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of Transportation
**Federal Railroad
Administration**

TREAD METAL BUILDUP ON RAILWAY WHEELS – Dynamometer Simulation

Office of Research and
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13. ABSTRACT

Recent dynamometer tests on a composition metal shoe with a high metal powder content developed tread metal pick up during testing at TTC. Additionally, the brake shoes and wheels that developed tread metal buildup during these tests became magnetized. A dynamometer test matrix was created. The matrix included a range of brake application pressures to emulate both typical and abnormal brake function as well as water spray in an attempt to influence the resultant friction.

No metal pickup was observed on any of the test wheels. Therefore, brake shoe force, moisture, and magnetism alone, or in combination, do not appear to be sufficient in them to produce wheel built-up tread based on the dynamometer tests conducted.

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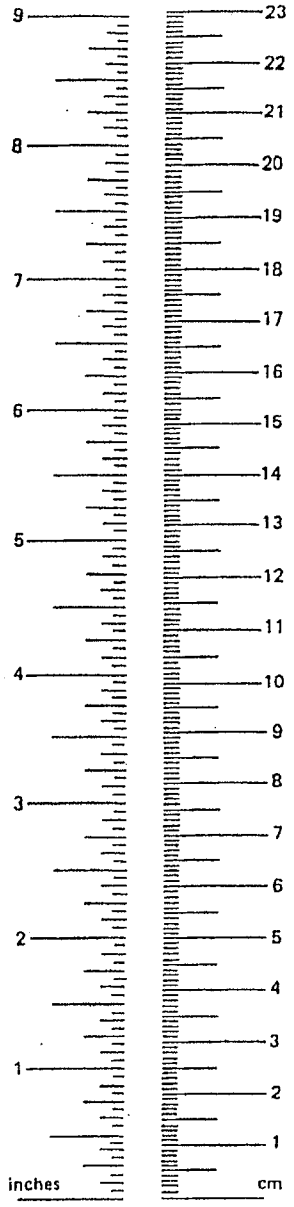
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

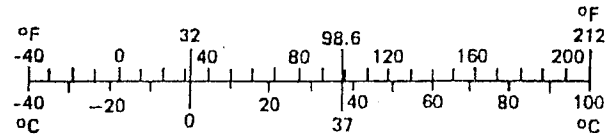
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.50	centimeters	cm
ft	feet	30.00	centimeters	cm
yd	yards	0.90	meters	m
mi	miles	1.60	kilometers	km
		AREA		
in^2	square inches	6.50	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.80	square meters	m^2
mi^2	square miles	2.60	square kilometers	km^2
	acres	0.40	hectares	ha
		MASS (weight)		
oz	ounces	28.00	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.90	tonnes	t
		VOLUME		
tsp	teaspoons	5.00	milliliters	ml
Tbsp	tablespoons	15.00	milliliters	ml
fl oz	fluid ounces	30.00	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.80	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0 76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in. = 2.54 cm (exactly)



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.40	inches	in
m	meters	3.30	feet	ft
m	meters	1.10	yards	yd
km	kilometers	0.60	miles	mi
		AREA		
cm^2	square centim.	0.16	square inches	in^2
m^2	square meters	1.20	square yards	yd^2
km^2	square kilom.	0.40	square miles	mi^2
ha	hectares (10,000 m^2)	2.50	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.10	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36.00	cubic feet	ft^3
m^3	cubic meters	1.30	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



EXECUTIVE SUMMARY

There is a limited history of documented information on the formation of wheel tread metal buildup. The occurrence of tread metal buildup in service is infrequent. However, its presence can influence the performance and safety of the vehicle.

Recent dynamometer tests on a composition shoe with a high metal powder content developed slight tread metal pick up during testing at Transportation Technology Center, Pueblo, Colorado. Further, the brake shoes and wheels that developed the slight buildup became magnetized.

Thus, building on the available knowledge about tread metal buildup, a dynamometer test matrix was created. The matrix included a range of brake application pressures to emulate both typical and abnormal brake function as well as water spray in an attempt to influence the resultant friction.

No metal pickup was observed on any of the test wheels during this testing even though two high metal content brake shoes were included in the testing. Thus, even the slight metal buildup appears to be from metal transferred to the wheel tread, because under similar conditions the slight tread metal formation could not be reproduced. Therefore, brake shoe forces and moisture do not appear to be sufficient to produce wheel tread buildup based on the dynamometer tests conducted.

From these tests, it appears that the mechanisms that produce substantial tread buildup are possibly caused or catalyzed by wheel/rail contact and sliding. Wheel slides cannot be performed as part of the current dynamometer capabilities. Thus, additional research should likely address the sliding of the wheel on the rail as part of full-scale trials.

Valuable information was gained in the unsuccessful attempt to produce thread metal buildup through dynamometer testing. This information along with previous data has been critical in narrowing the likely sources of this defect. However, additional investigation is required to determine the source of the metal and the mechanism by which it is transferred to the wheel tread from the source.

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1.0 INTRODUCTION

There is a limited history of documented information on the formation of wheel tread metal buildup. The occurrence of tread metal buildup in service is infrequent. However, its presence can influence the performance and safety of the vehicle as is obvious for the wheel shown in Figure 1.

In the early 1980s, the Association of American Railroads performed an on full-scale track brake shoe performance test at the Transportation Test Center (TTC), Pueblo, Colorado, that showed built-up tread to be associated with wet conditions.[1] Further, all of the different types of shoes in the brake shoe performance test had metal pick up, but each associated wheel did not necessarily pick up metal. Metal pick up seemed to be associated with hydroplaning (or at least a drop in the apparent coefficient of friction.) There was also no correlation between wheel location (R1, L2, etc.) and the presence of metal buildup.

In another study, Tse and Steets reported that the built-up tread problem could be attributed to malfunctioning quick service valves or high pressure spool valves, which caused the brake cylinder pressure to rise to high levels.[2] Additionally, studies by Canadian National have shown increased metal pick up during winter months.[3]

Recent dynamometer tests on a composition metal shoe with a high metal powder content developed tread metal pick up during testing at TTC. Additionally, the brake shoes and wheels that developed tread metal buildup during these tests became magnetized.

Thus, building on the available knowledge about tread metal buildup, a dynamometer test matrix was created. The matrix included a range of brake application pressures to emulate both typical and abnormal brake function as well as water spray in an attempt to influence the resultant friction.

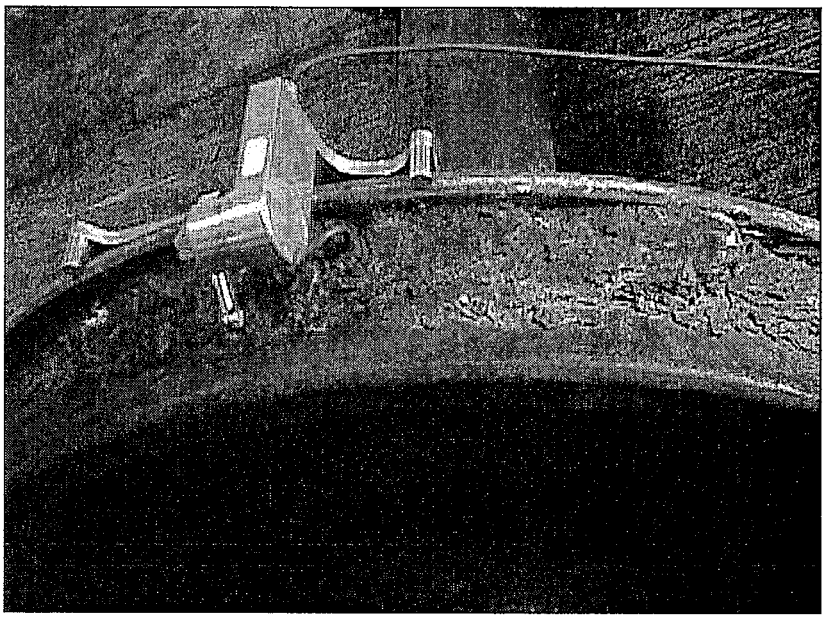


Figure 1. Built-up Metal on the Tread of a Wheel

2.0 OBJECTIVE

The objective of this research was to produce tread metal buildup on wheels tested with Transportation Technology Center, Inc.'s dynamometer, while simulating conditions by which it forms in service. In an attempt to simulate these conditions, a test matrix was created that included a range of brake pressures to simulate proper and improper brake operation. Additionally, a water spray was added to the wheel intended to influence the friction between the wheel and brake shoe to emulate wet conditions.

The ability to produce tread metal buildup in the laboratory during dynamometer tests was intended to allow modifications to equipment and/or train handling to reduce the occurrence of this phenomena in service. The conditions under which tread metal buildup have been consistently observed to occur in service include rain and/or snow at times in combination with improper brake operation.

3.0 FIELD OBSERVATIONS AND PRELIMINARY INTERPRETATION

To characterize wheels that developed built-up treads in service with those that were removed without surface damage, 12 wheels were examined June 5, 2002, by Progress Rail Service, Corp. in Sydney, Nebraska. Tread profile, magnetism, surface roughness, and hardness were measured at various locations around the circumference of each wheel. The results of these measurements are shown in Table 1 and detailed in the appendix.

Tread profile appears to have no effect on the formation of built-up treads. Built-up treads typically have developed a level of magnetism that is an order of magnitude higher than wheels without metal pick up. Further, the level of magnetism appears to increase with increasing tread metal buildup. Wheels with built-up treads have a higher surface roughness. This may be associated with the fact that metal picked up on the brake shoe surface probably occurs before transfer to the tread. The metal imbedded on the surface of the shoe is probably the cause of the roughened tread. It is speculated that the rough tread surface may facilitate the transfer of metal to the wheel. The tread hardness is, in all cases, harder than the specified 321-363 Bhn of new Class C wheels due to work hardening from wheel/rail contact. The higher hardness of the investigated wheels is consistent between both the built-up tread and undamaged wheels tested as Table 1 shows.

Table 1. Field Observations of Magnetism, Tread Profile, Tread Surface Roughness, and Tread Hardness of Wheels with and without Tread Metal Buildup

Wheel Number	Built-up Tread?	Maximum Magnetism, Gauss	Tread Profile	Average Hardness, Bhn	Average Surface Roughness, μ inches
07534	No	6.0	Normal	519	25
07598	No	6.3	2 mm hollow	505	43
12222	No	4.9	2 mm hollow	460	28
15489	No	7.1	3 mm hollow	512	44
50469	No	7.3	2 mm hollow	501	169
53168	No	7.3	Spalled	430	78
Average		**6.5**		**488**	**64.5**
49933	Slight	3.9	2 mm hollow	538	186
51124	Moderate	7.5	Normal	556	68
Average		**5.7**		**547**	**127**
10988	Heavy	36.5	Normal	494	310
10989	Heavy	12.6	Slight wear	487	401
14073	Heavy	44.5	Normal	430	434
38299	Heavy	22.0	Normal	428	372
Average		**28.9**		**460**	**379**

Tread Buildup Classification:
Slight = Less than 1-inch circumference: very minimal thin formation on wheel tread.
Moderate = Less than 3 inches: beginning of formations that could influence wheel performance.
Heavy = More than 3 inches: extremely large formations that would influence wheel performance.

4.0 DYNAMOMETER TESTS

A series of dynamometer tests were conducted to determine if tread buildup could be induced under a matrix of varying conditions of brake shoe force and moisture. Moisture was controlled and applied by a spray system that was capable of producing a fine spray at rates up to 800 ml/min. Figure 2 shows the spray system.

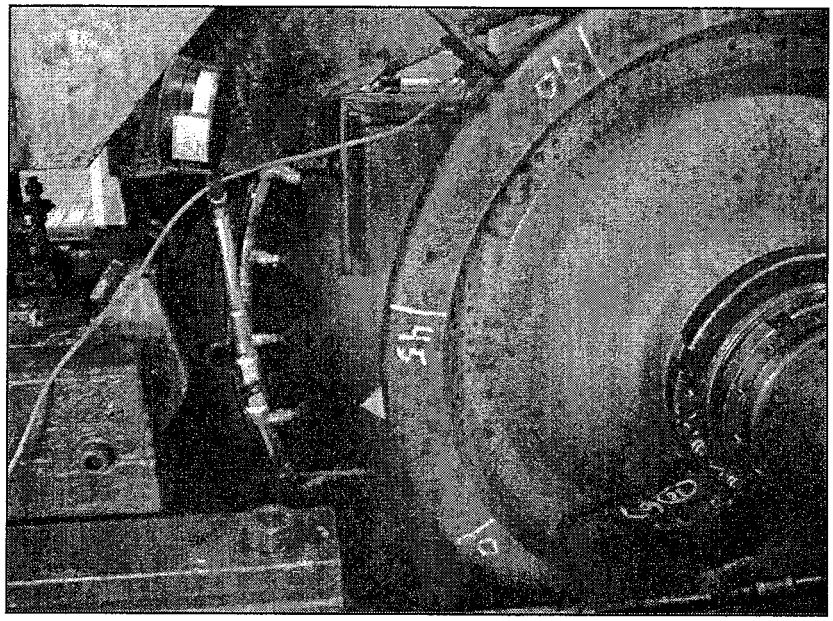


Figure 2. Dynamometer Spray Apparatus

4.1 Test Matrix

Fourteen dynamometer tests were performed, as Table 2 shows. Tests 1 through 7 were conducted at a constant speed of 20 mph with brake shoe forces varying between each of the tests from 400 to 10,000 pounds. Tests 8 and 10 were conducted at 20 mph with a 925-pound brake shoe force for 20 minutes followed by 20 mph with a 1,450-pound brake shoe force for 20 minutes and ended with a series of light braking stop tests from 80, 60, 40, and 20 mph using a 3,298-pound brake shoe force. These tests were designed in an attempt to produce metal pickup on the shoe and then subsequently deposit it on the wheel, as this may be a mechanism of occurrence. Test 9 was conducted at 80 mph with a 925-pound brake shoe force for 20 minutes followed by 80 mph with a 1,450-pound brake shoe force for 20 minutes, with a series of light braking stop tests from 80, 60, 40, and 20 mph using a 2,000-pound brake shoe force. Tests 11 through 14 were conducted at a constant speed of 20 mph using a variety of different brake shoes. Tests 13 and 14 employed test wheels that were pre-magnetized. The tests were again designed to produce metal pickup in the shoe with subsequent deposit on the wheel tread. Tests 6 through 14 also employed test wheels using a load of 7,500 pounds in an attempt to roughen the wheel tread surface.

Table 2. Built-up Tread Matrix. *Test wheels pre-magnetized

Test Number	Brake Shoe Force (lb)	Test Time (min)	Water Flow Rate (ml/min)	Rail Wheel Load (lb)	Brake Shoe	Metal Pick Up
1	10000	4	800	0	H4	No
2	6000	20	800	0	H4	No
3	4000	30	800	0	H4	No
4	2000	50	800	0	H4	No
5	800	105	800	0	H4	No
6	800	96	800	7500	H4	No
7	400	120	800	7500	H4	No
8	925 1450	45 45	0 0	7500 7500	High Abrasion	No
9	925 1450	45 45	0 0	7500 7500	High Metal Content A	No
10	925 1450	45 45	0 0	7500 7500	High Metal Content B	No
11	1450	60	0	7500	H4 with Metal Pick up	No
12	1450	60	0	7500	H4 removed From service	No
13*	1450	60	0	7500	H4 with Metal Pick up	No
14*	1450	60	0	7500	H4 removed From service	No

4.2 Dynamometer Test Results

No metal pickup was observed on any of the test wheels during this testing even though two high metal content brake shoes were included in the testing. Thus, even the slight metal buildup appears to be from metal transferred to the wheel tread, because under similar conditions the slight tread metal formation could not be reproduced. Therefore, brake shoe forces and moisture do not appear to be sufficient to produce wheel tread buildup based on the dynamometer tests conducted.

From these tests, it appears that the mechanisms that produce substantial tread buildup are possibly caused or catalyzed by wheel/rail contact and sliding. Wheel slides cannot be performed as part of the current dynamometer capabilities. Thus, additional research should likely address the sliding of the wheel on the rail as part of full-scale trials.

5.0 DISCUSSION

Examination of wheels that have formed metal buildup in service indicates the following:

1. Tread profile does not appear to be a factor in the formation of tread metal buildup.
2. Wheels with tread metal buildup have developed a surface roughness. However, it is unknown if this is a precursor of metal buildup or the result of brake shoe metal buildup.
3. Wheels with tread metal buildup have become magnetized. However, as with the case of surface roughness, it is unknown if this is a precursor of metal buildup or the result of brake shoe metal buildup. Further, the level of magnetism appears to increase with increasing tread metal buildup.
4. Dynamometer tests indicate that high brake shoe force and moisture are likely not sufficient to cause tread metal buildup.

5.1 Additional Tread Metal Build-Up Theories

A study of tread metal buildup was done at the University of Illinois at Urbana-Champaign (UIUC) during the 1980s that surmised that the metal pickup was, in fact, an alloy steel that was formed in situ, using iron oxides from the lining and wear debris from the rail and wheel.[4] Carbonaceous material from the brake shoe binder resin and rubber particles provided the energy for this alloy formation. It was found that, after only two snow brake applications of 1 minute duration each, smelted alloy steel formed as thick as 10 millimeters. A sample of the metal pickup material was mounted to prepare a metallographic sample of the longitudinal or lateral cross section. The "grain' path is totally inconsistent with the possible rubbing paths. Elemental mapping of the metal pickup material showed that it had a composition that was different from the rail, the wheel, or the iron particles in the brake linings. However, other analyses of built-up material have shown the composition of wheel or rail steel. It is difficult to imagine that such a reduction proposed by the research at UIUC would produce a steel composition and not a higher carbon "pig iron" composition.

5.2 Suggested Future Research

Valuable information was gained in the unsuccessful attempt to produce tread metal buildup through dynamometer testing. This information along with previous data has been critical in narrowing the likely sources of this defect. However, additional investigation is required to determine the source of the metal and the mechanism by which it is transferred to the wheel tread from the source. It is obvious that the mechanism is more complicated than can be reproduced on the dynamometer using water spray and varying brake shoe forces and wheel speeds. Thus, if additional trials were to be conducted in the attempt to intentionally produce metal buildup on the wheel tread, track tests would likely be required with moisture added to the rail to allow significant wheel slip. The sliding of the wheel on the rail and the subsequent metal removal and wheel profile change are possibly contributing to the tread buildup mechanism and should be addressed in order to clarify this phenomenon.

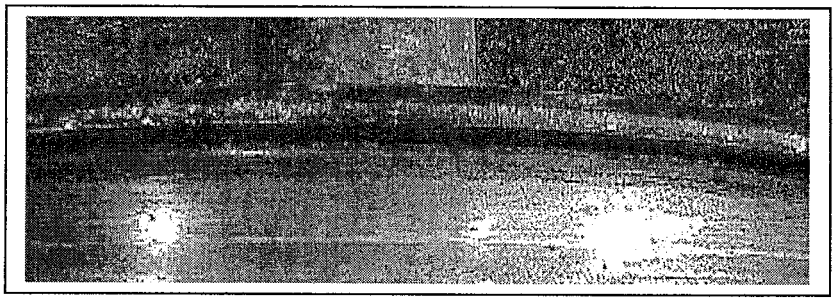
REFERENCES

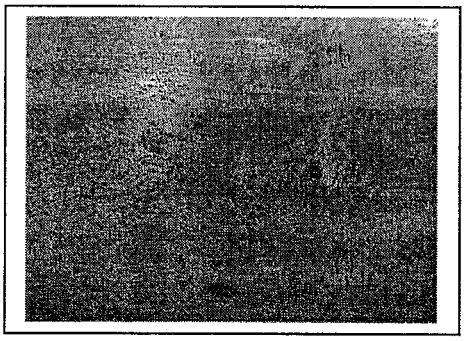
1. Anderson, G. B. W. P. Manos, and N. G. Wilson. "Brake Shoe Performance Test II," Association of American Railroads Research Report R-565A, December 1983.
2. Tse, Y. H. and P. G. Steets. "Wheel Impact Detection Cost Savings and Safety through Management by Prevention," *Rail Transportation – 1996,* RTD Vol. 12, ASME, (New York, 1996) pp. 1-10.
3. W. Blevins, "CN Wheel Spalling and Shelling," *Proceedings of the 91st Air Brake Association Technical Conference*, (Chicago, 1999) pp. 98-102.
4. Personal communication with Harry Wettencamp, Prof. Emeritus, UIUC, October 2002.

APPENDIX

Data for Wheels Removed from Service

Wheel 07534
No Tread Damage





F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 07534 Progress Rail Services Corp., Sidney, NE June 5, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	056	053	029
45 degrees	027	039	018
90 degrees	033	024	035
135 degrees	098	075	039
180 degrees	027	051	043
225 degrees	026	023	058
270 degrees	066	024	021
315 degrees	019	040	025

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	522	540	511
45 degrees	526	529	444
90 degrees	503	511	535
135 degrees	383	487	471
180 degrees	430	577	492
225 degrees	427	510	404
270 degrees	424	467	529
315 degrees	531	531	501

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 5, 2002

INSPECTION SUBJECT: TEST WHEEL #07534 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -2.5 to + 1.3 = 3.8

45 degrees. Flange rim around to tread rim. Gauss range read: -3.1 to + 0.1 = 4.2

90 degrees. Flange rim around to tread rim. Gauss range read: -4.1 to + 0.8 = 4.9

135 degrees. Flange rim around to tread rim.Gauss range read: -3.3 to + 0.6 = 3.9

180 degrees. Flange rim around to tread rim. Gauss range read: -3.1 to + 1.9= 5.0

225 degrees. Flange rim around to tread rim. Gauss range read: -2.7 to + 1.1 = 3.8

270 degrees. Flange rim around to tread rim. Gauss range read: -3.4 to + 0.3 = 3.7

315 degrees. Flange rim around to tread rim. Gauss range read: -2.6 to + 0.7 = 3.3

The maximum range of gauss in this wheel was from –4.1 to +1.9 or 6 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #07534 (on axle #8810-B)

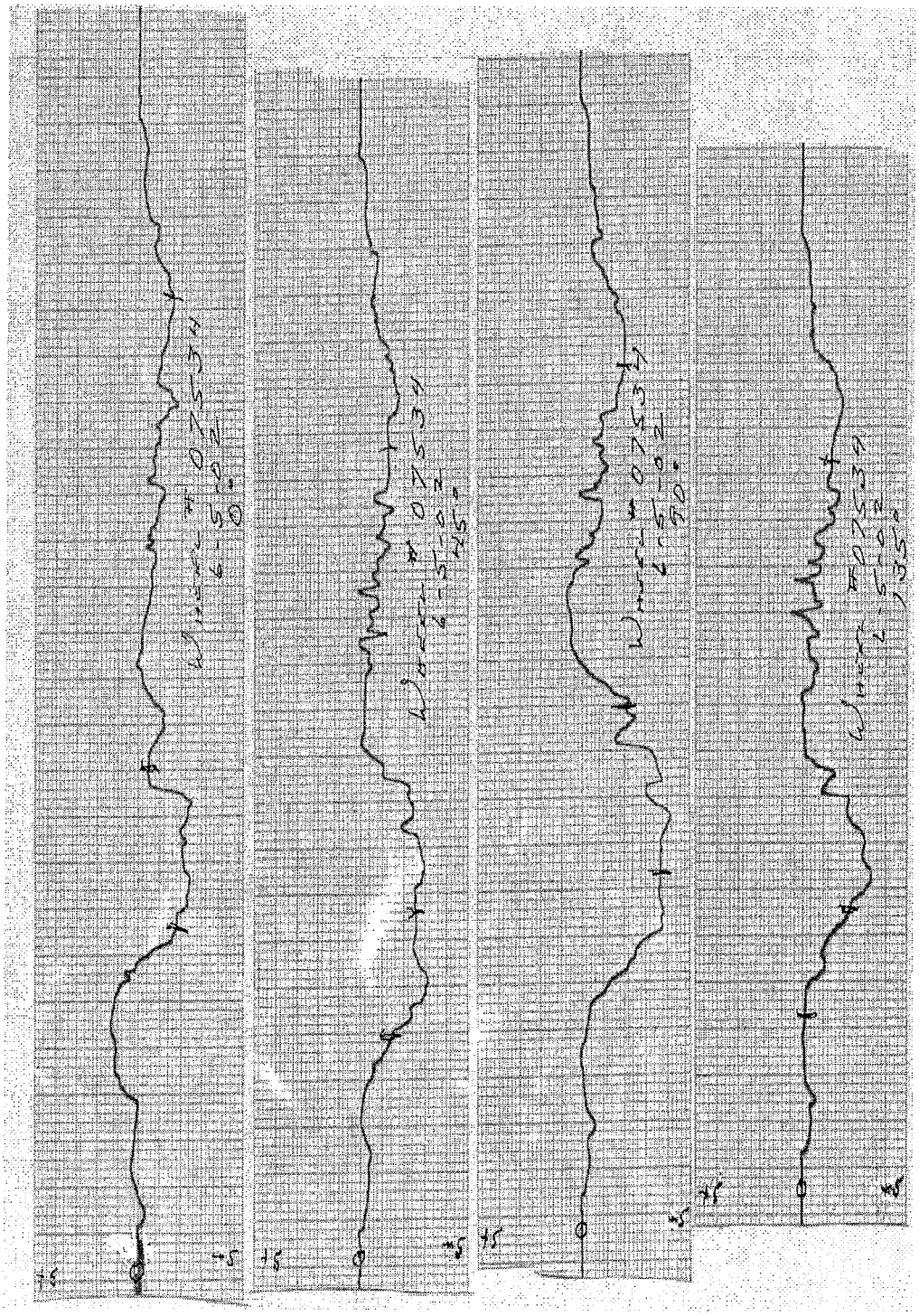
June 5, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

