back to a standard vehicle held by the Australian Road Research Board (ARRB) is made when reporting results. Different makes and models of vehicles and components have been used over time. While it may be possible to control and calibrate a diversity of vehicle configurations every effort should be made to conform to the vehicle and components used by ARRB and within the State Road Authorities at the time.

Care should be taken to check and maintain any component(s) of the vehicle or testing system that could potentially influence the ride of the vehicle or the recording of results.

5.1.1 Vehicle Components

(a) **Shock Absorbers:** Brand name rear shock absorbers are specified for uniformity and performance; however their major feature over alternatives is that they are adjustable. Before any shock absorbers are fitted for use in Roughness testing their uniformity and response must be tested to produce a force/displacement curve. Shock absorbers should be adjusted to comply as per Appendix 1. A printed copy of the response envelopes for each shock absorber must be retained as a record for the corresponding vehicle

(i) Shock absorbers may be re-used, rebuilt or transferred between vehicles provided they are checked for signs of oil leakage or damage and they are re-tested and again adjusted. New or rebuilt shock absorbers do not require being "run-in" on a vehicle before testing

(ii) Front suspension components are not usually changed or tested unless problems are experienced in achieving calibration which may be attributable to some adverse condition of those components

(b) **Springs:** Rear springs should be tested to ensure compliance with the manufacturer's specifications and reset or replaced as necessary

(c) **Wheels and Tyres:** Wheels must be balanced electronically and tyres checked for roundness. Tyres will generally require machining. Wheel rims need not be separately checked unless problems are indicated. Wheels should be fitted to the vehicle with wheel nuts tensioned alternately and to manufacturer's specifications using a torque wrench. Air operated equipment should not be used and wheels should not be "rotated" around the vehicle as is common during vehicle servicing. Wheels should not be removed unnecessarily

(d) **Odometer:** The vehicle odometer should be checked for accuracy of both speed and distance recording by at least running against distances measured to a known accuracy

(e) **Dynamometer Testing:** The vehicle should be run on an unloaded dynamometer at a speed of 80kmph for the equivalent of 15 km and not more than 30 roughness counts should be generated. Both the manual and electronic systems should be read during this testing. In the case of the manual system signs of cable "wind-up" should be investigated to ensure that counts, if any, are recorded evenly over each kilometre

5.1.2 Computer and Data Acquisition Systems

During the calibration process the manual counter should be read concurrently with the electronic system.

5.2 Reference Sections

Reference sections must be established so that the response of a Roughness vehicle can be correlated to the respective measurement established using a Laser Profilometer and "maintained" since the date of calibration. Apart from visually checking that sections have not obviously changed, maintenance of a site is implied by the ability to obtain correlation over the range of sections for properly prepared vehicles. For example a drift or sudden change in one calibration section would generally suggest a change in the site rather than a problem with the vehicle. Sufficient sections should be selected and measured to allow some redundancy of sections.

The integrity of any sections used as a reference diminishes with time and sites at the higher end of the scale in particular may change most rapidly. A centralised circuit of calibration sites traversed regularly by

a number of roughness vehicles is recommended. Re-measurement by a reference vehicle is required at intervals of between one and two years.

5.3 Initial Calibration Equation:

Repeat runs across the maintained set of reference sites are required to establish a calibration equation by means of correlation with the NAASRA standard Profilometer vehicle. The highest level of confidence in calibration arises where the Profilometer traverses the calibration sites with the vehicle being calibrated each tracking the same path. Alternatively the new or replacement vehicle must be calibrated on the reference sections at the same time as another calibrated roughness vehicle (preferably one which has been calibrated against the ARRB vehicle). Both vehicles should be operated to the same procedure as specified for road roughness testing.

