ROUGH DRAFT - NOT FOR PUBLICATION

A Study of Wet Track Abrasion Test Variables.

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A progress report prepared for presentation at the 26th Annual ISSA Convention, San Diego, California, January 16-20, 1988.

INTRODUCTION

ASTM D 3910 "Standard Practices for Design, Testing and Construction of Slurry Seal" recommends the use of the Hobart Manufacturing Company's Model C-100 planetary mixer in the performance of the Wet Track Abrasion Test. The C-100 mixer has been the standard of the industry since the introduction of the Test in 1964 by Kari and Coyne. The manufacture of the C-100 was discontinued about 2 years ago and it is necessary to select a substitute machine(s) and to correlate the new machines (Hobart Models N-50 and A-120) with the C-100.

ScanRoad (formerly Slurry Seal, Inc.) of Waco, Texas under the direction of Soren Marklund and Bob Province agreed to undertake the research which was performed by Tony Ng and David Jones. Their work, just presented, was meticulously conceived and performed. Their results are the best in precision we have seen.

The Ng-Jones work used only one high quality base asphalt, 3 emulsifiers and 3 aggregates regraded to a constant gradation and surface area. Only one constant film thicknesss was used corresponding to 16% emulsion content. In spite of the care taken, and the excellent results, there were some unexplained variations.

One possible variable was the specimen surface texture. Pierre Chazal and Jean Walter once commented that WTAT results were dependent upon surface texture. Because of the variations seen not only in the ScanRoad study but in results we frequently see, we undertook this study of variables which affect the precision and reproducibility of the WTAT.

In this study we also included a comparison of the Hobart C-100 and N-50 machines.

Our procedures have been modified to include:

1. An abrading head which offers a quick-change hose mandrel with fully guided lateral hose alignment supports. With this head it is unecessary to drill the hose. Installation time is less than one minute and the hose may be reused for 4 or 5 tests.

2. A raised lip mold is used with a wooden dowel strike-off. The standard flat template sometimes causes variable thickness while the squeegee strike-off causes "dishing". The raised lip mold used with the dowel strike-off produces more uniformily thick specimens and more uniform textures.

3. A removable spun metal pan is used. The specimen and pan are clamped to the fixed mounting plate by quick acting external clamps.

4. The specimens are handled on metal plates to prevent bending and cracking. The specimens are placed in racks on mesh trays while oven drying to ensure complete underside drying.

Here, we will report or comment upon the following sources of variations in WTAT results and precision;

Ingredients

- AC Quality
- Emulsifier Quality
- Emulsion Content
- Filler Content
- Cement Quality

Specimen Preparation

- Surface Texture
- Specimen Weight
- Specific Gravity
- Compaction
- Soak Time
- Water Content
- Compatibility
- Mixing Time

Test

- Machine Type
- Hose orientation
- Water depth
- Head dimensions and Tolerance
- Parallelness
- Substrate-Moisture

SERIES I

INITIAL EXPERIMENTS TO CORRELATE TEXTURE, WEIGHT AND C-100 AND N-50 MACHINES.

The initial experiment was intended to check the effects of specimen surface texture. The notion being that coarser textures would yield greater losses while heavier specimens would be thicker with more matrix and would yield lower losses. The materials used were Xenia 0/#4, type 2, crushed gravel and a production, commodity grade, CQS emulsion. 2 sets of 6 specimens at 12 and 16% emulsion contents for both the N-50 and C-100 mixes (24 total) were mixed and cast individually. After curing, 5 grams of 50-100 mesh silica sand was spread on the specimen surface with a rubber faced disc. The area covered was measured, area covered calculated and recorded along with the specimen weights.

The C-100 is a 10-quart mixer while the N-50 is a much smaller 5-quart mixer. In our 1st series we shorted the abrading head drive shaft to fit the N-50 machine. In the later series a spacer block was placed between the frame and motor assembly so that a standard length abrading head shaft could be used.

