National Radio Astronomy Observatory

Socorro, New Mexico

3-5-97

VLA Test Memo No.203

Waveguide Crossing

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1. Introduction

Crossing the waveguide, with any vehicle, has always generated concern. The waveguide system is the only mechanism for communicating with antennas and damaged waveguide would seriously effect the VLA's ability to operate. In recent years waveguide crossings have increased. The concern is real and every precaution should be taken to avoid damaging the waveguide. Any deformation, through physically deforming or collapsing the walls, will affect the waveguide operation.

2. History

A 1973 report prepared by Bechtel reviews suggested waveguide installations. The report discusses and analyzes various locations of the waveguide, with respect to the track system. In one of the proposed layouts the waveguide parallels the main line crossing (at 2 foot below the surface) under the spurs to each antenna station. With this approach, a loaded transporter (600000#) would cross the waveguide each time an antenna was set at a station. Bechtel indicated little concern, for the crossings, referencing the load distribution effects of the soil, at the proposed depth. With two transporter trucks over the waveguide (waveguide depth of 2 feet) their calculations indicated imposed soil pressures of 1.3 psi on the waveguide. The waveguide was eventually installed away from the track and antenna foundations.

The Bechtel report was more concerned with the proper placement of the waveguide, proper radius of curvature, and stability of waveguide in compression. These were areas where higher stresses were expected to occur. A separate analysis discussed the stability of waveguide in compression, due to thermal expansion. It assumes a waveguide operating temperature 20 degrees higher than the waveguide temperature at installation. Compressive loads were expected to be on the order of 4200 pounds.

With the present situation we have vehicles crossing the waveguide with much lower loads. The water truck or a gravel truck have estimated tandem wheel loads ranging from 8000# to 14000#, compared with transporter truck loads of 150000#. At depths of 2-4 feet the load distribution effects of the soil minimize imposed pressures on the waveguide. With the water and gravel trucks, soil pressures over the waveguide range from 3 to 6 psi.

3. Independent Field Test

To see what stresses could be developed; we ran a vehicle over a buried piece of waveguide. A 32" piece was borrowed from Cryo. Strain gauges were installed, at the center of the waveguide, in both the circumferential and longitudinal directions. The gauges were 6mm-120ohm encapsulated and were not temperature compensated. Data was recorded on a computer once per second and each reading represented 500 samples over half a second averaged together. Before each test the the readings were zeroed to remove drift caused by temperature effects. A protective coating of silicone was placed over the gauges.

The waveguide was placed in the ground at 36 inches (Sketch attached page 6), with the gauges facing down. The soil was re-compacted, gradually, using the backhoe. The water truck was filled with water, and aligned so one set of tandem wheels (approximately 9000 pounds) would cross the waveguide on center. The truck crossed over the waveguide a minimum of three times. Strain gauge readings were recorded and saved. The waveguide was uncovered and placed at 12 inches, the soil compacted and the readings recorded. Same for the surface test.

4. Test Results

Reduced data are attached (pages 6-9), in chart form, with the micro strain readings on the left and the stress readings (psi) on the right. With the waveguide at 36 inches recorded stresses ranged from 300-500 psi, in both axial and circumferential directions. At 12 inches the stresses averaged 1425 psi in the axial direction and 1780 psi in the circumferential direction. At the surface stresses ranged from 4300 psi to 10000 psi in the axial direction, and about 3500 psi to 4275 psi in the circumferential direction, the range is contributed to poor compaction. As the soil compacted the stresses dropped substantially. The final reading of 4300 psi is the stabilized reading. All the recorded stresses are well below the maximum allowable stress of the waveguide material; 42,700 psi. The waveguide was inspected by Cryo, and there were no visible signs of damage indicated.