5.4 Maintenance of calibration

5.4.1 Verification

Calibration of Roughness vehicles must be verified:

- At intervals not exceeding 5000 kilometres of vehicle travel regardless of actual testing distance or conditions traversed;
- When components likely to influence calibration are replaced repaired or adjusted such as tyres, wheel re-alignment and suspension components
- Where damage could reasonably be anticipated, such as after striking a kerb
- When replacement is made to any part or the whole of the instrument

Testing should be terminated where damage such as faulty wheel balance or alignment becomes obvious to the driver.

Checking of calibration is best achieved by following the same procedure on the same sites as used for the initial calibration. The checking of calibration is done by correlating the current roughness results obtained against the corresponding results obtained by the same car during initial calibration. If the degree of correlation with the original results is unacceptable the vehicle and the operating procedures require to be checked to identify the potential source of the difference. After modifications or adjustments have been made the calibration exercise should be repeated. A new calibration equation for the vehicle can only be obtained by reference to the measurements made by the Profilometer. The calibration equation is established by the statistical process of regression of the Roughness vehicle in its current state to the results obtained from the Profilometer.

A check of the state of calibration, or the drift in calibration with time, can be made by subsequent reference of the car to its own original sets of results. A local set of reference sites established by a calibrated RTRRMS remote from the initial calibration sites is adequate for checking calibration but not adequate for establishing an initial or new calibration equation for a vehicle.

5.4.2 Precautionary Measures

Reasonable care of the vehicle is required between testing applications particularly where a vehicle is used for other duties. It should be expected that people called upon for repairs, service or even installation will be unfamiliar with maintenance of a roughness vehicle. For example tyres may be changed or inflation pressures varied or the linkage cable could be damaged or broken due to jacking of the car body. The following control is required:

- The vehicle must not be overloaded or left loaded for any length of time;
- Avoid running over terrain likely to damage or upset the wheel balance and steering alignment;
- Tyre pressure should be maintained to avoid tyre wall damage;
- Damaged tyres should be replaced rather than repaired. Preferably replace a pair of tyres to maintain even tyre elasticity and wear
- If the period between tests is of long duration calibration should be carried out to compensate for change to both vehicle and operator performance

5.5 Change of Vehicle

When another vehicle is to be used for roughness measurements it must be calibrated with a vehicle already in use for roughness measurements or against the Profilometer as outlined for initial calibration.

5.6 Keeping of Records

A compilation of the calibration history of a Roughness vehicle should be maintained over the life of the vehicle. The format and details required are shown in Appendix 3. Equipment and components such as shock absorbers may be transferred to another vehicle and relevant corresponding documentation should be retained accordingly.

Records should detail:

- Modifications and adjustments that were required to achieve initial calibration
- Any damage and subsequent repairs to the vehicle or equipment
- Times and details of each check calibration and distance travelled since last calibration

5.6.1 The following maintenance checks should be made weekly

(a) Ensure all nuts and screws on the test instrument are tight

(b) Check cable wire for signs of fraying and chain for damaged links

(c) Check the tension spring for permanent set

(d) Check clutches for excessive play

APPENDIX 1

Roughness Car - Set-up and Operation

NAASRA Roughness Meter Installed as per "Standard Operating Instructions for the NAASRA Roughness Meter and Guide for the Present Serviceability Rating of Road Pavements" ©Austroads

Shock Absorbers

(i) KONI 80-2233 Special D Type adjustable rear shock absorbers are specified and their uniformity and response must be tested and adjusted to produce a force/displacement curve to comply as per Figure 1 at 1.5Hz excitation and 30mm displacement. A printed copy of the response envelopes for each shock absorber must be retained as a record for the corresponding vehicle

(ii) Shock absorbers may be re-used, rebuilt or transferred between vehicles provided that they are checked for signs of oil leakage or damage and they are re-tested and adjusted as per Figure 1

New or rebuilt shock absorbers do not require being "run-in" on a vehicle before testing

Front shock absorbing systems are not currently replaced or tested unless problems are experienced in achieving calibration which may be attributable to some adverse condition of those components