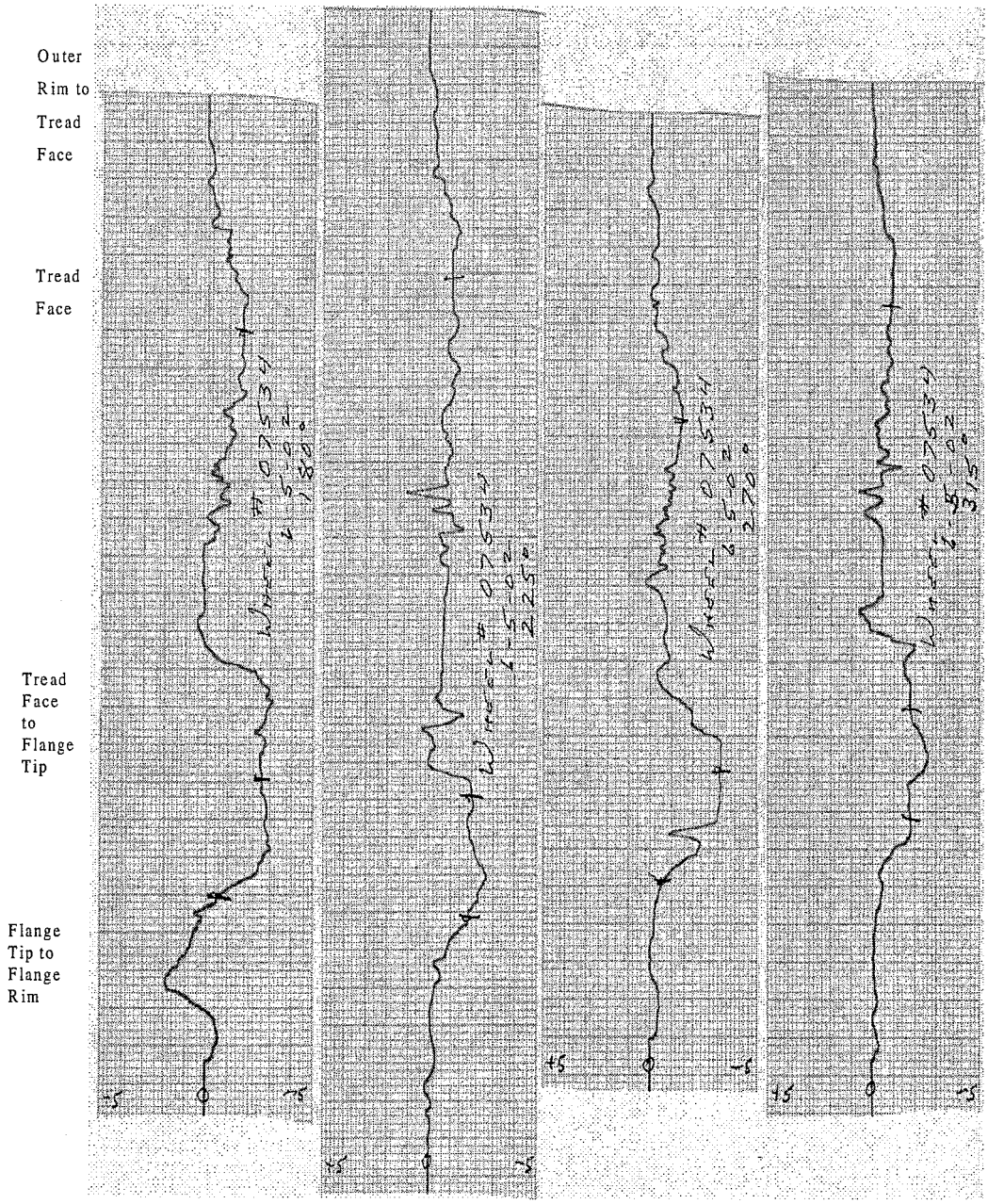
Flange Tip to Flange Rim

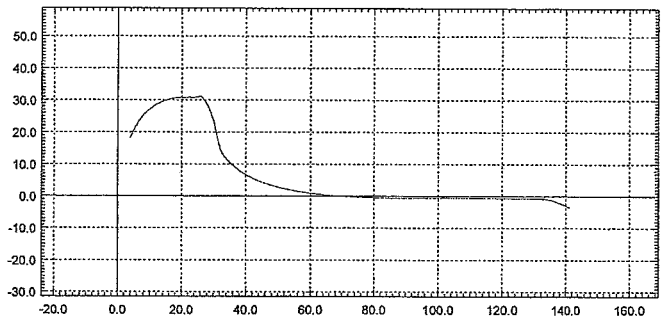


F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #07534 (on axle #8810-B)

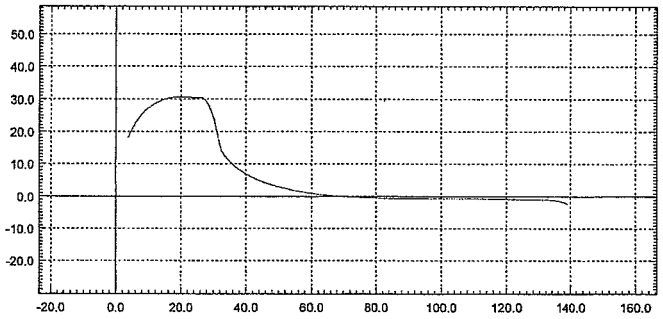
June 5, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings





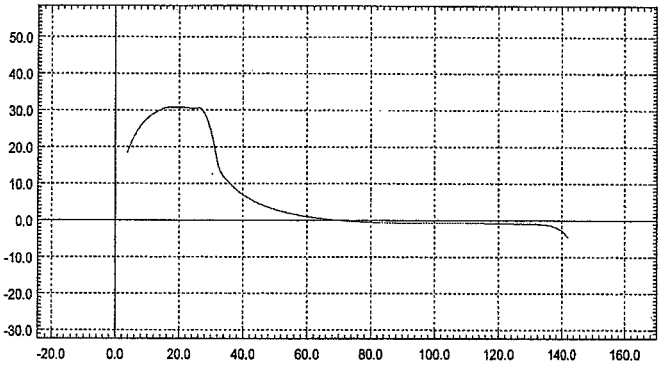
05062002-0211.whl
05/06/2002
130-0308

= 0°
Axle number = 8810 b
Wheel ID = 07534
Sd = 35.431 mm
Sh = 31.133 mm
qR = 7.795 mm
Flange width = 31.403 mm
Flange diameter = 975.879 mm
Taperline diameter = 913.603 mm



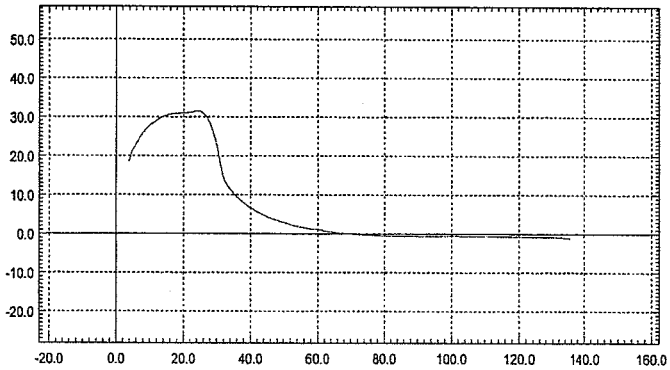
05062002-0221.whl
05/06/2002
130-0308

= 90°
Axle number = 8810 b
Wheel ID = 07534
Sd = 35.764 mm
Sh = 30.623 mm
qR = 7.506 mm
Flange width = 31.839 mm
Flange diameter = 977.088 mm
Taperline diameter = 915.842 mm



05062002-0231.whl
05/06/2002
130-0308

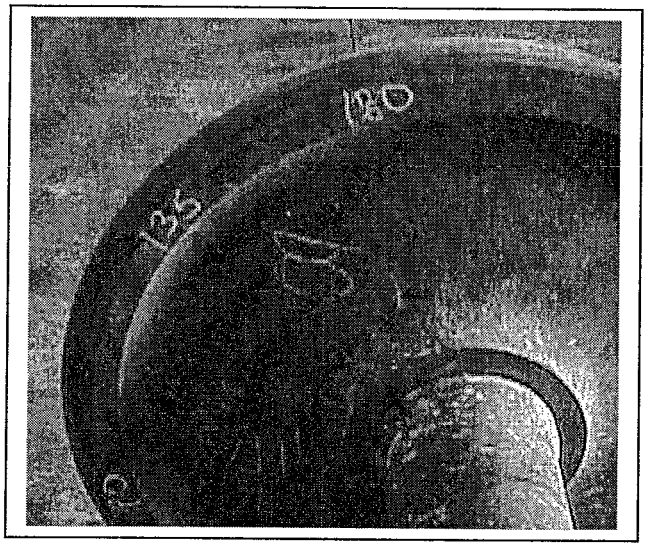
= 180°
Axle number = 8810 b
Wheel ID = 07534
Sd = 35.817 mm
Sh = 30.812 mm
qR = 7.689 mm
Flange width = 31.753 mm
Flange diameter = 981.378 mm
Taperline diameter = 919.758 mm

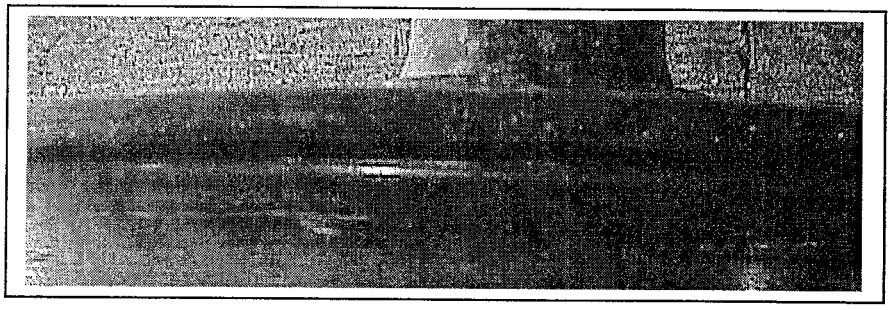


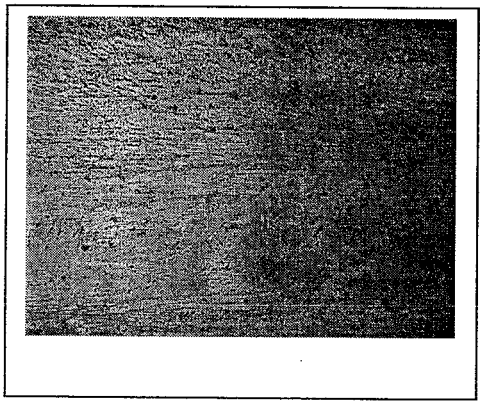
05062002-0241.whl
05/06/2002
130-0308

= 270°
Axle number = 8810 b
Wheel ID = 07534
Sd = 35.334 mm
Sh = 31.485 mm
qR = 8.057 mm
Flange width = 31.127 mm
Flange diameter = 974.122 mm
Taperline diameter = 911.197 mm

Wheel 07598
No Tread Damage







F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 07598 Progress Rail Services Corp., Sidney, NE June 5, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	150	043	047
45 degrees	128	091	026
90 degrees	122	045	026
135 degrees	114	041	039
180 degrees	112	024	023
225 degrees	144	034	025
270 degrees	106	018	026
315 degrees	107	048	040

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	529	520	538
45 degrees	540	548	526
90 degrees	494	466	458
135 degrees	456	518	463
180 degrees	518	533	515
225 degrees	497	436	482
270 degrees	555	503	585
315 degrees	439	520	459

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 5, 2002

INSPECTION SUBJECT: TEST WHEEL #07598 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -1.8 to + 0.4 = 2.2

45 degrees. Flange rim around to tread rim. Gauss range read: -2.5 to + 0.5 = 3.0

90 degrees. Flange rim around to tread rim. Gauss range read: -3.2 to + 0.6 = 3.8

135 degrees. Flange rim around to tread rim.Gauss range read: -1.9 to + 1.5 = 3.4

180 degrees. Flange rim around to tread rim. Gauss range read: -3.3 to + 1.0= 4.3

225 degrees. Flange rim around to tread rim. Gauss range read: -4.5 to + 0.6 = 3.8

270 degrees. Flange rim around to tread rim. Gauss range read: -4.6 to + 1.5 = 6.1

315 degrees. Flange rim around to tread rim. Gauss range read: -2.9 to + 1.7 = 4.6

The maximum range of gauss in this wheel was from -4.6 to +1.7 or 6.3 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #07598 (on axle #8810-B)

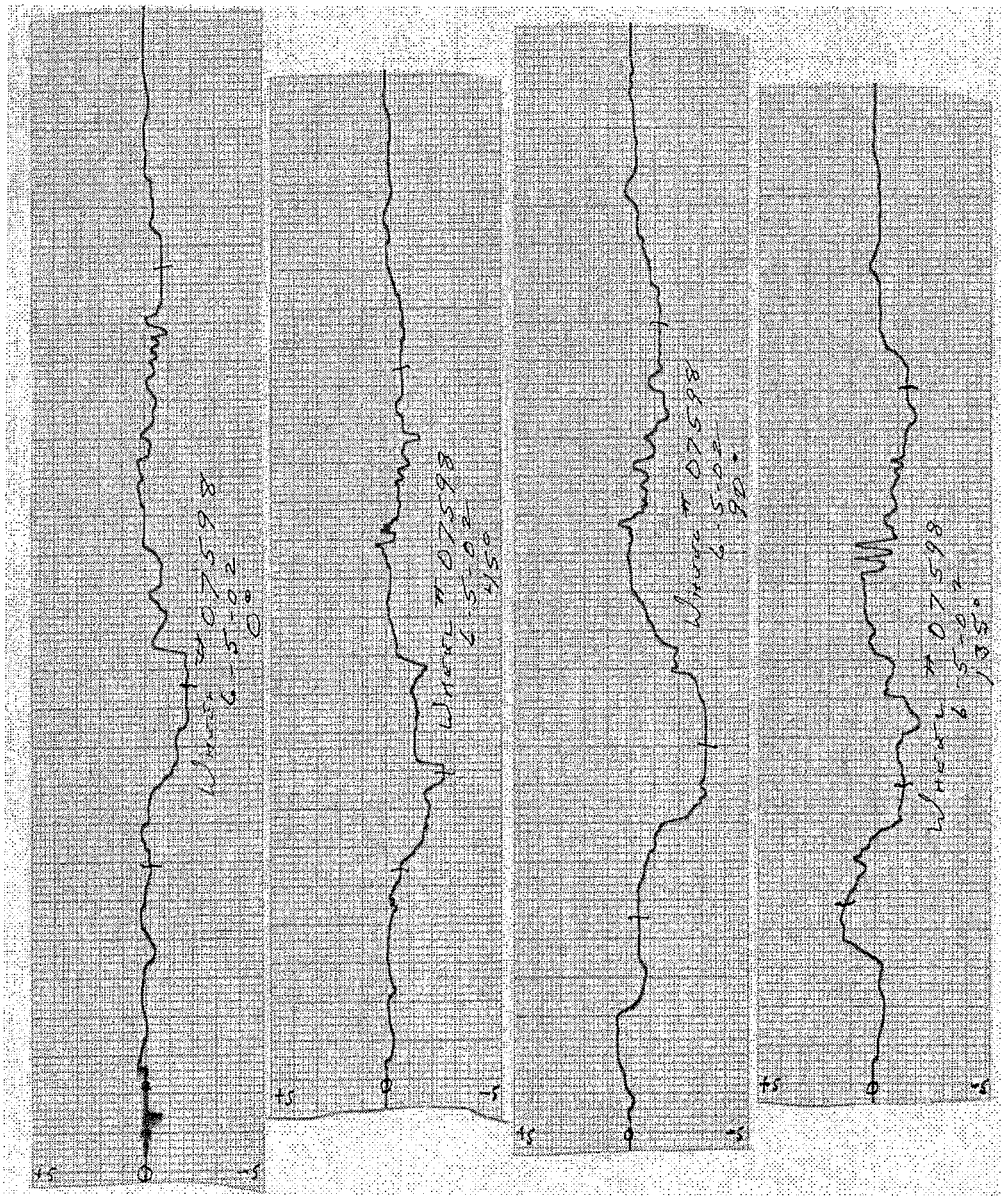
June 5, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

Flange Tip to Flange Rim



F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #07598 (on axle #8810-B)

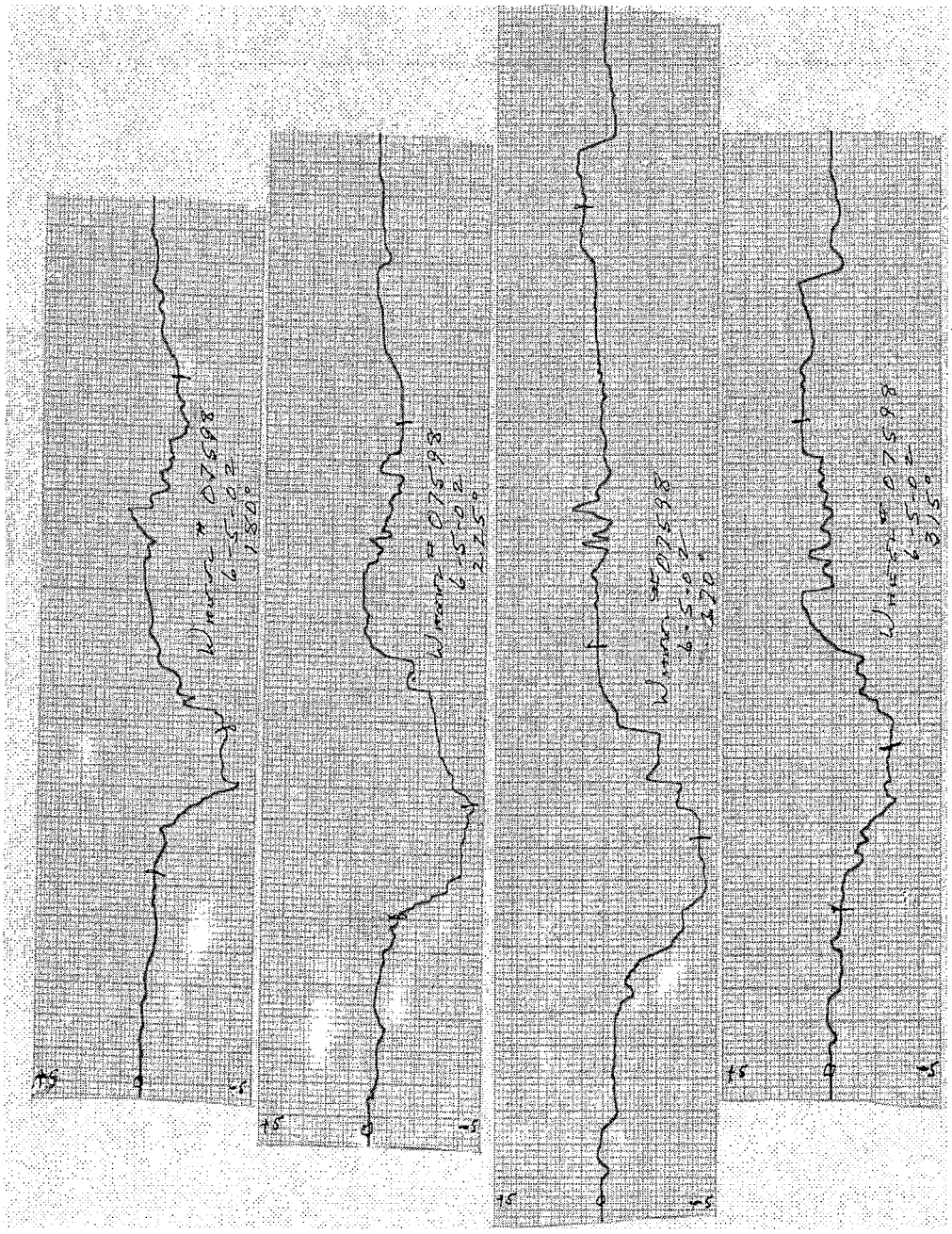
June 5, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings

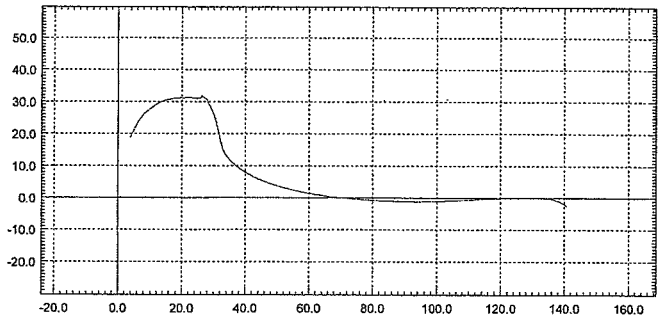
Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

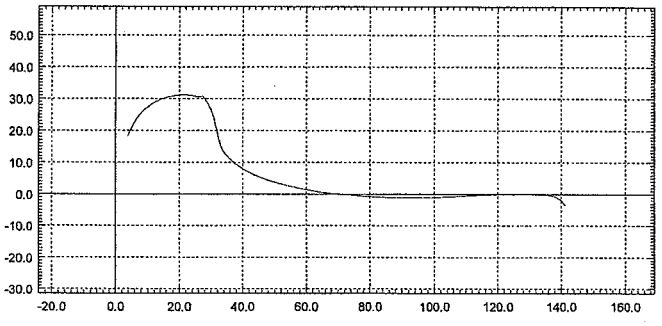
Flange Tip to Flange Rim





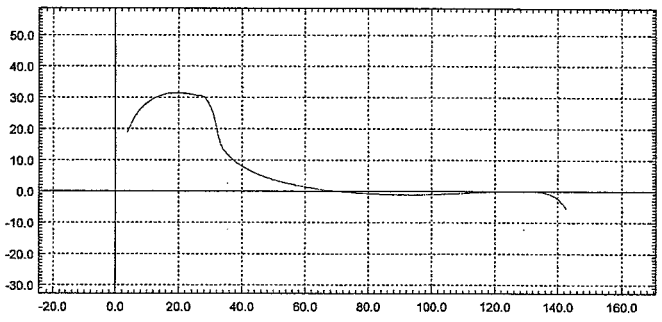
05062002-0171.whl
05/06/2002
130-0308

= 0°
Axle number = 8810 b
Wheel ID = 07598
Sd = 37.023 mm
Sh = 31.979 mm
qR = 9.099 mm
Flange width = 32.021 mm
Flange diameter = 980.129 mm
Taperline diameter = 917.567 mm



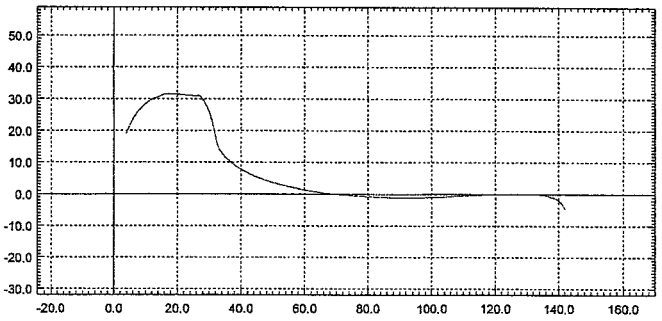
05062002-0181.whl
05/06/2002
130-0308

= 90°
Axle number = 8810 b
Wheel ID = 07598
Sd = 37.064 mm
Sh = 31.209 mm
qR = 8.557 mm
Flange width = 32.339 mm
Flange diameter = 975.693 mm
Taperline diameter = 913.269 mm



05062002-0191.whl
05/06/2002
130-0308

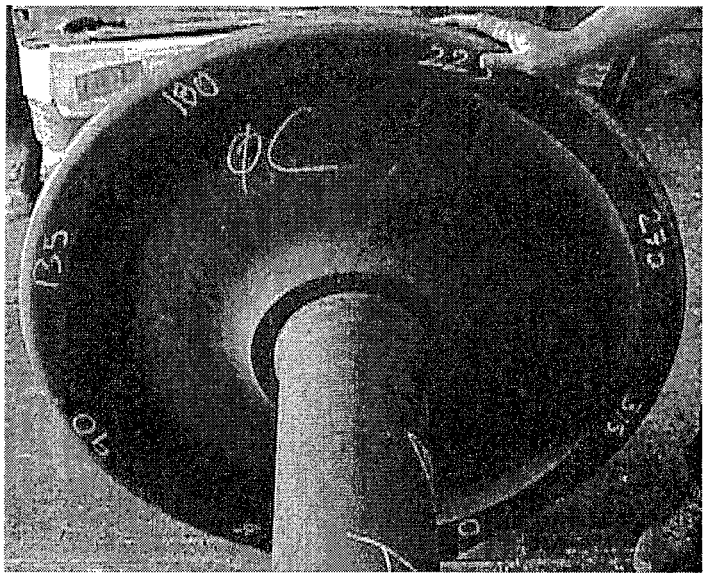
= 180°
Axle number = 8810 b
Wheel ID = 07598
Sd = 37.235 mm
Sh = 31.417 mm
qR = 8.601 mm
Flange width = 32.605 mm
Flange diameter = 981.443 mm
Taperline diameter = 918.611 mm

