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MAINTENANCE EXPENDITURE LIMITS (MEL) TIRES.(U)
AUG 77 J KENLEY

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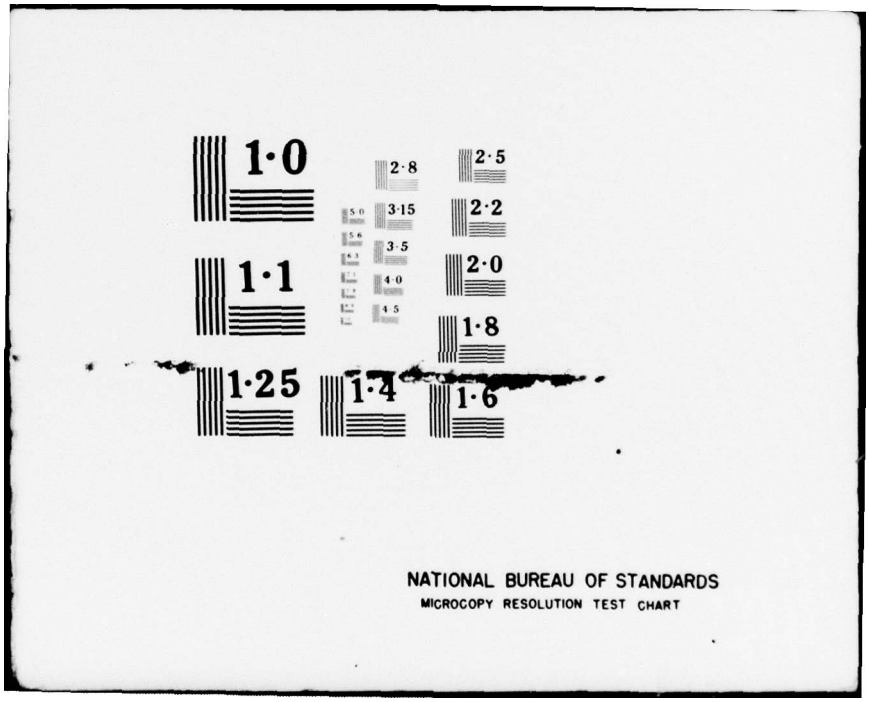
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REPORT NUMBER SA 7T-10

(1)

U.S. ARMY TARCOM

(6) MAINTENANCE EXPENDITURE LIMITS (MEL) TIRES.

(12) 22p.

(11) AUG 1977

(10) JACK KENLEY

(9) Final rpt.

(14) TARCOM-SA-7T-10

TARCOM

SYSTEMS ANALYSIS DIVISION, PLANS & ANALYSIS DIRECTORATE

U S ARMY TANK AUTOMOTIVE MATERIEL READINESS COMMAND

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Maintenance Expenditure Limits/Tires (MEL/T)		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Jack Kenley		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Plans & Analysis Directorate Systems Analysis Division US Army Tank-Auto Matl Readiness Cmd		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE August 77 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

(U) Tires; (U) Retread Evaluation; (U) Tire Maintenance; (U) Non-Destructive Testing; (U) Ultrasonic Testing.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this study was to derive an approach to determine a valid Maintenance Expenditure Limit (MEL) for tires. Historical data & field tests results were examined. Initial data from a Product Assurance test in Ober Ramstadt Germany was also used. It was found that ultrasonic testing of tire carcasses could provide reliable information about the quality of the carcass and its useful remaining life. The reading from the ultrasonic testing device is adjusted so that a new tire reads 50% of full scale. It is estimated that about 22% of the 1100 x 20 tires coming in to be retread are defective based on an ultrasonic

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reading of 20% of full scale. If this defective percentage is applied to the top ranking 20 tires (in terms of retread dollars spent) the annual cost savings would be in excess of $1,000,000. A revised MEL for tires should state that tires be retread, given the carcass has at least one remaining life; the remaining life being determined by pass/fail ultrasonic measurement using the 20% full scale as the standard for now. It is recommended that testing continue to determine the exact correlation between ultrasonic reading and remaining tire life.