Springs

(i) Rear coil springs shall be tested to ensure compliance with the manufacturer's specifications and replaced as necessary

Wheels and Tyres

(i) Tyres shall be Goodyear P185/75 SR14 Grand Rally S, or similar high conformity tyres

(ii) Wheels must be electronically balanced and checked for roundness. Tyres will generally require machining to provide roundness

(iii) Wheel rims need not be separately checked unless problems are indicated

(iv) Wheels shall be fitted to the vehicle with wheel nuts tensioned to manufacturers' specifications using a torque wrench

Note Air operated equipment must NOT be used.

(v) Operational tyre air pressure shall be 210kPa (cold)

(vi) Wheels shall not be unnecessarily removed from the vehicle

(vii) The practice of wheel rotation to equalise tyre wear must not be performed. Tyres shall always be treated as pairs, i.e. front pair and rear pair

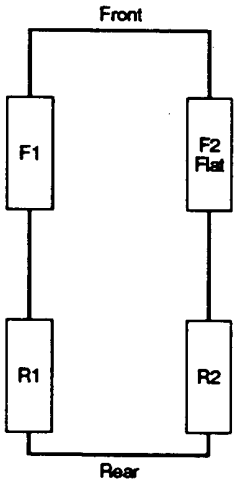
(viii) In the event of damage or puncture to a front tyre it may be replaced by the spare tyre and testing proceeds for the remainder of the current test journey

A new tyre should be fitted to replace the undamaged front tyre, in order to maintain a "pair" i.e. two tyres in the same condition at the front and rear of the vehicle

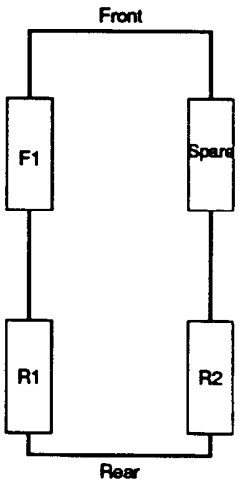
The damaged or flat tyre may be repaired at the first opportunity if replacement tyres are not available and refitted, with all tyres returning to their original positions on the vehicle

Any repaired tyre/rim combination must be checked electronically for balance and roundness as if it were a new tyre

FRONT TYRE FAILURE



TEMPORARY WHEEL CONFIGURATION

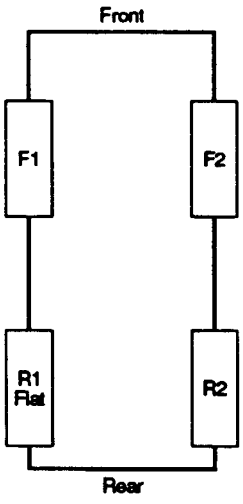


(ix) In the event of damage or puncture to a rear tyre, both rear tyres must be replaced by the front tyres. The good rear tyre and the spare tyre may then be fitted to the front of the vehicle and testing may proceed for the remainder of the current test journey

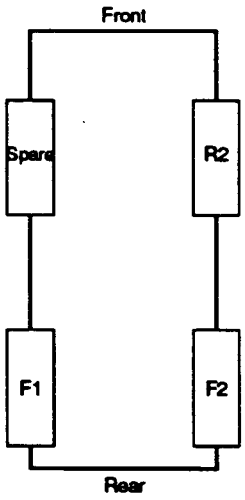
(x) A new tyre should be fitted to replace the undamaged tyre, in order to maintain a <169>pair<170>, i.e. two tyres in the same condition at the front and rear of the vehicle

(xi) The damaged or flat tyre may be repaired if replacement tyres are not available and refitted, with all tyres returning to their original positions on the vehicle. Any repaired tyre/rim combination must be checked electronically for balance and roundness as if it were a new tyre. The repaired tyre must be replaced at the first opportunity

REAR TYRE FAILURE



TEMPORARY WHEEL CONFIGURATION



IN ALL CASES, CALIBRATION MUST BE PERFORMED AT THE FIRST PRACTICAL OPPORTUNITY AFTER A TYRE HAS BEEN CHANGED

Dynamometer Testing

The vehicle shall be run on an unloaded dynamometer at both 50kph and 80kph for the equivalent of 15 km. The maximum permissible average roughness being 2 counts per kilometre.

