REPORT NOS. DOT-TSC-NHTSA-79-30 HS-804-828

DETERMINATION OF TIRE QUALITY FROM NONDESTRUCTIVE INSPECTION

S. N. Bobo

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
Transportation Systems Center
Cambridge MA 02142

NOVEMBER 1979
FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
Office of Research and Development
Washington DC 20590

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
HS-804-828		

4. Title and Subtitle
DETERMINATION OF THE TIRE QUALITY FROM NON DESTRUCTIVE INSPECTION

5. Report Date
November 1979

6. Performing Organization Code

7. Author(s)
S. N. Bobo

8. Performing Organization Report No.
DOT-TSC-NHTSA-79-30

9. Performing Organization Name and Address
U.S. Department of Transportation
Research and Special Programs Administration
Transportation Systems Center
Cambridge Massachusetts 02142

10. Work Unit No. (TRAIS)
HS027/R0404

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
U.S.Department of Transportation
National Highway Traffic Safety Administration
Office of Research and Development
Washington DC 20590

13. Type of Report and Period Covered
Final Report
Sep. 1975-Mar. 1979

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

A study was performed to determine the capability of an ultrasonic inspection system developed at TSC to identify anomalies in tires which would cause failure during the Compliance Test and to identify degradation of tires which had passed the Compliance Test by subsequent examination. A population of 1440 tires was used for this work.

The study demonstrated that all tires which failed the Compliance Test had multiple anomalies detected previously by non-destructive inspection, but that it was not possible, a priori, to determine which of these anomalies would lead to failure. A ranking procedure was developed which utilized the results of the non-destructive inspection and other factors to grade and rank each tire. By statistical analysis a threshold grade was determined which separates the groups in which all tires passed the Compliance Test from the groups which contained tires having failed the Test. The confidence level in the non-random nature of this threshold is near 99%.

The study also demonstrated that by subsequent nondestructive inspection, 43 tires which had passed the Compliance Test had undergone some degradation.

17. Key Words	18. Distribution Statement
Ultrasonic Inspection, Nondestructive Tire Inspection, Tire Analysis	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	68	

PREFACE

The author gratefully acknowledges the contributions by Drs. C. N. Abernethy, J. S. Dumas, and P. H. Mengert in regard to the statistical analysis of the data presented in this document.

Mr . M.J. Lourenco, Project Director, throughout the study provided valuable advice and guidance.

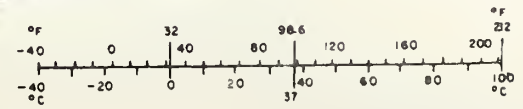
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	squsre centimeters	cm^2
ft^2	squars feet	0.09	squsre meters	m^2
yd^2	square yards	0.8	squsre meters	m^2
mi^2	squere miles	2.6	squsre kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	tasspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	qusrts	0.95	liters	l
gal	gsllons	3.8	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

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	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	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CONTINUED)

LIST OF TABLES

GLOSSARY

Anomaly: Departure from a regular condition. Specifically, in ultrasonic nondestructive inspection a deviation from the regular pattern of traces appearing in the hard-copy printout of the ultrasonic tire inspection system.

Analysis: The act of inspecting the ultrasonic hard-copy printout, listing the location and severity of anomalies as a function of their probable impact on four discrete parts of the tire: tread, belt, sidewall, carcass.

Defect: A latent condition within a failed tire found by nondestructive inspection or failure analysis as the cause of a specific failure.

Failure: A tire which has been considered to have failed MVSS 109; specifically, having one of the defects called out in that document: cord separation, groove or liner cracks, loss of air. A tire can be considered a failure when these defects can be proved to exist by nondestructive means.

Failure Analysis: The act of sectioning and inspection of a tire to identify the cause of failure of the tire.

Failure Mechanism: The connection between a condition judged to exist within a tire prior to its failure and the subsequent failure of that tire.*

Flaw: A characteristic within a tire which can be expected to lead to its degradation and possible failure.

Singularity: An anomalous condition of a tire observed either during visual inspection or during sectioning and analysis, with no known link to degradation and failure.

*S.K.Clark, Mechanics of Pneumatic Tires, National Bureau of Standards Monograph No. 122, Washington DC 20402, pp. 341-354, 1971.

1 INTRODUCTION AND SUMMARY

The principal objective of the study was to assess the capability of an ultrasonic nondestructive inspection system developed at TSC to identify tire groups with a high propensity to failure among the groups selected for the Compliance Test under MVSS 109. A secondary objective was to assess the capability of the system to identify changes caused by the Compliance Test. The tire population used for the study consisted of 1440 tires purchased by the NHTSA Office of Standards Enforcement.

The study demonstrated that all tires which failed the Compliance Test had multiple anomalies detected previously by nondestructive inspection (NDI), but that it was not possible, a priori, to determine which of these anomalies would lead to failure. A procedure was developed which utilized the results of the nondestructive inspection and other factors to produce a grade or ranking for each tire. By statistical analysis of the grade a threshold was determined which separated the groups where tires passed the Compliance Test from the groups where tires failed the Test. The confidence level in the non-random nature of this threshold grade is better than 99% (explained in Section 4).

The study also demonstrated that it is possible to identify degradation of tires which have passed the Compliance Test by subsequent nondestructive inspection.

2 STUDY PLAN

Under the first part of the study plan, as conceived initially, it was intended to perform a first inspection cycle of all 1440 tires and to identify tires likely to fail the Compliance Test as a result of anomalies detected by nondestructive inspection. From experience over the past several years, a Compliance Test failure rate of 2.5% (36 tires) was expected; comparison of predicted and actual failures was to be a measure of the validity of nondestructive quality screening. This part of the initial study plan had to be

modified for the following reasons:

(1) The number of failures was only 11 (0.8%)

(2) All failed tires had multiple anomalies previously detected by nondestructive inspection, but it was not possible to identify, a priori, the specific anomalies which would lead to failure.

Consequently, the study plan was modified to include the development of a grading procedure which identified tire groups (12) which had failed during wheel test. Since tire failures occurred in only the first batch of 62 tire groups examined, the grading procedure was confined to these 62 groups. The threshold grade assigned to a group (1 = poor to 9 = excellent) separated groups containing failures from those not containing failures. Statistical methods were used to separate these two groups.

Under the second part of the study plan, all tires which passed the Compliance Test were returned to TSC for a second non-destructive inspection cycle to determine if any changes not previously detected had occurred or if the detected anomalies had increased in size.

3 SYSTEM DESCRIPTION

Tire inspection by reflection ultrasound utilizes narrow band pulses of acoustic energy,[1] coupled to the tire by a water envelope.[2] The tire-handling part of the system used for this investigation is shown in Figure 3-1. It consists of a rotatable spider with three arms. With one arm in the vertical position, out of the water, a tire can be mounted and inflated. The arm is then moved 120° into the water where the tire is spun to remove bubbles and debris by high pressure water jets. It is then moved an additional 120° into the inspection position where it is rotated

(1) Feasibility of High Resolution Pulse-Echo Techniques for Automobile Tire Inspection, Ryan,R.P., June 1973, DOT-TSC-NHTSA-72-11, U.S.Department of Transportation, Interim Report.

(2) A Semi-Automated Pulse-Echo Ultrasonic System for Inspecting Tires, Ryan, R.P., July 1977, DOT-TSC-NHTSA-76-3,U.S. Department of Transportation, Interim Report.

through an array of transducers, shown in Figure 3-2 (shown out of the water for clarity). The inspection scan requires about 20 seconds after which the tire is returned to the vertical position, deflated, removed, and replaced by another tire for inspection. Transducers are independently adjustable to ensure that the ultrasonic energy flux is perpendicular to the laminar structure of the tire; the adjustment is carried out manually under water and requires about 30 minutes. No further adjustment is required for a sequence of similar tires from the same manufacturer. The location of transducers around a typical tire is shown in Figure 3-3. Figure 3-4 is a printout of the display produced by the inspection system. Along the horizontal axis of the display, there are twenty channels of information, one from each transducer. Channels designated 2 - 6 cover the serial-number sidewall, channels 7 - 9 one shoulder, channels 10 - 13 the tread center, channels 14 - 16 the other shoulder and channels 17 - 21 the other sidewall. The vertical axis of the display represents the 360° clockwise rotation of the tire when viewed from the serial-number side, with 0° at the top, 180° half-way down and 360° at the bottom.

4 ANALYSIS OF NONDESTRUCTIVE INSPECTION DATA

The 1440 tires used in the study were purchased by the NHTSA Office of Standards Enforcement. They were inspected nondestructively at TSC before undergoing tests at the Compliance Laboratories and were then returned to TSC where the tires which failed the Compliance Test were inspected visually to determine if the cause of failure could be related to anomalies identified in prior nondestructive inspection. The tires which passed the Compliance Test were inspected visually and nondestructively a second time.

The printouts of the initial nondestructive inspection were analyzed and graded as described in Appendix A, on a scale from 1 to 9, relative to the quality of four tire components: tread, belts, sidewalls,and carcass. The individual grades for all the tires are listed in Appendix B. The particulars of the failed