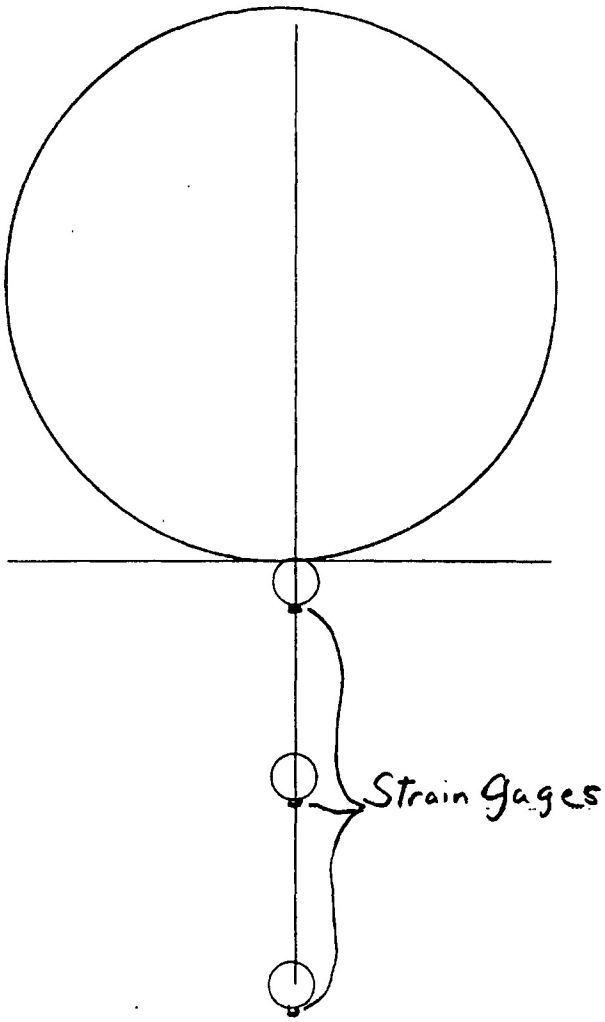
5. Conclusion

The waveguide is not harmed when vehicles cross over; with minimal stresses developed in the 1-3 foot range. Exposed waveguide should never be crossed. Strain gauge plots are attached for review. Waveguide profile drawings were reviewed to check installed depths. The drawings indicate buried depths ranging from 3-10 foot. There were a few spots in the 2-3 foot range. On the west and north arms there are sandy areas. In these areas the top soil shifts dramatically and the waveguide could be deeper or nearer the surface. Most roads and areas where the transporter might cross are cased. The drawings do not show any casing at the center of the wye (under the track) and at State Route 52.

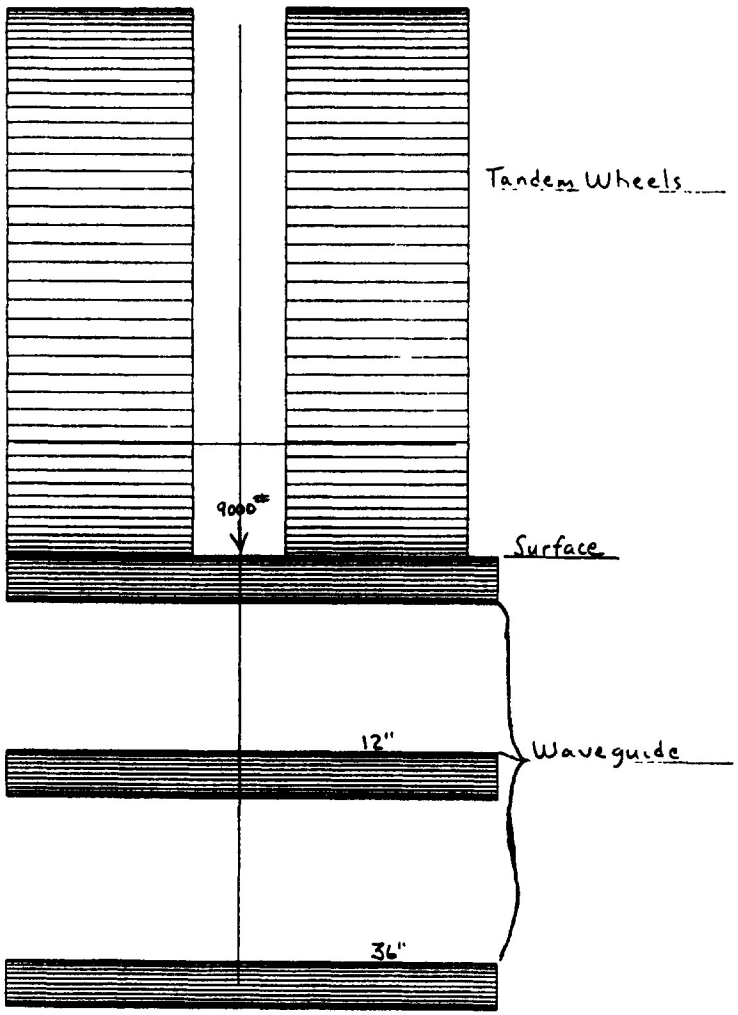
6. Recommendations

Intuitively it seems we should avoid, wherever possible, crossing the waveguide. In lieu of the test results, I recommend the following:

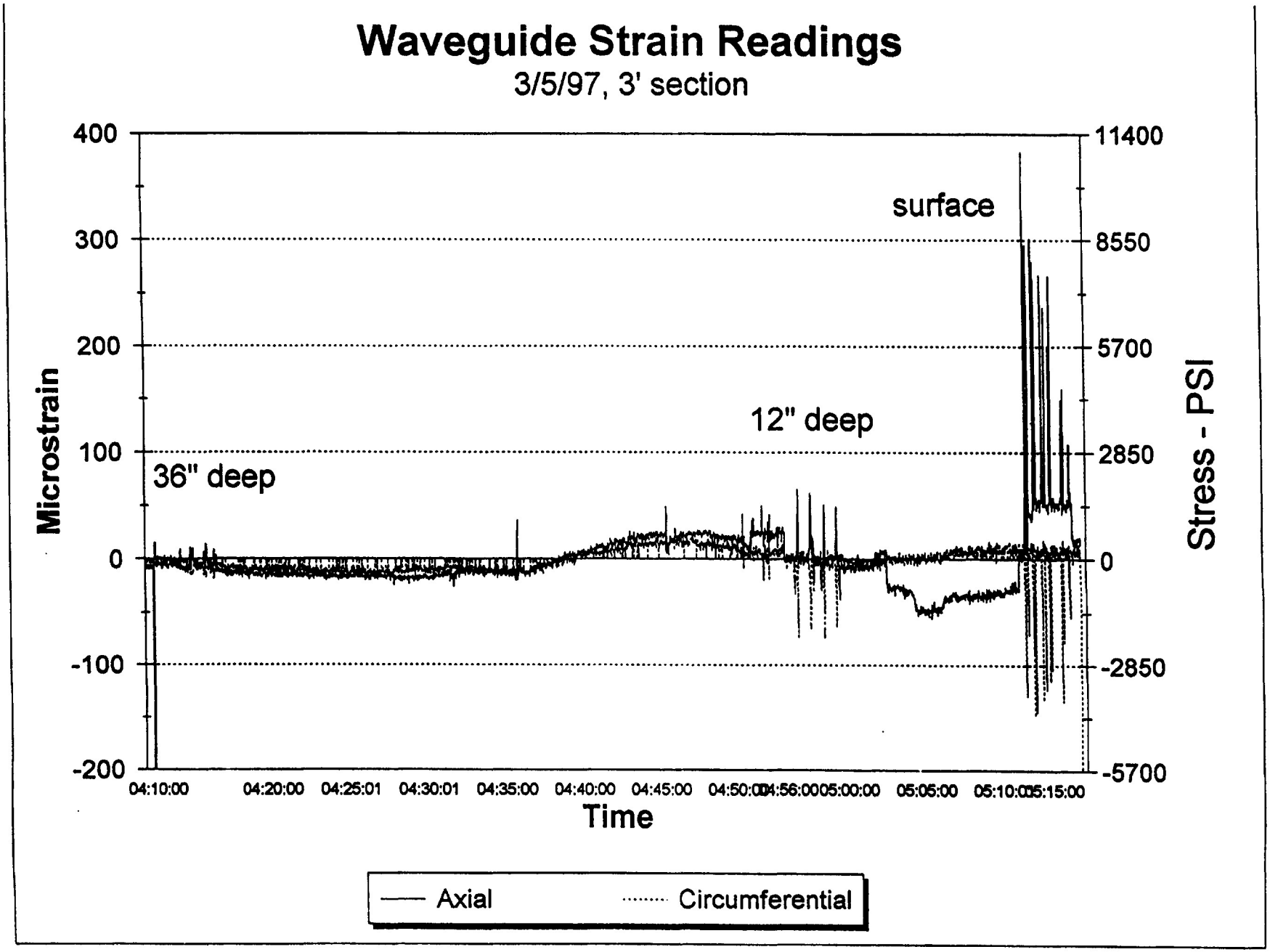
1. Whenever possible do not cross the waveguide.
2. If no other path exists, and the waveguide is 2-3 feet deep, vehicles can safely cross it.
3. In sandy areas where the top soil tends to shift, and the exact depth of the waveguide is unknown, only smaller vehicles such as pickup trucks and cars, should cross the waveguide. Larger vehicles such as the water truck, gravel truck or semi-trailers loaded with rail related supplies should not cross the waveguide. Exposed waveguide should never be crossed.