Both the manual and electronic systems shall be read during this testing. In the case of the manual system signs of cable "wind-up" must be investigated to ensure that counts, if any, are recorded evenly over each kilometre.

Computer

A lap-top computer used in the test vehicle shall be mounted in accordance with Australian Design Rule 21.

Ballast

Ballast is to be of 100kg dead load, securely located over the rear axle and placed symmetrically on each side of the tower assembly.

The ballast should be adjustable to make allowance for extra load in the form of additional fuel, luggage, etc.

APPENDIX 2

Data Collection and Reporting

(i) Road Roughness values must always be reported in the form:

NAASRA Roughness counts per kilometre

(ii) Unedited raw data and vehicle calibration history shall be retained in a secure, long-term repository

(iii) Routine survey interval is one hundred (100) metres

(iv) All data shall be collected using the Roads and Traffic Authority, NSW, road referencing system "ROADLOC"

(v) Survey results shall be reported in the appropriate format for upload to the relevant corporate database

APPENDIX 3

CALIBRATION PROCEDURE

It is essential that the vehicle be in optimum testing condition prior to calibration:

- Wheels balanced and aligned
- tyres round (milled) and correct pressure (210 kPa - cold)
- full fuel tank at start of test

Sites

(i) There shall be at least fifteen sites surveyed by ARRB Profilometer, selected to provide examples spanning the range of Roughness measurements

(ii) The number of sites should allow for redundancy due to reconstruction or repair, particularly among those sites at the high (175 counts/km = terminal Roughness of minor urban road) end of the Roughness range

(iii) Each site shall be of constant Roughness for the whole site, at least one (1) kilometre in length and as straight as local terrain permits

Procedure

(i) Calibration shall be performed at 50kph and 80kph to derive calibration factors for application to data collected in both urban and rural surveys

(ii) Survey interval for calibration purposes shall be five hundred (500) metres

(iii) Each site shall be tested eight (8) times at each survey speed and reported in the form: Roughness counts/kilometre @ z kph

(iv) From these measurements, the mean, standard deviation and percentage coefficient of variation shall be calculated for each site at each speed.

(v) The mean result of a set of site calibration runs shall be considered to represent the roughness value for that site at that given speed, as measured by the vehicle being calibrated, where the percentage coefficient of variation is less than 5

(%CoV = (standard deviation/mean) * 100).

The mean measured value for each calibration site shall be compared with the NAASRA value and the relationship between the two sets of values defined using the 'least squares' criterion. This correlation shall be reported in algebraic and graphical form, as per Figure 2.

The calibration equations for application to test results gathered by the vehicle being calibrated shall be in the form:

$Y = aX + c$ at z kilometres per hour

Where:

Y	=	NAASRA Roughness value (counts/km)
X	=	Measured Roughness value (counts/km)
a	=	slope (or gradient)
c	=	intercept (or constant)
z	=	survey speed i.e. 50kph or 80kph