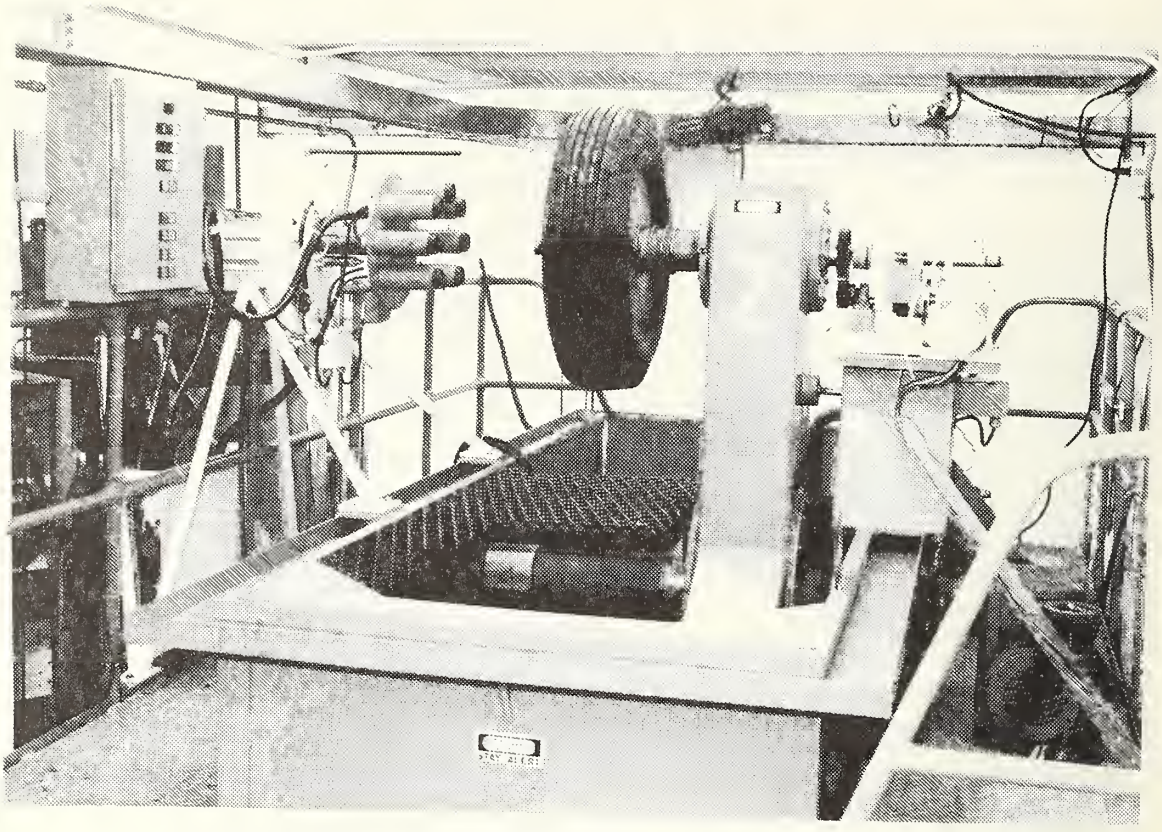


FIGURE 3-1. ULTRASONIC INSPECTION SYSTEM

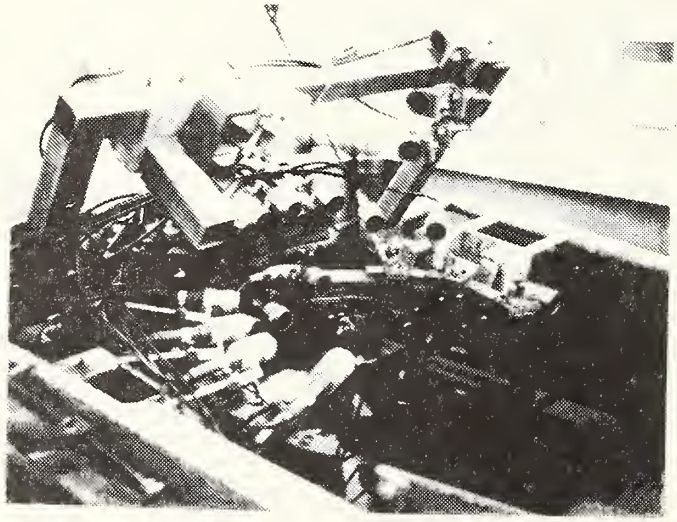


FIGURE 3-2. TRANSDUCER ARRAY

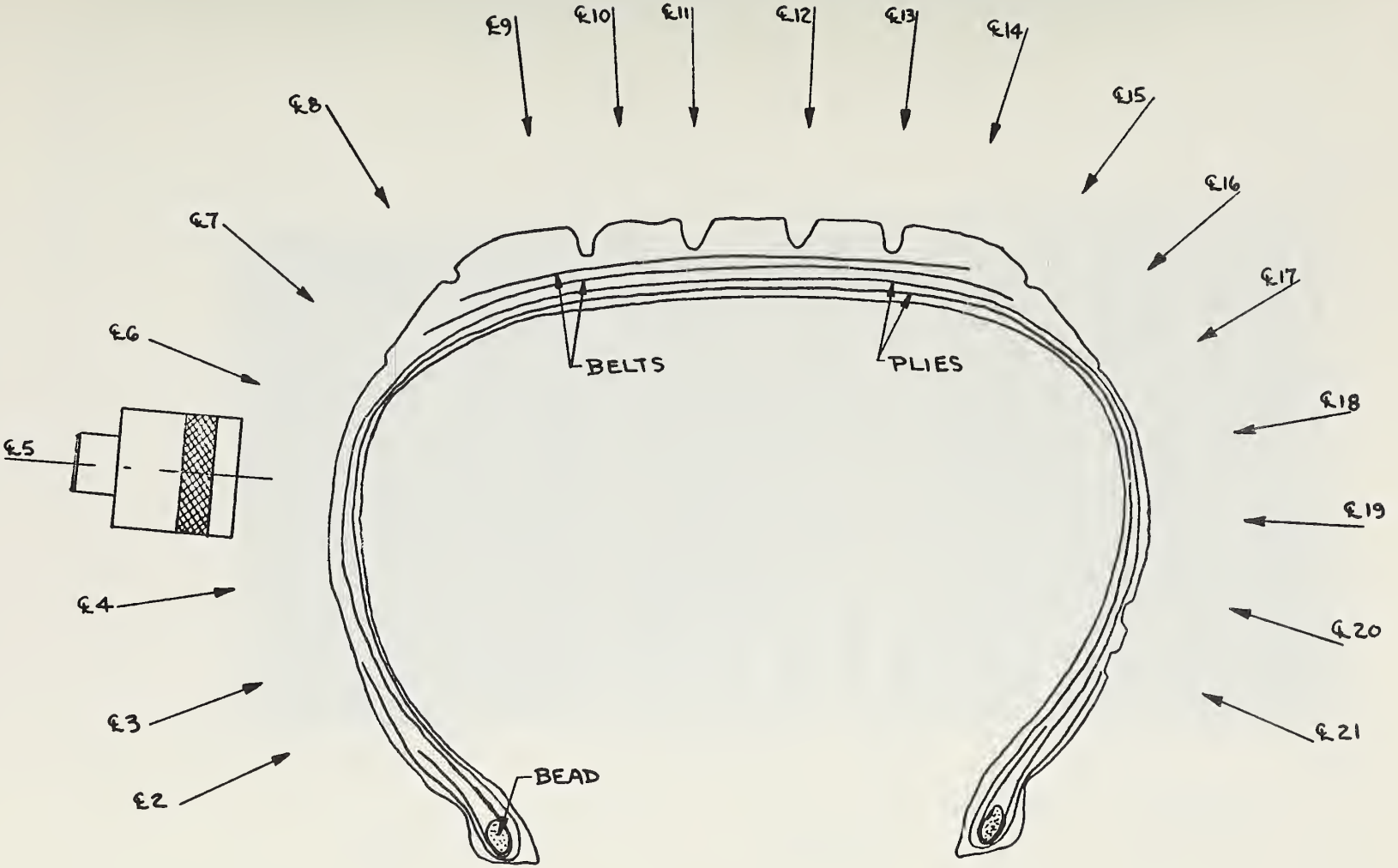


FIGURE 3-3. TRANSDUCER LOCATIONS

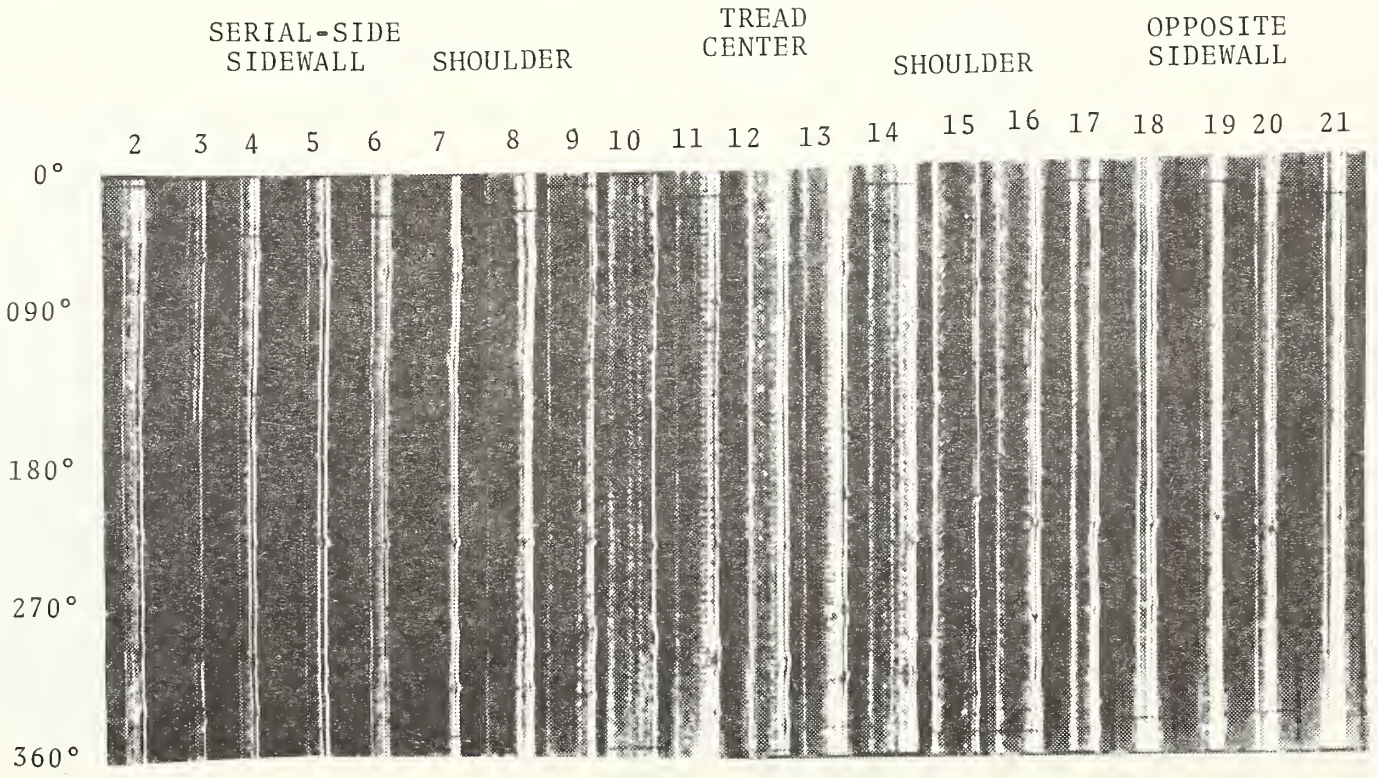


FIGURE 3-4. ULTRASONIC TIRE SCAN DISPLAY

tires and their individual grades are listed in Table 4-1. Seven tires had grades of 6 or less. The other 4 have higher grades and there appears to be no clear-cut relationship between the grade of individual tires and specific tire failure. However, if the tires are considered in groups of twelve, then the grades of the 62 groups indicate that all the failed tires belong to the groups listed in Table 4-2 where at least one tire had a grade of 6 or less. This observation suggests that a threshold grade of 6 or less for one or more tires in a group signals a potential failure of that group. The confidence level in the non-random result obtained if tire groups are selected in this manner was obtained by the χ^2-test of independence[3] as follows:

Let R_a = number of groups having one or more tires with the assigned threshold grade or less, and at least one tire which failed Compliance Tests

R_b = Number of groups having all tires with grades greater than the threshold and at least one Compliance Test failure.

S_a = Number of groups having one or more tires with a threshold of 0.5 or below and no Compliance Test failure.

S_b = number of groups having all tires with grades greater than the threshold and no Compliance Test failures.

n = total number of tire groups

Then, $$\chi^2 = \frac{n\left[R_a S_b - R_b S_a - \frac{n}{2}\right]^2}{(R_a + R_b)(S_a + S_b)(R_a + S_a)(R_b + S_b)} .$$

The confidence level is obtained from tabulated values of χ^2. Threshold grades for all groups are presented in Table 4-3, from which the quantities R_a, S_a, R_b, and S_b can be obtained. Values of χ^2 for threshold grades of 6, 5 and 4 are given in Table 4-4, which shows that highest confidence level is obtained for the threshold value of 5.

---

[3] Experimental Statistics, N.B.S. Handbook 91, October 1966, p. 8-16, p. T-4.

TABLE 4-1 TIRES FAILED BY COMPLIANCE LABORATORIES

TIRE NUMBER	NAME AND GROUP	FAILURE MECHANISM	POINT OF ** INITIATION OF FAILURE θ	φ	ANOMALY DETECTED BY NDI WHICH CAUSED FAILURE	GRADE T. B. S. C.
1. B7S 7061B	Riviera (23)	Break in Ply Cords	060	135	Inclusion In Sidewall	9, 9, 8, 7
2. D7S 7201B	Cheetah (45)	Break in Ply Cords	140	235	Discontinuity in Sidewall	8, 7, 4, 4
3. D7S 2199B	Cheetah (46)	Shoulder Separation	400		Off-Center Belts	7, 6, 6, 5
4. D7S 2204B	Cheetah (46)	Shoulder Separation	400		Off-Center Belts	7, 6, 6, 6
5. D7S 2056B	Delta (50)	Cut in Sidewall	250	300	Detected Visually on Return To TSC	8, 7, 6, 7
6. D7S 2059B	Delta (50)	Flexbreak in Sidewall	165	300	Sidewall Discontinuity	7, 7, 5, 6
7. D7S 2060B	Delta (50)	Cut in Sidewall	150	300	Detected Visually on Return To TSC	8, 8, 8, 7
8. B7S 7341B	Saratoga (51)	Flexbreak in Sidewall	350	090	Sidewall Discontinuity	8, (*), 5, 6
9. D7S 2108C	Seiberling (62)	Tread to Carcass Separation	150-300	WW Shoulder	Porosity	4, (*). 6, 8
10. B7S 7106B	Seiberling (61)	Flex Break At Splice	190	270	Splice Discontinuity	8, (*), 7, 7
11. B7S 7108B	Seiberling (61)	Flex Break in Sidewall	170	090	Sidewall Discontinuity	9, (*), 9, 8

* No Belts

** Coordinate designations are defined in the following manner:
Theta position - With the tire's serial number facing the operator, zero degrees theta (θ) is located at the first character of the serial number that follows DOT. Increasing values of theta are in the clockwise direction, circumferentially around the tire.

Phi position - Phi (φ) is used to define the position on the tire from bead to bead. Zero degrees phi (φ) is taken from a point located in the centerline plane of the tire between the two beads and 2-1/2 in. from the bead in the direction of the tread. The position of φ180 is at center tread. The curb strips are at 090 on serial side and 270 on the whitewall side.

T--tread
B--belts
S--sidewalls
C--carcass

TABLE 4-2 PARTICULARS OF GROUPS CONTAINING COMPLIANCE TEST FAILURES

GROUP	BRAND	GRADE OF FAILED TIRE(S) T B S C *	NUMBER OF GRADES FOR GROUP 6	5	4
23	Riviera	9, 9, 8, 7	0	1	0
45	Cheetah	8, 7, 4, 4	2	0	2
46	Cheetah	7, 6, 6, 6 7, 6, 6, 5	10	3	0
50	Delta	8, 7, 6, 7 7, 7, 5, 6 8, 8, 8, 7	10	2	0
51	Saratoga	8, 5, 6	6	1	0
62	Seiberling	8, 7, 7 9, 9, 8	2	1	0
61	Seiberling	4, 6, 8	9	2	1

* T = Tread
B = Belts
S = Sidewalls
C = Carcass

TABLE 4-3. THRESHOLD GRADES FOR ALL GROUPS

FAIL	BELO6	BELO5	BELO7	GROUP
0	3	0	10	1
0	4	0	7	2
0	1	1	5	3
0	0	0	1	4
0	0	0	1	5
0	0	0	0	6
0	0	0	2	7
0	1	0	7	8
0	1	0	3	9
0	0	0	0	10
0	0	0	3	11
0	1	0	3	12
0	0	0	0	13
0	0	0	0	14
0	0	0	2	15
0	0	0	0	16
0	0	0	0	17
0	0	0	2	18
0	0	0	5	19
0	3	0	9	20
0	0	0	1	21
0	0	0	0	22
1	1	0	1	23
0	1	0	1	24
0	2	1	2	25
0	0	0	1	26
0	0	0	3	27

FAIL	BELO6	BELO5	BELO7	GROUP
0	2	0	10	28
0	0	0	2	29
0	1	0	1	30
0	7	2	11	31
0	0	0	2	32
0	0	0	0	33
0	0	0	5	34
0	0	0	1	35
0	0	0	3	36
0	1	0	3	37
0	0	0	0	38
0	0	0	2	39
0	2	0	9	40
0	0	0	0	41
0	0	0	6	42
0	0	0	1	43
0	0	0	0	44
1	1	2	2	45
2	3	0	6	46
0	1	0	7	47
0	2	0	5	48
0	1	0	9	49
3	2	0	7	50
1	2	0	5	51
0	0	0	1	52
0	0	0	1	53
0	0	0	4	54

FAIL	BELO6	BELO5	BELO7	GROUP
0	4	1	6	55
0	2	0	10	56
0	0	0	3	57
0	1	0	4	58
0	1	0	6	59
0	0	0	2	60
1	1	0	2	61
2	3	1	7	62

TABLE 4-4 ELEMENTS FOR STATISTICAL COMPUTATION

THRESHOLD GRADE	R_a	S_a	R_b	S_b	χ^2	CONFIDENCE LEVEL%
6	7	44	0	11	0.61	∿44
5	7	21	0	34	7.25	∿99
4	2	4	5	51	1.25	∿50

Among the 21 groups having tires with threshold grades of 5 or less but no compliance failures, three brands had the largest number of low grades and the following comments apply.

Uniroyal. Construction of Uniroyal and BIG-O (also made by Uniroyal) is two-ply polyester, two steel belts, and a nylon breaker over the belts. The purpose of the breaker is to hold the belt edges down and prevent belt edge separation. This is Uniroyal's premium tire and as far as is known has performed over a number of years in a satisfactory manner on the Compliance Tests and in road service. It is manufactured under a proprietary process involving automatic builders. These builders leave an exceptionally long splice on the belts and this long splice plus the force exerted by the nylon breaker leaves an ultrasonically dense region in the splice area. This region is shown in Figure 4-1 as a typical singularity/shadow system as defined in Appendix A. For this reason the Uniroyal grades are lower than performance indicates.

Interstate. A careful examination has revealed no substantive irregularities in these tires nor any information as to why their grades should be so low. More information is required on these tires and their ultrasonic characteristics.

Valiant. The Valiant tires are reported to have passed MVSS109 in 1977, however the results of visual inspection show several serious flaws which WERE DETECTED BY NONDESTRUCTIVE AND VISUAL INSPECTION AFTER THE TIRES WERE RETURNED TO TSC ON COMPLETION OF THE COMPLIANCE TESTS. OBSERVATIONS ON FOUR OF THESE TIRES WHICH PASSED THE COMPLIANCE TEST ARE GIVEN IN TABLE 4-5.