AUGUST 1977

MAINTENANCE EXPENDITURE LIMITS (MEL) TIRES

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1. STATEMENT OF THE PROBLEM

The present maintenance expenditure limit (MEL) for rebuilding tires is 90% of the present new acquisition cost. If a bad carcass is retreaded or if a good carcass is retreaded poorly, the tire will fail shortly. The net result is a loss of money and not a cost savings for retreading. State-of-the art non-destructive testing methods, especially ultrasonic echoing, can aid in inspecting tire carcasses. How can these new techniques be best used in finding an improved MEL for tires?

2. OBJECTIVE

The objective of this study is to determine an approach for deriving a valid Maintenance Expenditure Limit (MEL) for rebuilding tires.

3. BACKGROUND

The army acquires in excess of 350,000 new tires in a given year. Regulation AR 750-36 mandates that 75% of the Army's replacement needs for pneumatic tires be retreaded. The large volume and associated dollar expense require scrutiny of entire retreading area. Unified Industries, under TARCOM contract DAAE07-76-C-0302, has examined the current tire retreading literature and regulations as well as conducted personal interviews with tire retreaders. This report was published 7 March 1977, and although it is not a scientific examination there are nonetheless data and opinions of value. Those pertinent to this study are listed below;

a. Retreaded passenger tires are available at a cost of about 1/2 that of a new tire.

b. About 70% of the cost of a truck tire is in the cord body leaving the remaining 30% cost in the tread. This would indicate the larger the tire, the greater the savings of retread.

c. About 38% of truck tires purchased are retreads.

d. Precured tread retreads exhibit almost a 20% longer life than conventional retreads.

e. The cost of the Army retreading a 10.00 x 20 tire varies from 50 to 85% more than a reasonable average estimate for the commercial retreaders cost standard.

f. A USATACOM Supply Letter of 18 June 71 establishes that returned code F tires will be accepted and given a 50% credit (of present acquisition price).

g. Historically the retreading industry has had difficulty in obtaining quality passenger carcasses. There was about an 80% rejection rate.

h. Federal Specifications ZZ-T-441D and ZZ-T-4166 cover retreaded and repaired pneumatic tires and their materials. AR 750-36 requires retreading in accordance with these directives.

i. Some commercial retreaders did not want to bid to qualify as a GSA contractor because they felt they had to retread all sizes or none.

j. Air Treads Inc. stated that the airlines would not pay an additional 50 cents per tire for non-destructive testing of retreads.

k. An unreferenced Navy study examined 6,578 tires (type unspecified) and 68 were set aside because of separations greater than 1/2 inch; 140 had separations less than 1/2 inch and these did not demonstrate any problem.

l. The Army cannot compete with commercial retreads because of outmoded equipment and high labor and overhead.

The Unified Industries examination concluded that "If passenger tires and light truck tires cannot be retreaded, either in-house or on GSA or local contract, for less than one-half of new acquisition cost similar to current commercial practice, then consideration should be given to disposing of these worn tires and replacing them with new tires . . ."

A field test comparing new versus retreaded NDCC tires was conducted at Yuma in July 74 through May 75. This examination, in spite of the limited sampling and testing, does provide some valid data and conclusions. Summarily,

a. Retread tires have essentially the same wear out life as new tires.

b. Retread tire failures increase with carcass age (nine years appears to be a critical point).

c. Tire cord condition (i.e., degradation) can be measured via ultrasonic pulse echolation.

d. The ultrasonic pulse echo technique can evaluate condition of the retread bond between tread and casing.

e. Ply separations originally inherent in the tire cannot predict remaining tire. The cord condition can be determined.

f. Some cord loosening occurs during 'hot' retreading.