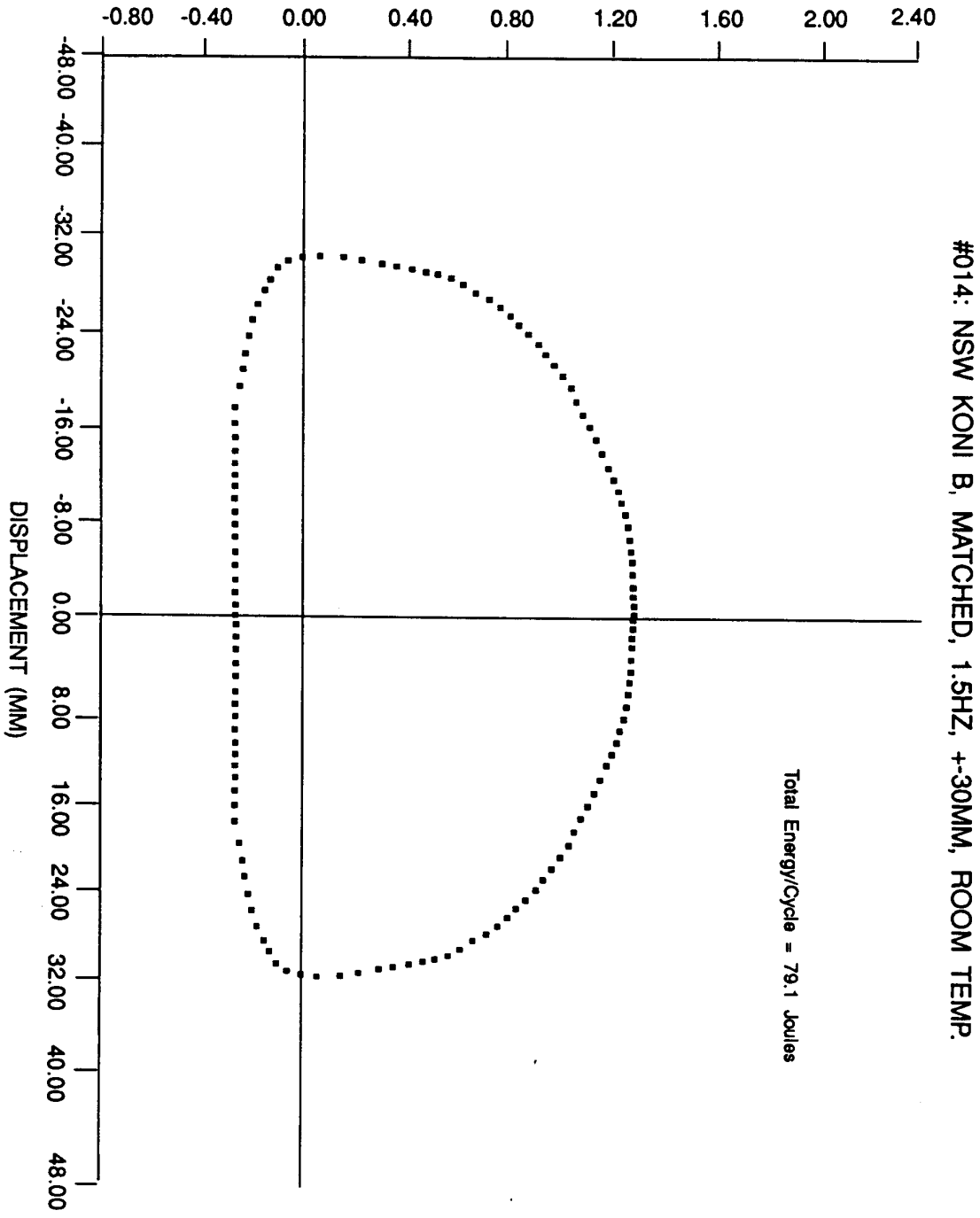

-0.80
-0.40
0.00
0.40
0.80
1.20
1.60
2.00
2.40
-48.00
-40.00
-32.00
-24.00
-16.00
-8.00
0.00
8.00
16.00
24.00
32.00
40.00
48.00
DISPLACEMENT (MM)
#014: NSW KONI B, MATCHED, 1.5HZ, +-30MM, ROOM TEMP.
Total Energy/Cycle = 79.1 Joules