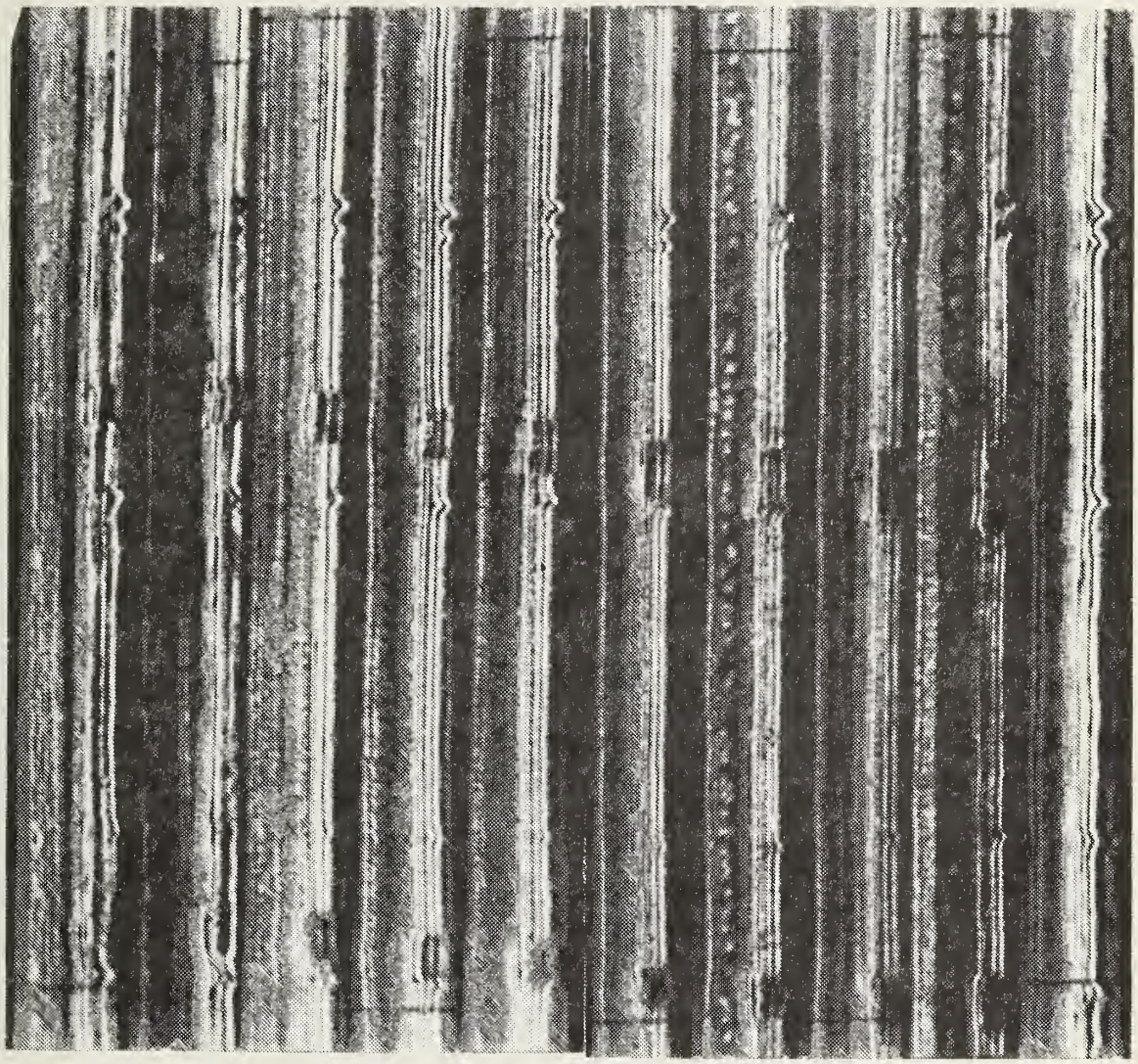


FIGURE 4-1. PRINTOUT OF UNIROYAL

TABLE 4-5 FLAWS OF VALIANTS AFTER COMPLIANCE TEST

SERIAL NO.	OBSERVATION AND B GROUP NO.	OBSERVED FLAW	LOCATION OF FLAW θ	LOCATION OF FLAW ϕ	ANOMALY DETECTED BY NDI
B7S7130C 1	644-54	Buffed Sidewall	270-000	225	Sidewall Discont.
B7X7131B 2	645-54	Groove cracks	290	210	Not detected
		Buffed sidewall	210	230	"
		Reverted rubber area on tread	290	210	Excessive rubber thickness
B7S7131C 3	646-54	Liner cracks	240-050	180	Not detected
B757132B 4	647-54	Reverted rubber area on tread	080	300	Excessive Rubber thickness
			220	300	"

5 NONDESTRUCTIVE AND VISUAL INSPECTION SUBSEQUENT TO COMPLIANCE TESTING

The printouts from nondestructive inspection before and after the Complaince Test were compared and analyzed. Table 5-1 lists the 43 tires from 19 groups where changes were observed. Most of these changes were due to changes in tire shape which occurred during the Compliance Test, but did not impair tire quality. In eight cases, the changes were considered sufficiently serious (i.e., safety related) to warrant sectioning; the findings are reported in Appendix C. The results of visual inspection of tires with notations from the Compliance Laboratories regarding anomalies are given in Appendix D which also contains additional data for the two groups of Valiants which had low grades.

From the inspection subsequent to the Compliance Tests, it was concluded that the grading standard should be lowered when inclusions are observed in radial tires and that additional study is necessary to improve the grading methodology related to tires with uneven splices.

6 CONCLUSIONS

The study demonstrated that nondestructive inspection can identify anomalies in tires which may ultimately lead to Compliance Test failures, but that in the present case only 11 tires in 336 so identified failed the Compliance Test. In order to relate failures to nondestructive inspection results, a methodology was developed which relates tire failures to a threshold grade for each tire group of twelve tires with a high level of confidence. Because the failure rate of the population was less than 1%, it will be necessary to conduct a similar large quantity tire study for refinement of the grading methodology. It might then be possible to select only those groups for Compliance Tests which are graded below a decisive threshold, obviating the need to test sound tire groups. In the present case only 28 out of 62 groups would have been so selected, with a saving to NHTSA in tire purchase and testing fees in excess of $100,000.

TABLE 5-1. ORIGINAL GRADES OF TIRES DEGRADED BY THE COMPLIANCE TEST.

0	OBS.	T	B	S	C	GROUP	TIRE	BRAND
0	29	8	4	5	6	3	27B	LARAMIE
0	121	8	7	7	7	11	2163B	EMPEROR
0	123	7	6	7	7	12	2301B	FALCON
0	223	8	6	7	6	19	88B	UNITED
0	227	9	7	8	8	19	90B	UNITED
0	232	8	7	5	6	20	72C	TRIUMPH
0	250	7	8	7	7	21	59C	SEARS
0	265	9	9	8	7	23	7061B	RIVIERA
0	267	9	7	8	8	23	62B	RIVIERA
0	268	8	7	7	8	23	62C	RIVIERA
0	269	8	8	7	8	23	63B	RIVIERA
0	272	9	7	5	7	23	64C	RIVIERA
0	276	9	8	7	9	23	66C	RIVERIA
0	277	8	8	7	7	24	2061B	RIVIERA
0	278	8	8	8	9	24	61C	RIVIERA
0	281	9	8	7	8	24	63B	RIVIERA
0	286	8	9	7	8	24	65C	RIVIERA
0	287	8	7	7	8	24	66B	RIVIERA
0	299	9	5	5	9	25	72B	CORDOVAN
0	325	9	6	9	8	28	2229B	MUSTANG
0	327	9	6	9	8	28	30B	MUSTANG
0	335	8	6	8	8	28	34B	MUSTANG
0	360	9	8	8	8	30	88C	UNION
0	362	5	5	6	6	31	49C	UNIROYAL
0	363	6	5	7	7	31	50B	UNIROYAL
0	365	7	6	8	8	31	51B	UNIROYAL
0	380	9	8	8	8	32	90C	BIG O
0	381	9	8	9	8	32	91B	BIG O
0	385	9	8	7	8	33	7043B	AVALON
0	386	9	8	7	7	33	43C	AVALON
0	391	8	7	7	7	33	46B	AVALON
0	396	9	8	7	7	33	48C	AVALON
0	458	9	7	9	8	39	95C	MACH 7
0	460	7	7	7	8	39	96C	MACH 7
0	483	9	8	9	9	41	92B	LEE
0	486	9	9	8	9	41	93C	LEE
0	512	9	8	7	8	43	62C	FIRESTONE
0	579	7	6	7	7	49	56B	DELTA
0	580	8	5	6	7	49	56C	DELTA
0	583	8	6	6	6	49	58B	DELTA
0	591	8	7	6	7	50	56B	DELTA
0	592	8	7	7	8	50	56C	DELTA
0	595	9	7	8	7	50	58B	DELTA
0	599	8	8	8	7	50	60B	DELTA
0	615	9	0	7	7	52	38B	SARATOGA
0	616	9	0	8	7	52	38C	SARATOGA
0	620	9	0	7	7	52	40C	SARATOGA
0	622	8	0	7	7	52	41C	SARATOGA
0	624	8	0	6	8	52	42C	SARATOGA
0	712	9	0	8	8	60	74C	CBI
0	719	9	0	8	9	60	78B	CBI

The study also demonstrated that degradation from Compliance Tests can be identified by nondestructive inspection. Forty-three tires were identified in this manner.

Eight tires were found to have flaws, not detected by the Compliance Test, which violated the letter of FMVSS109. This demonstrates that NDI can identify tires in a group, in addition to those that fail the Compliance Test (such as Valiants), which would provide sufficient supporting evidence to make a case for recall of an otherwise marginal tire.

APPENDIX A

Procedure for Analysis of Nondestructive Inspection Data

M.P. Byrne

The analysis of the printouts was performed by individuals trained in data interpretation but having no knowledge of tire technology. A form (Figure A-1) was devised and then completed for each tire in the population. It lists the identification number, manufacturer, construction, ply material, and belt material. Across the top of the form, numbers 2 to 21 correspond to the 20 transducer channels on the printout. On the right side of the form are ten inspection criteria. Some of these criteria apply to individual channels, others apply to combinations of channels. A whole-number scoring value from 1 = poor to 9 = excellent is entered into the appropriate blocks by the evaluator. The inspection criteria and transducer channels to which they apply are defined below:

Data Quality (combination of all channels)
Degree of clarity and focus of traces, black and white detail and gray shades (good quality - Figure A-2; poor quality, Figure A-3).

Registration (combination of all channels)
In some cases it is desirable to superimpose traces as in"before and after" data on the same tire. It is therefore necessary to have the $\Theta=0$ location always at the top of the display. When this does not occur, it is called a registration error. Figure 4 shows two examples of this condition on the same tire.

Turnup Modulation (channels 2 and 21)
Abrupt brightness change (Figure A-5). It is caused by overlapping or separation of material near the tire beads.

Inclusion (all channels)
A lack of reflection from several depths and generally present in more than one channel (see Figure A-6), not to be confused with a single trace separation or fading of a trace. It is caused by a hole or foreign material in the tire structure.

TIRE NO.: CONSTRUCTION: BELT MATERIAL:

MANUFACTURER: PLY MATERIAL:

— CHANNELS —																				
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	CHARACTERISTIC
																				TURNUP MODULATION CHANNELS 2&21
																				INCLUSIONS
																				SINGULARITY SHADOW
																				RADIAL RUNOUT CHANNEL 10
																				LATERAL RUNOUT CHANNELS 5&18
																				INTENSITY CHANGE
																				TRACE DISCONTINUITY
																				SHAPE DISCONTINUITY

DATA QUALITY	REGISTRATION	TREAD	BELTS	SIDEWALL	CARCASS	COMMENTS:

FIGURE A-1. GRADING FORM

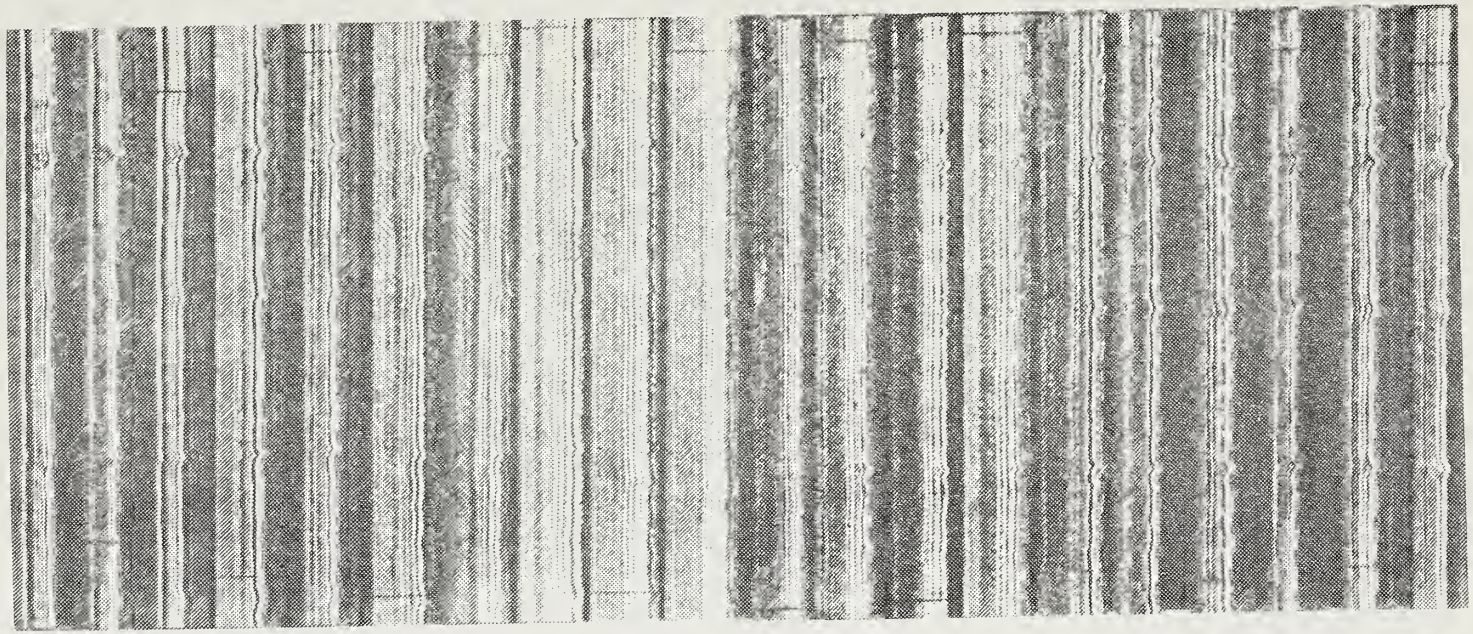


FIGURE A-2 HIGH QUALITY DATA PRINTOUT

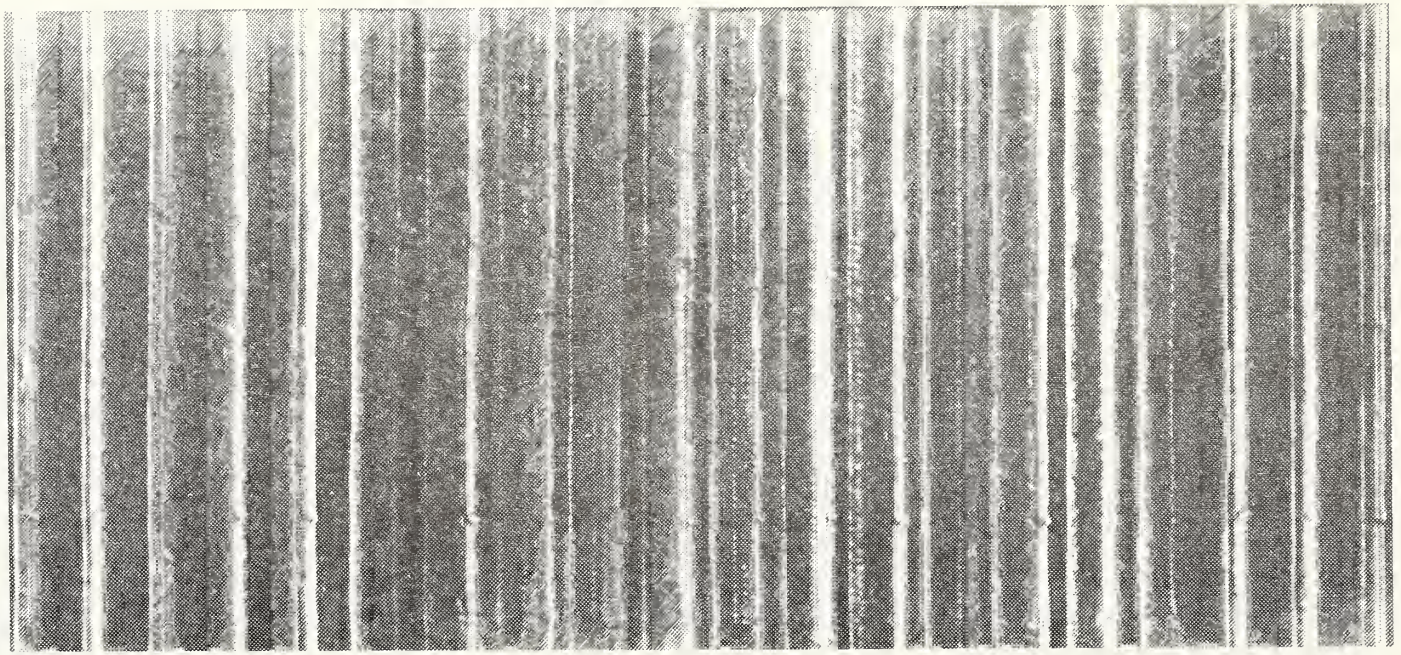


FIGURE A-3 POOR QUALITY DATA PRINTOUT

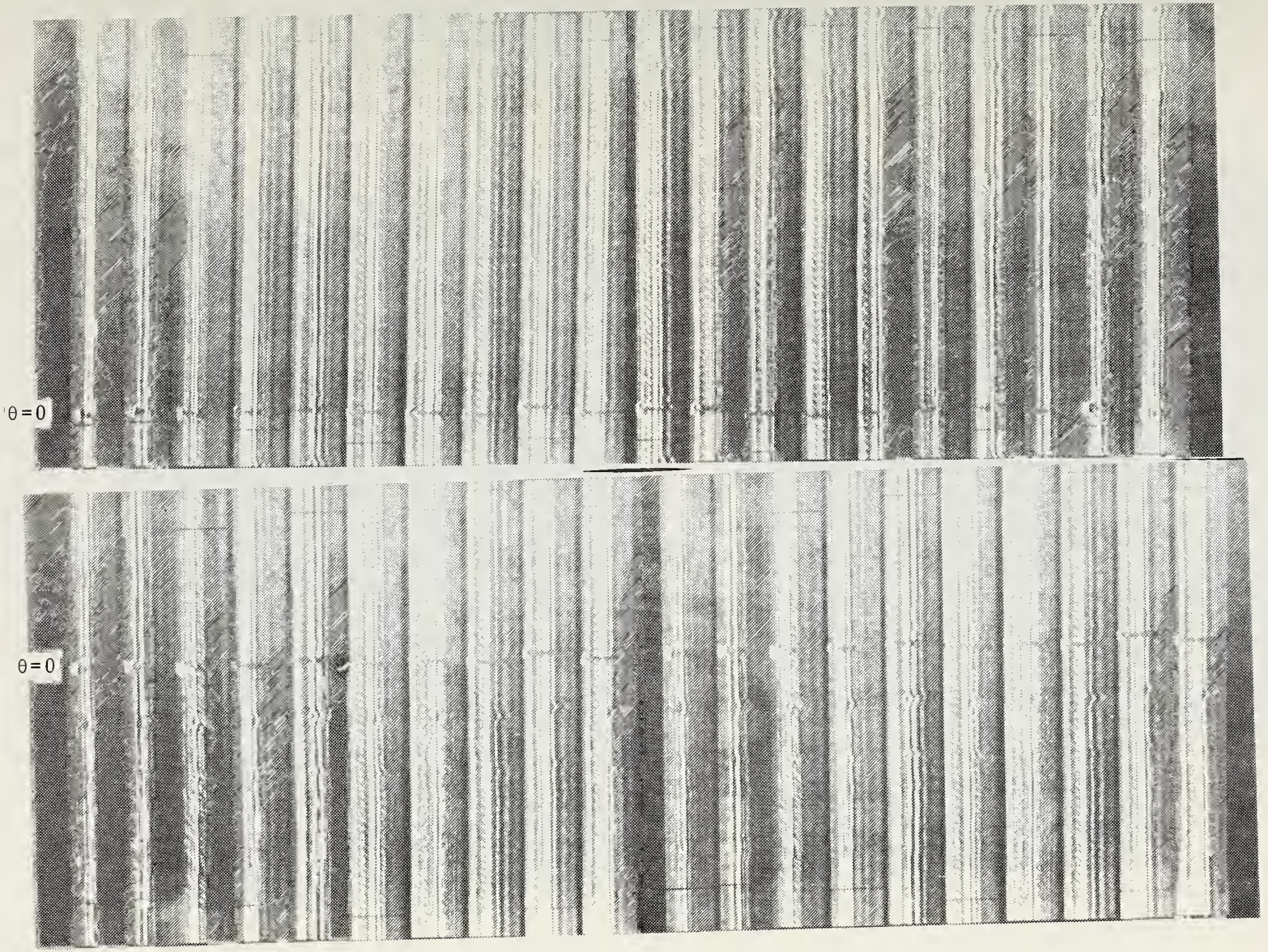
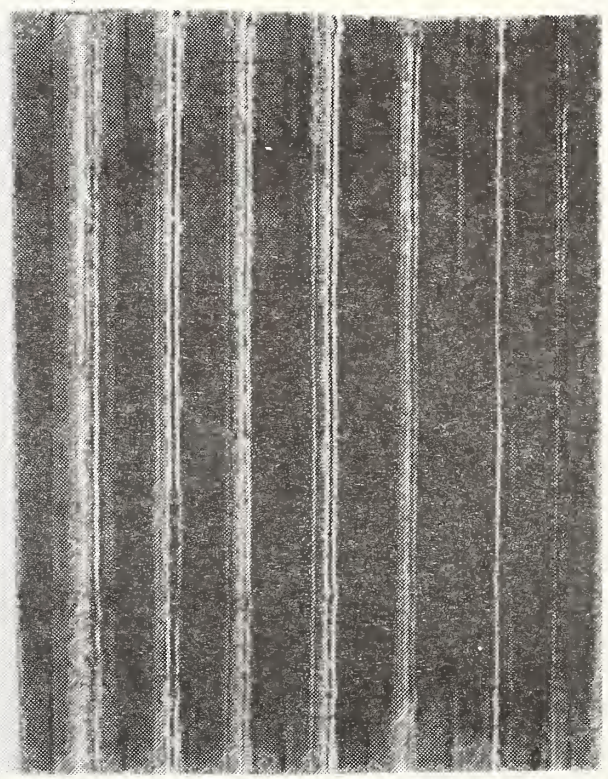


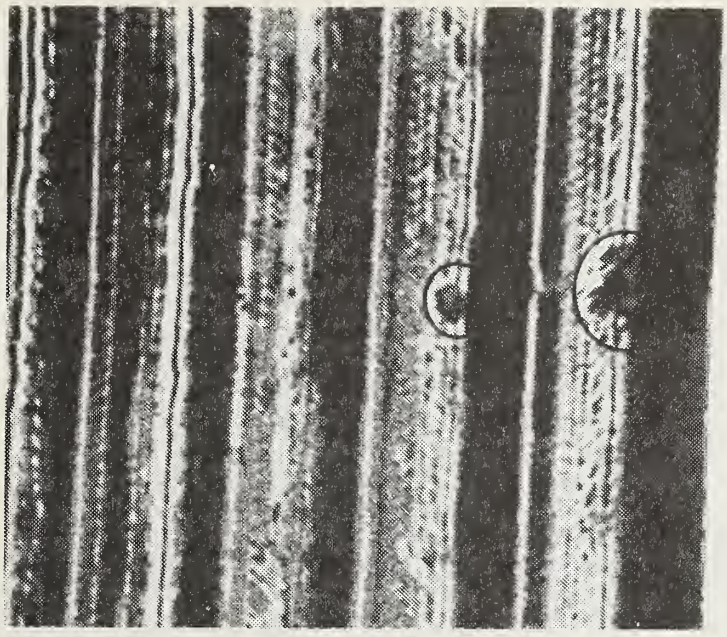
FIGURE A-4 EXAMPLE OF REGISTRATION ERROR



LITTLE OR NO
TURNUP MODULATION

SEVERE TURNUP
MODULATION

FIGURE A-5 TURN-UP AREA



10

FIGURE A-6. EXAMPLE OF INCLUSION

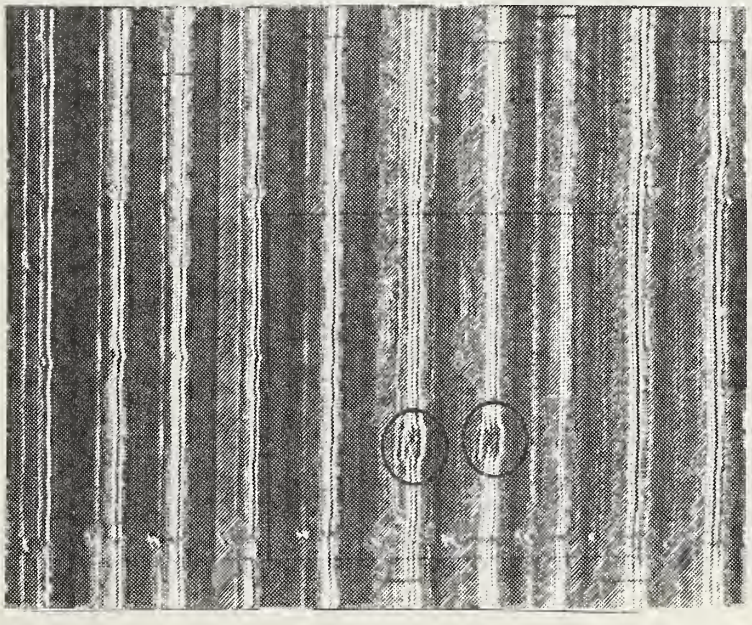


FIGURE A-7 EXAMPLE OF SINGULARITY/SHADOW

Singularity/Shadow (all channels)
A bright spot adjacent to a shadow (Figure A-7). It is caused by a separation or other discontinuity.

Radial Runout (channel 10)
Skewed or wavy trace (Figure A-8). Caused by "out of roundness"; the resulting "high spot" passes closer to transducer #10 than the remainder of the tire.

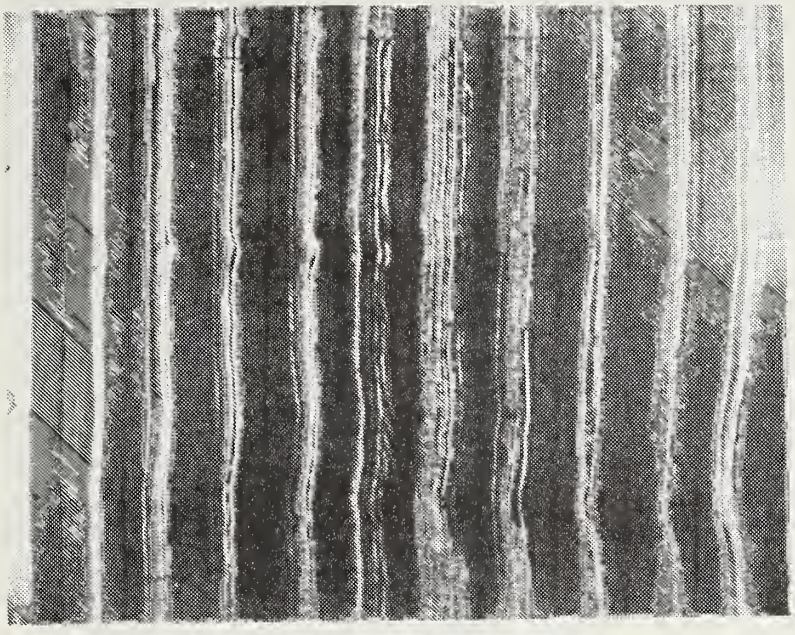
Lateral Runout (channels 5 and 18)
Wavy trace (Figure A-9). Caused by a change in tire width.

Intensity Change (all channels)
Abrupt brightness change (Figure A-10). Caused by a change of material thickness.

Trace Discontinuity (all channels)
Interruption of a trace (Figure A-11), not to be confused with an inclusion which is usually indicated in more than one channel. It is caused by abnormal displacement of material.