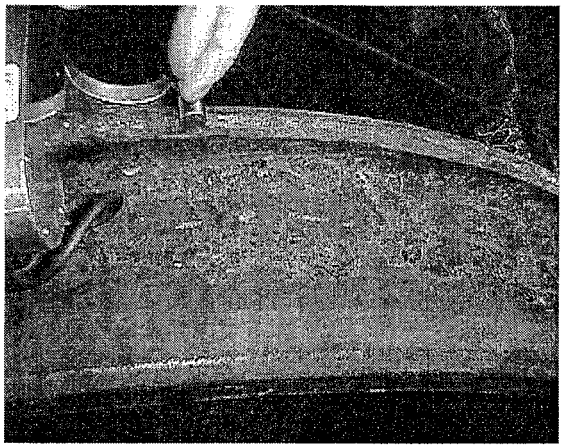


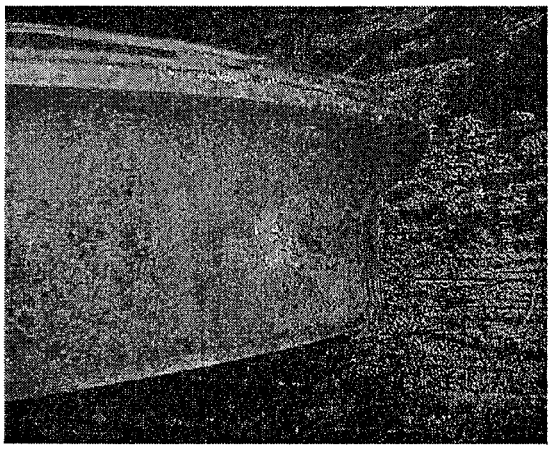
05062002-0201.whl
05/06/2002
130-0308

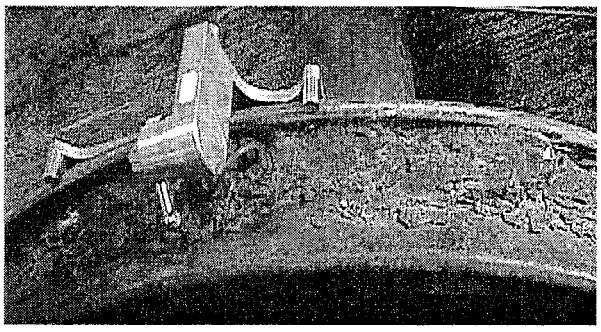
= 270°
Axle number = 8810 b
Wheel ID = 07598
Sd = 36.812 mm
Sh = 31.572 mm
qR = 8.679 mm
Flange width = 32.124 mm
Flange diameter = 977.491 mm
Taperline diameter = 914.336 mm

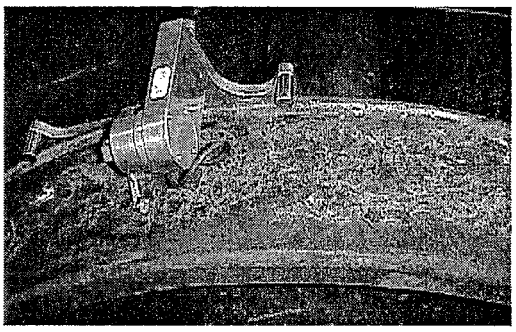
Wheel 10988
Built Up Tread


180
225
135
270
315
90
0









F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 10988 Progress Rail Services Corp., Sidney, NE June 5, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	274	331	335
45 degrees	652	273	223
90 degrees	205	546	205
135 degrees	290	170	181
180 degrees	234	168	158
225 degrees	170	225	133
270 degrees	276	687	593
315 degrees	199	085	475

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	647	497	438
45 degrees	317	674	471
90 degrees	520	557	484
135 degrees	427	354	463
180 degrees	472	554	435
225 degrees	313	250	286
270 degrees	387	542	321
315 degrees	517	529	339

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 5, 2002

INSPECTION SUBJECT: TEST WHEEL #10988 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -3.5 to + 3.0 = 6.5

45 degrees. Flange rim around to tread rim. Gauss range read: -1.0 to + 4.0 = 5.0

90 degrees. Flange rim around to tread rim. Gauss range read: -4.0 to + 7.0 = 11.0

135 degrees. Flange rim around to tread rim.Gauss range read: -28.0 to + 8.5 = 36.5

180 degrees. Flange rim around to tread rim. Gauss range read: -26.0 to + 0.0= 26.0

225 degrees. Flange rim around to tread rim. Gauss range read: -5.0 to + 0.0 = 5.0

270 degrees. Flange rim around to tread rim. Gauss range read: -9.0 to + 0.0 = 6.1

315 degrees. Flange rim around to tread rim. Gauss range read: -8.0 to + 0.0 = 8.0

The maximum range of gauss in this wheel was from –28.0 to +8.5 or 36.5 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #10988 (on axle #BN4606)

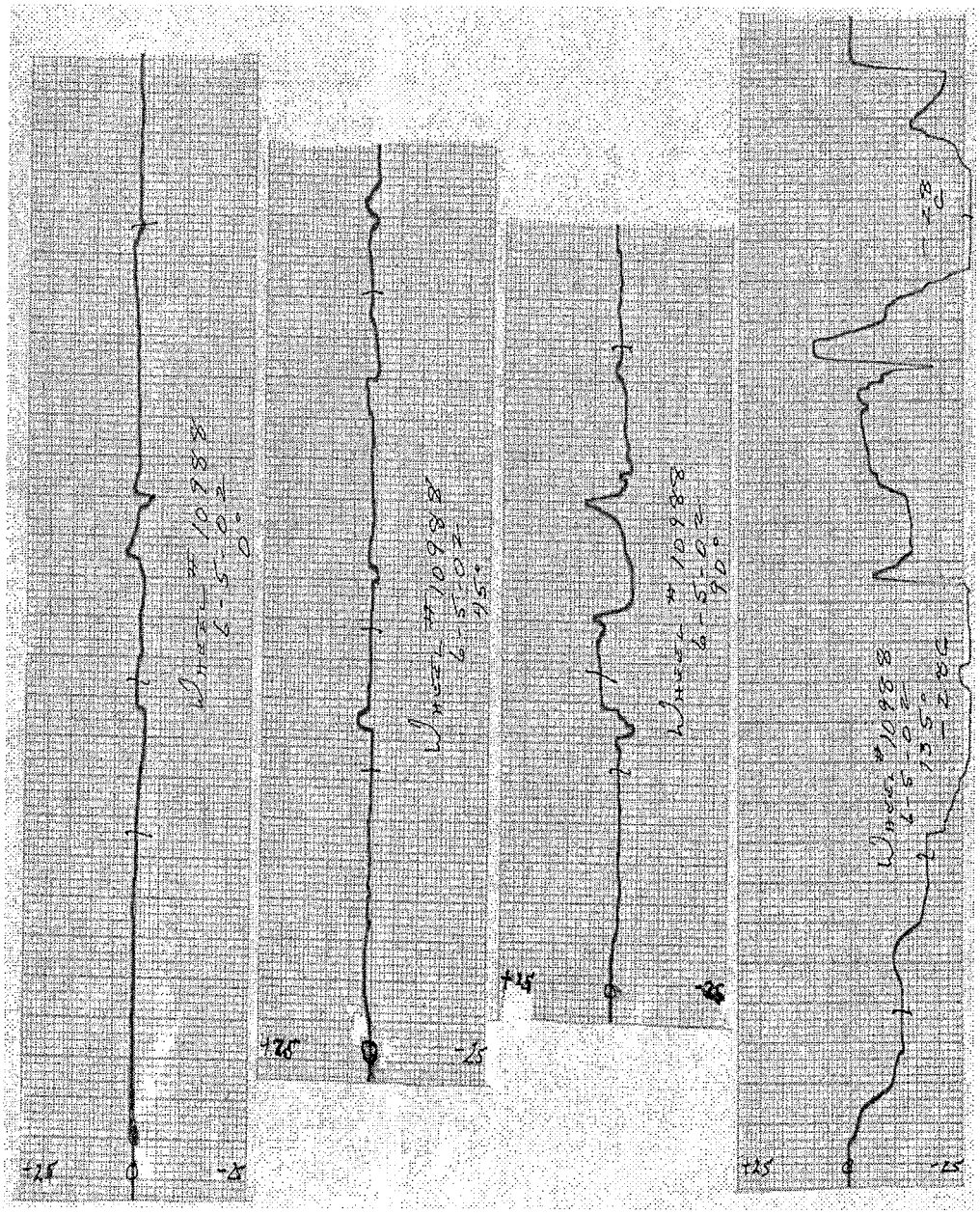
June 5, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

Flange Tip to Flange Rim



F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #10988 (on axle #BN4606)

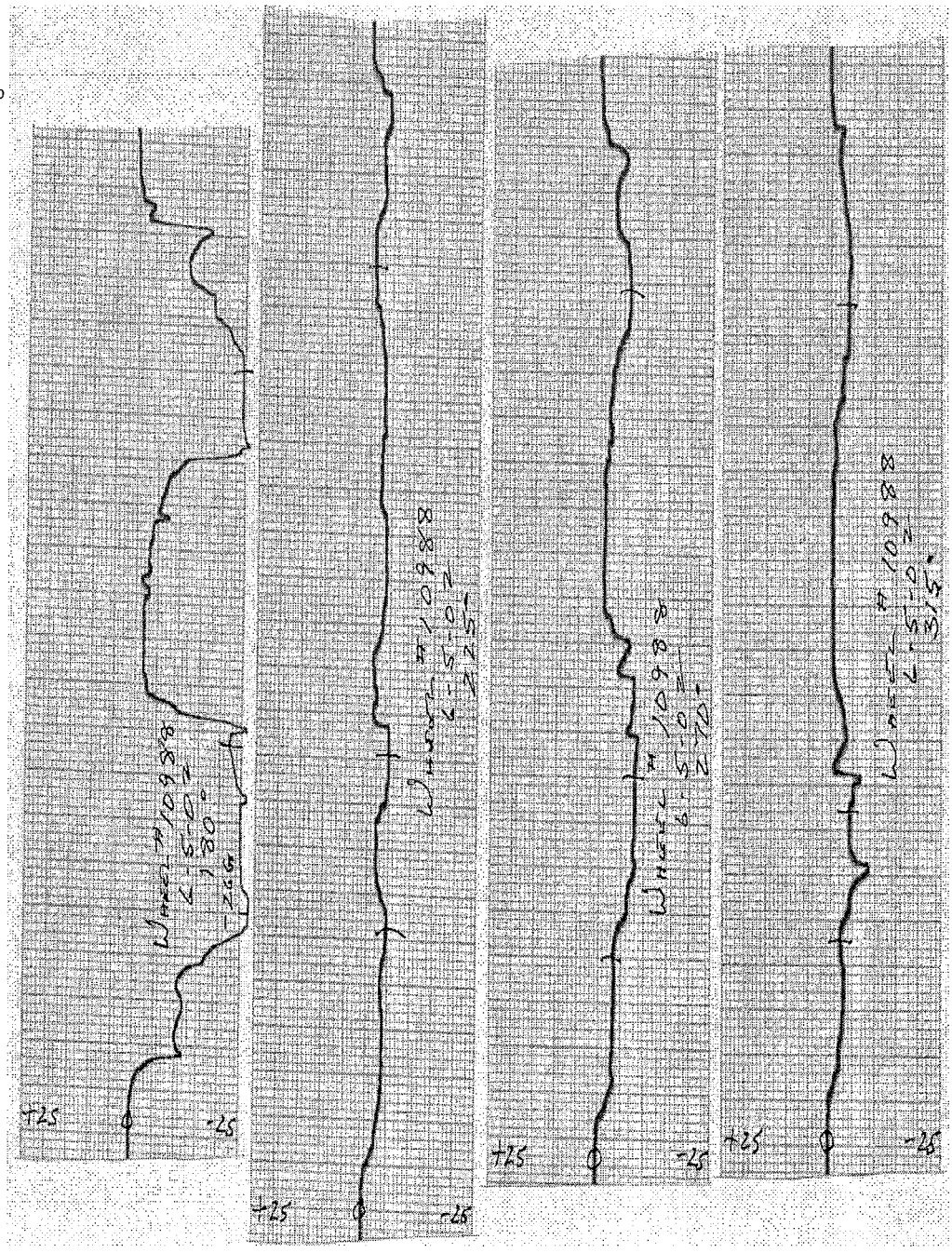
June 5, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings

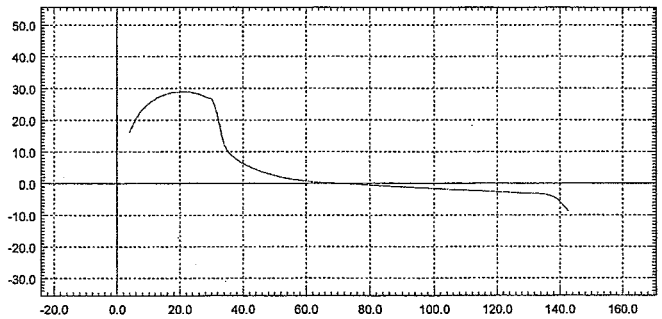
Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

Flange Tip to Flange Rim

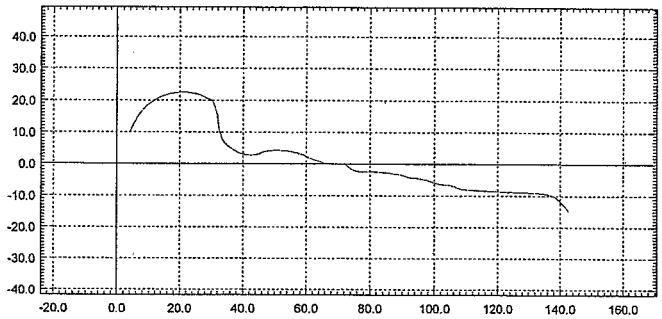




05062002-0011.whl
05/06/2002
130-0308

= 0 °

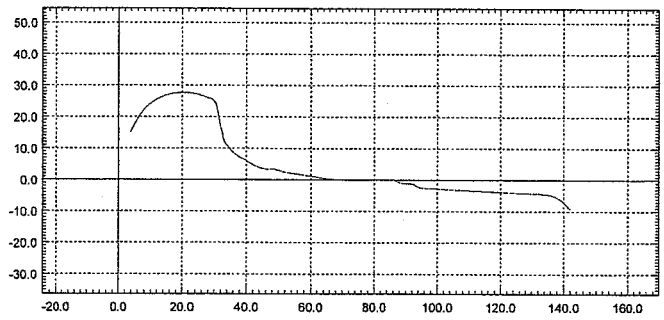
Axle number	= bn 4606
Wheel ID	= 10988
Sd	= 35.434 mm
Sh	= 28.962 mm
qR	= 6.464 mm
Flange width	= 33.374 mm
Flange diameter	= 977.140 mm
Taperline diameter	= 919.265 mm



05062002-0021.whl
05/06/2002
130-0308

= 90 °

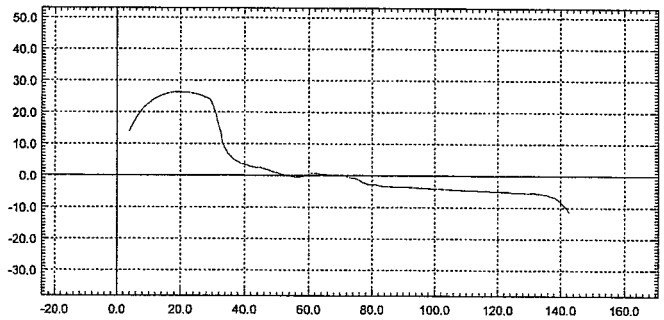
Axle number	= bn 4606
Wheel ID	= 10988
Sd	= 32.779 mm
Sh	= 22.601 mm
qR	= 4.179 mm
Flange width	= 33.186 mm
Flange diameter	= 976.676 mm
Taperline diameter	= 931.513 mm



05062002-0031.whl
05/06/2002
130-0308

= 180 °

Axle number	= bn 4606
Wheel ID	= 10988
Sd	= 34.867 mm
Sh	= 27.657 mm
qR	= 5.606 mm
Flange width	= 32.720 mm
Flange diameter	= 978.224 mm
Taperline diameter	= 922.917 mm



05062002-0041.whl
05/06/2002
130-0308

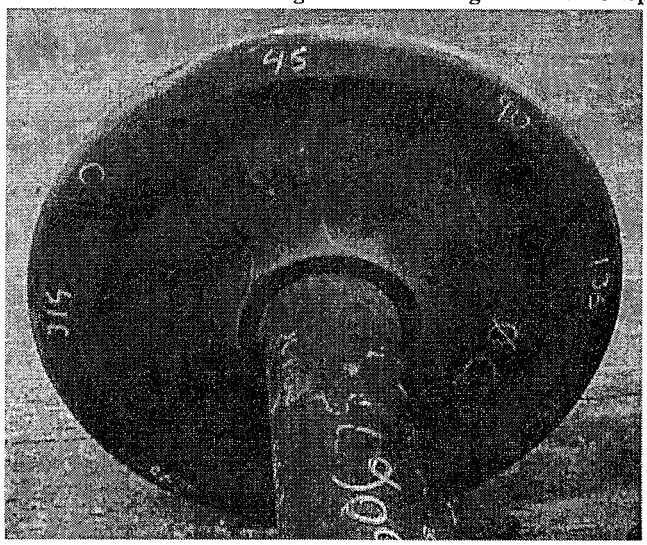
= 270 °

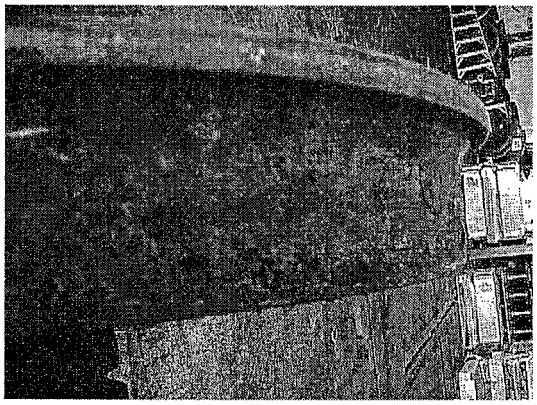
Axle number	= bn 4606
Wheel ID	= 10988
Sd	= 33.239 mm
Sh	= 26.424 mm
qR	= 4.544 mm
Flange width	= 32.752 mm
Flange diameter	= 976.503 mm
Taperline diameter	= 923.689 mm

Wheel 10989
Built Up Tread

F.R.A. TREAD BUILD-UP TEST

Wheel #10989 a tread damaged wheel at Progress Wheel Shop





F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 10989 Progress Rail Services Corp., Sidney, NE June 5, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	761	497	282
45 degrees	530	1091	311
90 degrees	238	392	184
135 degrees	231	290	213
180 degrees	187	258	149
225 degrees	232	212	196
270 degrees	271	211	815
315 degrees	317	261	154

HARDNESS READINGS (HB) of TREAD® FACE

Location	Near Flange	Center	Near outer rim
0 degrees	371	632	460
45 degrees	365	304	517
90 degrees	337	410	461
135 degrees	489	517	503
180 degrees	477	517	391
225 degrees	643	577	524
270 degrees	472	367	463
315 degrees	489	573	496

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 5, 2002

INSPECTION SUBJECT: TEST WHEEL #12222 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -3.3 to + 1.5 = 4.8

45 degrees. Flange rim around to tread rim. Gauss range read: -2.5 to + 0.6 = 3.1

90 degrees. Flange rim around to tread rim. Gauss range read: -3.3 to + 0.8 = 4.1

135 degrees. Flange rim around to tread rim.Gauss range read: -2.2 to + 1.0 = 3.2

180 degrees. Flange rim around to tread rim. Gauss range read: -3.0 to + 0.4= 3.4

225 degrees. Flange rim around to tread rim. Gauss range read: -2.9 to + 0.7 = 3.6

270 degrees. Flange rim around to tread rim. Gauss range read: -3.4 to + 0.2 = 3.6

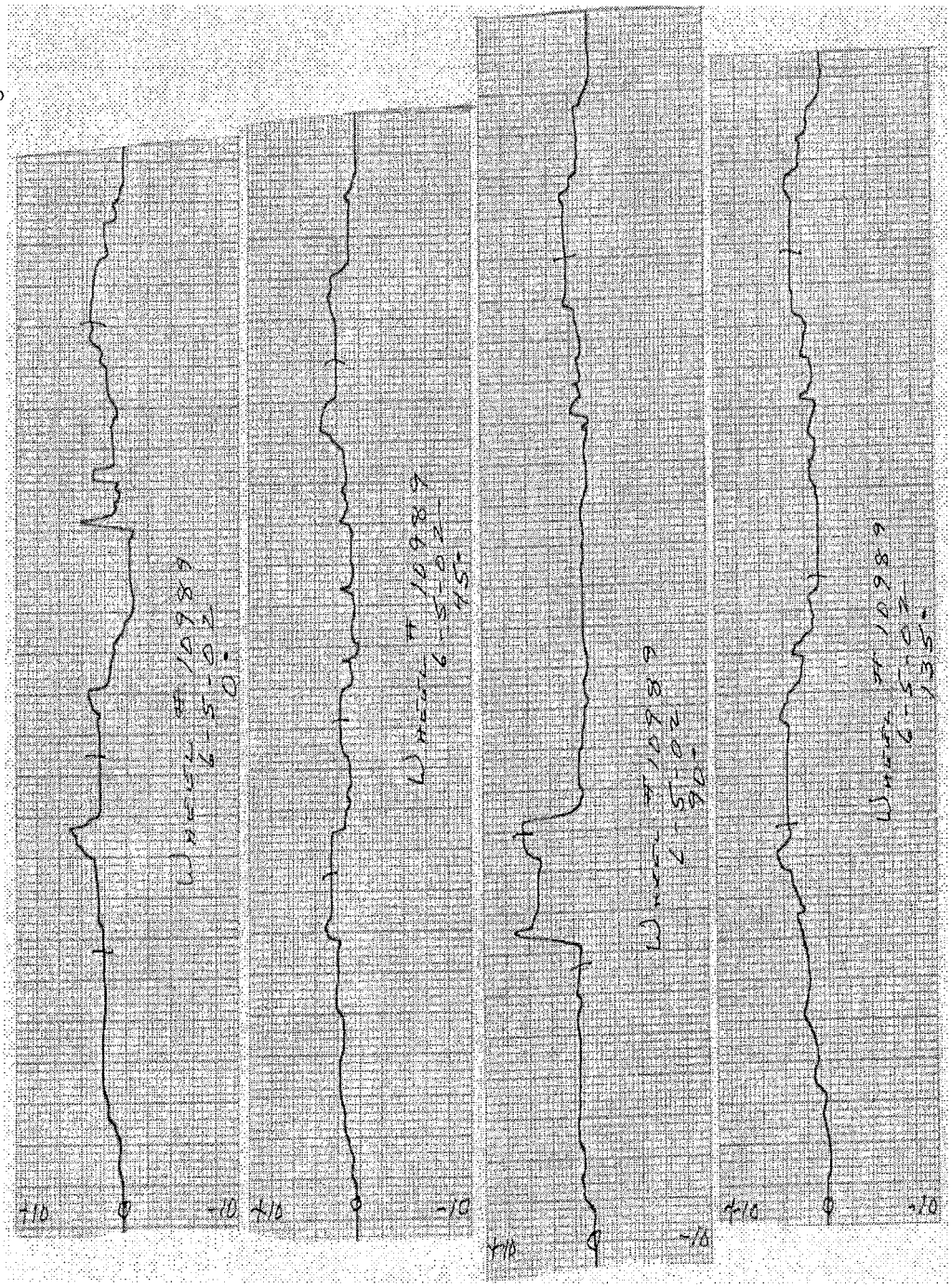
315 degrees. Flange rim around to tread rim. Gauss range read: -2.8 to + 1.5 = 4.3

The maximum range of gauss in this wheel was from –3.4 to +1.5 or 4.9 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #10989 (on axle #BN4606)

June 4, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings



F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #10989 (on axle #BN4606)

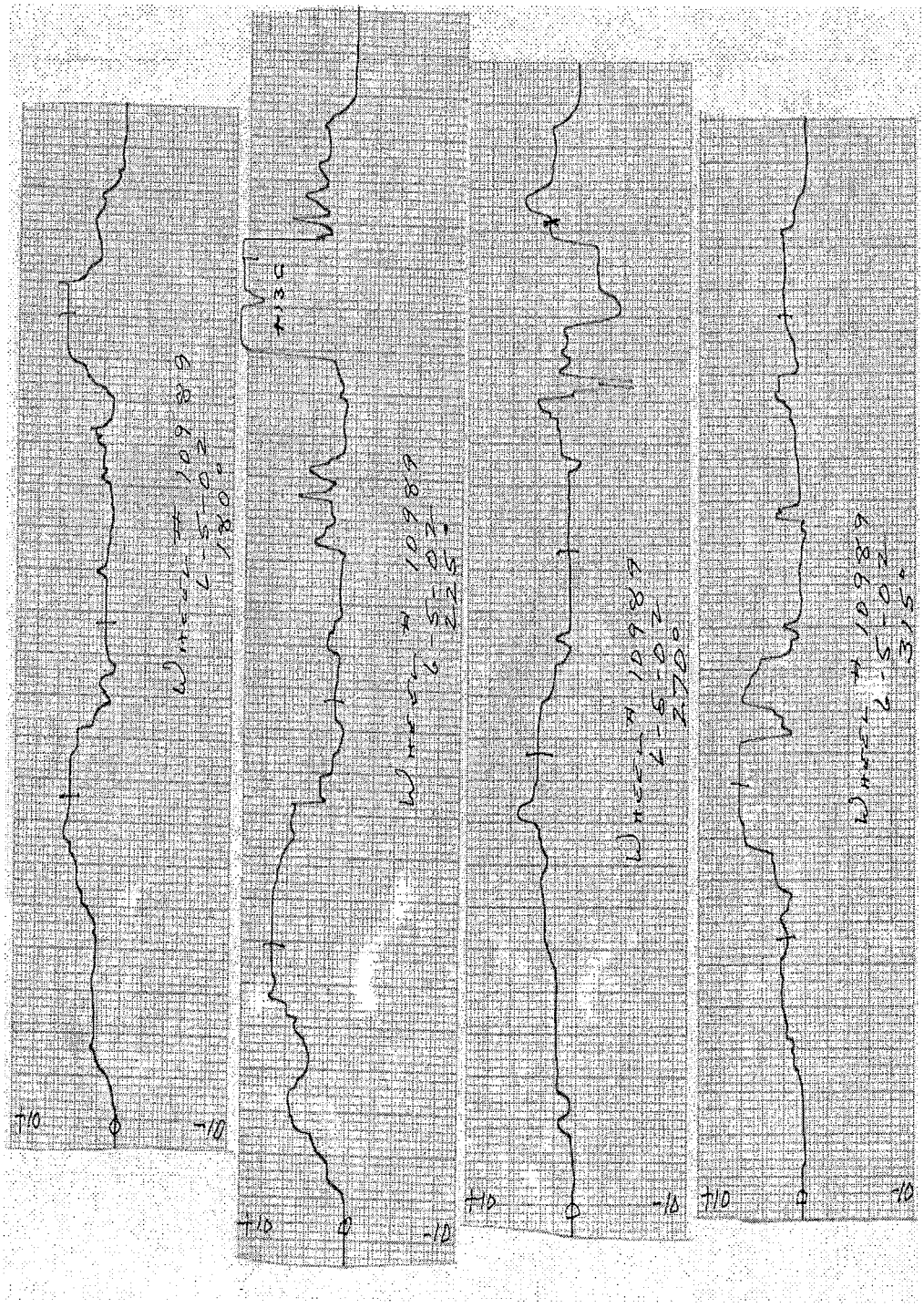
June 5, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings

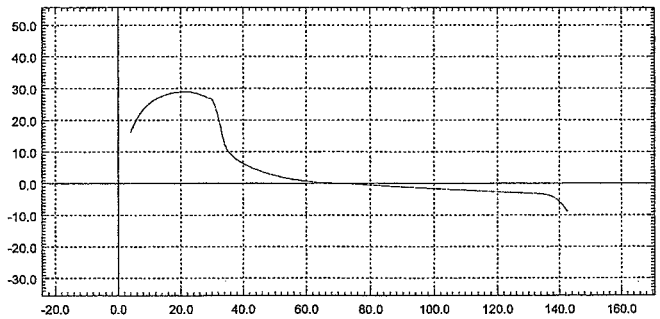
Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

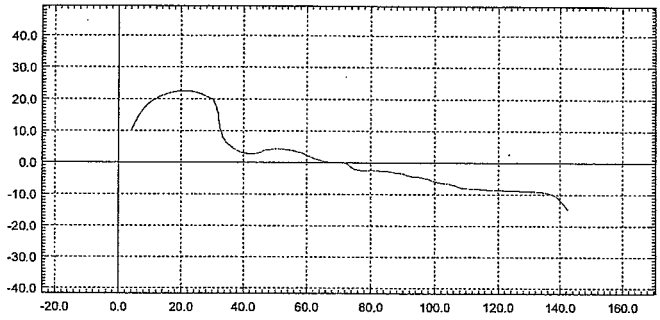
Flange Tip to Flange Rim





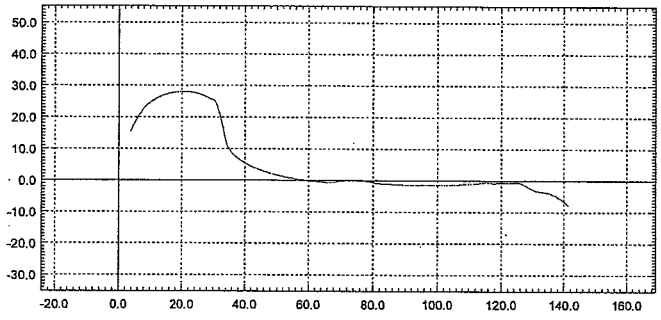
05062002-0011.whl
05/06/2002
130-0308

= 0 °
Axle number = bn 4606
Wheel ID = 10988
Sd = 35.434 mm
Sh = 28.962 mm
qR = 6.464 mm
Flange width = 33.374 mm
Flange diameter = 977.140 mm
Taperline diameter = 919.265 mm



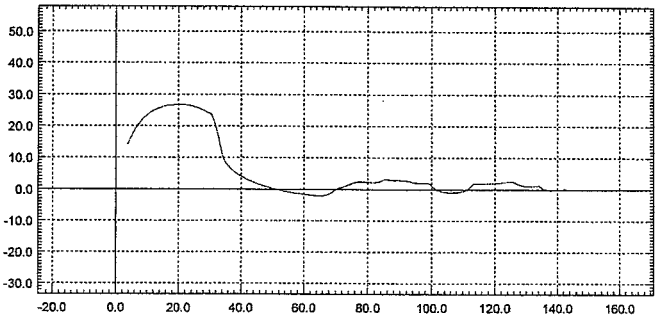
05062002-0021.whl
05/06/2002
130-0308

= 90 °
Axle number = bn 4606
Wheel ID = 10988
Sd = 32.779 mm
Sh = 22.601 mm
qR = 4.179 mm
Flange width = 33.186 mm
Flange diameter = 976.676 mm
Taperline diameter = 931.513 mm



05062002-0071.whl
05/06/2002
130-0308

= 180 °
Axle number = bn 4606
Wheel ID = 10989
Sd = 35.090 mm
Sh = 28.207 mm
qR = 6.618 mm
Flange width = 33.596 mm
Flange diameter = 978.405 mm
Taperline diameter = 922.149 mm



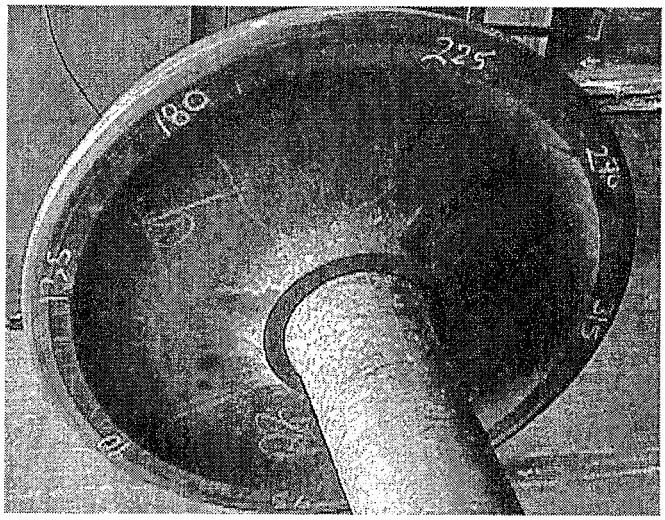
05062002-0081.whl
05/06/2002
130-0308

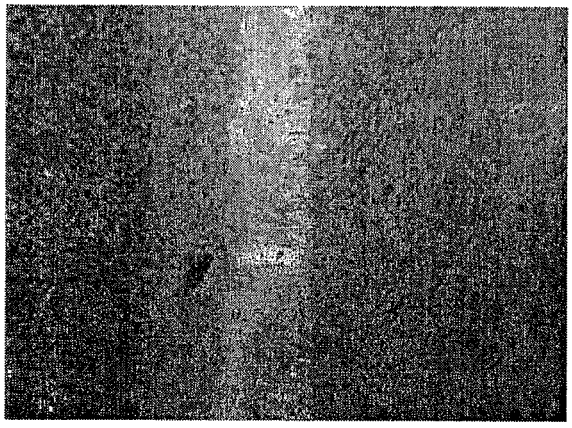
= 270 °
Axle number = bn 4606
Wheel ID = 10989
Sd = 34.384 mm
Sh = 26.910 mm
qR = 5.970 mm
Flange width = 33.613 mm
Flange diameter = 978.024 mm
Taperline diameter = 921.128 mm

Wheel 12222
Slight Metal Build Up

F.R.A. TREAD BUILD-UP TEST

Wheel #12222 a "No tread damage" wheel at Progress Wheel Shop





F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 12222 Progress Rail Services Corp., Sidney, NE June 5, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	107	022	077
45 degrees	022	022	027
90 degrees	099	020	038
135 degrees	086	049	068
180 degrees	079	017	024
225 degrees	100	022	043
270 degrees	096	041	030
315 degrees	128	030	053

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	589	452	494
45 degrees	531	487	497
90 degrees	513	407	561
135 degrees	463	438	415
180 degrees	533	405	455
225 degrees	518	453	464
270 degrees	464	511	417
315 degrees	520	527	571

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 5, 2002

INSPECTION SUBJECT: TEST WHEEL #12222 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -3.3 to + 1.5 = 4.8

45 degrees. Flange rim around to tread rim. Gauss range read: -2.5 to + 0.6 = 3.1

90 degrees. Flange rim around to tread rim. Gauss range read: -3.3 to + 0.8 = 4.1

135 degrees. Flange rim around to tread rim.Gauss range read: -2.2 to + 1.0 = 3.2

180 degrees. Flange rim around to tread rim. Gauss range read: -3.0 to + 0.4= 3.4

225 degrees. Flange rim around to tread rim. Gauss range read: -2.9 to + 0.7 = 3.6

270 degrees. Flange rim around to tread rim. Gauss range read: -3.4 to + 0.2 = 3.6

315 degrees. Flange rim around to tread rim. Gauss range read: -2.8 to + 1.5 = 4.3

The maximum range of gauss in this wheel was from –3.4 to +1.5 or 4.9 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #12222 (on axle #8810)

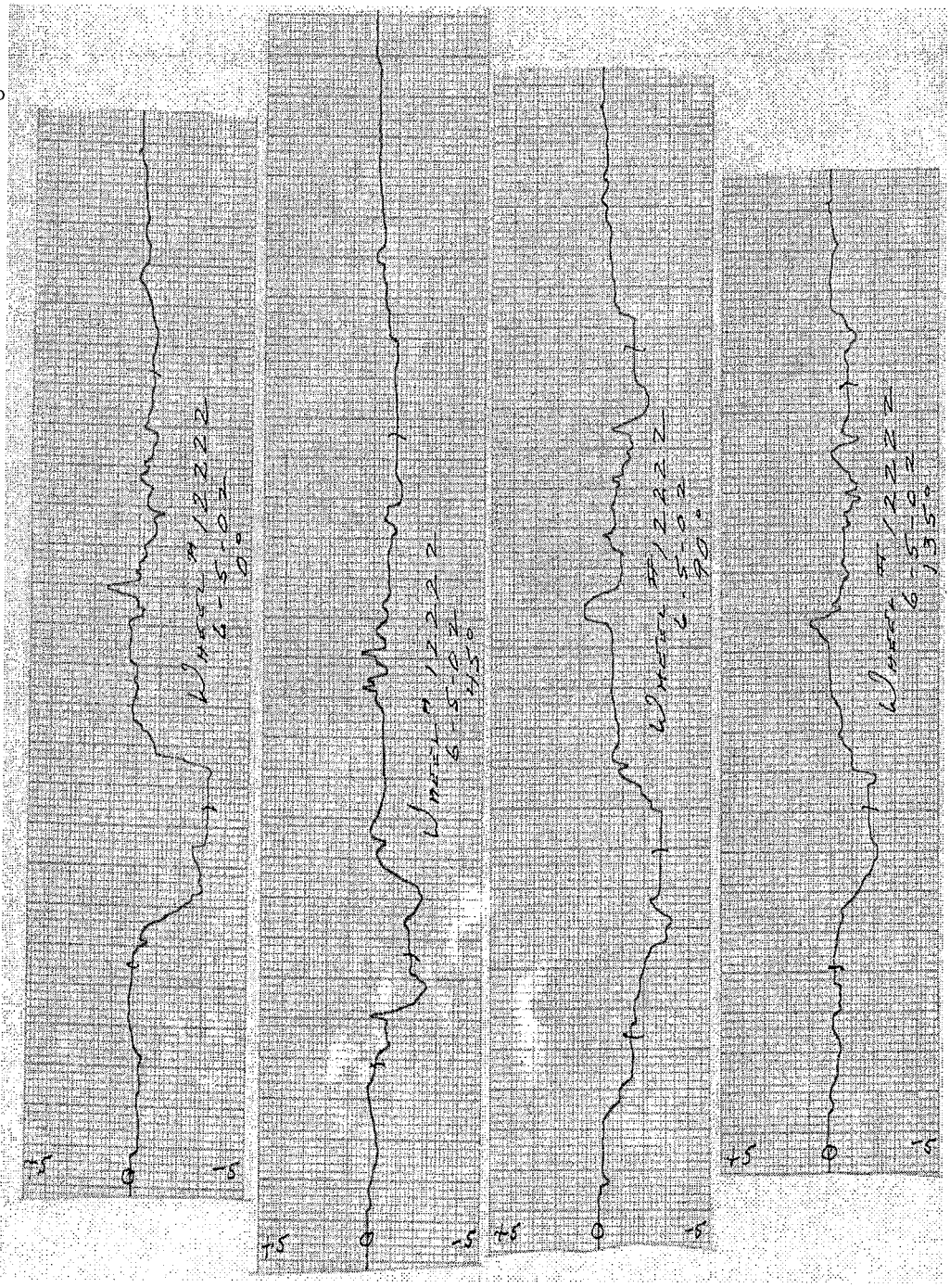
June 5, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

Flange Tip to Flange Rim



F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #12222 (on axle #8810)

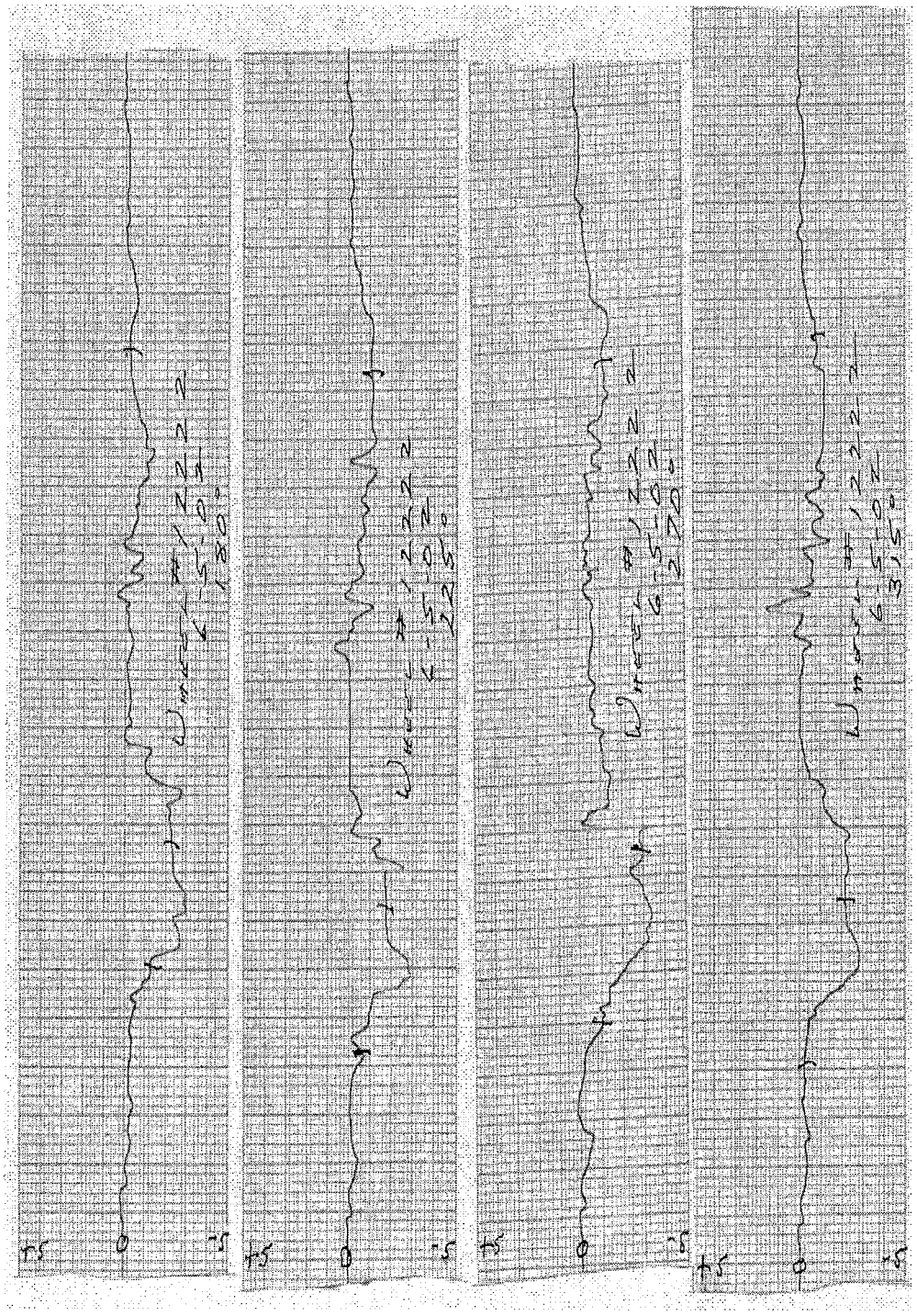
June 5, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings

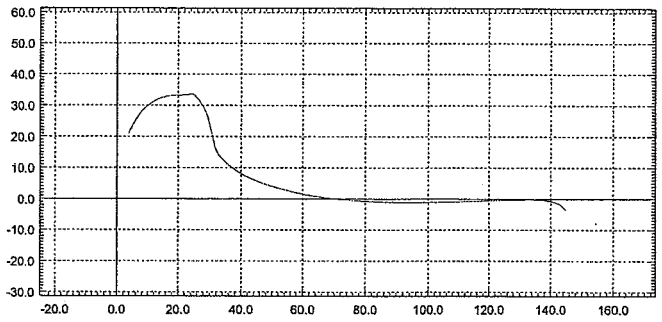
Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

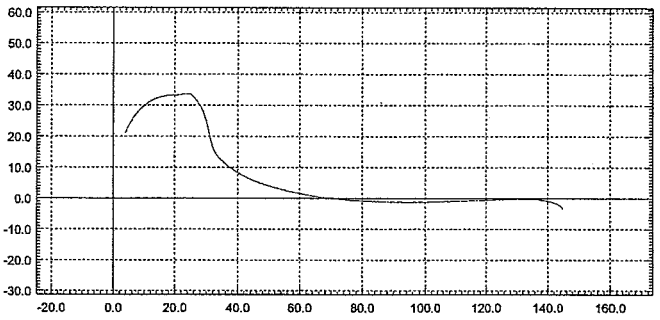
Flange Tip to Flange Rim





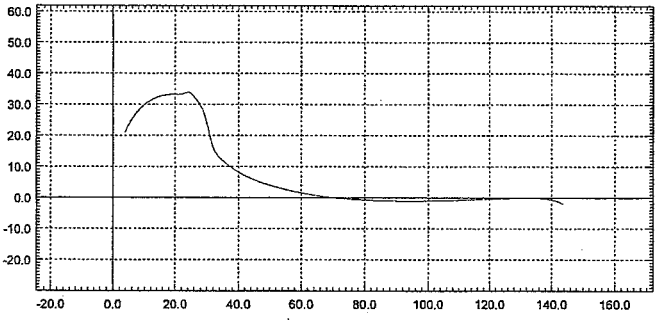
05062002-0291.whl
05/06/2002
130-0308

Stock	=
Car number	= 0
Axle number	= 8810
Wheel ID	= 12222 -0°
Sd	= 37.050 mm
Sh	= 33.659 mm
qR	= 10.555 mm
Flange width	= 30.900 mm
Flange diameter	= 979.130 mm
Taperline diameter	= 911.833 mm



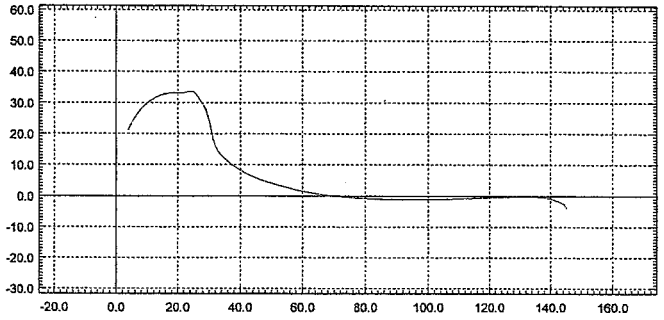
05062002-0301.whl
05/06/2002
130-0308

Stock	=
Car number	= 90
Axle number	= 8810
Wheel ID	= 12222 -90°
Sd	= 37.434 mm
Sh	= 33.716 mm
qR	= 10.521 mm
Flange width	= 31.162 mm
Flange diameter	= 977.983 mm
Taperline diameter	= 910.551 mm



05062002-0311.whl
05/06/2002
130-0308

Stock	=
Car number	= 180
Axle number	= 8810
Wheel ID	= 12222 -180°
Sd	= 37.222 mm
Sh	= 33.957 mm
qR	= 10.807 mm
Flange width	= 30.866 mm
Flange diameter	= 972.931 mm
Taperline diameter	= 905.023 mm



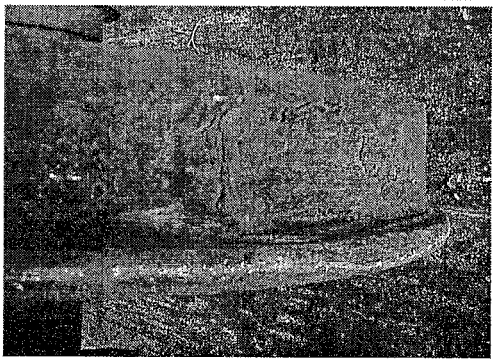
05062002-0321.whl
05/06/2002
130-0308

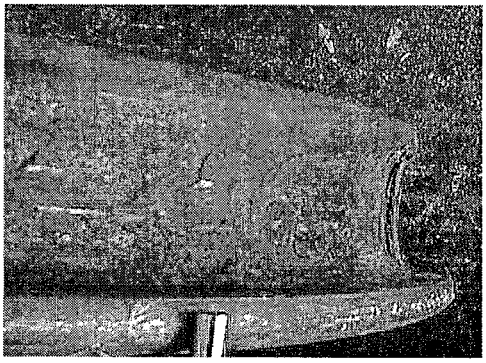
Stock	=
Car number	= 270
Axle number	= 8810
Wheel ID	= 12222 -270°
Sd	= 37.277 mm
Sh	= 33.821 mm
qR	= 10.660 mm
Flange width	= 30.986 mm
Flange diameter	= 972.674 mm
Taperline diameter	= 905.413 mm

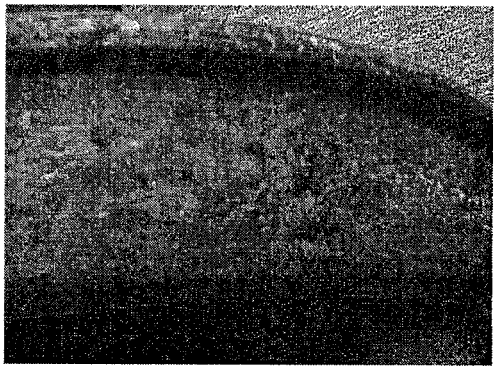
Wheel 14073
Built Up Tread

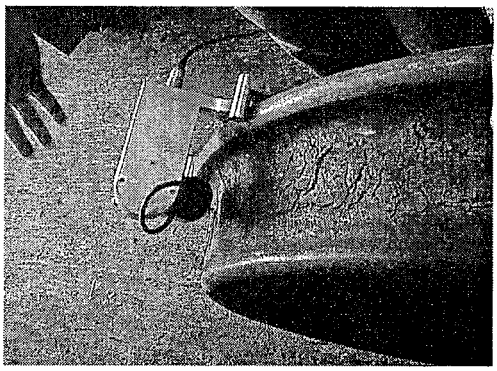
F.R.A. TREAD BUILD-UP TEST

Wheel #14073 a tread damaged wheel at Progress Wheel Shop









F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 14073 Progress Rail Services Corp., Sidney, NE June 5, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	318	203	142
45 degrees	250	360	216
90 degrees	212	427	506
135 degrees	1089	339	341
180 degrees	678	441	826
225 degrees	156	991	164
270 degrees	229	282	243
315 degrees	159	429	178

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	538	492	474
45 degrees	538	405	471
90 degrees	610	450	461
135 degrees	293	393	430
180 degrees	318	552	439
225 degrees	222	387	435
270 degrees	503	432	389
315 degrees	496	335	486

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 5, 2002

INSPECTION SUBJECT: TEST WHEEL #15489 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -5.4 to + 1.0 = 6.4

45 degrees. Flange rim around to tread rim. Gauss range read: -3.2 to + 0.8 = 4.0

90 degrees. Flange rim around to tread rim. Gauss range read: -3.7 to + 1.7 = 5.4

135 degrees. Flange rim around to tread rim.Gauss range read: -3.3 to + 0.5 = 3.8

180 degrees. Flange rim around to tread rim. Gauss range read: -3.9 to + 0.5= 5.0

225 degrees. Flange rim around to tread rim. Gauss range read: -1.7 to + 0.8 = 12.0

270 degrees. Flange rim around to tread rim. Gauss range read: -4.7 to + 1.0 = 5.7

315 degrees. Flange rim around to tread rim. Gauss range read: -5.0 to + 1.2 = 6.2

The maximum range of gauss in this wheel was from –5.4 to +1.7 or 7.1 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #14073 (on axle #6767)