Relative to the last statement above, ultrasonic testing detects the looseness of the cord in the tire carcass. As the cord becomes very loose, ply separation will occur and thus a failure. (In a new tire, any ply separation present is not due to cord degradation but rather manufacturing process irregularities). Cord degradation appears around the circumference of the tire. The obvious advantage to ultrasonic testing is that while measuring cord degradation an estimate of the remaining tire life could be made. The data from the test is insufficient.

The ultrasonic device used gives a graphic scope output. The output was adjusted so that a new tire could read 50% of full scale. The most important result of the study was that almost 80% of the tire failures had ultrasonic readings of 20% (or less). The essential point is that it appears that this non-destructive ultrasonic testing provides a way to estimate the remaining tire life. Extended testing could provide the exact correlation between an ultrasonic reading and remaining tire life.

The Quality Assurance Directorate of TARCOM was conducting an in-field ultrasonic examination of tires at Ober Ramstadt Germany. To date, five hundred and fifty tires have been examined and the graphic scope reading as well as a corresponding digital reading were recorded. (This was an attempt to correlate the two readings). After the tires are retread, and a failure occurs, readings were to be taken again. The ultrasonic machine used failed and was returned to the United States for repair. This test is now in abeyance due to lack of funds. A summary analysis of the data is presented in the following Section.

Last year GARD Inc., a manufacturer of ultrasonic detection devices, presented the Product Assurance Directorate of TARCOM, with an unsolicited report demonstrating the cost

effectiveness of ultrasonic testing. They used the previously mentioned questionable data from the Yuma field test in their analysis as well as some very shakey cost numbers. Notwithstanding this, they concluded:

a. "Ultrasonic inspection is capable of predicting useful mileage of tires which ultimately fail due to ply separation in a low quality casing."

b. "Ultrasonic inspection can, in conjunction with pattern recognition techniques, detect poor tread adhesion or undercure."

The last conclusion depicts a second important feature of ultrasonic detection; that being, the determination of the quality of a retreaded tire.

4. DISCUSSION AND ANALYSIS

This study is centered around the validity of the existing maintenance expenditure limit (MEL) for tires in the Army system. The data, both quantitative and qualitative have been derived from the studies and tests mentioned in the previous Background section as well as from the Item Master Data Record (IMDR) and the biannual Retreading Report. These are maintained within the NICP, USATARCOM, Warren, Michigan. Additional qualitative data were ascertained from personnel from the office of the Item Manager for tires and the Tactical Vehicle Division of the Maintenance Directorate, USATARCOM.

The scope of the study is necessarily constrained by the following assumptions:

a. Non-destructive test methods exist which can inexpensively determine the quality of a tire carcass as a retread candidate or the quality of a newly retread tire.

b. The total demand for a given tire (a specific NSN) is the sum of the quantity retreaded as given in the Retread Report plus the new tires issued as stated in the IMDR.

c. The annual demand is constant in a non-conflict environment.

d. No estimate of savings will be generated concerning increased probability of determining bad retreads.

e. The cost incurred in fielding and operating ultrasonic degradation monitors is not considered. This cost, probably minimal, will reduce total savings.

f. Only sample ultrasonic readings for 1100 x 20 tires are used. No others exist presently.

g. Calendar year cost averages for new and retread tires are used.

The analysis includes the following;

a. The IMDR will be queried to determine the top 100 new tires purchased both by total quantity and total dollar value. The base year will be 1976.

b. The Report of Tire Retreading (for the same base year) will be analyzed to determine ranking of retreads, again both by total quantity and total dollar value.

c. The aforementioned rankings will be condensed and combined yielding total demand by tire size. A realistic estimate of the proportion of the total demand for tires that are retread will be generated.

d. An examination of the initial test data of ultrasonic readings of retread candidate tire carcasses at Ober Ramstadt, Germany will yield a distribution of in-field carcass quality.