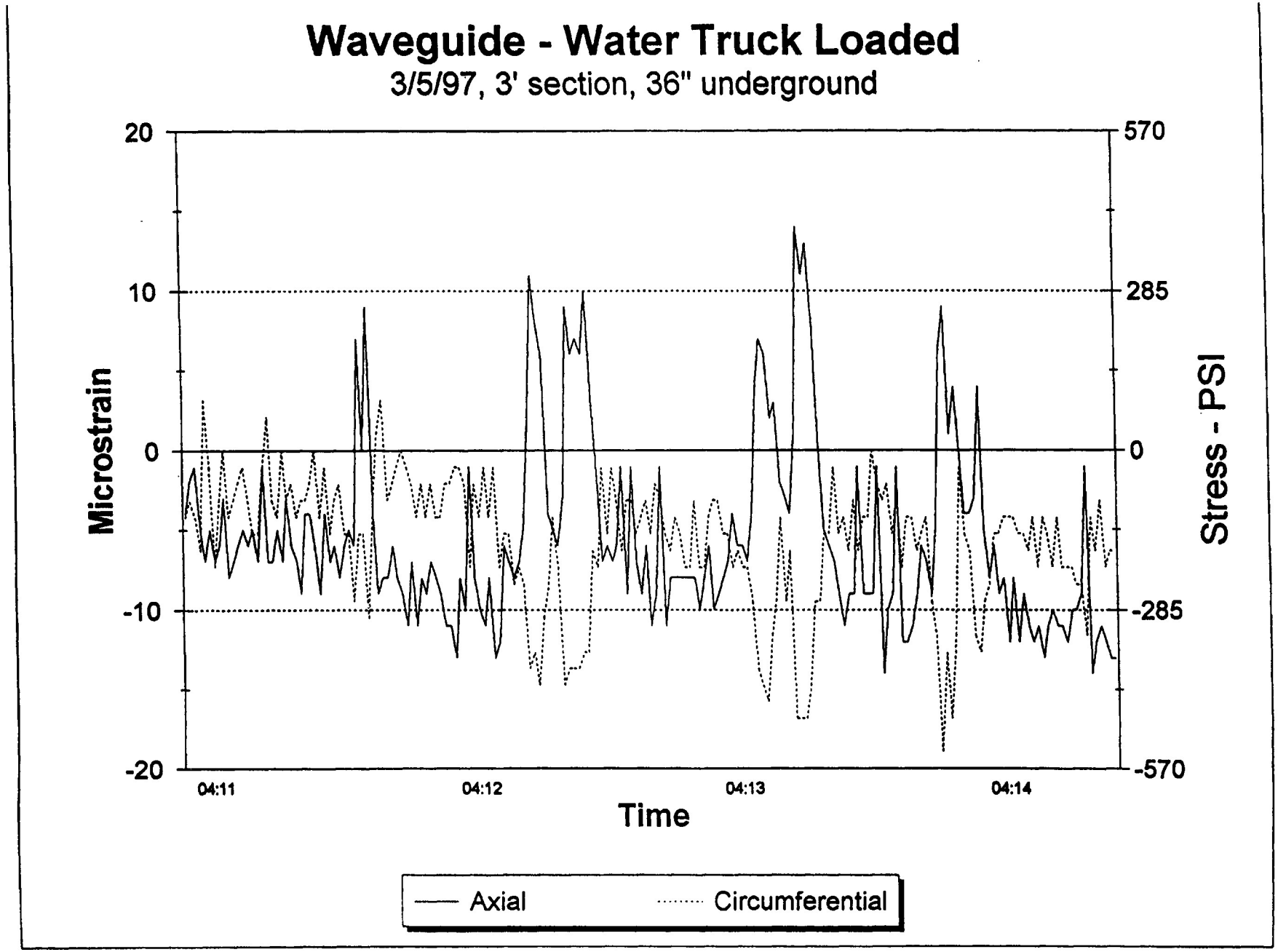


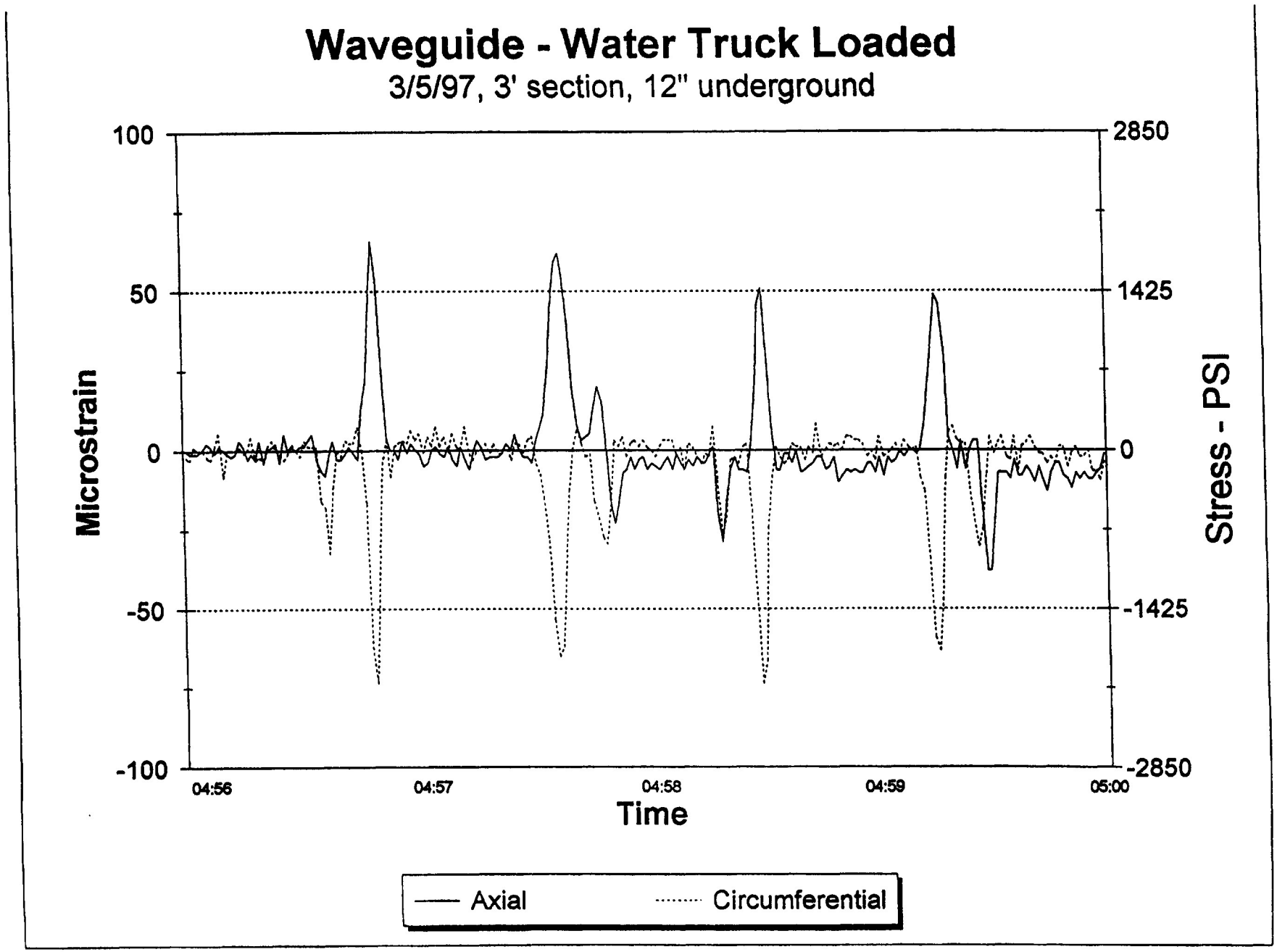
End

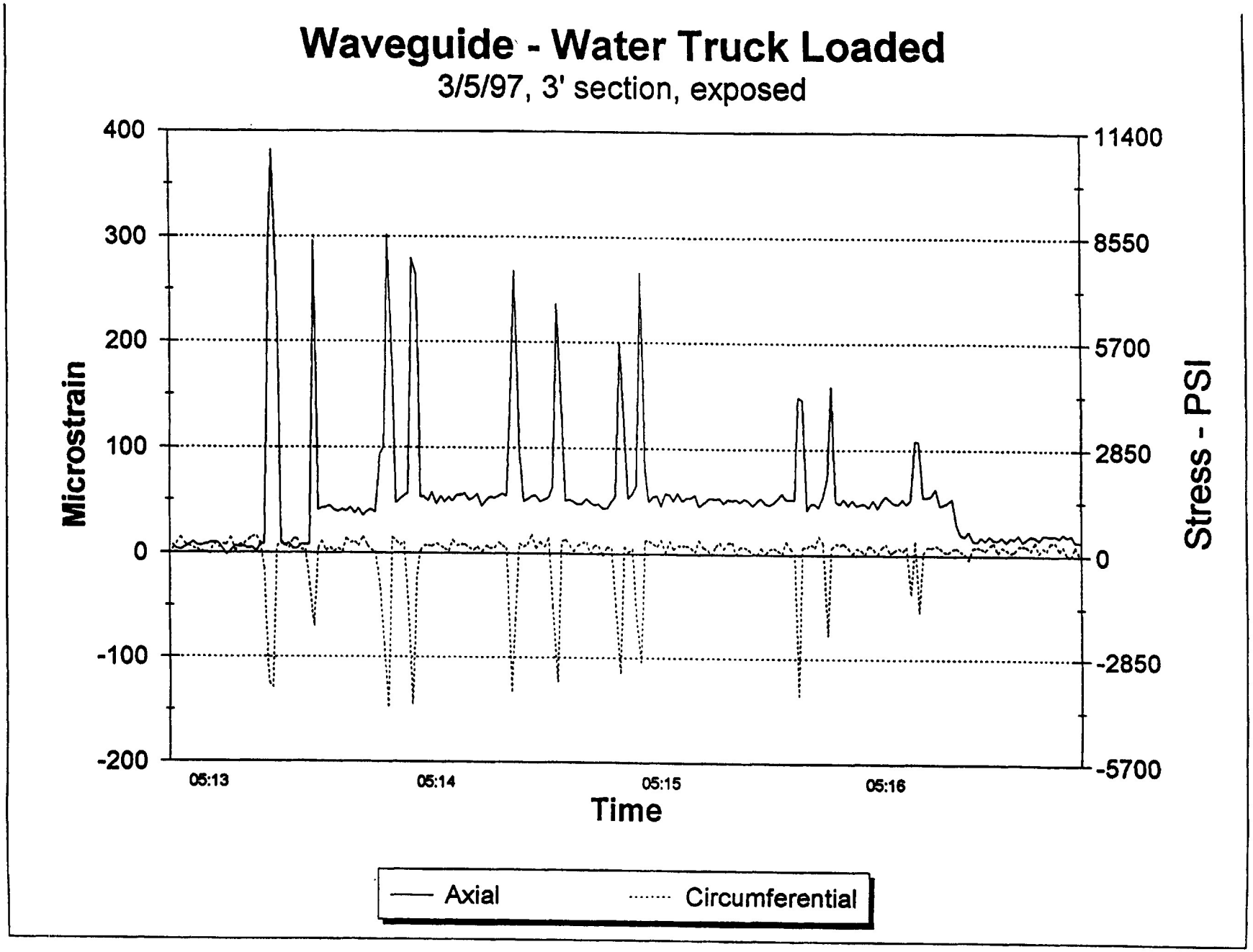


Front


Waveguide Strain Readings
3/5/97, 3' section
400
300
200
100
0
-100
-200
Microstrain
11400
8550
5700
2850
0
-2850
-5700
Stress - PSI
surface
12" deep
36" deep
04:10:00
04:20:00
04:25:01
04:30:01
04:35:00
04:40:00
04:45:00
04:50:00
04:56:00
05:00:00
05:05:00
05:10:00
05:15:00
Time
Axial
Circumferential


Waveguide - Water Truck Loaded
3/5/97, 3' section, 36" underground
20
10
0
-10
-20
Microstrain
570
285
0
-285
-570
Stress - PSI
04:11
04:12
04:13
04:14
Time
Axial
Circumferential


Waveguide - Water Truck Loaded
3/5/97, 3' section, 12" underground
Microstrain
Stress - PSI
100
50
0
-50
-100
2850
1425
0
-1425
-2850
04:56
04:57
04:58
04:59
05:00
Time
Axial
Circumferential


Waveguide - Water Truck Loaded
3/5/97, 3' section, exposed
400
300
200
100
0
-100
-200
Microstrain
11400
8550
5700
2850
0
-2850
-5700
Stress - PSI
05:13
05:14
05:15
05:16
Time
Axial
Circumferential