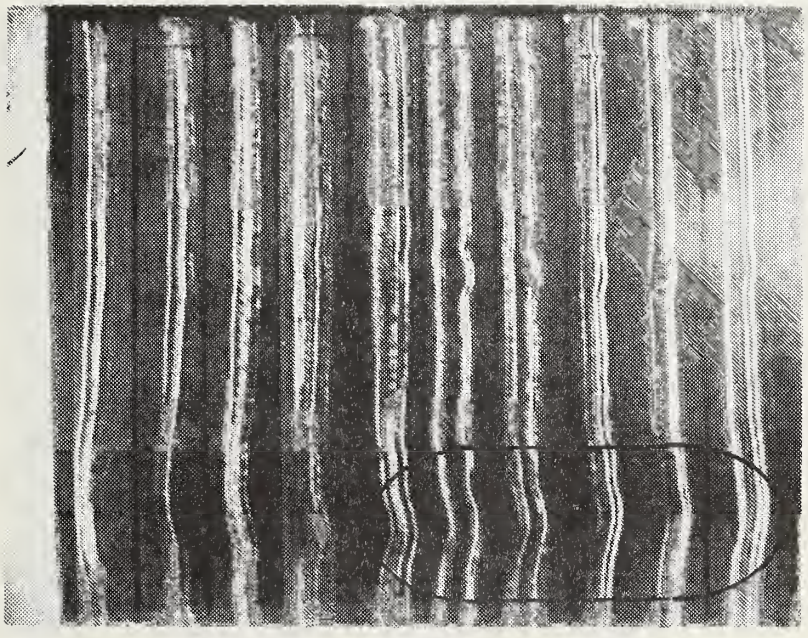
Shape Discontinuity (all channels)
Abrupt change of shape of trace (Figure A-12). It is caused by excess of material or distorted ply structure.

The scores for tread, belts, sidewall, and carcass are derived from the above inspection criteria, taking all factors known about the tire into account. An experienced tire inspector can readily be trained for this task.



5 10

FIGURE A-8. RADIAL RUNOUT



12 18

FIGURE A-9. LATERAL RUNOUT

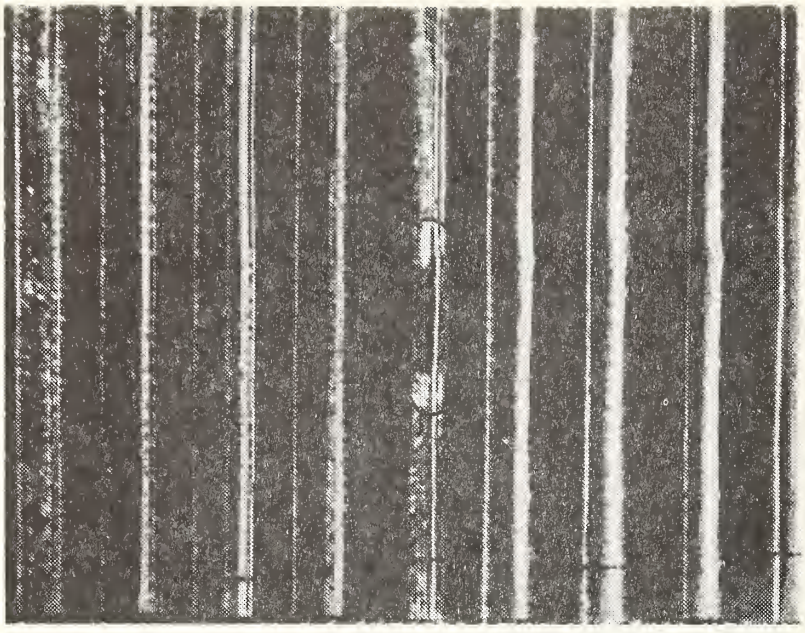
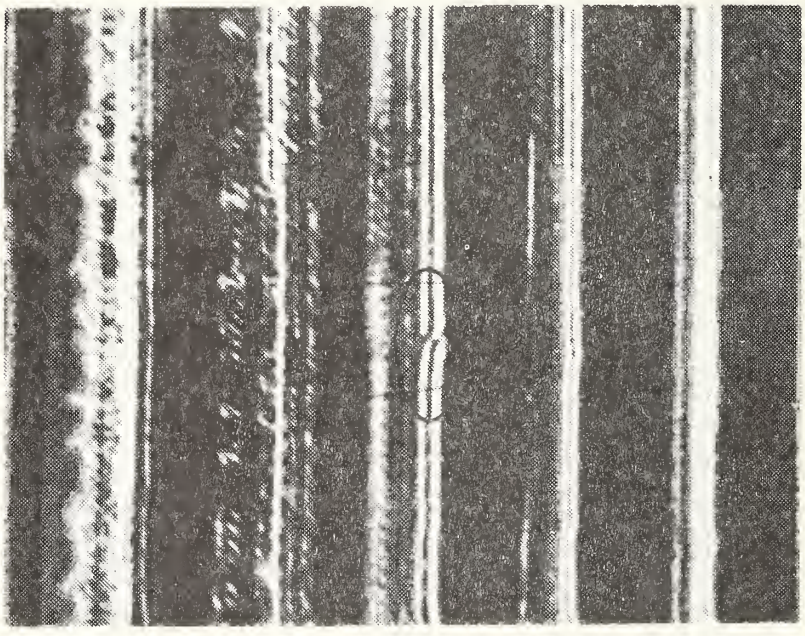


FIGURE A-10. INTENSITY CHANGE



17

FIGURE A-11. TRACE DISCONTINUITY

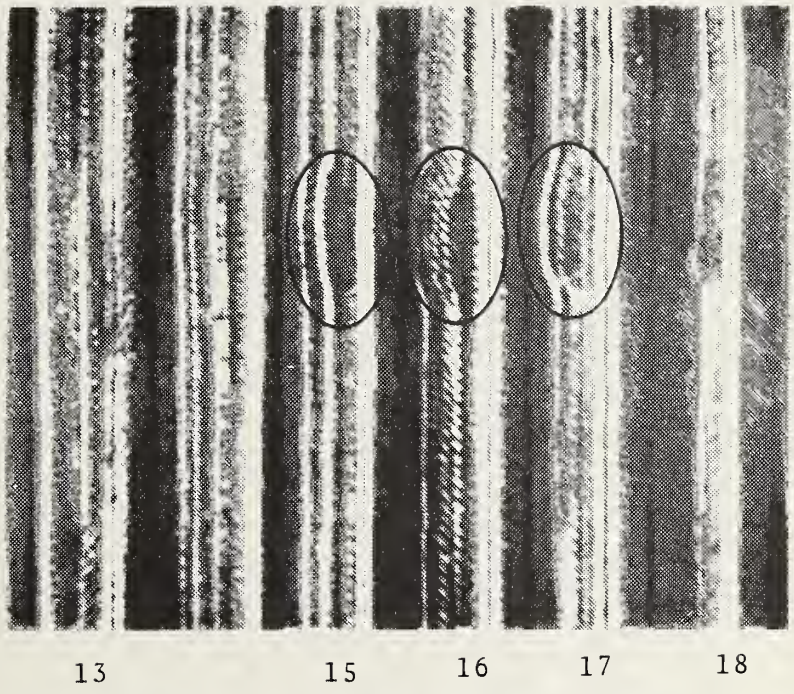


FIGURE A-12. SHAPE DISCONTINUITY

APPENDIX B

Grading of NDI Printouts

A.J. Scapicchio, M.P. Byrne, G. Berube

OBS.	T	B	S	C	GROUP	TIRE	BRAND
1	8	9	7	7	1	2277B	GRAPL
2	8	8	6	6	1	2277C	GRAPL
3	8	8	5	7	1	2278B	GRAPL
4	9	9	7	7	1	2278C	GRAPL
5	9	7	5	7	1	2279B	GRAPL
6	8	8	6	7	1	2279C	GRAPL
7	8	9	6	6	1	2280B	GRAPL
8	9	7	6	7	1	2080C	GRAPL
9	8	8	6	7	1	81B	GRAPL
10	8	9	7	6	1	81C	GRAPL
11	9	8	5	6	1	82B	GRAPL
12	8	7	6	6	1	82C	GRAPL
13	7	8	5	6	2	2169B	INTST
14	7	7	7	7	2	69C	INTST
15	7	6	5	5	2	70B	INTST
16	7	8	6	6	2	70C	INTST
17	7	6	5	6	2	71B	INTST
18	6	7	5	5	2	71C	INTST
19	8	7	6	6	2	72B	INTST
20	7	7	6	6	2	72C	INTST
21	7	8	7	7	2	73B	INTST
22	9	9	7	7	2	73C	INTST
23	7	7	7	7	2	74B	INTST
24	7	8	7	7	2	74C	INTST
25	8	7	6	6	3	2325B	LARME
26	8	7	6	6	3	25C	LARME
27	8	7	7	6	3	26B	LARME

OBS.	T	B	S	C	GROUP	TIRE	BRAND
28	8	7	7	7	3	26C	LARME
29	8	4	5	6	3	27B	LARME
30	8	7	6	7	3	27C	LARME
31	8	8	7	7	3	28B	LARME
32	9	8	7	7	3	28C	LARME
33	8	8	7	7	3	29B	LARME
34	8	7	7	7	3	29C	LARME
35	9	7	7	7	3	30B	LARME
36	9	8	7	7	3	30C	LARME
37	8	7	7	6	4	2145B	MONAC
38	9	8	8	8	4	45C	MONAC
39	9	9	7	8	4	46B	MONAC
40	9	9	8	8	4	46C	MONAC

41	9	9	8	8	4	47B	MONAC
42	9	9	8	8	4	47C	MONAC
43	9	9	8	7	4	48B	MONAC
44	8	7	8	8	4	48C	MONAC
45	8	8	8	8	4	49B	MONAC
46	8	8	7	8	4	49C	MONAC
47	9	9	8	8	4	50B	MONAC
48	9	9	8	8	4	50C	MONAC
49	8	8	8	8	5	2223B	OHTSU
50	7	8	9	8	5	23C	OHTSU
51	8	8	7	7	5	24B	OHTSU
52	7	7	7	7	5	24C	OHTSU
53	8	8	7	7	5	25B	OHTSU
54	8	8	6	7	5	25C	OHTSU

OBS.	T	B	S	C	GROUP	TIRE	BRAND
55	8	8	7	7	5	26B	OHTSU
56	7	8	7	7	5	26C	OHTSU
57	7	8	7	7	5	27B	OHTSU
58	8	8	8	8	5	27C	OHTSU
59	8	8	8	7	5	28B	OHTSU
60	8	8	8	8	5	28C	OHTSU
61	9	7	8	8	6	7001B	PIREL
62	8	7	7	7	6	01C	PIREL
63	9	7	9	8	6	02B	PIREL
64	9	8	7	8	6	02C	PIREL
65	9	8	8	8	6	03B	PIREL
66	8	8	7	7	6	03C	PIREL
67	8	8	8	8	6	04B	PIREL
68	8	8	8	8	6	04C	PIREL
69	8	8	9	8	6	05B	PIREL
70	9	9	9	9	6	05C	PIREL
71	9	9	9	8	6	06B	PIREL
72	9	9	9	9	6	06C	PIREL
73	9	8	8	9	7	2001B	PIREL
74	9	8	8	7	7	01C	PIREL
75	8	8	8	7	7	02B	PIREL
76	8	6	7	6	7	02C	PIREL
77	8	9	8	7	7	03B	PIREL
78	8	6	7	6	7	03C	PIREL
79	8	7	8	7	7	04B	PIREL
80	8	7	7	8	7	04C	PIREL
81	8	7	7	8	7	05B	PIREL

OBS.	T	B	S	C	GROUP	TIRE	BRAND
82	9	9	9	9	7	05C	PIREL
83	8	7	8	8	7	06B	PIREL
84	8	7	7	7	7	06C	PIREL
85	7	7	5	6	8	7121B	GOODY
86	9	8	8	8	8	21C	GOODY
87	9	8	6	8	8	22B	GOODY
88	7	7	6	6	8	22C	GOODY
89	9	8	7	8	8	23B	GOODY
90	9	8	7	8	8	23C	GOODY
91	9	8	6	7	8	24B	GOODY
92	9	7	8	8	8	24	GOODY
93	9	6	7	7	8	25B	GOODY

94	9	8	8	8	8	25C	GOODY
95	9	6	6	7	8	26B	GOODY
96	8	6	7	7	8	26C	GOODY
97	9	7	7	8	9	21218	GOODY
98	9	6	7	7	9	21C	GOODY
99	8	7	5	6	9	228	GOODY
100	8	7	6	7	9	22C	GOODY
101	9	7	7	7	9	23B	GOODY
102	9	9	7	7	9	23C	GOODY
103	9	8	8	8	9	24B	GOODY
104	9	9	8	8	9	24C	GOODY
105	9	8	7	8	9	25B	GOODY
106	9	8	7	8	9	25C	GOODY
107	9	8	7	8	9	26B	GOODY
108	9	8	7	8	9	26C	GOODY

OBS.	T	B	S	C	GROUP	TIRE	BRAND
109	8	8	8	8	10	21758	FULDA
110	9	8	7	8	10	75C	FULDA
111	9	8	8	8	10	768	FULDA
112	9	8	7	8	10	76C	FULDA
113	9	8	8	8	10	778	FULDA
114	9	8	8	8	10	77C	FULDA
115	9	8	8	9	10	78B	FULDA
116	9	8	8	9	10	78C	FULDA
117	8	8	8	8	10	798	FULDA
118	9	9	8	9	10	79C	FULDA
119	7	8	9	8	10	80B	FULDA
120	9	9	8	8	10	80C	FULDA
121	8	7	7	7	11	2163B	EMPER
122	8	6	7	7	11	2163C	EMPER
123	8	9	7	7	11	648	EMPER
124	9	8	8	8	11	64C	EMPER
125	8	9	7	8	11	65B	EMPER
126	8	8	8	8	11	65C	EMPER
127	8	7	7	8	11	66B	EMPER
128	8	6	8	7	11	66C	EMPER
129	8	7	7	6	11	678	EMPER
130	8	7	7	7	11	67C	EMPER
131	8	7	7	7	11	68B	EMPER
132	8	7	7	7	11	68C	EMPER
133	7	6	7	7	12	23018	FALCO
134	7	5	7	7	12	01C	FALCO
135	7	7	7	7	12	02B	FALCO

OBS.	T	B	S	C	GROUP	TIRE	BRAND
136	7	6	7	7	12	02C	FALCO
137	7	6	7	7	12	03B	FALCO
138	7	6	7	7	12	03C	FALCO
139	8	7	8	8	12	04B	FALCO
140	8	7	7	8	12	04C	FALCO
141	8	7	8	8	12	05B	FALCO
142	8	6	8	8	12	05C	FALCO
143	7	6	7	7	12	06B	FALCO
144	7	6	8	8	12	06C	FALCO
145	8	8	8	8	13	72118	ZENIT
146	8	7	8	8	13	11C	ZENIT