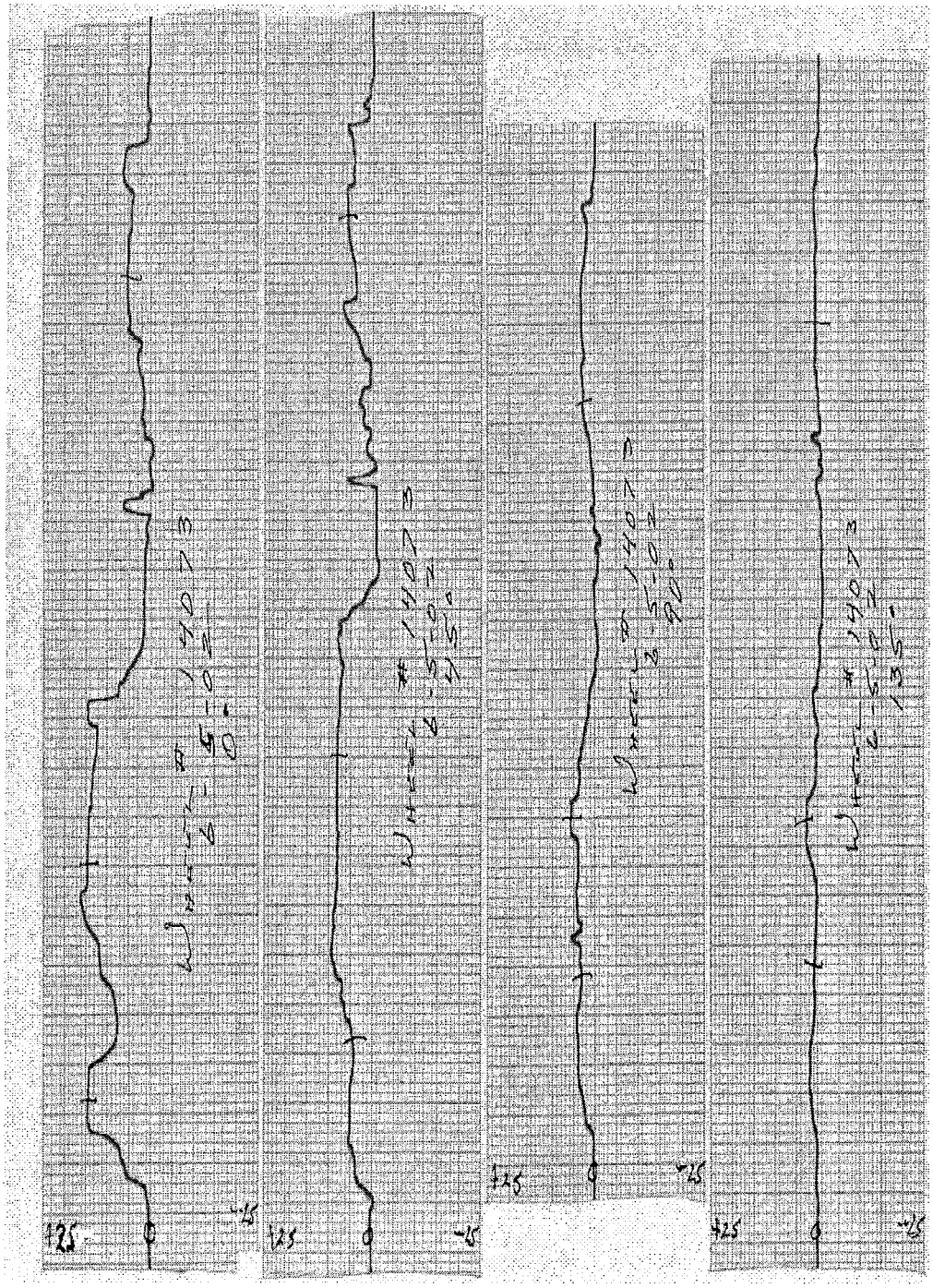
June 5, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

Flange Tip to Flange Rim



F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #14073 (on axle #6767)

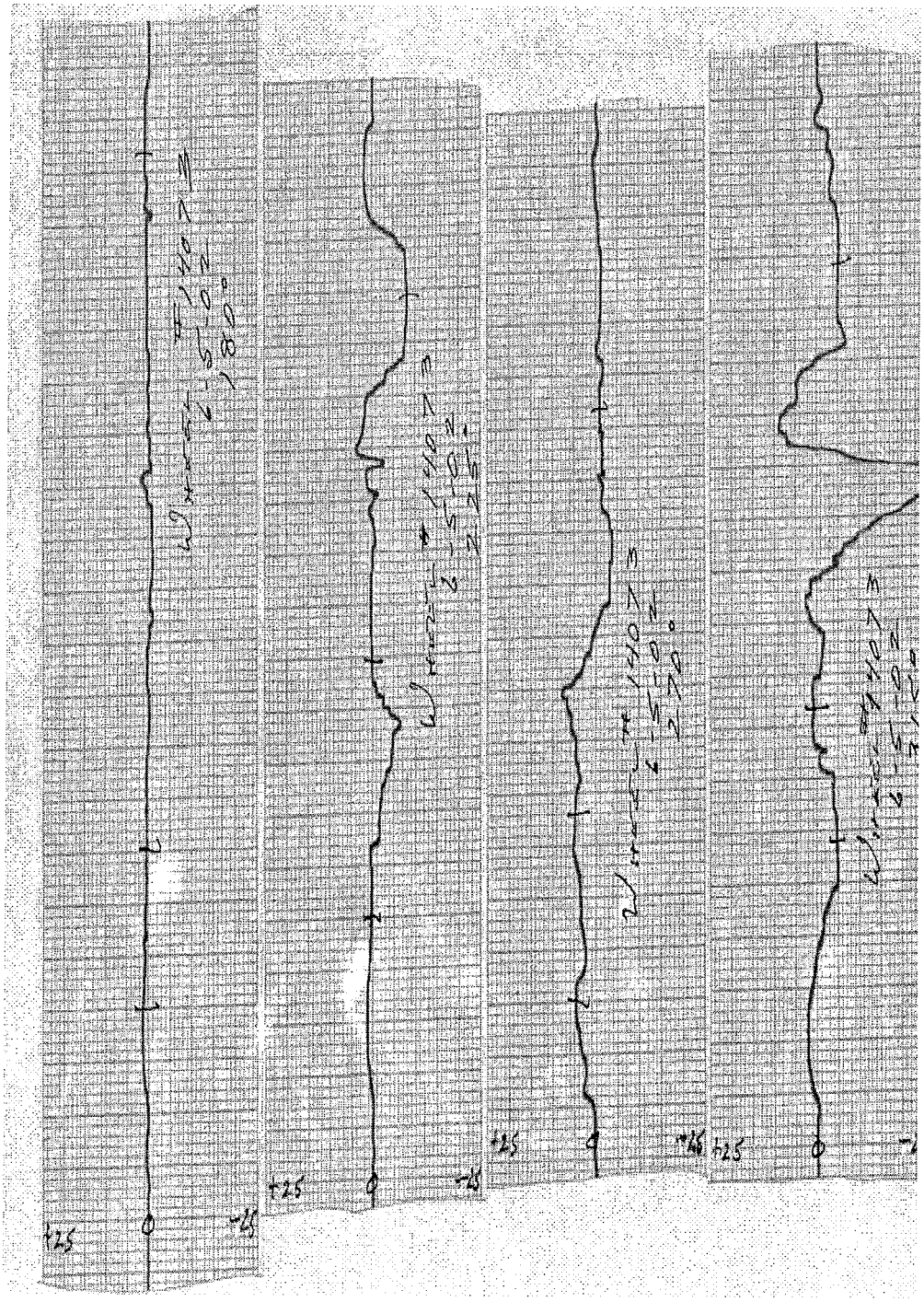
June 5, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings

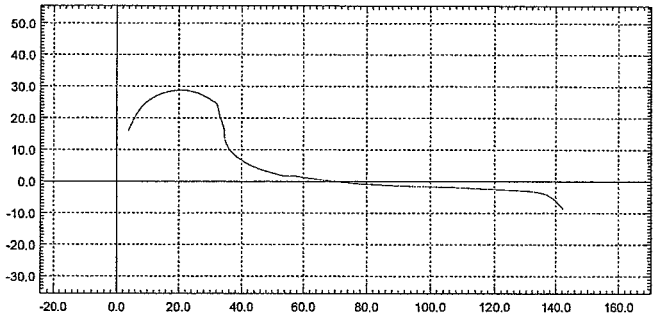
Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

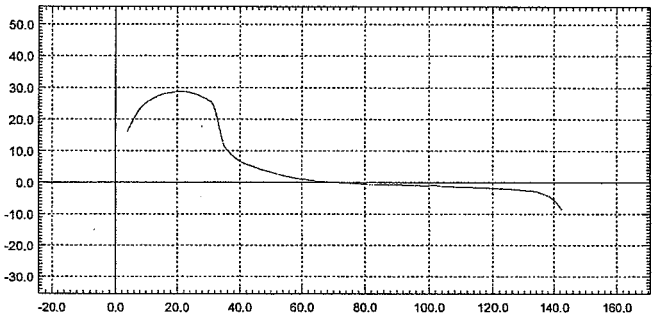
Flange Tip to Flange Rim





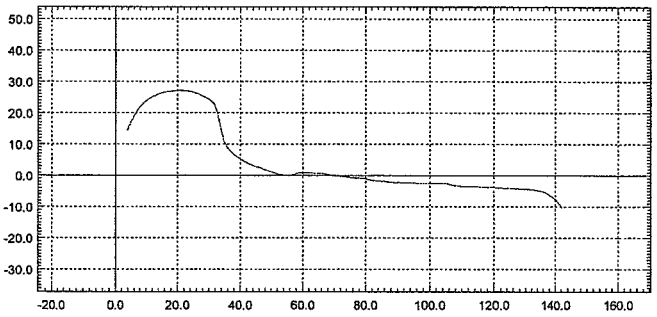
05062002-0131.whl
05/06/2002
130-0308

Stock	=
Car number	= 0
Axle number	= 6767
Wheel ID	= 14073 - 0°
Sd	= 36.175 mm
Sh	= 28.748 mm
qR	= 7.778 mm
Flange width	= 34.502 mm
Flange diameter	= 970.278 mm
Taperline diameter	= 912.746 mm



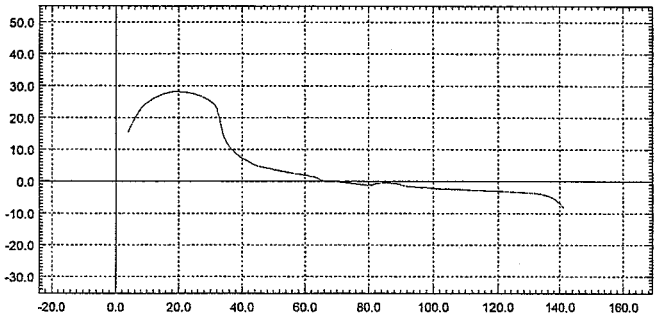
05062002-0141.whl
05/06/2002
130-0308

Stock	=
Car number	= 90
Axle number	= 6767
Wheel ID	= 14073 - 90°
Sd	= 36.097 mm
Sh	= 28.807 mm
qR	= 7.553 mm
Flange width	= 34.059 mm
Flange diameter	= 977.762 mm
Taperline diameter	= 920.141 mm



05062002-0151.whl
05/06/2002
130-0308

Stock	=
Car number	= 180
Axle number	= 6767
Wheel ID	= 14073 - 180°
Sd	= 35.220 mm
Sh	= 27.124 mm
qR	= 6.701 mm
Flange width	= 34.221 mm
Flange diameter	= 976.752 mm
Taperline diameter	= 922.491 mm



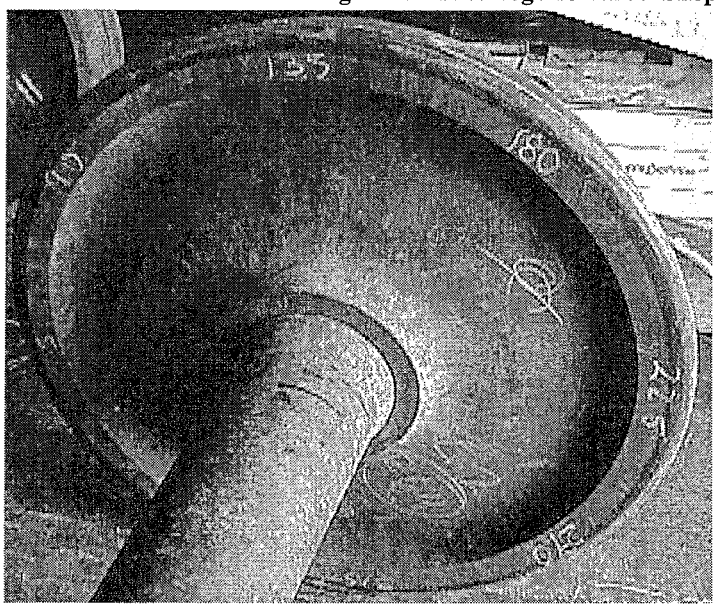
05062002-0161.whl
05/06/2002
130-0308

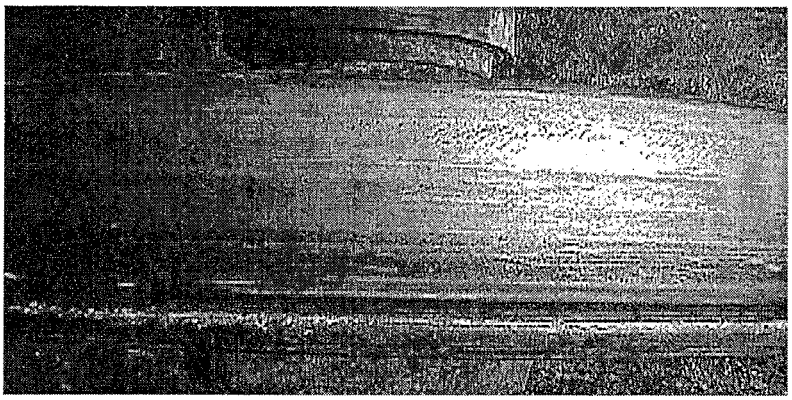
Stock	=
Car number	= 270
Axle number	= 6767
Wheel ID	= 14073 - 270°
Sd	= 36.783 mm
Sh	= 28.256 mm
qR	= 8.592 mm
Flange width	= 34.208 mm
Flange diameter	= 972.152 mm
Taperline diameter	= 915.676 mm

Wheel 15489
Thermal Cracks on Tread

F.R.A. TREAD BUILD-UP TEST

Wheel #15489 a "No tread damage" wheel at Progress Wheel Shop





F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 15489 Progress Rail Services Corp., Sidney, NE June 5, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	091	026	067
45 degrees	038	042	084
90 degrees	025	053	028
135 degrees	025	016	028
180 degrees	052	022	032
225 degrees	026	024	078
270 degrees	026	041	045
315 degrees	033	028	036

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	479	506	542
45 degrees	513	602	643
90 degrees	411	453	538
135 degrees	421	510	587
180 degrees	474	522	550
225 degrees	486	448	577
270 degrees	472	484	464
315 degrees	554	569	577

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 5, 2002

INSPECTION SUBJECT: TEST WHEEL #15489 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -5.4 to + 1.0 = 6.4

45 degrees. Flange rim around to tread rim. Gauss range read: -3.2 to + 0.8 = 4.0

90 degrees. Flange rim around to tread rim. Gauss range read: -3.7 to + 1.7 = 5.4

135 degrees. Flange rim around to tread rim.Gauss range read: -3.3 to + 0.5 = 3.8

180 degrees. Flange rim around to tread rim. Gauss range read: -3.9 to + 0.5= 5.0

225 degrees. Flange rim around to tread rim. Gauss range read: -1.7 to + 0.8 = 12.0

270 degrees. Flange rim around to tread rim. Gauss range read: -4.7 to + 1.0 = 5.7

315 degrees. Flange rim around to tread rim. Gauss range read: -5.0 to + 1.2 = 6.2

The maximum range of gauss in this wheel was from –5.4 to +1.7 or 7.1 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #15489 (on axle #8810)

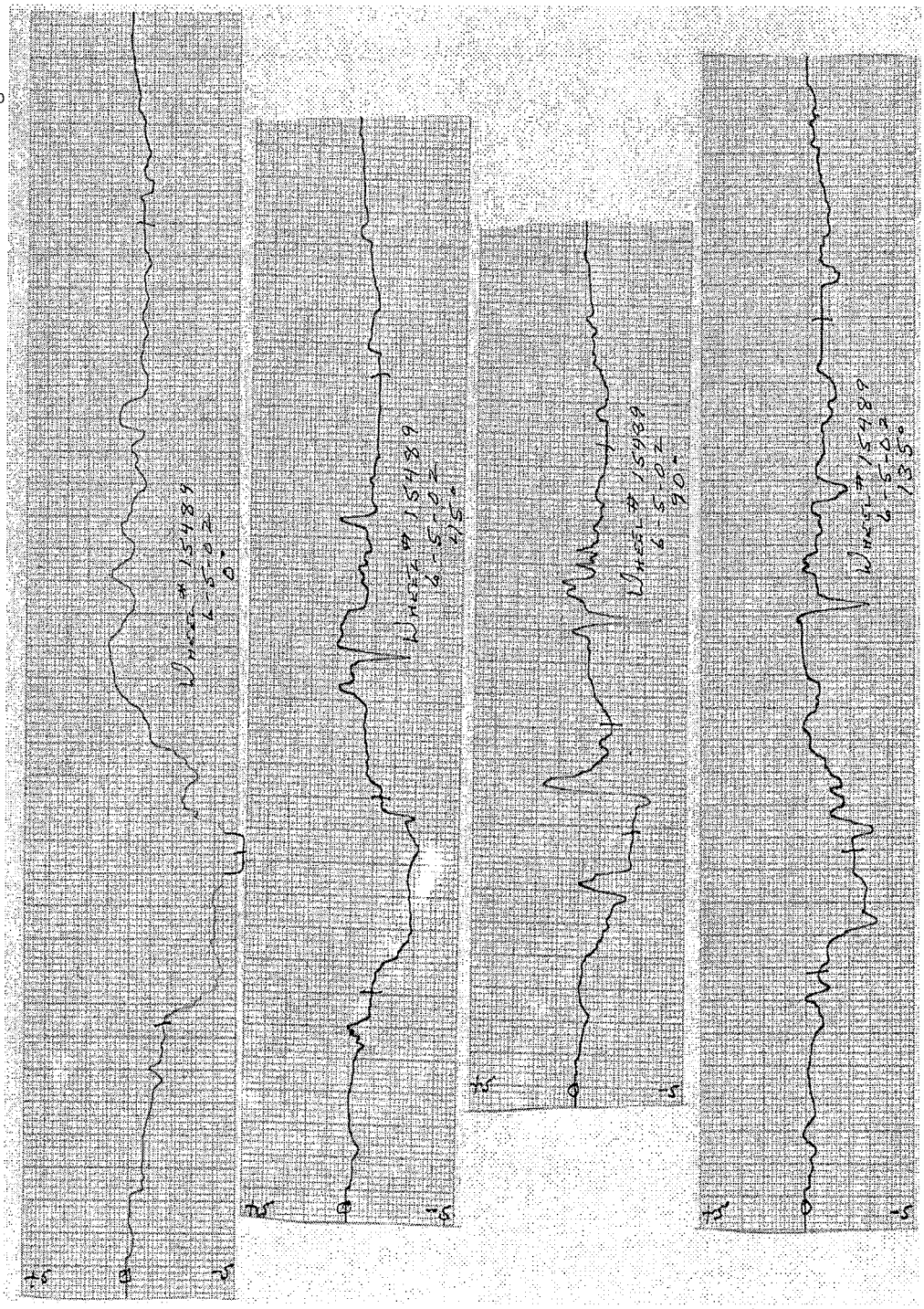
June 5, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

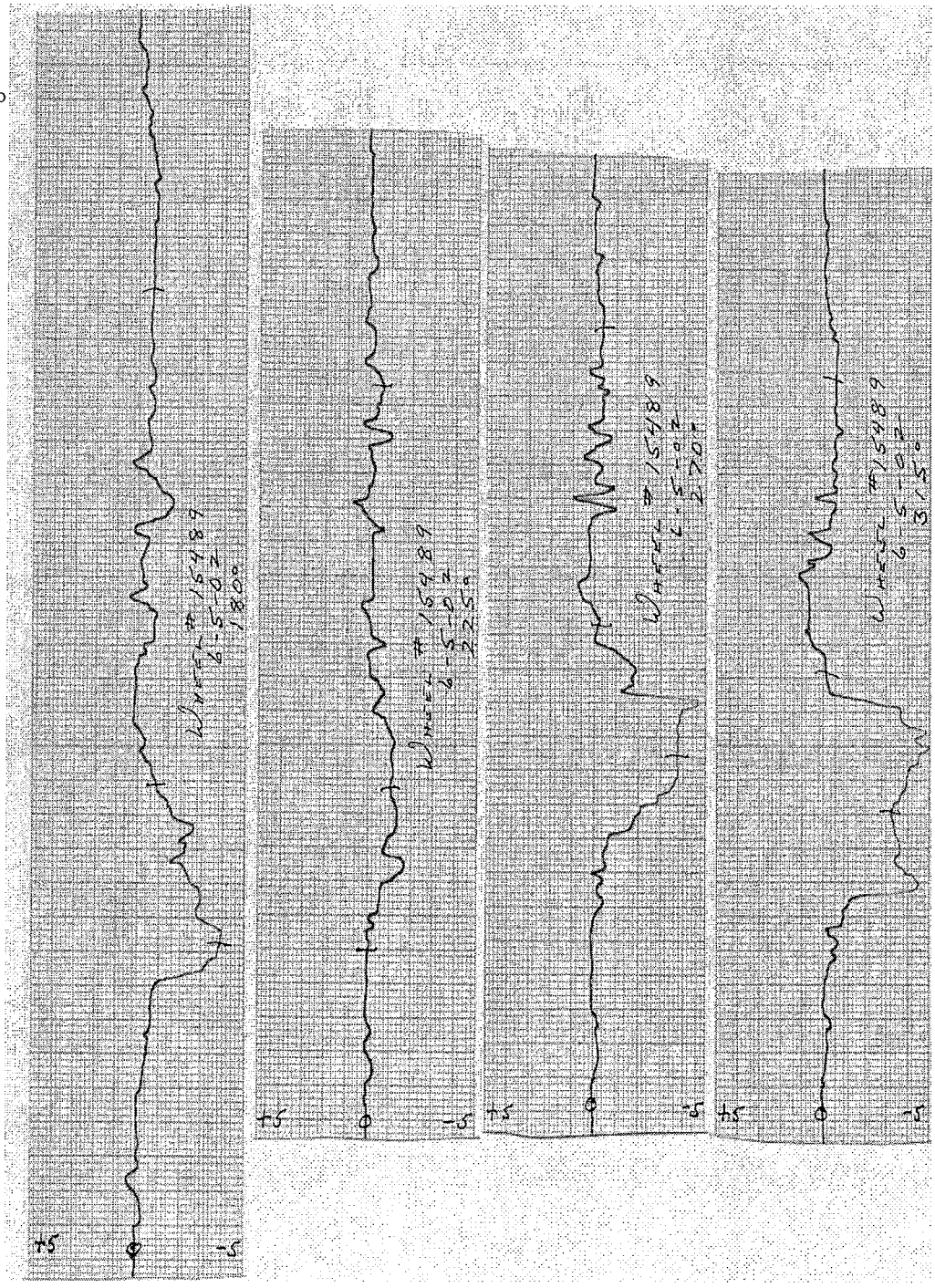
Flange Tip to Flange Rim

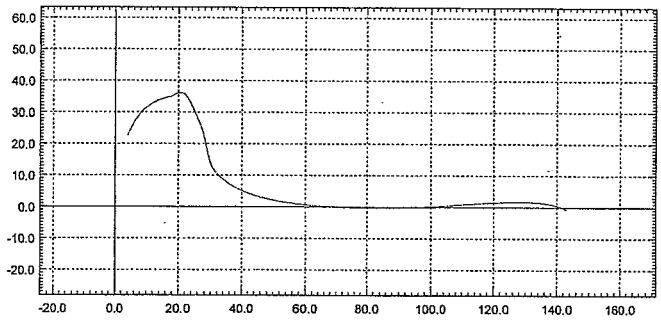


F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #15489 (on axle #8810)

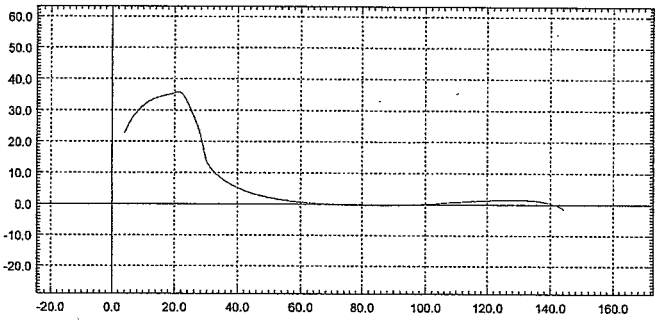
June 5, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings





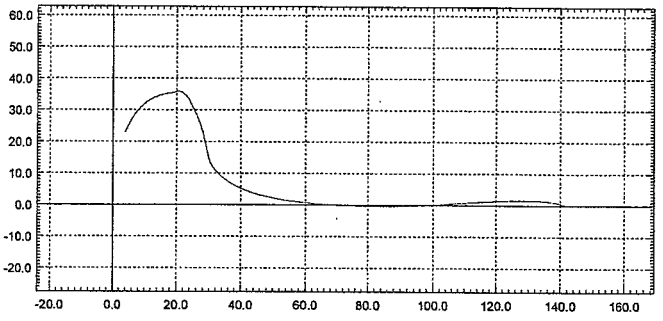
05062002-0251.whl
05/06/2002
130-0308

Stock	=
Car number	= 0
Axle number	= 8810
Wheel ID	= 15489 - 0°
Sd	= 32.497 mm
Sh	= 36.114 mm
qR	= 9.423 mm
Flange width	= 27.878 mm
Flange diameter	= 961.631 mm
Taperline diameter	= 889.413 mm



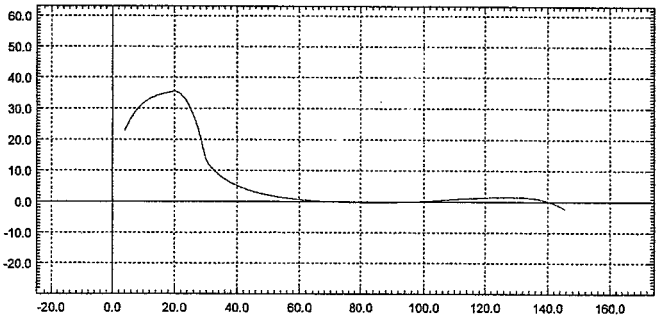
05062002-0261.whl
05/06/2002
130-0308

Stock	=
Car number	= 90
Axle number	= 8810
Wheel ID	= 15489 - 90°
Sd	= 32.522 mm
Sh	= 35.810 mm
qR	= 9.177 mm
Flange width	= 27.978 mm
Flange diameter	= 977.845 mm
Taperline diameter	= 906.227 mm