Previous work has purported ultrasonic measurements of 20% (of full scale) or below indicate a tire carcass of poor quality not worthy of retreading. (A new tire reads 50% of full scale).

e. Using the above criterion against Ober Ramstadt data will produce the percentage of retread candidate that would have been retreaded but were of poor quality. Using a 30% (of full scale) and 40% reading would produce different cost savings.

f. Cost savings will be computed for the top ranking (dollar value) tires considering the above stated ultrasonic reading distribution.

g. The cost savings will be determined for the 1/4, 1 1/4, 2 1/2 and 5 ton truck: These would be 700 x 16, 900 x 16, 900 x 20 and 1100 x 20 tires respectively.

h. Additionally a correlation analysis between the ultrasonic digital and scope readings of the Ober Ramstadt data will be performed.

The essence of this examination is to determine where the tire retreading dollars are spent and to evaluate the use of a non-destructive testing device in determining tire carcass candidate quality. Funds are limited and actual testing is not being conducted. In light of this, the initial portion of test data available is used to generate an anticipated cost savings.

5. RESULTS

Table 1 shows the ranking of the top 20 tires that are retread in terms of quantity. Table 2 shows the top 20 tires that are retread in terms of total dollar value. The number and price of new tires purchased, as stated by the installations themselves, is also shown; these are different from the actual quantities as derived from the IMDR which are shown in Table 3. The percentage difference in the two reporting systems vary up to almost 7,000%. The quantity as found in the IMDR reflects other service demands, however, this alone would not account for the discrepancies.

Table 4 shows the demands of major tire size for the 1/4, 1 1/4, 2 1/2 and 5 ton trucks. Table 5 shows the total demand and the percentage of this demand that is retread. It can be seen that there is about 42% retreading achieved. This is not the 75% level that is required. Again, it should be noted here that the total demand includes new tire demand from other services. An analysis of Table 2 shows the cost of a retread tire varies between 26 and 80% of the new tire cost. The average percentage is about 46% (std dev of 12.5). This is almost one half of present MEL.

The data from the testing at Ober Ramstadt Germany is shown in Table 6. There are 312 data points. Both the graphic scope reading and the corresponding digital readout from the ultrasonic device are shown. A regression analysis was performed in an effort to correlate these two readings. The correlation coefficient was found to be .85. This was for a linear least square fit. The corresponding linear equation and coefficients is given below,

$$DR = 14.3SR - 82.2$$

where DR is the digital reading and SR is the scope reading.

Table 7 depicts the numerical distribution of the ultrasonic scope readings from the tire sample data. The readings of greater than 50 were considered extraneous; complete ply separations were visible. From Table 7 we see that about 78.2% (100 - 21.9) of the tires examined had a scope reading of 20 or better. This figure of 20 will be used as a baseline until further testing determines a better value.

A simple method to arrive at a possible cost savings is to use the retread data in Table 2 and apply the 21.9% defective carcass figure across the ranking 20 tires. This figure is purported to represent the visually undetectable proportion of the sample data. The dollar savings per tire would include the explicit cost of retreading but not the scrap value of a bad carcass nor any savings derived from detection of poor bonding after retreading. The cost of ultrasonic inspection is not included.

Table 8 gives the annual cost savings which, for the tires considered, amounts to $1,151,040. Considering the major tires for the 1/4, 1 1/4, 2 1/2 and 5 ton trucks the savings would be $827,240.