147	8	8	8	8	13	12B	ZENIT
148	8	7	8	8	13	12C	ZENIT
149	8	7	7	8	13	13B	ZENIT
150	8	8	8	8	13	13C	ZENIT
151	9	9	8	9	13	14B	ZENIT
152	9	9	8	9	13	14C	ZENIT
153	9	9	9	9	13	15B	ZENIT
154	8	9	9	8	13	15C	ZENIT
155	8	8	7	8	13	16B	ZENIT
156	8	7	8	8	13	16C	ZENIT
157	7	7	8	8	14	2211B	ZENIT
158	8	8	8	8	14	11C	ZENIT
159	7	8	8	8	14	12B	ZENIT
160	8	8	8	8	14	12C	ZENIT
161	8	8	8	8	14	13B	ZENIT
162	8	8	7	8	14	13C	ZENIT

OBS.	T	B	S	C	GROUP	TIRE	BRAND
163	8	8	8	8	14	14B	ZENIT
164	8	8	8	8	14	14C	ZENIT
165	9	9	8	9	14	15B	ZENIT
166	9	8	8	9	14	15C	ZENIT
167	9	8	9	9	14	16B	ZENIT
168	9	9	8	9	14	16C	ZENIT
169	8	7	7	8	15	2181B	VEITH
170	9	8	8	8	15	81C	VEITH
171	9	8	8	7	15	82B	VEITH
172	9	8	7	7	15	82C	VEITH
173	9	8	7	8	15	83B	VEITH
174	9	8	7	8	15	83C	VEITH
175	8	7	7	8	15	84B	VEITH
176	8	8	8	8	15	84C	VEITH
177	0	0	0	0	15	85B	VEITH
178	8	8	8	9	15	85C	VEITH
179	8	8	8	8	15	86B	VEITH
180	7	8	7	8	15	86C	VEITH
181	9	9	9	8	16	7163B	EMPER
182	9	9	9	9	16	63C	EMPER
183	9	9	9	8	16	64B	EMPER
184	9	8	9	7	16	64C	EMPER
185	9	9	8	8	16	65B	EMPER
186	9	8	9	9	16	65C	EMPER
187	9	8	9	7	16	66B	EMPER
188	9	9	8	8	16	66C	EMPER
189	9	9	9	8	16	67B	EMPER

OBS.	T	B	S	C	GROUP	TIRE	BRAND
190	9	9	9	9	16	67C	EMPER
191	9	9	9	9	16	68B	EMPER
192	9	9	9	7	16	68C	EMPER
193	9	8	8	8	17	2205B	DUNLO
194	7	7	7	7	17	05C	DUNLO
195	9	9	8	9	17	06B	DUNLO
196	9	9	9	9	17	06C	DUNLO
197	9	9	8	9	17	07B	DUNLO
198	9	9	9	9	17	07C	DUNLO
199	9	9	8	8	17	08B	DUNLO

200	9	9	7	9	17	08C	DUNLO
201	9	9	8	9	17	09B	DUNLO
202	7	9	8	7	17	09C	DUNLO
203	9	9	9	9	17	10B	DUNLO
204	9	9	7	7	17	10C	DUNLO
205	9	7	8	8	18	7085B	UNITE
206	8	7	7	7	18	85C	UNITE
207	9	7	6	6	18	86B	UNITE
208	9	8	7	7	18	86C	UNITE
209	8	7	7	8	18	87B	UNITE
210	9	7	7	7	18	87C	UNITE
211	7	8	7	7	18	88B	UNITE
212	9	8	8	8	18	88C	UNITE
213	8	7	6	7	18	89B	UNITE
214	9	8	8	7	18	89C	UNITE
215	8	7	8	7	18	90B	UNITE
216	9	8	8	7	18	90C	UNITE

OBS.	T	B	S	C	GROUP	TIRE	BRAND
217	9	7	8	7	19	2085B	UNITE
218	9	7	6	6	19	85C	UNITE
219	8	8	7	7	19	86B	UNITE
220	9	7	7	7	19	86C	UNITE
221	7	7	7	6	19	87B	UNITE
222	8	8	6	8	19	87C	UNITE
223	8	6	7	6	19	88B	UNITE
224	8	8	7	7	19	88C	UNITE
225	8	8	8	7	19	89B	UNITE
226	8	7	6	7	19	89C	UNITE
227	9	7	8	8	19	90B	UNITE
228	9	7	8	8	19	90C	UNITE
229	8	8	7	7	20	2271B	TRIUM
230	9	9	7	7	20	71C	TRIUM
231	8	6	7	7	20	72B	TRIUM
232	8	7	5	6	20	72C	TRIUM
233	8	8	7	7	20	73B	TRIUM
234	9	8	5	7	20	73C	TRIUM
235	9	7	5	6	20	74B	TRIUM
236	9	7	6	7	20	74C	TRIUM
237	8	7	6	6	20	75B	TRIUM
238	9	8	6	7	20	75C	TRIUM
239	9	8	6	6	20	76B	TRIUM
240	8	6	7	6	20	76C	TRIUM
241	8	8	8	7	21	2355B	SEARS
242	8	7	8	8	21	55C	SEARS
243	8	8	9	8	21	56B	SEARS

OBS.	T	B	S	C	GROUP	TIRE	BRAND
244	8	7	8	8	21	56C	SEARS
245	8	8	7	9	21	57B	SEARS
246	8	7	7	7	21	57C	SEARS
247	7	8	7	7	21	58B	SEARS
248	8	7	7	8	21	58C	SEARS
249	7	8	8	7	21	59B	SEARS
250	7	8	7	7	21	59C	SEARS
251	7	7	7	7	21	60B	SEARS
252	7	7	8	7	21	60C	SEARS

OBS.	T	B	S	C	GROUP	TIRE	BRAND
253	9	9	8	9	22	2247B	SUMIT
254	9	9	9	8	22	47C	SUMIT
255	9	9	9	9	22	48B	SUMIT
256	9	8	9	9	22	48C	SUMIT
257	9	9	8	9	22	49B	SUMIT
258	9	9	9	9	22	49C	SUMIT
259	9	9	8	9	22	50B	SUMIT
260	9	9	9	9	22	50C	SUMIT
261	9	9	9	9	22	51B	SUMIT
262	9	9	9	9	22	51C	SUMIT
263	9	9	9	8	22	52B	SUMIT
264	9	9	9	8	22	52C	SUMIT
265	9	9	8	7	23	7061B	RIVIE (F)
266	9	9	7	7	23	61C	RIVIE
267	9	7	9	8	23	62B	RIVIE
268	8	7	7	8	23	62C	RIVIE
269	8	8	7	8	23	63B	RIVIE
270	8	8	7	8	23	63C	RIVIE

OBS.	T	B	S	C	GROUP	TIRE	BRAND
271	7	9	7	8	23	64B	RIVIE
272	9	7	5	7	23	64C	RIVIE
273	9	9	7	8	23	65B	RIVIE
274	9	9	8	9	23	65C	RIVIE
275	8	8	8	8	23	66B	RIVIE
276	9	8	7	9	23	66C	RIVIE
277	8	8	7	7	24	2061B	RIVIE
278	8	8	8	9	24	61C	RIVIE
279	7	9	5	6	24	2062B	RIVIE
280	8	9	8	9	24	62C	RIVIE
281	9	8	7	8	24	63B	RIVIE
282	8	8	7	7	24	63C	RIVIE
283	8	8	8	8	24	64B	RIVIE
284	9	9	8	8	24	64C	RIVIE
285	9	8	9	9	24	65B	RIVIE
286	8	9	7	8	24	65C	RIVIE
287	8	7	7	8	24	66B	RIVIE
288	9	9	7	8	24	66C	RIVIE
289	8	8	8	8	25	7067B	CORDO
290	9	8	9	9	25	67C	CORDO
291	9	9	8	8	25	68B	CORDO
292	9	9	9	9	25	68C	CORDO
293	9	9	9	9	25	69B	CORDO
294	9	9	9	9	25	69C	CORDO
295	9	9	9	9	25	70B	CORDO
296	9	8	9	9	25	70C	CORDO
297	9	9	8	9	25	71B	CORDO

OBS.	T	B	S	C	GROUP	TIRE	BRAND
298	9	9	9	9	25	71C	CORDO
299	9	5	5	9	25	72B	CORDO
300	9	9	7	4	25	72C	CORDO
301	9	8	9	8	26	2265B	DIAMO
302	9	7	9	9	26	65C	DIAMO
303	9	8	9	9	26	66B	DIAMO
304	9	7	9	8	26	66C	DIAMO
305	9	9	9	8	26	67B	DIAMO

OBS.	T	B	S	C	GROUP	TIRE	BRAND
306	9	8	8	7	26	67C	DIAMO
307	9	8	7	8	26	68B	DIAMO
308	8	7	8	7	26	68C	DIAMO
309	9	8	8	8	26	69B	DIAMO
310	9	9	7	8	26	69C	DIAMO
311	9	8	8	8	26	70B	DIAMO
312	9	6	9	8	26	70C	DIAMO
313	9	7	8	8	27	2097B	CONTI
314	8	7	8	7	27	97C	CONTI
315	9	8	7	7	27	98B	CONTI
316	8	7	8	7	27	98C	CONTI
317	8	9	8	8	27	99B	CONTI
318	8	8	8	8	27	99C	CONTI
319	9	7	8	7	27	2100B	CONTI
320	9	8	7	8	27	2100C	CONTI
321	8	7	7	8	27	01B	CONTI
322	7	6	7	7	27	01C	CONTI
323	8	6	7	7	27	02B	CONTI
324	8	6	8	7	27	02C	CONTI

OBS.	T	B	S	C	GROUP	TIRE	BRAND
325	9	6	7	8	28	2229B	MUSTA
326	9	5	8	7	28	29C	MUSTA
327	9	6	9	8	28	30B	MUSTA
328	9	7	8	8	28	30C	MUSTA
329	9	6	9	8	28	31B	MUSTA
330	9	6	8	8	28	31C	MUSTA
331	9	5	9	8	28	32B	MUSTA
332	9	6	8	8	28	32C	MUSTA
333	9	6	8	8	28	33B	MUSTA
334	9	6	9	8	28	33C	MUSTA
335	8	6	8	8	28	34B	MUSTA
336	9	7	9	8	28	34C	MUSTA
337	7	7	6	7	29	2217B	SAXON
338	7	7	7	7	29	17C	SAXON
339	8	8	8	8	29	18B	SAXON
340	8	8	7	8	29	18C	SAXON
341	8	6	8	6	29	19B	SAXON
342	7	8	7	7	29	19C	SAXON
343	9	8	8	8	29	20B	SAXON
344	8	8	7	8	29	20C	SAXON
345	8	8	8	8	29	21B	SAXON
346	9	9	8	8	29	21C	SAXON
347	0	0	0	0	29	22B	SAXON
348	7	8	7	7	29	22C	SAXON
349	8	8	8	5	30	2283B	UNION
350	9	9	7	8	30	83C	UNION
351	9	9	8	8	30	84B	UNION

OBS.	T	B	S	C	GROUP	TIRE	BRAND
352	9	9	8	8	30	84C	UNION
353	9	8	8	8	30	85B	UNION
354	9	9	7	7	30	85C	UNION
355	9	9	7	7	30	86B	UNION
356	9	8	7	8	30	86C	UNION
357	8	7	7	7	30	87B	UNION
358	9	8	7	8	30	87C	UNION

359	9	9	7	7	30	88B	UNION
360	9	8	8	8	30	88C	UNION
361	4	3	7	6	31	20498	UNIRO
362	5	5	6	6	31	49C	UNIRC
363	6	5	7	7	31	50B	UNIRO
364	7	5	8	8	31	50C	UNIRO
365	7	6	8	8	31	51B	UNIRO
366	7	7	8	7	31	51C	UNIRO
367	7	7	6	6	31	52B	UNIRO
368	7	5	8	8	31	52C	UNIRO
369	7	5	7	7	31	53B	UNIRO
370	7	6	8	7	31	53C	UNIRO
371	5	7	7	6	31	54B	UNIRC
372	7	6	8	8	31	54C	UNIRO
373	8	7	9	8	32	21878	BIG O
374	9	8	9	8	32	87C	BIG O
375	8	8	9	8	32	88B	BIG O
376	8	8	9	9	32	88C	BIG O
377	8	8	9	9	32	89B	BIG O
378	9	8	9	9	32	89C	BIG O

OBS.	T	B	S	C	GROUP	TIRE	BRAND
379	9	9	9	9	32	90B	BIG O
380	9	8	8	8	32	90C	BIG O
381	9	8	9	8	32	91B	BIG C
382	9	6	7	7	32	91C	BIG O
383	9	6	8	8	32	92B	BIG O
384	8	7	8	8	32	92C	BIG O
385	9	8	7	8	33	7043B	AVALO
386	9	8	7	7	33	43C	AVALO
387	9	7	7	8	33	44B	AVALO
388	9	7	7	8	33	44C	AVALO
389	8	7	7	8	33	45B	AVALO
390	9	8	7	8	33	45C	AVALO
391	8	7	7	7	33	46B	AVALO
392	9	9	7	8	33	46C	AVALO
393	9	8	7	7	33	47B	AVALO
394	9	7	7	7	33	47C	AVALO
395	8	7	7	7	33	48B	AVALO
396	9	8	7	7	33	48C	AVALO
397	9	8	6	6	34	2043B	AVALO
398	8	7	6	7	34	43C	AVALO
399	9	8	7	8	34	44B	AVALO
400	9	8	7	7	34	44C	AVALO
401	8	7	7	7	34	45B	AVALO
402	8	8	8	8	34	45C	AVALO
403	9	6	6	6	34	46B	AVALO
404	9	7	7	7	34	46C	AVALO
405	8	7	8	7	34	47B	AVALO

OBS.	T	B	S	C	GROUP	TIRE	BRAND
406	8	7	8	8	34	47C	AVALO
407	9	7	6	6	34	48B	AVALO
408	8	6	7	6	34	48C	AVALO
409	8	8	7	8	35	70198	BRIDG
410	8	8	7	7	35	19C	BRIDG
411	8	8	6	7	35	208	BRIDG