05062002-0271.whl
05/06/2002
130-0308

Stock	=
Car number	= 180
Axle number	= 8810
Wheel ID	= 15489 - 180°
Sd	= 32.726 mm
Sh	= 35.803 mm
qR	= 9.264 mm
Flange width	= 28.213 mm
Flange diameter	= 969.931 mm
Taperline diameter	= 898.320 mm



05062002-0281.whl
05/06/2002
130-0308

Stock	=
Car number	= 270
Axle number	= 8810
Wheel ID	= 15489 - 270°
Sd	= 32.376 mm
Sh	= 35.520 mm
qR	= 9.429 mm
Flange width	= 27.929 mm
Flange diameter	= 991.113 mm
Taperline diameter	= 920.054 mm

Wheel 38299
Tread Metal Build Up

F.R.A. TREAD BUILD-UP TEST

Wheel #38299 a tread damaged wheel at Progress Wheel Shop

F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 38299 Progress Rail Services Corp., Sidney, NE June 5, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	451	173	122
45 degrees	188	281	110
90 degrees	357	191	209
135 degrees	745	553	123
180 degrees	362	550	516
225 degrees	1284	326	581
270 degrees	422	334	380
315 degrees	307	570	254

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	576	499	472
45 degrees	348	482	333
90 degrees	469	374	450
135 degrees	430	366	423
180 degrees	394	455	438
225 degrees	497	383	455
270 degrees	396	472	397
315 degrees	415	390	415

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 5, 2002

INSPECTION SUBJECT: TEST WHEEL #38299 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -4.4 to + 6.6 = 11.0

45 degrees. Flange rim around to tread rim. Gauss range read: -7.8 to + 4.8 = 12.6

90 degrees. Flange rim around to tread rim. Gauss range read: -6.0 to + 1.4 = 7.4

135 degrees. Flange rim around to tread rim.Gauss range read: -12.0 to + 2.2 = 14.2

180 degrees. Flange rim around to tread rim. Gauss range read: -2.4 to + 1.4= 3.8

225 degrees. Flange rim around to tread rim. Gauss range read: -1.0 to + 2.6 = 3.6

270 degrees. Flange rim around to tread rim. Gauss range read: -0.0 to + 5.0 = 5.0

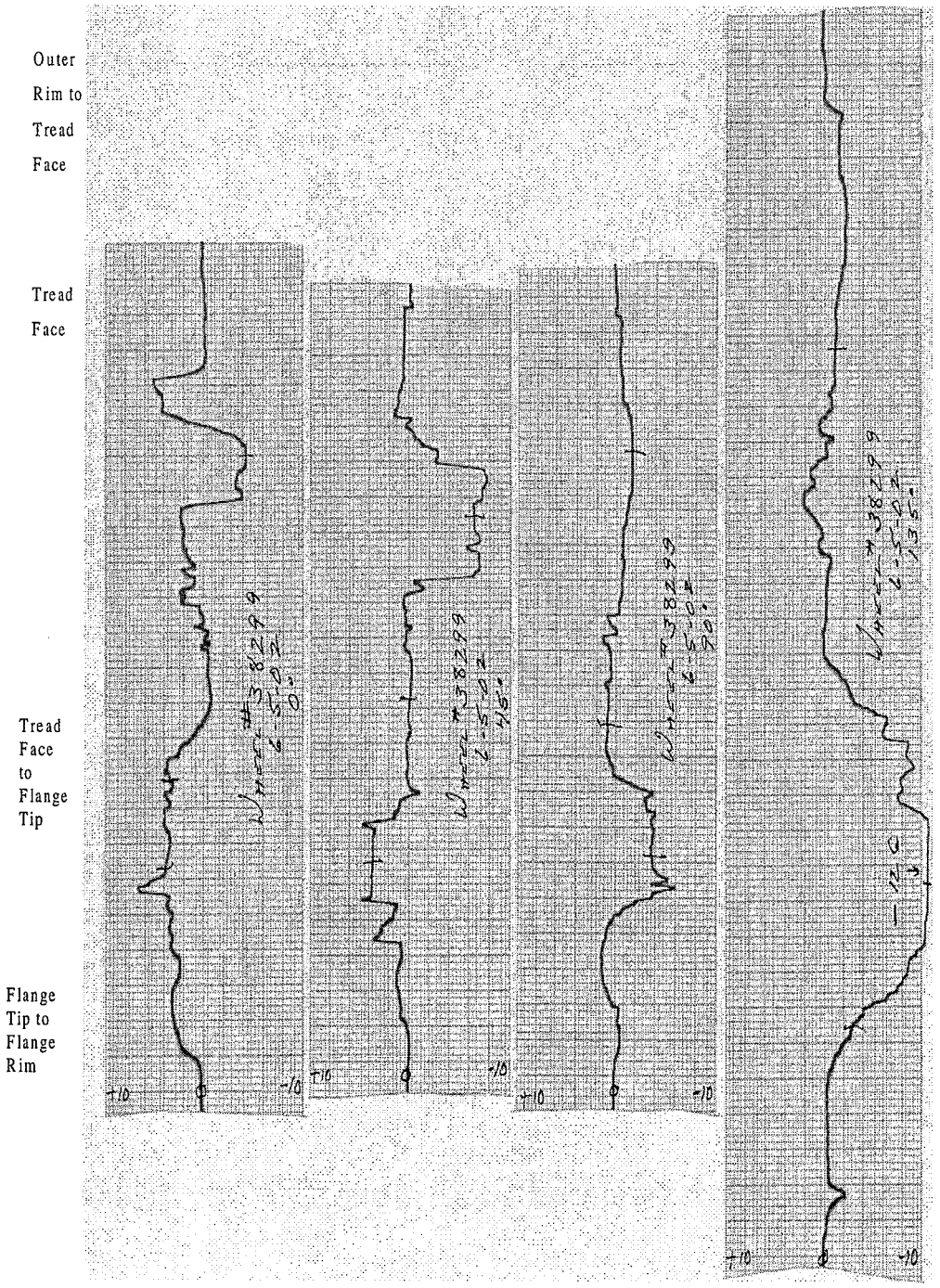
315 degrees. Flange rim around to tread rim. Gauss range read: -0.0 to + 10.0 = 10.0

The maximum range of gauss in this wheel was from –12.0 to +10.0 or 22.0 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #38299 (on axle #6767)

June 5, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings



F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #38299 (on axle #6767)

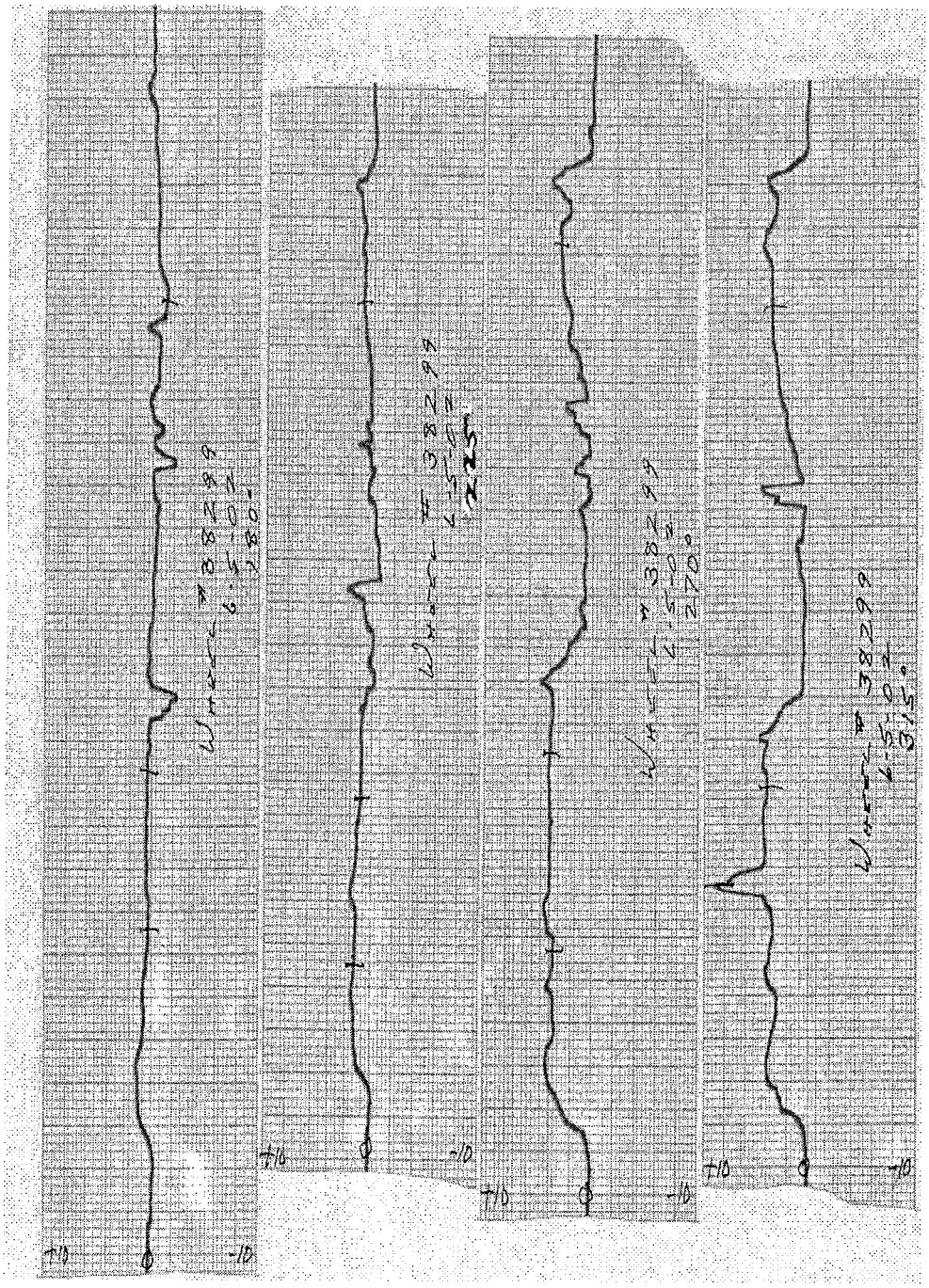
June 5, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings

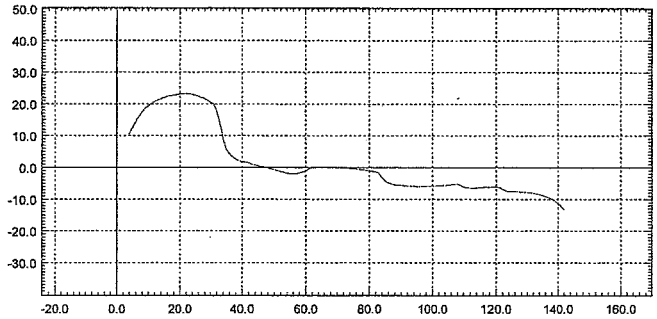
Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

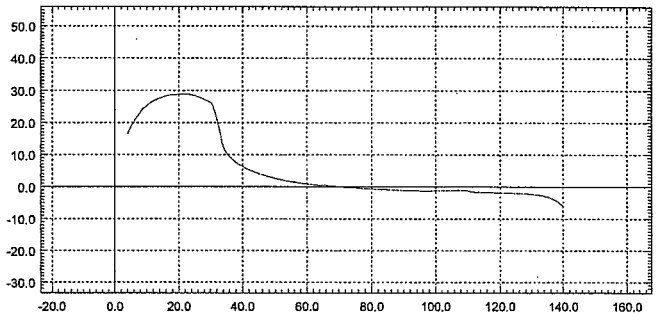
Flange Tip to Flange Rim





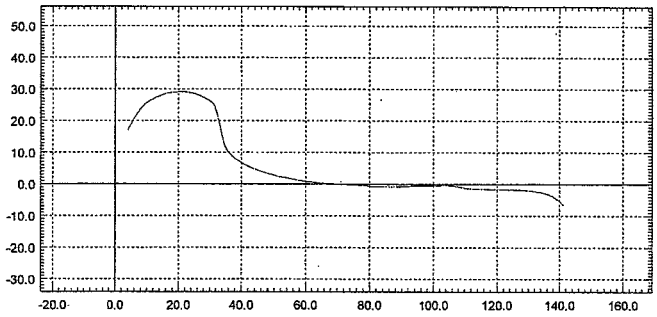
05062002-0111.whl
05/06/2002
130-0308

Stock	=
Car number	= 180
Axle number	= 6767
Wheel ID	= 38299 - 180°
Sd	= 33.716 mm
Sh	= 23.265 mm
qR	= 5.140 mm
Flange width	= 33.875 mm
Flange diameter	= 980.251 mm
Taperline diameter	= 933.705 mm



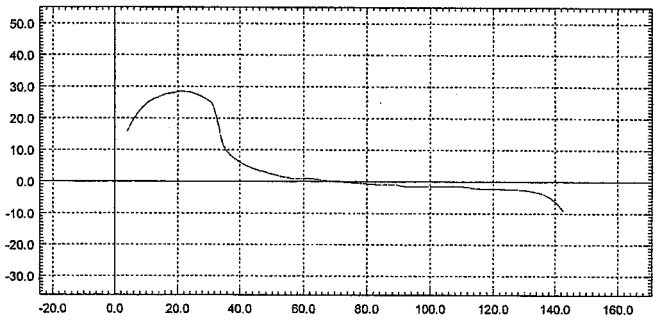
05062002-0121.whl
05/06/2002
130-0308

Stock	=
Car number	= 270
Axle number	= 6767
Wheel ID	= 38299 - 270°
Sd	= 35.384 mm
Sh	= 28.845 mm
qR	= 6.674 mm
Flange width	= 33.411 mm
Flange diameter	= 984.719 mm
Taperline diameter	= 927.072 mm



05062002-0091.whl
05/06/2002
130-0308

Stock	=
Car number	= 0
Axle number	= 6767
Wheel ID	= 38299 - 0°
Sd	= 36.071 mm
Sh	= 29.112 mm
qR	= 7.597 mm
Flange width	= 33.968 mm
Flange diameter	= 960.864 mm
Taperline diameter	= 902.606 mm



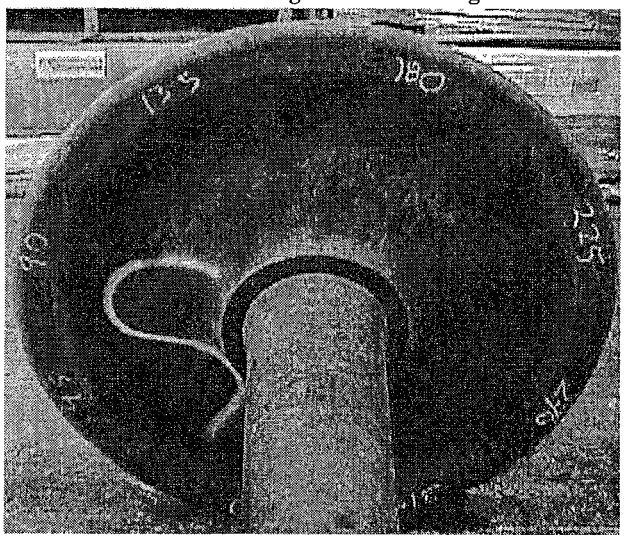
05062002-0101.whl
05/06/2002
130-0308

Stock	=
Car number	= 90
Axle number	= 6767
Wheel ID	= 38299 - 90°
Sd	= 35.512 mm
Sh	= 28.498 mm
qR	= 7.074 mm
Flange width	= 33.882 mm
Flange diameter	= 972.317 mm
Taperline diameter	= 915.287 mm

Wheel 49933
Tread Metal Build Up

F.R.A. TREAD BUILD-UP TEST

Wheel #49933 a tread damaged wheel at Progress Wheel Shop



F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 49933 Progress Rail Services Corp., Sidney, NE June 4, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	338	073	154
45 degrees	058	066	137
90 degrees	499	066	303
135 degrees	125	069	145
180 degrees	115	137	150
225 degrees	155	086	314
270 degrees	099	103	158
315 degrees	070	231	075

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	486	491	591
45 degrees	415	453	513
90 degrees	400	494	332
135 degrees	529	589	540
180 degrees	494	610	479
225 degrees	442	585	612
270 degrees	424	569	455
315 degrees	458	518	486

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 4, 2002

INSPECTION SUBJECT: TEST WHEEL #49933 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -0.5 to + 0.2 = 0.7

45 degrees. Flange rim around to tread rim. Gauss range read: -0.9 to + 2.0 = 2.9

90 degrees. Flange rim around to tread rim. Gauss range read: -1.9 to + 0.2 = 2.1

135 degrees. Flange rim around to tread rim.Gauss range read: -1.1 to + 0.1 = 1.2

180 degrees. Flange rim around to tread rim. Gauss range read: -1.2 to + 0.3= 1.5

225 degrees. Flange rim around to tread rim. Gauss range read: -0.4 to + 0.9 = 1.3

270 degrees. Flange rim around to tread rim. Gauss range read: -0.6 to + 0.9 = 1.5

315 degrees. Flange rim around to tread rim. Gauss range read: -0.5 to + 0.6 = 1.1

The maximum range of gauss in this wheel was from –1.9 to +2.0 or 3.9 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #49933 (on axle #MRL-8748-19)

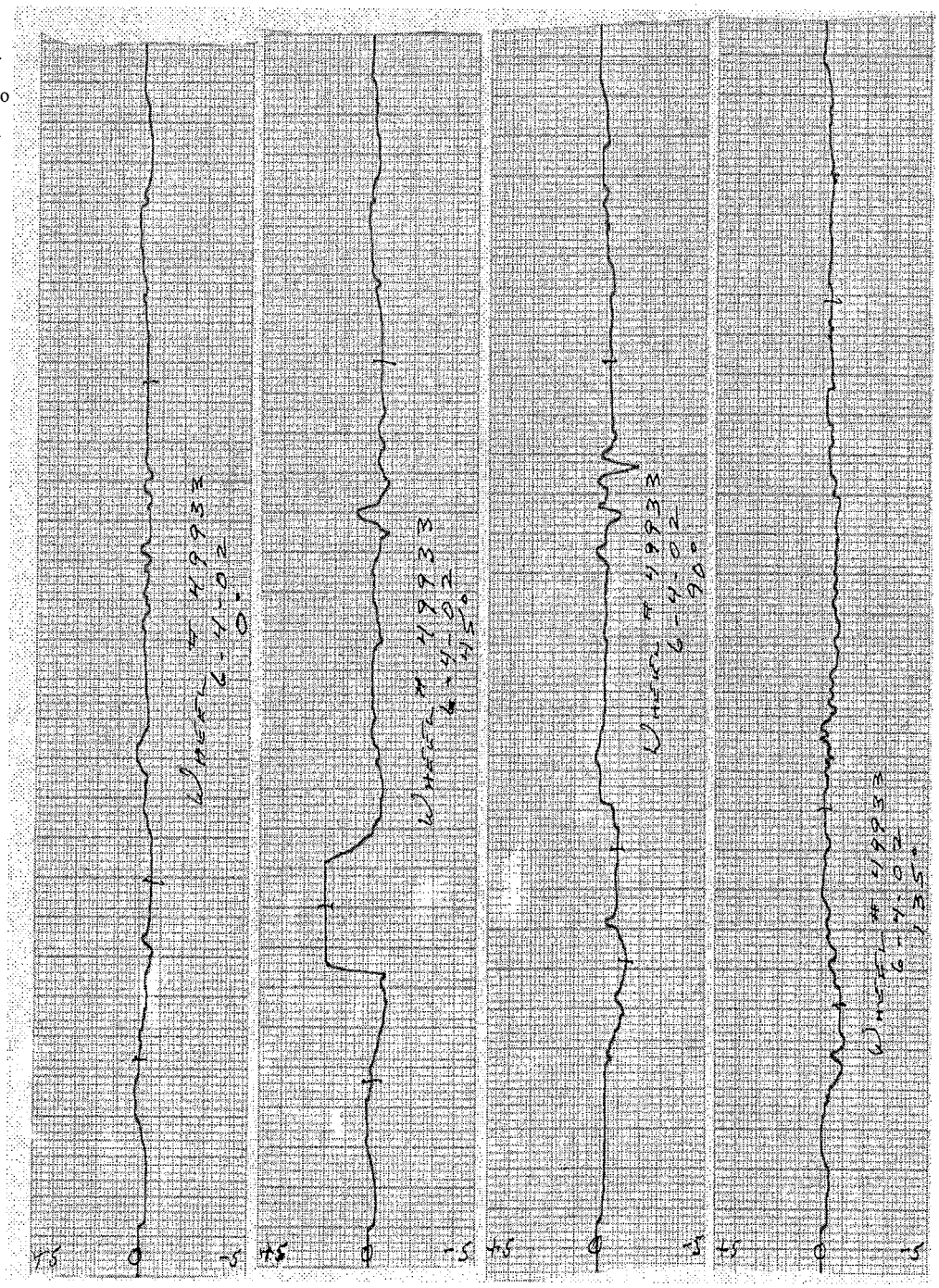
June 4, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

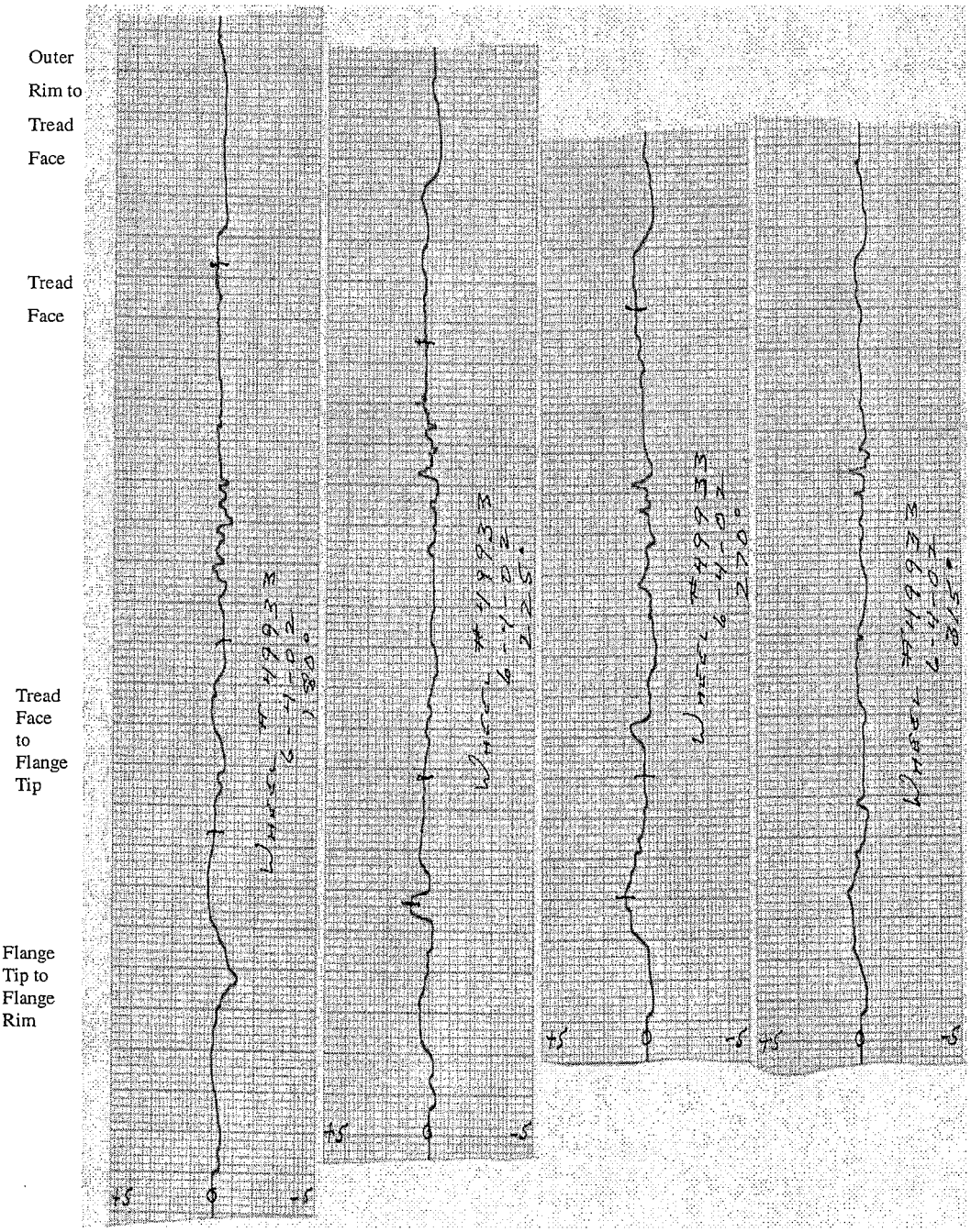
Flange Tip to Flange Rim

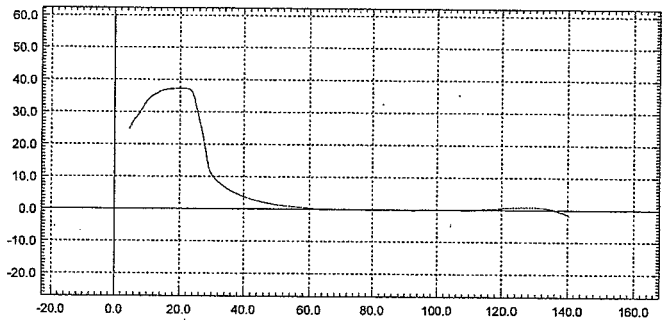


F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #49933 (on axle #MRL-8748-19)