NSN	Tire Size	Quantity Retreaded	Unit Retread Cost	Total Cost	New Tires Acquired	Unit New Cost
2628677	900 x 20	38,420	$32.57	$1,251,340	6,634	$ 60.05
2628653	1100 x 20	37,388	44.85	1,676,850	10,756	85.34
6781363	700 x 16	36,544	15.16	554,000	4,576	18.92
4897973	G78 - 15	20,274	11.36	230,310	11,406	23.78
5404719	900 x 16	8,598	30.08	258,630	1,336	49.68
2044091	1100 x 20	6,782	46.56	315,770	866	173.27
4898005	G78 x 15	3,740	11.81	44,170	1,486	22.62
4897975	H78 x 15	2,918	11.93	34,810	3,002	19.65
1425367	825 x 15	2,748	12.68	34,840	142	28.20
2044060	1100 x 20	2,486	48.94	121,660	90	173.03
4897961	H78 x 14	2,438	10.68	26,037	2,420	20.73
1371597	G78 x 15	2,146	10.41	22,340	1,488	28.94
1776879	800 x 16.5	1,904	15.86	30,200	1,282	38.00
1630423	1100R x 20	1,770	55.17	97,650	1,534	183.00
0609959	750 - 18	1,474	26.65	39,280	220	82.94
4897957	F78 x 14	1,426	10.96	15,630	3,368	19.48
2044026	1000 x 20	1,398	35.83	50,090	384	92.51
2043939	825 x 20	1,366	27.43	37,470	458	63.37
4897959	G78 x 14	1,214	10.30	12,500	304	20.50
1425389	650 x 16	1,210	15.36	18,590	552	22.17

TABLE 1
Retread Tire Ranking By Quantity As Stated In
Report On Tire Retreading (1976)

NSN	Tire Size	Quantity Retreaded	Unit Retread Cost	Total Cost	New Tires Acquired	Unit New Cost
2628653	1100 x 20	37,388	$ 44.85	$1,676,850	10,756	$ 85.34
2628677	900 x 20	38,420	32.57	1,251,340	6,634	60.05
6781363	700 x 16	36,544	15.16	554,000	4,576	18.92
2044091	1100 x 20	6,782	46.56	315,770	866	173.27
5404719	900 x 16	8,598	30.08	258,630	1,336	49.68
4897973	G78 x 15	20,274	11.36	230,310	11,406	23.78
5546250	1400 x 24	1,186	119.64	141,890	894	252.51
5546222	2950 x 29	94	1476.13	138,760	96	2881.00
2044060	1100 x 20	2,486	48.94	121,660	90	173.03
7265164	1750 x 25	742	133.90	99,350	378	327.00
1630423	1100 x 20	1,770	55.17	97,650	1,534	183.00
2044026	1000 x 20	1,398	35.83	50,090	384	92.51
4898005	G78 x 15	3,740	11.81	44,170	1,486	22.62
0609959	750 x 18	1,474	26.65	39,280	220	82.94
2043939	825.x 20	1,366	27.43	37,470	458	63.37
1425367	825 x 15	2,748	12.68	34,840	142	28.20
4897975	H78 x 15	2,918	11.93	34,810	3,002	19.65
9447002	1000 x 20	758	44.88	34,020	66	97.42
1776879	800 x 16.5	1,904	15.86	30,200	1,282	38.00
2757995	900 x 20	994	28.47	28,300	146	81.00

TABLE 2

Retread Tire Ranking By Total Cost As Stated
In Report On Tire Retreading (1976)

NSN	Tire Size	New Tire Purchases	Unit Price	Total Cost	*New Tire Purchases	% Diff
~~5557289~~	~~2650 x 25~~	~~26,176~~ Invalid	~~9760.00~~	~~$19,893,760~~	~~N.A.~~	~~-~~
~~5552494~~	~~2700 x 33~~	~~26,175~~ Invalid	~~171.00~~	~~4,475,930~~	~~N.A.~~	~~-~~
2628653	1100 x 20	36,810	89.28	3,286,400	10,756	342
2628677	900 x 20	31,559	55.76	1,759,730	6,634	475
5546222	3350 x 33	267	2680.00	715,560	96	278
4897973	G78 x 15	37,091	18.08	670,600	11,406	325
5546250	1400 x 24	2,329	234.00	544,986	894	260
7265164	1750 x 25	1,647	304.00	500,690	378	435
2044091	1100 x 20	4,757	101.00	480,460	866	549
5404725	1200 x 20	3,978	118.00	469,400	58	6858
6781363	700 x 16	23,297	19.42	452,430	4,576	509
8783225	1100 x 15	3,549	126.00	447,170	433	820
2043939	825 - 20	6,965	62.26	433,640	458	1520
2757995	900 - 20	5,698	70.83	403,590	146	3902
7202244	650 - 16	13,744	23.66	325,182	450	3054
2044026	1000 - 20	3,854	84.16	324,430	384	1000
5404719	900 - 16	6,526	44.98	293,539	1,336	488
1630423	1100 - 20	1,617	171.00	276,500	1,534	94
5922434	1600 - 25	509	540.00	274,860	N.A.	-
2628816	900 - 20	3,756	73.17	274,830	82	4580