412	9	8	7	7	35	20C	BRIOG
413	9	7	7	7	35	21B	BRIOG
414	9	8	7	8	35	21C	BRIOG
415	8	8	7	8	35	22B	BRIOG
416	9	7	7	7	35	22C	BRIOG
417	9	8	8	8	35	23B	BRIOG
418	9	8	7	8	35	23C	BRIDG
419	9	9	9	9	35	24B	BRIOG
420	9	7	8	7	35	24C	BRIOG
421	8	8	7	7	36	2019B	BRIOG
422	8	8	7	7	36	19C	BRIOG
423	9	8	8	8	36	20B	BRIOG
424	9	8	7	8	36	20C	BRIOG
425	8	8	7	8	36	21B	BRIOG
426	9	8	7	8	36	21C	BRIOG
427	8	6	7	7	36	22B	BRIOG
428	9	6	7	7	36	22C	BRIOG
429	9	8	7	8	36	23B	BRIOG
430	7	6	6	6	36	23C	BRIOG
431	8	8	7	8	36	24B	BRIDG
432	8	8	8	8	36	24C	BRIDG

OBS.	T	B	S	C	GROUP	TIRE	BRAND
433	8	8	7	7	37	7037B	BFGOO
434	7	6	5	6	37	37C	BFGOO
435	8	8	6	6	37	38B	BFGOO
436	8	8	7	8	37	38C	BFGOO
437	9	8	7	7	37	39B	BFGOC
438	6	7	7	8	37	39C	BFGOO
439	7	8	7	7	37	40B	BFGOO
440	8	7	7	7	37	40C7	BFGOO
441	7	8	7	7	37	41B	BFGOO
442	7	7	7	8	37	41C	BFGOO
443	7	8	7	8	37	42B	BFGOC
444	8	7	8	8	37	42C	BFGOO
445	8	8	7	7	38	2037B	BFGOO
446	9	8	7	7	38	37C	BFGCO
447	8	8	7	7	38	38B	BFGOO
448	9	8	8	8	38	38C	BFGOO
449	9	8	8	8	38	39B	BFGOO
450	8	7	7	7	38	39C	BFGOO
451	7	7	7	7	38	40B	BFGOO
452	8	7	7	7	38	40C	BFGOO
453	8	8	7	7	38	41B	BFGOO
454	9	8	7	7	38	41C	BFGOO
455	8	8	7	8	38	42B	BFGCO
456	8	8	7	7	38	42C	BFGOO
457	9	8	9	9	39	7295B	MACH7
458	9	7	9	8	39	95C	MACH7
459	9	7	7	7	39	96B	MACH7

OBS.	T	B	S	C	GROUP	TIRE	BRAND
460	7	7	7	8	39	96C	MACH7
461	9	7	7	8	39	97B	MACH7
462	7	7	7	8	39	97C	MACH7
463	9	7	6	7	39	98B	MACH7
464	9	7	8	7	39	98C	MACH7

465	9	8	7	8	39	99B	MACH7
466	9	7	7	7	39	99C	MACH7
467	9	8	6	7	39	7300B	MACH7
468	8	8	7	7	39	7300C	MACH7
469	9	8	6	7	40	71158	HOLID
470	9	8	6	7	40	15C	HOLID
471	8	7	6	6	40	16B	HOLID
472	9	9	8	8	40	16C	HOLID
473	9	7	6	7	40	17B	HOLID
474	8	8	5	6	40	17C	HOLID
475	9	7	8	6	40	18B	HOLID
476	8	8	7	7	40	18C	HOLID
477	9	7	7	6	40	19B	HOLID
478	6	6	5	5	40	19C	HOLID
479	9	9	8	9	40	20B	HOLID
480	8	8	7	8	40	20C	HOLID
481	9	9	9	9	41	70918	LEE
482	9	9	9	9	41	91C	LEE
483	9	8	9	9	41	92B	LEE
484	9	8	9	9	41	92C	LEE
485	9	8	9	8	41	93B	LEE
486	9	9	8	9	41	93C	LEE

OBS.	T	B	S	C	GROUP	TIRE	BRAND
487	9	9	8	7	41	94B	LEE
488	9	9	9	9	41	94C	LEE
489	9	9	8	8	41	95B	LEE
490	9	8	9	8	41	95C	LEE
491	9	7	9	8	41	96B	LEE
492	9	9	9	8	41	96C	LEE
493	8	7	7	7	42	7109B	ELIMI
494	7	8	7	7	42	09C	ELIMI
495	7	7	8	7	42	10B	ELIMI
496	6	6	6	6	42	10C	ELIMI
497	7	7	6	6	42	11B	ELIMI
498	6	6	6	6	42	11C	ELIMI
499	7	7	7	7	42	12B	ELIMI
500	8	8	7	7	42	12C	ELIMI
501	8	8	8	8	42	13B	ELIMI
502	8	8	6	6	42	13C	ELIMI
503	8	8	6	6	42	14B	ELIMI
504	8	6	6	7	42	14C	ELIMI
505	9	8	7	8	43	22598	FIRES
506	7	7	7	7	43	59C	FIRES
507	8	8	7	7	43	60B	FIRES
508	8	8	8	8	43	60C	FIRES
509	9	8	7	7	43	61B	FIRES
510	9	8	7	8	43	61C	FIRES
511	9	8	7	7	43	62B	FIRES
512	9	8	7	8	43	62C	FIRES
513	9	6	7	8	43	63B	FIRES

OBS.	T	B	S	C	GROUP	TIRE	BRAND
514	8	8	8	8	43	63C	FIRES
515	9	8	9	8	43	64B	FIRES
516	7	7	8	8	43	64C	FIRES
517	9	9	9	9	44	7133B	STAR

OBS.	T	B	S	C	GROUP	TIRE	BRAND
518	9	9	7	7	44	33C	STAR
519	8	8	8	8	44	34B	STAR
520	7	8	7	7	44	34C	STAR
521	9	8	9	9	44	35B	STAR
522	9	8	8	8	44	35C	STAR
523	9	8	8	8	44	36B	STAR
524	9	9	9	8	44	36C	STAR
525	9	8	8	7	44	37B	STAR
526	9	8	8	8	44	37C	STAR
527	9	9	9	8	44	38B	STAR
528	9	9	9	8	44	38C	STAR
529	8	7	4	4	45	7201B (F)	CHEET
530	9	7	8	7	45	7201C	CHEET
531	9	7	8	8	45	04B	CHEET
532	9	7	7	7	45	03C	CHEET
533	9	7	8	8	45	04C	CHEET
534	9	8	8	8	45	7200B	CHEET
535	8	7	7	7	45	7199B	CHEET
536	9	7	7	8	45	7202B	CHEET
537	9	8	8	7	45	03B	CHEET
538	9	7	7	8	45	02C	CHEET
539	9	7	6	6	45	01C	CHEET
540	9	8	8	8	45	7199C	CHEET

OBS.	T	B	S	C	GROUP	TIRE	BRAND
541	8	7	7	7	46	2204C	CHEET
542	9	8	8	9	46	00C	CHEET
543	8	8	7	7	46	2199C	CHEET
544	7	6	6	6	46	2204B (F)	CHEET
545	7	7	8	7	46	03B	CHEET
546	7	8	8	8	46	02C	CHEET
547	7	6	6	5	46	2199B (F)	CHEET
548	8	8	5	6	46	2203C	CHEET
549	8	8	5	6	46	02B	CHEET
550	8	8	6	7	46	01B	CHEET
551	7	8	6	6	46	00B	CHEET
552	8	7	7	8	46	01C	CHEET
553	8	7	6	7	47	2235B	VANNE
554	8	8	6	6	47	35C	VANNE
555	8	8	6	6	47	36B	VANNE
556	7	8	6	6	47	36C	VANNE
557	8	8	7	7	47	37B	VANNE
558	8	8	7	7	47	37C	VANNE
559	8	8	8	8	47	38B	VANNE
560	8	8	6	6	47	38C	VANNE
561	9	9	7	7	47	39B	VANNE
562	8	7	7	9	47	39C	VANNE
563	9	9	5	6	47	40B	VANNE
564	8	8	6	6	47	40C	VANNE
565	7	6	9	7	48	7307B	SUP G
566	8	7	7	7	48	07C	SUP G
567	7	6	5	5	48	08B	SUP G

OBS.	T	B	S	C	GROUP	TIRE	BRAND
568	7	7	6	6	48	08C	SUP G
569	8	7	7	7	48	09B	SUP G
570	7	6	7	6	48	09C	SUP G

571	7	8	5	5	48	10B	SUP G
572	8	8	8	7	48	10C	SUP G
573	8	7	8	7	48	11B	SUP G
574	8	8	8	7	48	11C	SUP G
575	8	8	8	8	48	12B	SUP G
576	8	7	7	7	48	12C	SUP G
577	8	6	6	6	49	7055B	DELTA
578	8	7	7	7	49	55C	DELTA
579	7	6	7	7	49	56B	DELTA
580	8	5	6	7	49	56C	DELTA
581	8	6	7	7	49	57B	DELTA
582	8	6	6	7	49	57C	DELTA
583	8	6	6	6	49	58B	DELTA
584	9	6	8	7	49	58C	DELTA
585	8	6	7	6	49	59B	DELTA
586	8	7	8	7	49	59C	DELTA
587	8	6	7	7	49	60B	DELTA
588	8	7	7	7	49	60C	DELTA
589	7	6	8	7	50	2055B	DELTA
590	7	6	5	6	50	55C	DELTA
591	8	7	6	7	50	56B (F) CUT	DELTA
592	8	7	7	8	50	56C	DELTA
593	8	6	7	6	50	57B	DELTA
594	8	7	7	7	50	57C	DELTA

OBS.	T	B	S	C	GROUP	TIRE	BRAND
595	9	7	8	7	50	58B	DELTA
596	8	6	7	6	50	58C	DELTA
597	7	7	5	6	50	59B (F)	DELTA
598	8	7	8	8	50	59C	DELTA
599	8	8	8	7	50	60B (F) CUT	DELTA
600	8	8	8	7	50	60C	DELTA
601	7	0	7	8	51	7337B	SARAT
602	7	0	6	7	51	37C	SARAT
603	7	0	7	8	51	38B	SARAT
604	7	0	6	7	51	38C	SARAT
605	7	0	6	7	51	39B	SARAT
606	8	0	7	7	51	39C	SARAT
607	7	0	7	7	51	40B	SARAT
608	8	0	7	8	51	40C	SARAT
609	8	0	5	6	51	41B (F)	SARAT
610	8	0	7	7	51	41C	SARAT
611	8	0	7	7	51	42B	SARAT
612	7	0	6	6	51	42C	SARAT
613	9	0	7	8	52	2337B	SARAT
614	8	0	8	7	52	37C	SARAT
615	9	0	7	7	52	38B	SARAT
616	9	0	8	7	52	38C	SARAT
617	8	0	8	8	52	39B	SARAT
618	8	0	7	7	52	39C	SARAT
619	8	0	7	7	52	40B	SARAT
620	9	0	7	7	52	40C	SARAT
621	8	0	8	7	52	41B	SARAT

OBS.	T	B	S	C	GROUP	TIRE	BRAND
622	8	0	7	7	52	41C	SARAT
623	8	0	8	9	52	42B	SARAT

624	8	0	6	8	52	42C	SARAT
625	8	0	9	9	53	71398	SHELL
626	8	0	9	9	53	39C	SHELL
627	8	0	9	9	53	408	SHELL
628	7	0	7	8	53	40C	SHELL
629	7	0	9	8	53	41B	SHELL
630	7	0	9	9	53	41C	SHELL
631	7	0	7	7	53	42B	SHELL
632	7	0	8	8	53	42C	SHELL
633	9	0	7	8	53	438	SHELL
634	9	0	8	8	53	43C	SHELL
635	6	0	9	6	53	44B	SHELL
636	8	0	8	8	53	44C	SHELL
637	7	0	8	7	54	7127B	VALLI
638	8	0	8	8	54	27C	VALLI
639	7	0	6	6	54	288	VALLI
640	8	0	6	6	54	28C	VALLI
641	8	0	6	6	54	298	VALLI
642	7	0	8	7	54	29C	VALLI
643	7	0	9	6	54	30B	VALLI
644	8	0	8	8	54	30C	VALLI
645	9	0	7	7	54	31B	VALLI
646	8	0	8	7	54	31C	VALLI
647	8	0	7	7	54	32B	VALLI
648	8	0	8	7	54	32C	VALLI

OBS.	T	B	S	C	GROUP	TIRE	BRAND
649	9	0	9	7	55	2127B	VALLI
650	8	0	7	6	55	27C	VALLI
651	8	0	7	7	55	288	VALLI
652	9	0	6	7	55	28C	VALLI
653	9	0	9	8	55	29B	VALLI
654	8	0	7	7	55	29C	VALLI
655	9	0	7	9	55	30B	VALLI
656	5	0	5	6	55	30C	VALLI
657	5	0	6	6	55	31B	VALLI
658	7	0	5	4	55	31C	VALLI
659	7	0	7	7	55	32B	VALLI
660	5	0	5	6	55	32C	VALLI
661	7	0	7	6	56	22538	JETZ
662	8	0	7	8	56	53C	JETZ
663	6	0	6	6	56	548	JETZ
664	7	0	7	6	56	54C	JETZ
665	6	0	6	6	56	55B	JETZ
666	6	0	6	6	56	55C	JETZ
667	7	0	7	7	56	56B	JETZ
668	7	0	6	6	56	56C	JETZ
669	6	0	5	6	56	57B	JETZ
670	6	0	6	5	56	57C	JETZ
671	7	0	6	6	56	58B	JETZ
672	7	0	6	6	56	58C	JETZ
673	7	0	7	8	57	23198	MOBIL
674	7	0	8	7	57	19C	MOBIL
675	9	0	7	9	57	20B	MOBIL

OBS.	T	B	S	C	GROUP	TIRE	BRAND
676	8	0	7	7	57	20C	MOBIL

OBS.	T	B	S	C	GROUP	TIRE	BRAND
677	8	0	8	8	57	21B	MOBIL
678	8	0	7	7	57	21C	MOBIL
679	8	0	7	7	57	22B	MOBIL
680	8	0	8	8	57	22C	MOBIL
681	8	0	8	8	57	23B	MOBIL
682	8	0	8	8	57	33C	MOBIL
683	9	0	7	8	57	24B	MOBIL
684	9	0	6	7	57	24C	MOBIL
685	7	0	7	7	58	22898	HAVRE
686	9	0	9	9	58	89C	HAVRE
687	9	0	7	7	58	90B	HAVRE
688	6	0	6	6	58	90C	HAVRE
689	8	0	9	9	58	91B	HAVRE
690	7	0	9	9	58	91C	HAVRE
691	6	0	9	9	58	92B	HAVRE
692	7	0	9	9	58	92C	HAVRE
693	7	0	9	9	58	93B	HAVRE
694	7	0	9	9	58	93C	HAVRE
695	6	0	7	6	58	94B	HAVRE
696	5	0	6	6	58	94C	HAVRE
697	9	0	7	6	59	7151B	DOUG
698	8	0	7	7	59	51C	DOUG
699	8	0	5	5	59	52B	DOUG
700	8	0	6	6	59	52C	DOUG
701	6	0	6	6	59	53B	DOUG
702	8	0	6	6	59	53C	DOUG