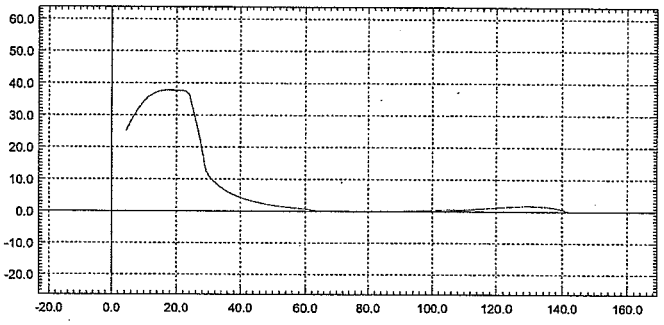
June 4, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings





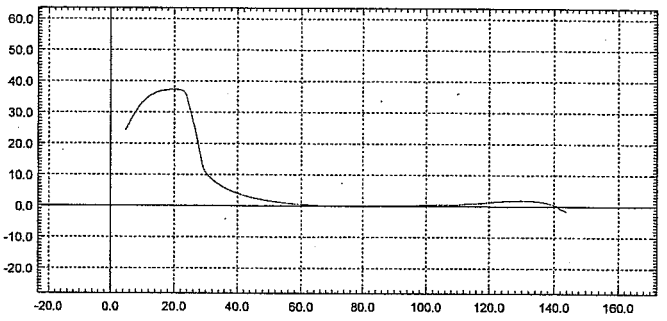
04062002-0121.whl
04/06/2002
130-0308

Stock	=
Car number	= 0
Axle number	= 8748-19
Wheel ID	= 49933 - 0°
Sd	= 30.414 mm
Sh	= 37.235 mm
qR	= 6.242 mm
Flange width	= 27.050 mm
Flange diameter	= 973.869 mm
Taperline diameter	= 899.400 mm



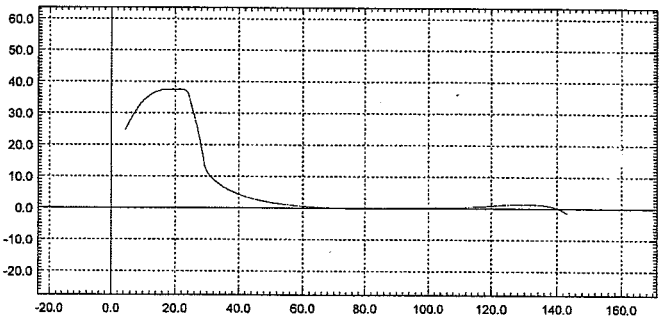
04062002-0131.whl
04/06/2002
130-0308

Stock	=
Car number	= 90
Axle number	= 8748-19
Wheel ID	= 49933 - 90°
Sd	= 30.832 mm
Sh	= 37.732 mm
qR	= 6.729 mm
Flange width	= 26.999 mm
Flange diameter	= 974.379 mm
Taperline diameter	= 898.889 mm



04062002-0141.whl
04/06/2002
130-0308

Stock	=
Car number	= 180
Axle number	= 8748-19
Wheel ID	= 49933 - 180°
Sd	= 30.394 mm
Sh	= 37.288 mm
qR	= 6.617 mm
Flange width	= 26.778 mm
Flange diameter	= 974.220 mm
Taperline diameter	= 899.639 mm



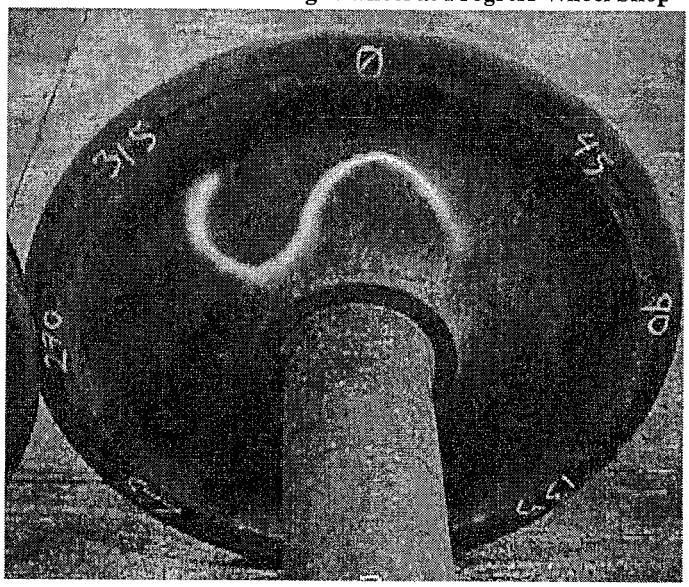
04062002-0151.whl
04/06/2002
130-0308

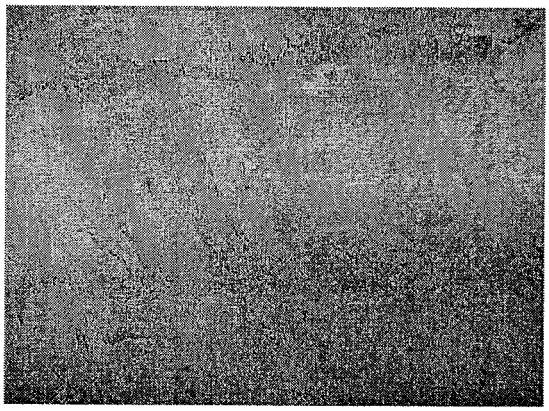
Stock	=
Car number	= 270
Axle number	= 8748-19
Wheel ID	= 49933 - 270°
Sd	= 30.986 mm
Sh	= 37.547 mm
qR	= 6.778 mm
Flange width	= 27.262 mm
Flange diameter	= 974.372 mm
Taperline diameter	= 899.259 mm

Wheel 50469
Minor Tread Build Up

F.R.A. TREAD BUILD-UP TEST

Wheel #50469 a tread damaged wheel at Progress Wheel Shop





F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 50469 Progress Rail Services Corp., Sidney, NE June 4, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	050	358	065
45 degrees	156	174	091
90 degrees	114	052	074
135 degrees	136	141	090
180 degrees	151	060	079
225 degrees	129	070	040
270 degrees	203	238	048
315 degrees	151	259	057

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	567	387	522
45 degrees	442	540	499
90 degrees	524	546	575
135 degrees	444	567	472
180 degrees	513	518	491
225 degrees	537	497	489
270 degrees	535	448	517
315 degrees	474	508	508

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 4, 2002

INSPECTION SUBJECT: TEST WHEEL #50469 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -3.3 to + 0.1 = 3.4

45 degrees. Flange rim around to tread rim. Gauss range read: -4.6 to + 0.0 = 4.6

90 degrees. Flange rim around to tread rim. Gauss range read: -4.7 to + 0.5 = 5.2

135 degrees. Flange rim around to tread rim.Gauss range read: -4.5 to + 0.3 = 4.8

180 degrees. Flange rim around to tread rim. Gauss range read: -3.6 to + 1.9= 5.5

225 degrees. Flange rim around to tread rim. Gauss range read: -5.4 to + 0.7 = 6.1

270 degrees. Flange rim around to tread rim. Gauss range read: -5.4 to + 0.0 = 5.4

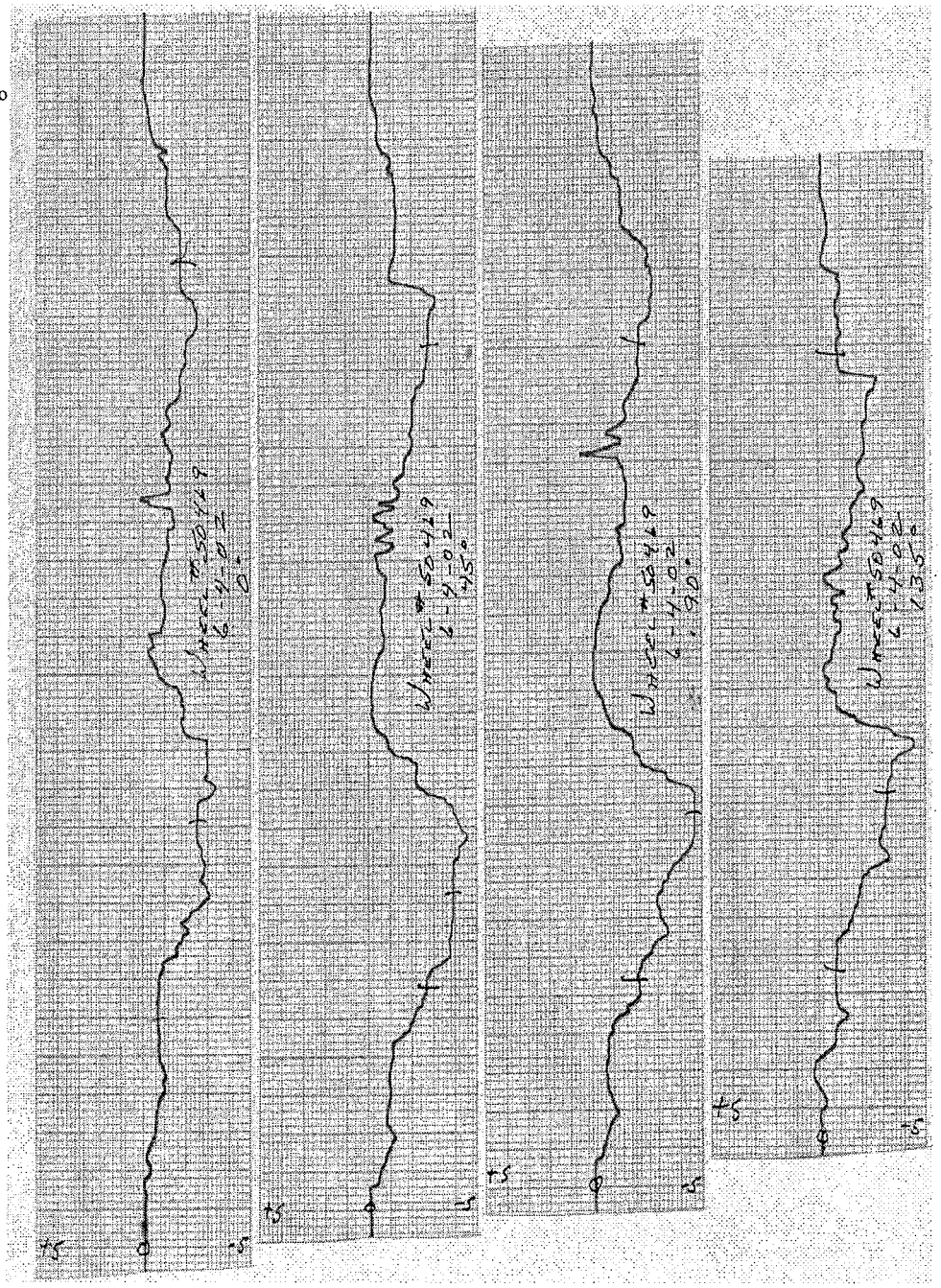
315 degrees. Flange rim around to tread rim. Gauss range read: -4.8 to + 0.8 = 5.6

The maximum range of gauss in this wheel was from –5.4 to +1.9 or 7.3 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #50469 (on axle #MRL-8748-19)

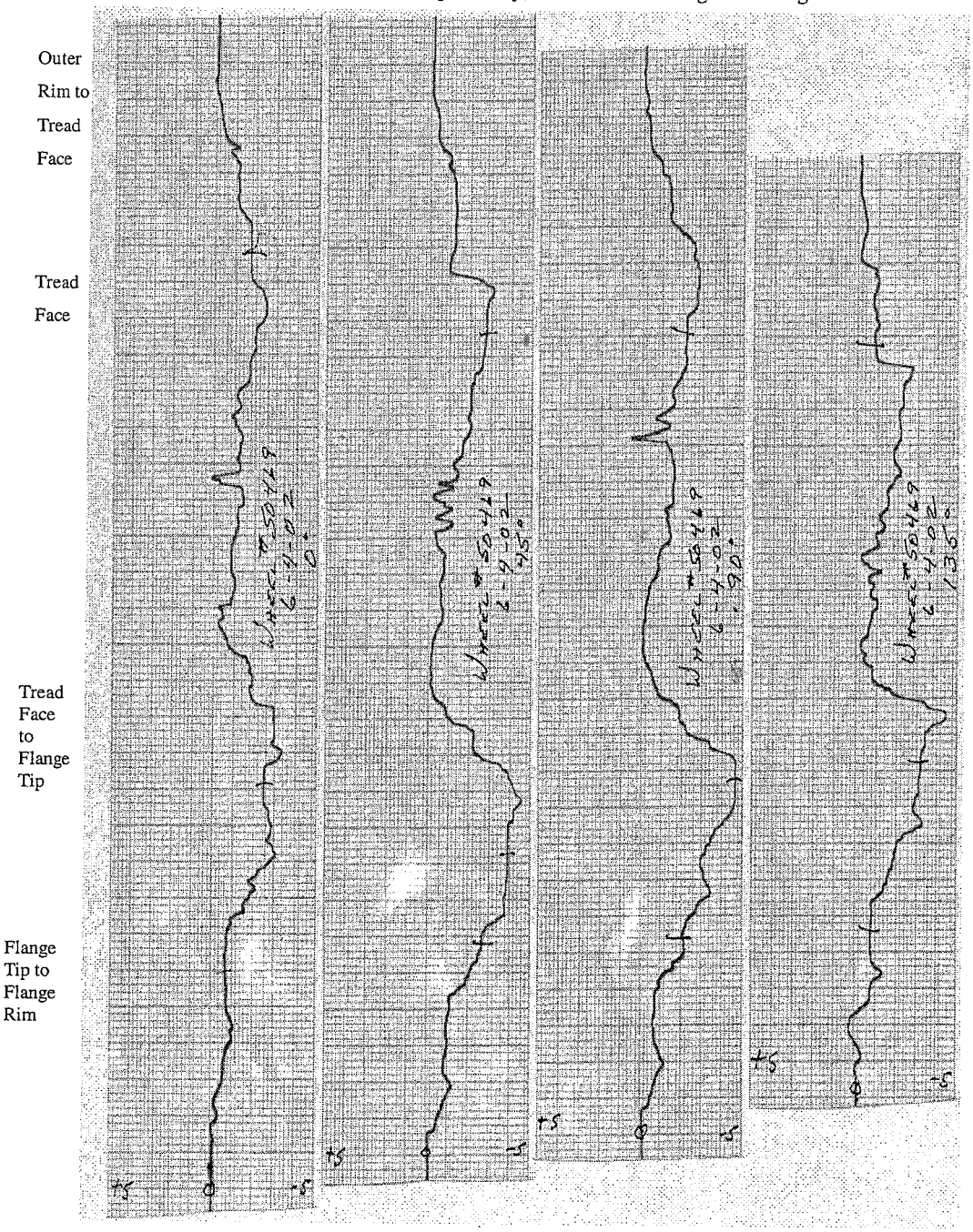
June 4, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

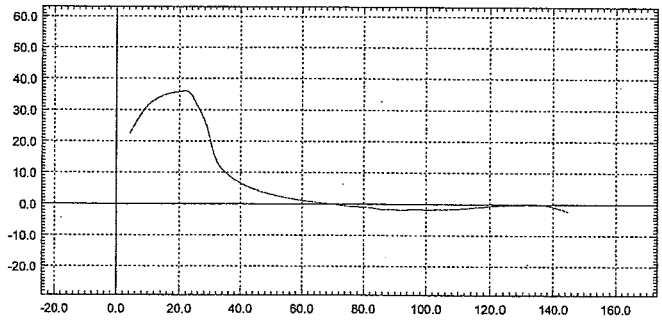


F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #50469 (on axle #MRL-8748-19)

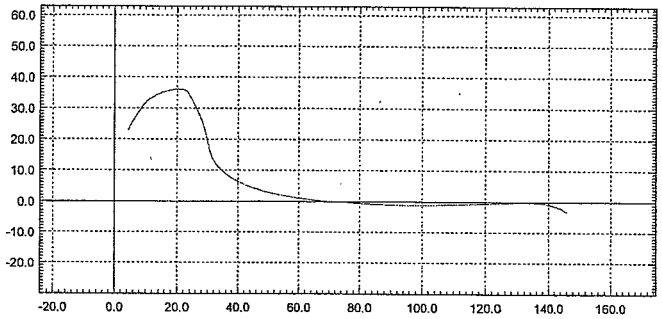
June 4, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings





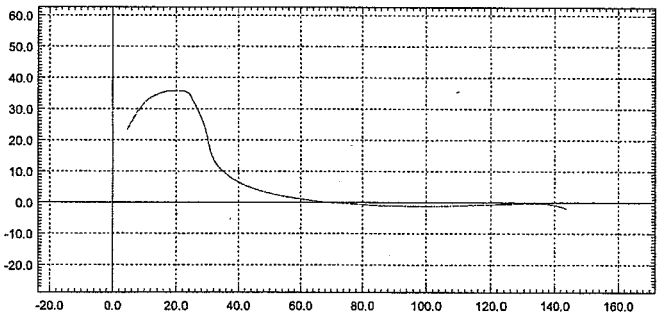
04062002-0081.whl
04/06/2002
130-0308

Stock	=
Car number	= 0
Axle number	= 8748-19
Wheel ID	= 50469 −0°
Sd	= 35.061 mm
Sh	= 36.242 mm
qR	= 10.849 mm
Flange width	= 29.555 mm
Flange diameter	= 987.999 mm
Taperline diameter	= 916.235 mm



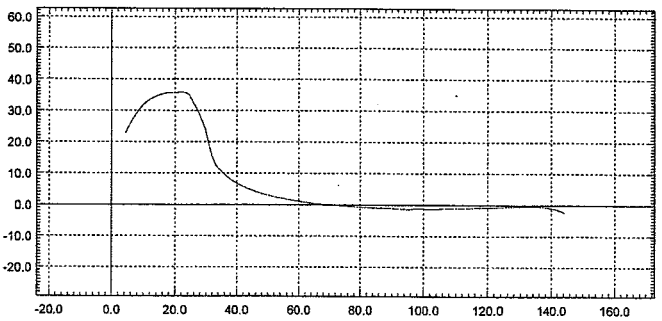
04062002-0091.whl
04/06/2002
130-0308

Stock	=
Car number	= 90
Axle number	= 8748-19
Wheel ID	= 50469 − 90°
Sd	= 34.562 mm
Sh	= 36.178 mm
qR	= 10.721 mm
Flange width	= 29.220 mm
Flange diameter	= 978.561 mm
Taperline diameter	= 906.196 mm



04062002-0101.whl
04/06/2002
130-0308

Stock	=
Car number	= 180
Axle number	= 8748-19
Wheel ID	= 50469 −180°
Sd	= 34.932 mm
Sh	= 35.778 mm
qR	= 10.299 mm
Flange width	= 29.714 mm
Flange diameter	= 995.490 mm
Taperline diameter	= 923.939 mm



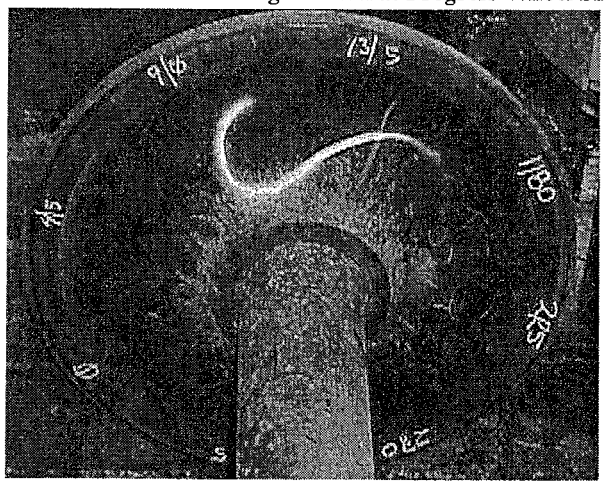
04062002-0111.whl
04/06/2002
130-0308

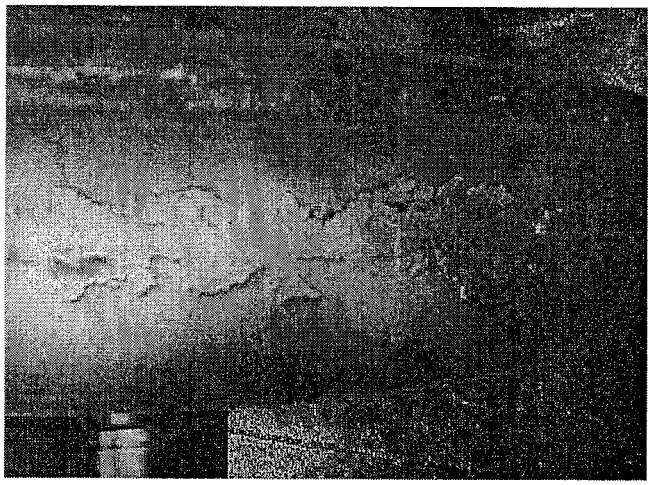
Stock	=
Car number	= 270
Axle number	= 8748-19
Wheel ID	= 50469 - 270°
Sd	= 35.486 mm
Sh	= 35.816 mm
qR	= 10.359 mm
Flange width	= 30.336 mm
Flange diameter	= 977.375 mm
Taperline diameter	= 905.687 mm

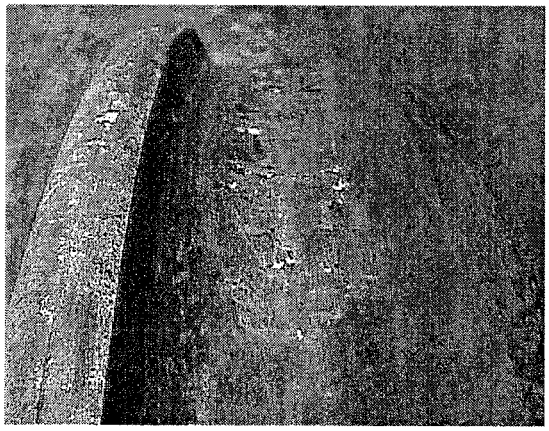
Wheel 51124
Tread Metal Build Up

F.R.A. TREAD BUILD-UP TEST

Wheel #51124 a tread damaged wheel at Progress Wheel Shop







F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 51124 Progress Rail Services Corp., Sidney, NE June 4, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	107	060	071
45 degrees	089	069	105
90 degrees	120	050	060
135 degrees	054	101	080
180 degrees	065	071	061
225 degrees	130	064	119
270 degrees	046	061	062
315 degrees	046	068	094

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	375	373	433
45 degrees	448	438	455
90 degrees	591	423	444
135 degrees	497	487	405
180 degrees	441	496	429
225 degrees	408	441	448
270 degrees	455	456	447
315 degree	367	398	439

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 4, 2002

INSPECTION SUBJECT: TEST WHEEL #51124 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -2.3 to + 0.1 = 2.4

45 degrees. Flange rim around to tread rim. Gauss range read: -3.7 to + 2.3 = 6.0

90 degrees. Flange rim around to tread rim. Gauss range read: -3.5 to + 0.1 = 3.6

135 degrees. Flange rim around to tread rim.Gauss range read: -5.2 to + 0.1 = 5.3

180 degrees. Flange rim around to tread rim. Gauss range read: -2.4 to + 0.7= 3.1

225 degrees. Flange rim around to tread rim. Gauss range read: -2.5 to + 1.1 = 3.6

270 degrees. Flange rim around to tread rim. Gauss range read: -4.0 to + 0.0 = 4.0

315 degrees. Flange rim around to tread rim. Gauss range read: -4.0 to + 0.2 = 4.2

The maximum range of gauss in this wheel was from –5.2 to +2.3 or 7.5 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #51124 (on axle #MRL-8748-9)

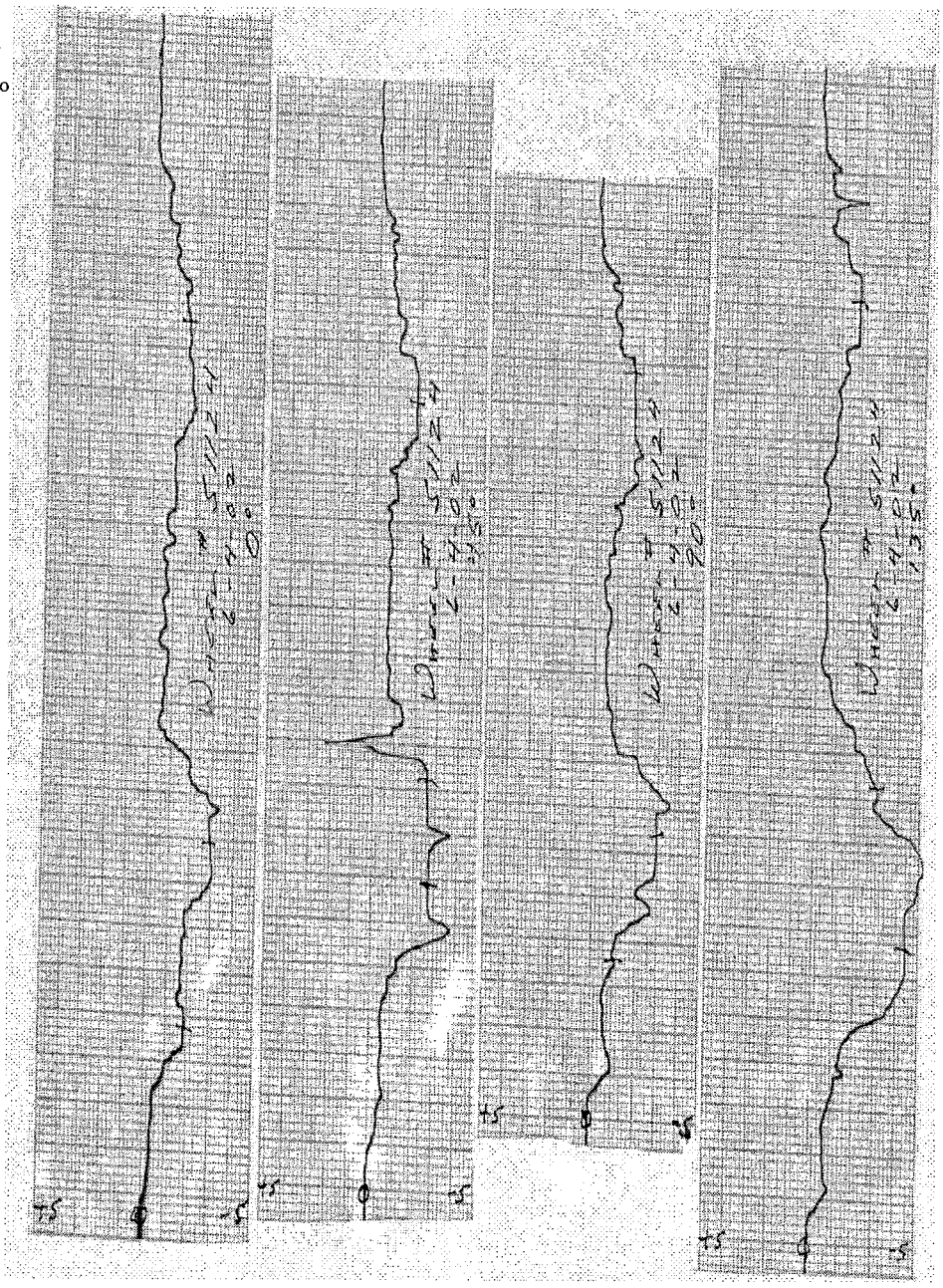
June 4, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings

Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

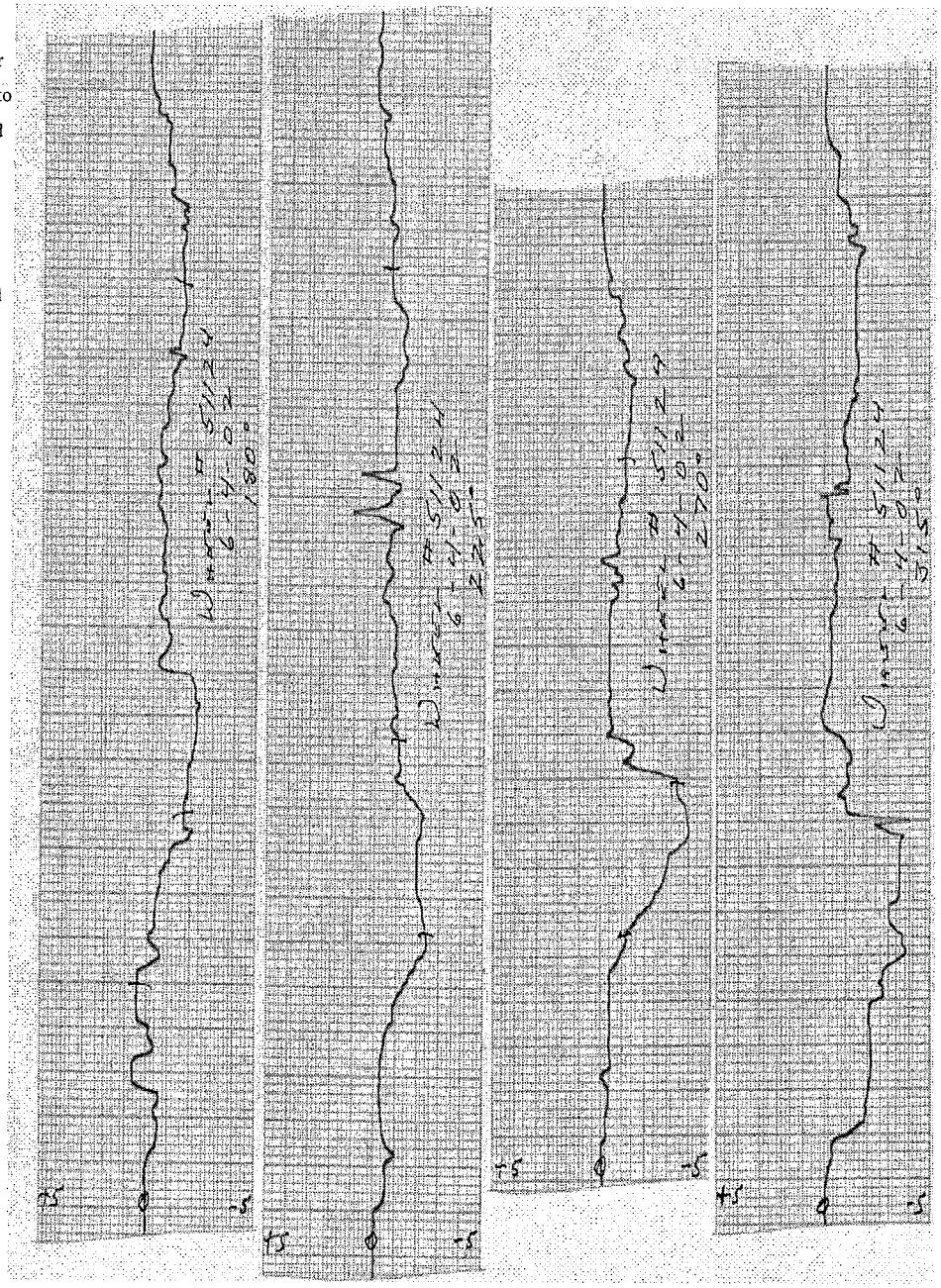
Flange Tip to Flange Rim

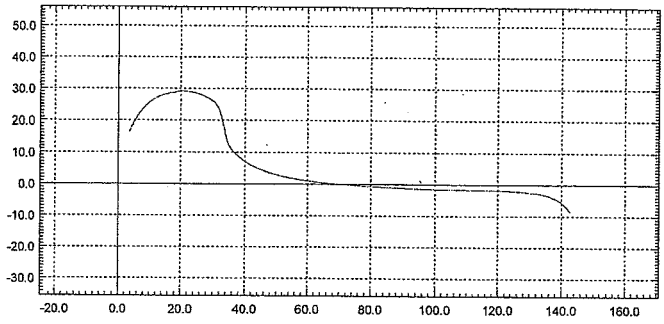


F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #51124 (on axle #MRL-8748-9)

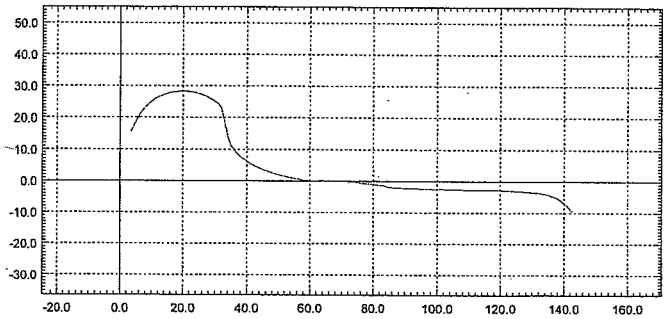
June 4, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings





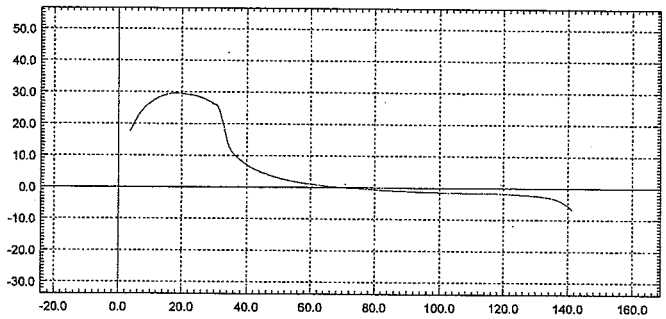
04062002-0011.whl
04/06/2002
130-0308

Stock	=
Car number	=
Axle number	= 8748-9
Wheel ID	= 51124 −0°
Sd	= 36.514 mm
Sh	= 29.196 mm
qR	= 8.457 mm
Flange width	= 33.944 mm
Flange diameter	= 917.067 mm
Taperline diameter	= 858.669 mm



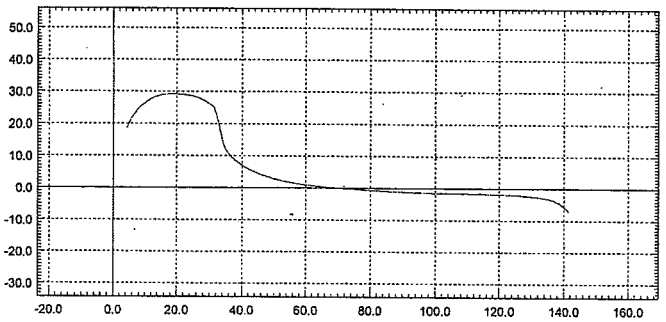
04062002-0041.whl
04/06/2002
130-0308

Stock	=
Car number	= 90
Axle number	= 8748-9
Wheel ID	= 51124 −90°
Sd	= 35.923 mm
Sh	= 28.313 mm
qR	= 7.994 mm
Flange width	= 34.015 mm
Flange diameter	= 898.996 mm
Taperline diameter	= 842.381 mm



04062002-0031.whl
04/06/2002
130-0308

Stock	=
Car number	= 180
Axle number	= 8748-9
Wheel ID	= 51124 −180°
Sd	= 36.373 mm
Sh	= 29.646 mm
qR	= 9.033 mm
Flange width	= 33.694 mm
Flange diameter	= 896.402 mm
Taperline diameter	= 837.095 mm



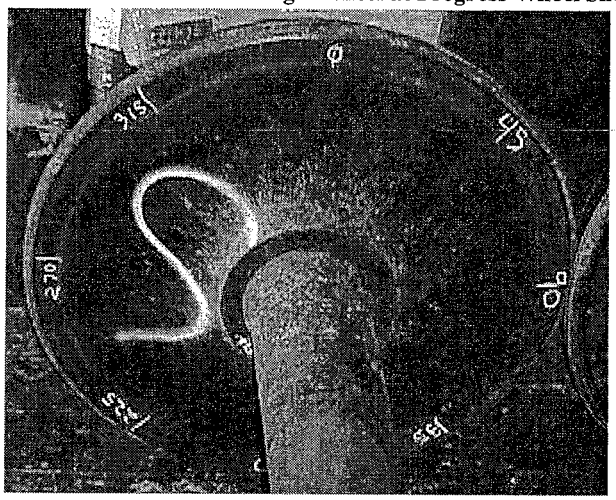
04062002-0021.whl
04/06/2002
130-0308

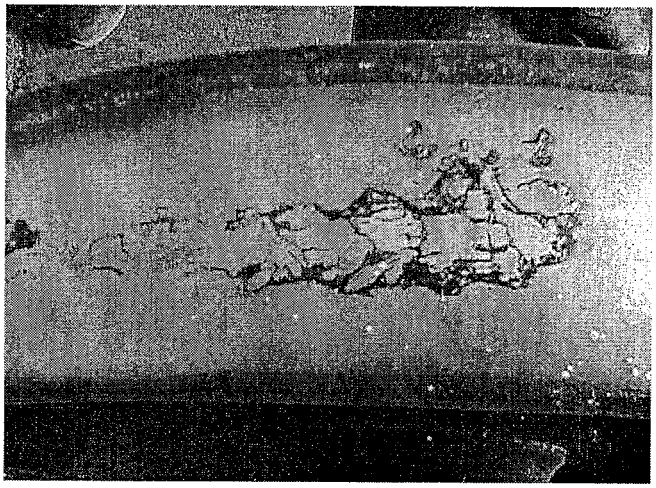
Stock	=
Car number	=
Axle number	= 8748-9
Wheel ID	= 51124 -270°
Sd	= 36.473 mm
Sh	= 29.285 mm
qR	= 8.451 mm
Flange width	= 33.906 mm
Flange diameter	= 893.330 mm
Taperline diameter	= 834.769 mm

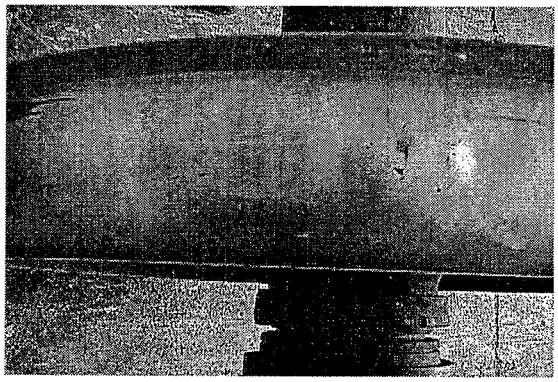
Wheel 53168
Built Up Tread

F.R.A. TREAD BUILD-UP TEST

Wheel #53168 a tread damaged wheel at Progress Wheel Shop







F.R.A. TREAD BUILD-UP TEST
SURFACE CONDITION and HARDNESS READINGS
WHEEL # 53168 Progress Rail Services Corp., Sidney, NE June 4, 2002

SURFACE CONDITION READINGS of TREAD FACE

Location	Near flange	Center	Near outer rim
0 degrees	069	110	089
45 degrees	065	053	065
90 degrees	079	052	084
135 degrees	069	047	118
180 degrees	067	060	060
225 degrees	153	104	097
270 degrees	107	104	048
315 degrees	125	093	065

HARDNESS READINGS (HB) of TREAD FACE

Location	Near Flange	Center	Near outer rim
0 degrees	391	413	314
45 degrees	439	407	329
90 degrees	466	393	347
135 degrees	366	427	408
180 degrees	433	421	351
225 degrees	386	417	370
270 degrees	394	433	344
315 degrees	387	533	499

TRANSPORTATION TECHNOLOGY CENTER, INC.
Non-destructive Testing Report

DATE: June 4, 2002

INSPECTION SUBJECT: TEST WHEEL #53168 This is a test of a wheel which was selected at the Progress Wheel Shop in Sidney, NE for use on the F.R.A. TREAD BUILD-UP TEST (A1K1T1).

INSPECTION METHOD(S): This test was conducted using an RFL Industries, Model 750A, Gaussmeter, to determine if there is any residual magnetism in the various areas around the wheel.

FINDINGS: The gaussmeter charts are on an attached page, and show a chart for each of the following locations:

0 degrees. Flange rim around to tread rim. Gauss range read: -3.1 to + 0.7 = 3.8

45 degrees. Flange rim around to tread rim. Gauss range read: -3.3 to + 3.7 = 7.0

90 degrees. Flange rim around to tread rim. Gauss range read: -2.9 to + 0.5 = 3.4

135 degrees. Flange rim around to tread rim.Gauss range read: -1.3 to + 0.9 = 2.2

180 degrees. Flange rim around to tread rim. Gauss range read: -3.6 to + 0.2= 3.8

225 degrees. Flange rim around to tread rim. Gauss range read: -2.5 to + 0.8 = 3.3

270 degrees. Flange rim around to tread rim. Gauss range read: -2.4 to + 0.0 = 2.4

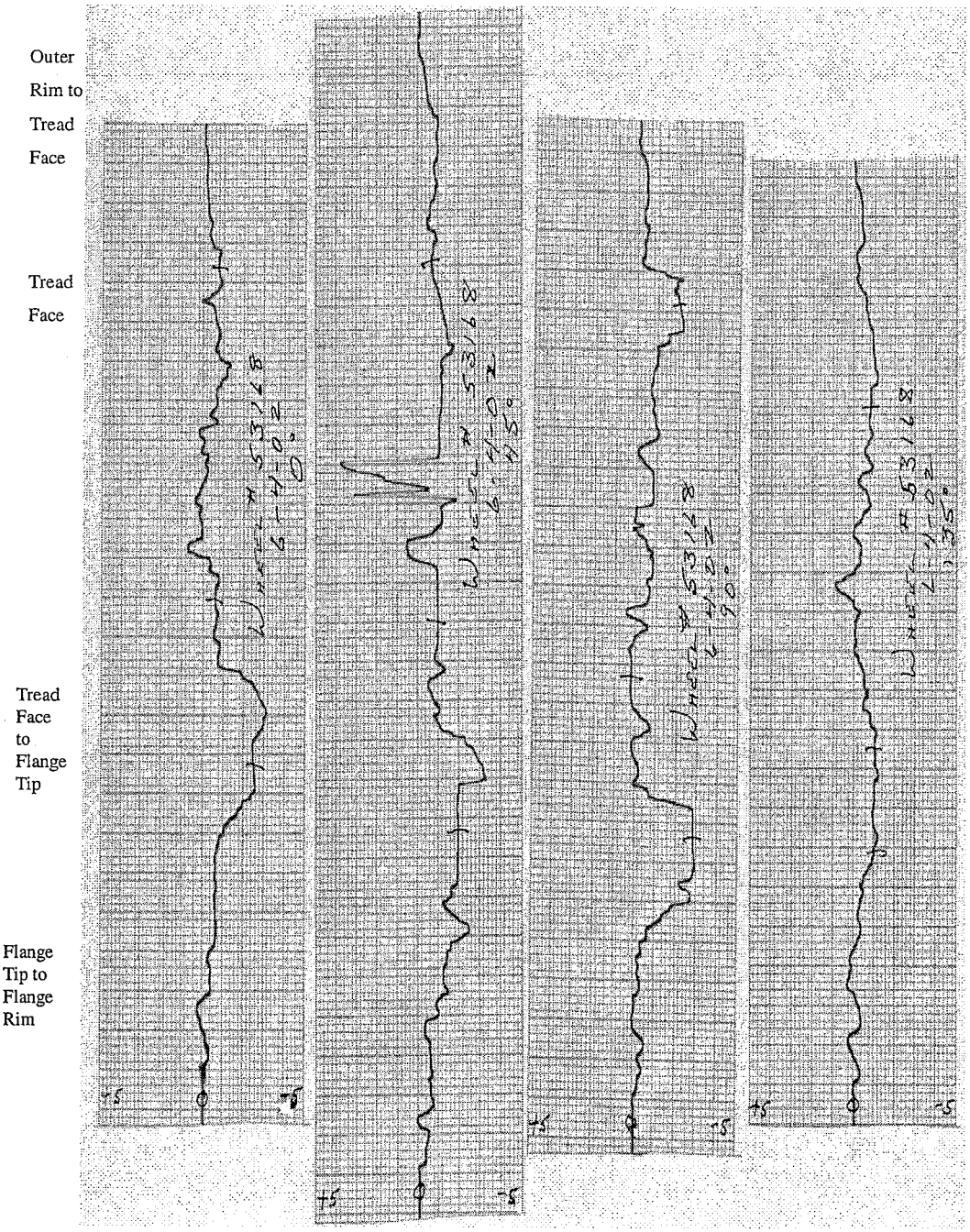
315 degrees. Flange rim around to tread rim. Gauss range read: -3.3 to + 0.0 = 3.3

The maximum range of gauss in this wheel was from –3.6 to +3.7 or 7.3 gauss.

F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #53168 (on axle #MRL-8748-9)

June 4, 2002 Progress Wheel Shop, Sidney, NE 0 to 135 degree readings



F.R.A. TREAD BUILD-UP TEST

GAUSSMETER READINGS OF WHEEL #53168 (on axle #MRL-8748-9)

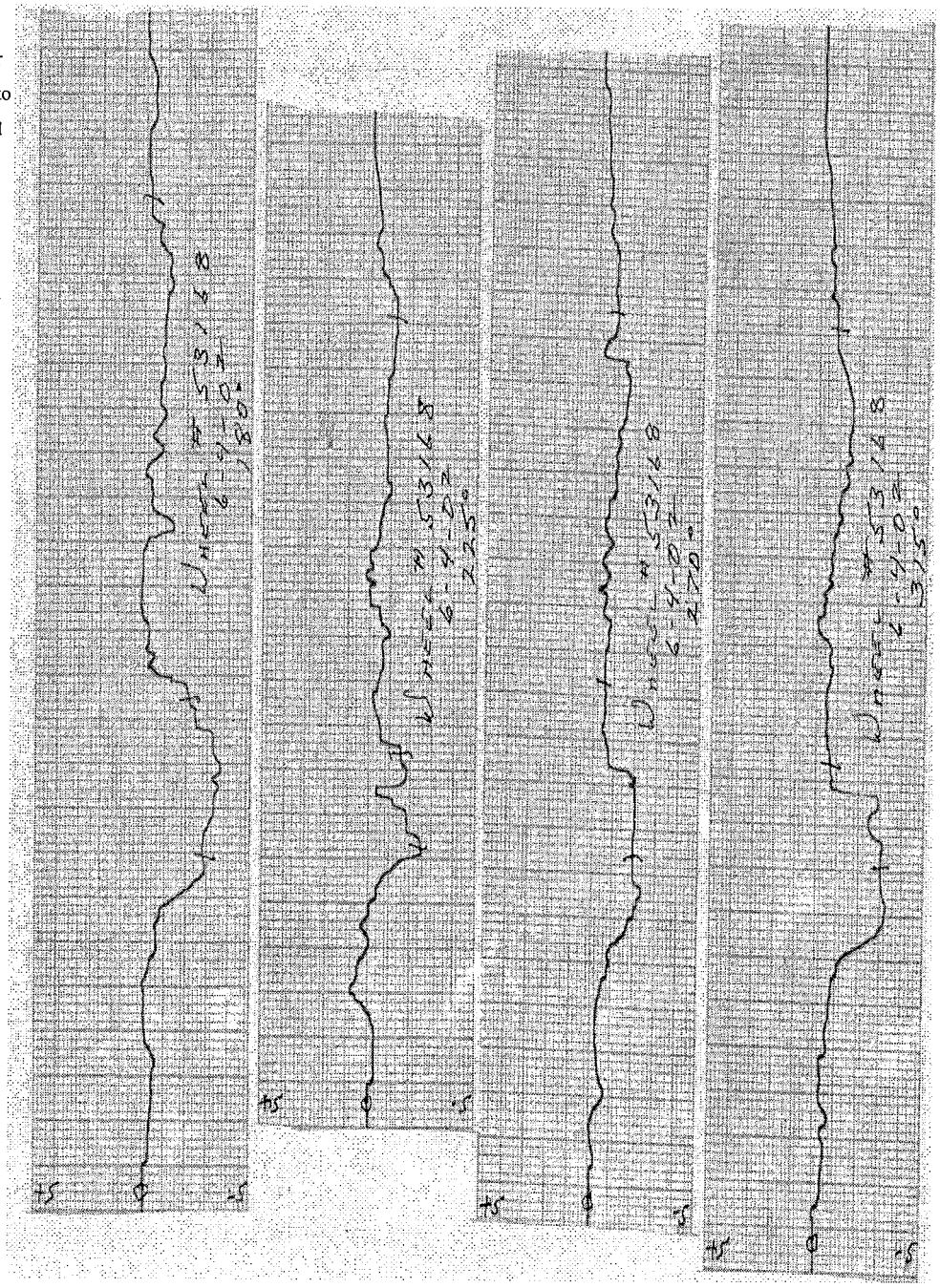
June 4, 2002 Progress Wheel Shop, Sidney, NE 180 to 315 degree readings

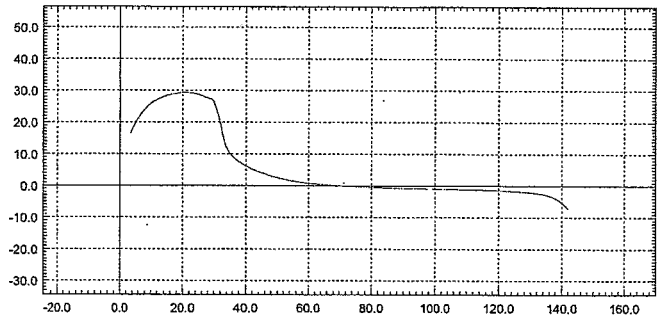
Outer Rim to Tread Face

Tread Face

Tread Face to Flange Tip

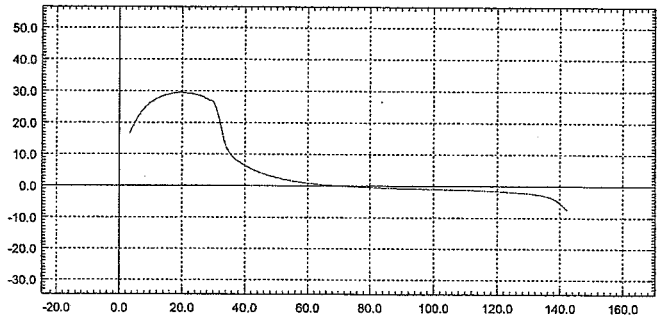
Flange Tip to Flange Rim





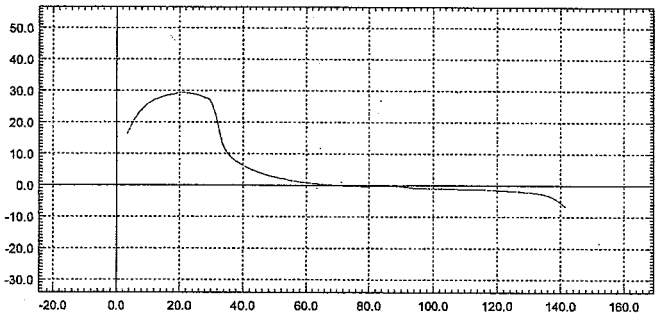
04062002-0051.whl
04/06/2002
130-0308

Stock	=
Car number	= 0
Axle number	= 8748-9
Wheel ID	= 53168 - 0°
Sd	= 35.233 mm
Sh	= 29.382 mm
qR	= 6.350 mm
Flange width	= 32.859 mm
Flange diameter	= 896.980 mm
Taperline diameter	= 838.211 mm



04062002-0071.whl
04/06/2002
130-0308

Stock	=
Car number	= 180
Axle number	= 8748-9
Wheel ID	= 53168 - 180°
Sd	= 35.575 mm
Sh	= 29.525 mm
qR	= 7.554 mm
Flange width	= 33.172 mm
Flange diameter	= 897.380 mm
Taperline diameter	= 838.324 mm



04062002-0061.whl
04/06/2002
130-0308

Stock	=
Car number	= 270
Axle number	= 8748-9
Wheel ID	= 53168 - 270°
Sd	= 35.376 mm
Sh	= 29.505 mm
qR	= 6.359 mm
Flange width	= 32.977 mm
Flange diameter	= 891.440 mm
Taperline diameter	= 832.448 mm