*From The Report On Tire Retreading

TABLE 3
New Tire Acquisition Ranking
As Derived From IMDR (1976)

NSN	Vehicle & Tire Size	Quantity Retreaded	Unit Retread Cost	Total Cost	New Tire Acquired	Unit New Cost
2628653	(5 Ton)1100x20	37,398	$44.85	$1,676,850	36,810	$89.28
2628677	(2½ Ton)900-20	38,420	32.57	1,251,340	31,559	55.76
5404719	(1¼ Ton)900-16	8,598	30.08	258,630	6,526	44.98
6781363	(¼ Ton)700-16	36,544	15.16	554,000	23,297	19.42

TABLE 4

New and Retread Tire Data For Leading Tires
Of ¼, 1¼, 2½ and 5 Ton Trucks (1976)

NSN	TIRE SIZE	ANNUAL DEMAND	% RETREAD
2628653	1100 x 20	74,098	50.5%
2628677	900 x 20	69,979	54.9%
6781361	700 x 16	59,841	61.1%
2044091	1100 x 20	11,539	58.2%
5404719	900 x 16	15,124	56.8%
4897973	G78 x 15	57,365	35.4%
5546250	1400 x 24	3,515	33.7%
5546222	2950 x 29	361	26.0%
2044060	1100 x 20	3,499	71.0%
7265164	1750 x 25	2,389	31.0%
1630423	1100 x 20	3,387	52.3%
2044026	1000 x 20	5,252	26.6%
4898005	G78 x 15	10,179	36.7%
0609959	750 x 18	2,725	54.0%
2043939	825 x 20	8,331	16.4%
1425367	825 x 15	4,748	57.8%
4897975	H78 x 15	11,407	26.4%
9447002	1000 x 20	1,948	38.9%
1776879	800 x 16.5	6,598	28.8%
2757995	900 x 20	6,692	14.8%
		Average	41.6%
2628653	1100 x 20 (5 Ton)	74,098	50.5%
2628677	900 x 20 (2½ Ton)	69,979	54.9%
5404719	900 x 16 (1¼ Ton)	15,124	56.8%
6781363	700 x 16 (¼ Ton)	59,841	61.1%

TABLE 5

Retread Analysis

for the

Leading Tire Sizes (1976)

Scope Reading

10	15		20		25	30		35	40	45	50
25	266	66	274	76	304	400	706	380	680	599	288
36	250	95	325	105	239	238	316	453	454	275	554
102	205	132	430	82	206	357	374	409	509	753	714
52	80	135	299	224	159	385		523	420	530	277
25	47	171	162	147	218	362		415	610	544	249
101	94	69	125	160	379	465		484	698	553	233
74	156	154	142	204	112	403		433	599	492	735
54	122	156	104	112	265	617		500	363	548	636
67	118		152	147	256	501		390	363		633
	293		278	253	177	402		296	549		696
	132		187	164	291	454		413	502		
	232		141	306	299	234		393	463		
	68		248	262	323	371		366	508		
	89		145	194	335	510		429	524		
	75		165	254	238	372		441	571		
	129		143	419	331	153		657	437		
	67		346	181	417	449		416	760		
	63		149	348	223	345		417	716		
	64		117	133	392	466		605	630		
	129		201	162	317	445		245	680		
	114		241	191	238	538		532	567		
	50		102	221	360	258		451	524		
	56		229	215	230	239		352	404		
	52		98	209	170	199		555	547		
	93		296		163	342		370	556		
	53		212		230	264		460	593		
	74		128		187	233			447		
	71		100		214	264					
	153		184		387	476					
	117		143		435	358					
	134		132		279	340					
	147		150		288	357					
	106		123		346	312					
	55		104		306	490					
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	108		240		245	368					
	148		198		345	469					
	145		243		300	444					
	142		228		356	273					
	131		165		263	241					
	167		171			394					
	105		225			446					
	75		406			293					
	79		145			277					
	96		225			317					
	145		104			448					
	95		127			373					