Figure 1

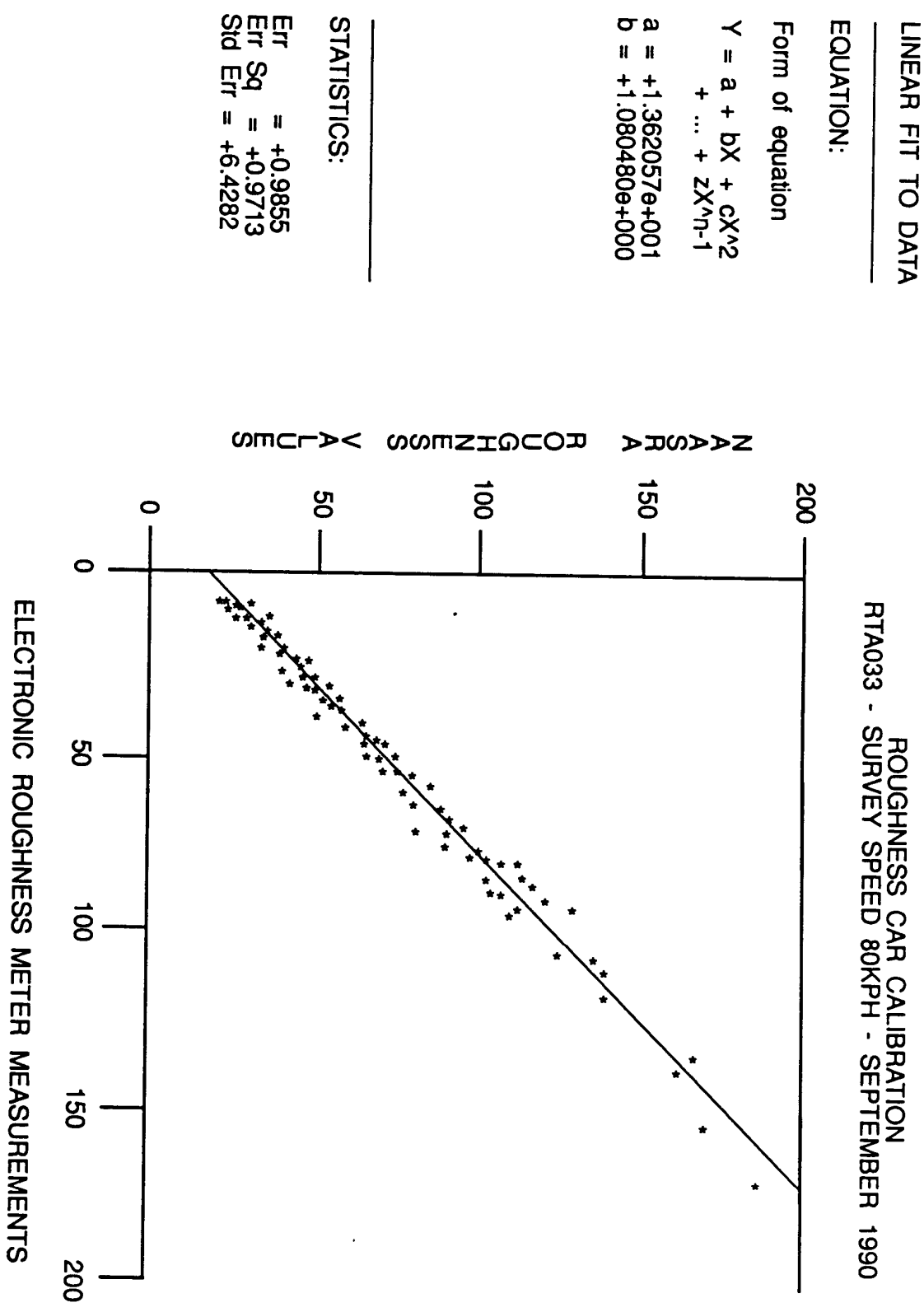


Figure 2

RMS 12.420