OBS.	T	B	S	C	GROUP	TIRE	BRAND
703	8	0	8	7	59	54B	DOUG
704	8	0	8	8	59	54C	DOUG
705	8	0	7	7	59	55B	DOUG
706	9	0	8	9	59	55C	DOUG
707	7	0	8	9	59	65B	DOUG
708	7	0	6	7	59	56C	DOUG
709	9	0	8	8	60	70738	CBI
710	9	0	8	8	60	73C	CBI
711	9	0	7	7	60	74B	CBI
712	9	0	8	8	60	74C	CBI
713	9	0	7	8	60	75B	CBI
714	8	0	9	7	60	75C	CBI
715	9	0	7	9	60	76B	CBI
716	9	0	8	8	60	76C	CBI
717	8	0	8	6	60	77B	CBI
718	9	0	8	8	60	77C	CBI
719	9	0	8	9	60	78B	CBI
720	9	0	6	8	60	78C	CBI
721	9	0	8	8	61	7103B	SEIBE
722	8	0	7	8	61	03C	SEIBE
723	9	0	7	7	61	04B	SEIBE
724	9	0	7	8	61	04C	SEIBE
725	7	0	5	6	61	05B	SEIBE
726	9	0	7	7	61	05C	SEIBE
727	8	0	7	7	61	06B	SEIBE
728	9	0	7	8	61	06C	SEIBE
729	9	0	7	8	61	07B	SEIBE

OBS.	T	B	S	C	GROUP	TIRE	BRAND

```
730  9  0  6  61  07C  (F)  SEIBE
731  8  0  8  61  08B       SEIBE
732  9  0  8  61  08C       SEIBE
733  8  0  5  62  21038       SEIBE
734  9  0  8  62  03C       SEIBE
735  8  0  5  62  04B       SEIBE
736  9  0  6  62  04C       SEIBE
737  9  0  7  62  05B       SEIBE
738  7  0  6  62  05C       SEIBE
739  9  0  7  62  06B       SEIBE
740  7  0  6  62  06C       SEIBE
741  9  0  7  62  07B       SEIBE
742  8  0  6  62  07C       SEIBE
743  8  0  7  62  08B  (F)  SEIBE
744  4  0  8  62  08C       SEIBE
```

APPENDIX C

Sectioning Data

A.J. Scapicchio

Sumitomo - D7S 2251C

Sonograph shows 2 trace discontinuities or singularity/shadows at the following coordinates:

θ 140/ϕ270

θ 270/ϕ270

In both places an 8" wall section was cut into 1/2" strips beginning at the lower shoulder and extending to the turn-up.

At each of these coordinates, one spread cord was discovered. This could have been the spread cord mentioned, or a splice with no overlap.

In any case, the patterns are identical and they were found exactly where the sonograph indicated a suspicious area. Photos of the sonograph and of the tire class section were taken and are available.

Sumitomo - D7S 2250B

Sonograph shows a significant radial run-out across the tread.

The tread width was cut open in several places at and around the area indicated by the sonograph; examination was made with X-ray as well, but nothing was seen.

Sumitomo- D7S 2252C

The sonograph indicates a singularity shadow at θ 310/ϕ 270.

As in tire 2251C, the side wall at this coordinate, was cut open and a "rubber-rich" carcass splice was discovered at this spot.

Photographs of the sonograph and the problem area were taken and are available.

D7S 2359C Sears Radial

2 steel belts

2 polyester plys

Suspicious areas at θ 200/ϕ 100 and θ105/ϕ270.

The tire was cut open and the side wall in the two areas was cut into strips 1/4" to 3/8" wide - nothing was found.

D7S 2230B Mustang Radial
2 polyester plys
2 steel belts

θ285/φ130
θ285/φ225 extensive areas in and around these

coordinates were sectioned and examined -- nothing was found.

B75 7163B Emperor Radial
2 polyester plys
2 glass belts

θ320/φ225 - Separation 1/2"x 2 3/4".

The separation is at the cap junction. The separation falls at the edge of the #2 belt. A photo was taken and is attached to the data package.

D7S 2327B Laramie
2 glass belts
1 steel belt

A suspicious area at θ090/φ080 was the result of an undulating turn up. At this particular coordinate, a ply of the turn-up ended abruptly as seen in a photo of the cross section.

θ180/φ135 - the sonograph shows a belt edge separation. It is in the glass belt edge that the problem lies, and it actually turns out to be a loosening or socketing of the cords.

D7S 2338B Saratoga
4 ply polyester

At θ060/φ110 - 12" of the sidewall, with its center at θ060, was cut into 1/8" to 1/4" strips - nothing was found.

Another suspicious area at θ090 - θ140/φ255 was cut into strips as well, but nothing was found there either.

APPENDIX D

Visual Inspection Data of Tires With Notations From the Compliance Testing Laboratories Reporting Anomalies (includes all failed tires)

A.J. Scapicchio and G. Berube

Sieberling D7S2108C-

Tread to carcass separations - Separations exist in both shoulders;

Whitewall Shoulder - between θ150 and θ300 large separations about 10" to 12" long.

Blackwall Shoulder - Pockets of smaller, isolated separations extend around the circumference. Sporadic porosity in both shoulders, the heavier concentration located on the W/W side at the above locations. It can be reasonably assumed that the existing porosity seriously impaired the bond integrity between tread rubber and carcass. Because shoulders are high stress areas, the inevitable flexing and heat generation degraded and eroded what little physical bond remained and resulted in massive separations.

Sieberling B7S7106B

Side wall failure at θ190/ϕ270.

There is a strong possibility that suggests the failure was caused by an open splice in the side wall. This effectively created a distinct and concentrated weakness at this point. It is especially severe because of its side wall location. In addition, a small crack developed at this very location during the wheel test. The mechanism by which the crack developed may be due,in part, to the existing weakness in the open splice and to its location, a high flex area.

Sieberling B7S7108C

A ragged crack appeared in the sidewall. It was open to the fourth ply layer,and its location was θ170/ϕ090. It appears to have been made by a foreign object that penetrated the cover rubber. It is difficult,however, to accurately determine what kind of object it was and exactly how it penetrated.

United D7S2085C

Nail θ300/ϕ220

Liner defect θ600/ϕ180

A ring shank nail (1-1/4" long) penetrated the tire at θ300/φ220. The nail entered at an angle parallel to the tread surface and perpendicular to the sidewall. It exited through the liner.

The liner has a molding defect. A strip of stray flashing became lodged between the butyl bladder and the tire preform during the molding process. The strip created a linear impression in the liner 9" long and approximately 1/4" deep. There are ply cords at the base of the impression that are partially exposed.

Saratoga B7S7341B

Rupture of the sidewall cover rubber measuring about 9"x5" and located at θ350/φ090.

Through a series of long liner cracks,extending 360° around the black wall shoulder, air passed from the inner chamber through the ply structure and separated the cover rubber from the #4 ply. As more air passed into the separation the more the cover grew or ballooned until finally it burst.

Douglas D7S2155C

Rim Leak: there are no visible defects that could be attributed to the tire's inability to hold air.

There is some bead toe damage at θ060/φ300 - it is the result of mounting and dismounting but would not contribute to a rim leak.

Cheetah D7S2199B & D7S2204B

The side wall came apart at the shoulder line, severing itself from the carcass (both tires).

The failure was caused by a misaligned belt system that brought the belt edges deep into the shoulder area. It considerably stiffened the shoulder,creating severe stresses and heat build-up. The heat generated as a result,contributed greatly to the disintegration and failure. The failure is a "hinge point failure".

Cheetah B7S7201B

Blow-out about 2"x2" at θ140/ϕ235. This tire is a "blem". During the normal course of buffing side walls to correct runout, this tire was buffed, cutting into the ply structure.

Number 2 ply was mutilated at the point where the failure occurred. A separation was created, became enlarged, and propagated to, and beyond, the belt edge, and down to the white wall. The area was seriously weakened and ultimately failed.

Riviera B7S7061B

Wing failures at:

θ060/ϕ135 - 5"x3/4"

θ110/ϕ135 - 2"x1"

These are open-type separations that occurred at the edges of the tread cap (at the shoulder line). Visual examination revealed that the separations were probably the result of contamination that prevented an integral bond between tread cap and tread base. Inspection under low magnification showed both surfaces to be extremely smooth and the bond, at no time, to be ever more than superficial.

Initial ultrasonic inspection indicated small inclusions in these areas. These manufacturing flaws led to ultimate failure under the flexing and heating during the wheel test.

Delta D7S2059B

A hole in the lower side wall θ165/ϕ300.

The tire was not capable of holding air due to a cut in the cover rubber at the turn-up.

As the area was examined and probed further, a disrupted cord structure could be seen. Observation of the liner, in that area, revealed a crack through which air could escape.

Delta D7S2060B

At θ150/ϕ300; a cut in the cover rubber in the turn-up area. The cut is superficial and there was no cord or liner damage noted. The tire was able to maintain air pressure and cannot be considered a failure.

It is difficult, however, to determine what caused the cut.

Delta D752056B

At θ250/ϕ300; a cut in the cover rubber - in the turn up area.

The cut, as in the Delta tire D7S2060B, was entirely superficial with no further damage to cord or liner. It did not lose air pressure and cannot be considered as having failed.

Valiant B7S7132B

Areas showing heat discoloration just above the beads in the turn-up areas.

θ080/ϕ300 - 2"x2 1/2"

θ220/ϕ300 - 1"x2 1/2"

B7S7131C

The liner, under the tread crown, is dotted with small liner cracks in a random pattern. The cracks appear in an area beginning at θ240 and ending at θ050 with the phi coordinate at ϕ180.

B7S7131B

θ290/ϕ210 - an area of tread surface measuring 3"x6" shows evidence of high heat exposure. The surface appears to have become crystallized under the heat, taking on a look of porcelain. The durometer in this area measured 88.

The undertread, as seen from the groove bottoms, reveals a network of cracks as the tire is deflected.

θ310/ϕ230 in the high wall region - length of about 19" has been dressed (ground off),perhaps to correct for lateral run out. Although not labeled as such, the tire may have been a "blem".

D7S2127C

θ060/ϕ000 (B/W side)

Damaged bead face - the damage is in the nature of a small chunk-out (1/2" x 1/2"),essentially located on the face of the bead but continuing into the bead heel. It is possible that the damage would prevent the establishment of a continuous seal between head and rim,creating a potential leak source. The damage is probably the result of poor mounting techniques.

D7S2127B

θ015/ϕ000 B/W bead

θ130/ϕ330 W/W bead

D7S2129B θ0335 to ϕ000 B/W bead

Both of the above tires have bead toe damage resulting from mounting and dismounting. The damage is minor and would probably present no problem to the tire.

D7S2131B

Bead damage - a molding defect at θ060/ϕ000 B/W on the bead heel. The damage, approximately 4" long, exposes turn-up fabric, and although it does not appear to be serious, it could be a potential leak source.

D7S2132B

Bead damage θ125/ϕ000 B/W. The damage is a molding defect located at the bead heel. A length of skin rubber, approximately 3 1/2" long, became stuck to the mold; when removing the tire after curing, the rubber was torn away from the bead heel exposing a portion of the turn-up fabric.

The number and character of the defects found in some of the 24 Valiants could have been related to mold curing. A decision was therefore made to obtain rubber hardness readings on every tire. Average durometer was 69.23 with a standard deviation of 1.25.

B7S7128B

(1) Four liner separations about 3/8" to 1/2" in diameter at the following locations;

θ195/ϕ250

θ215/ϕ250

θ230/ϕ250

θ260/ϕ250

(2) Minor bead toe damage θ000/ϕ330, the result of bad mounting and dismounting technique.

(3) Serial number located on the W/W side of the tire.

B7S7130C

Evidence of buffed sidewall from θ270/ϕ060 on the white sidewall side. Buffing is cosmetic and will not affect tire performance.

VALIANT

	HARDNESS (4 READINGS) 1 2 3 4	AVG. DURO-METER	TREAD DEPTH (AVG. OF 4 READINGS)	COMMENTS
B7S7127B	69 70 69 69	69.25	11/32"	Bead Toe damage θ090/ϕ330
B7S7128B	67 68 68 67	67.5	11/32"	OK
B7S7128B	67 66 70 68	67.75	11/32"	Liner Splice-wide Ser. No. on wrong sidewall
B7S7128C	68 69 69 68	68.5	11/32"	OK
B7S7129B	68 69 68 69	68.5	11/32"	OK
B7S7129C	68 67 69 65	67.25	11/32"	OK
B7S7130B	67 67 69 69	68.0	11/32"	OK
B7S7130C	68 67 68 68	67.75	11/32"	Sidewall Buffing; from θ270 to θ000 ϕ225. The buffing is minor.
BS7131C	67 65 68 78	69.50	11/32"	Groove cracks - evidence of tread seps.
B7S7131C	68 68 68 67	67.75	11/32"	Liner Crack
B7S7132B	67 67 68 69	67.75	11/32"	Parched Areas - 2"x2" @ θ080/ϕ300 & θ220/ϕ300
B7S7132C	68 70 69 70	69.25	11/32"	OK

220 copies

D-9/D-10

VALIANT

	HARDNESS (4 READINGS) 1 2 3 4	AVG. DURO-METER	TREAD DEPTH (AVG. OF 4 READINGS	COMMENTS
D7S2127B	70 69 71 70	70.0	11/32"	Mounting damage to bead toe θ015-B/W- minor θ130-W/W- "
D7S2127C	70 70 70 70	70.0	11/32"	Bead face damage θ060-B/W side.
D7S2128B	70 70 70 70	70.0	11/32"	OK
D7S2128C	71 70 70 71	70.5	11/32"	Extra wide splice approx. 1 1/2" wide.
D7S2129B	69 69 72 71	70.25	11/32"	Mounting damage to bead toe (minor) θ035 to θ100 (B/W side.)
D7S2129C	70 68 71 69	69.5	11/32"	Bad liner splice (not a tight splice)
D7S2130B	70 72 71 71	71.0	11/32"	OK
D7S2130C	69 71 71 71	70.5	11/32"	Bad liner splice (not tight)
D7S2131B	70 72 72 71	71.25	11/32"	Bead heel: molding defect
D7S2131C	70 71 71 71	70.75	11/32"	OK
D7S2132B	72 70 70 70	70.5	11/32"	Exposed turn-up cords on bead heel. (molding defect)
D7S2132C	69 66 69 70	68.5	11/32"	OK

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE, CAMBRIDGE, MA. 02142

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF TRANSPORTATION
513