ultrasonic digital readings

TABLE 6

RETREAD READING CORRELATION

Reading	Frequency	Scope Reading	Frequency	%
0	1	0	0	0
5	0	5	1	-
10	9	10	1	-
15	57	15	10	3.2
	73	20	67	21.9
	42	25	140	45.9
	52	30	182	59.7
35	26	35	234	76.7
40	27	40	260	85.2
45	8	45	287	94.0
50	10	50	305	100.0

TABLE 7

Distribution of the Sample

Ultrasonic Readings - Ober Ramstadt (1976)

NSN	Tire Size	Projected Defectives	Unit Retread Cost	Unit Savings
2628653	1100 x 20	8,188	$ 44.85	$367,230
2628677	900 x 20	8,414	32.57	274,040
6781363	700 x 16	8,003	15.16	129,330
2044091	1100 x 20	1,486	46.56	69,150
5404719	900 x 16	1,883	30.08	56,640
4897973	G78 x 15	4,440	11.36	50,440
5546250	1400 x 24	260	119.64	31,070
5546222	2950 x 29	21	1,476.13	30,390
2044060	1100 x 20	545	48.94	26,640
7265164	1750 x 25	163	133.90	21,760
1630423	1100 x 20	388	55.17	21,390
2044026	1000 x 20	306	35.83	10,970
4898005	G78 x 15	819	11.81	9,670
0609959	750 x 18	323	26.65	8,600
2043939	825 x 20	300	27.43	8,210
1425367	825 x 15	602	12.68	7,630
4897975	H78 x 15	639	11.93	7,620
9447002	1000 x 20	166	44.88	7,450
1776879	800 x 16.5	417	15.86	6,610
2757995	900 x 20	218	28.47	6,200
				1,151,040

TABLE 8

Estimated Cost Saving by Tire Size

6. CONCLUSIONS

The object of this study was to derive an approach to determine a more appropriate MEL for tires. Non-destructive techniques, viz ultrasonic echoing, can effectively be used in evaluating retread candidate carcasses. Although the exact correlation between an ultrasonic reading and the remaining tire life has yet to be determined, a baseline reading (20% of full scale) presently appears a valid criterion for acceptance/rejection. The cost of ultrasonic detection equipment is minimal (less than $5,000.00 per device) as is the actual examination cost itself. The average retread cost expressed as a percentage of new tire cost for those tires considered was about 46% (std dev is 12.5). Although the 90% upper cost limit may seem high, there appears no justification for any percentage cost standard, so long as there is a tire carcass life remaining. The cost to retread a given tire should be in line with the historical data (as measured as a percentage of new tire cost) and industry standards. It is also apparent that retreading is an excellent way to conserve resources.

7. RECOMMENDATIONS

It is recommended that a revised MEL for tires should state that tires be retread, given the carcass has at least one life left; the remaining life being determined by pass-fail ultrasonic measurement using the 20% full scale as the standard now. This 20% value will be subject to change as testing continues and provides additional information. It is cost-wise important not to wait until the 'perfect' value (for the ultrasonic measurement) is found, but to act in step with available data.

It is also recommended that testing continues to determine the exact correlation between ultrasonic readings and remaining tire life.