In order to fit the smaller N-50 dimensions, the N-50 specimen was cast in 10" diameter molds (650 grams) while the C-100 uses the 11" diameter mold (800 grams).

All tests were run at the standard 5 minutes (300 seconds) with no adjustment for area covered or number of revolutions.

SERIES I SUMMARY:

	CORRELATION				N-50, %
	TEXTURE	WEIGHT	TOTAL (6) WEIGHT LOSS,g.		(C-100=100%)
12% C-100 (6)	Yes	Slight	124.8	145.2	116 %
12% N-50 (6)	No	No			
16% C-100 (6)	No	Slight	12.5	24.1	193%
16% N-50 (6)	Yes	Yes			
	TOTALS		137.3	169.3	avg.123%

TABLE I - SERIES I SUMMARY

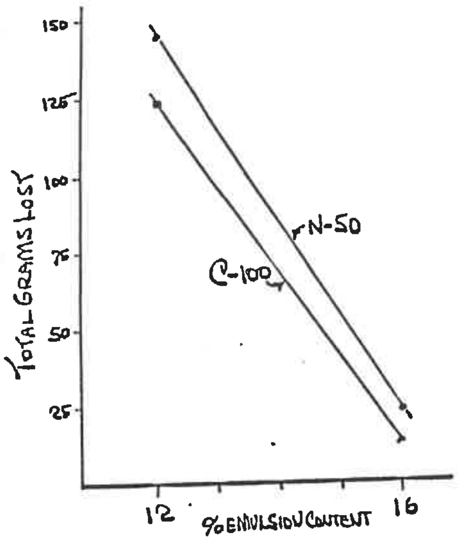

FIGURE 1. TOTAL GRAMS WTAT LOSS 300 SECONDS N-50 & C-100 (4 SETS OF 6 EACH) SERIES I

SERIES I CONCLUSIONS:

1. Texture and weight correlation is indicative but inconclusive.
2. N-50 losses were 23% greater than the C-100.
3. Low losses at high emulsion contents shows much greater C-100, N-50 percent differences than high losses at low emulsion content.
4. Very low losses distort the percentage differences.

NOTE: Only the 5-minute grams loss is reported. Multiplying the grams lost by the standard C-100 3.06 factor or the N-50 factor (3.49) greatly distorts the percentage results, especially with high losses.

SERIES II

EFFECT OF SOAKING TIME

In series I it was found that very small losses created large percentage variations. In series II we attempted to generate larger losses by using lower emulsion contents as determined by the following C-100 WTAT curve at 8, 10, 12, 14, & 16% emulsion contents.

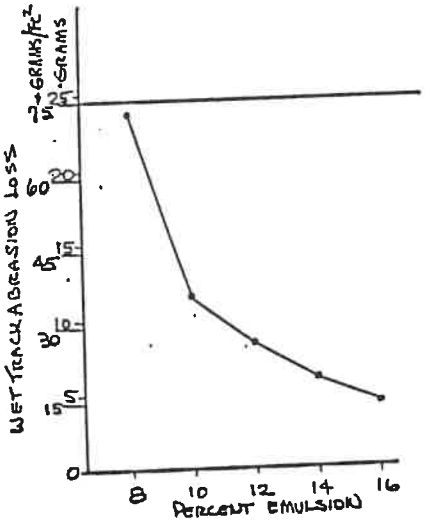

FIG.2. WTAT CURVE, SERIES II

14% and 10% emulsion contents according to this curve should have yielded losses of 20 and 40 g/SF or 6.5 and 13 grams for 1 hour soaks respectively. However, this was not the case for reasons which will be discussed later.

A performance quality CQS 1-h emulsion was used with Sandusky 0/#4 type 2 Dolomite in this and subsequent experiments unless otherwise noted.

Four sets (for the 4 soaking times) of duplicate specimens at 10 and 14% emulsion content for both the C-100 and N-50 (32 total) machines were prepared in the usual manner.

The four complete sets were placed in the ambient bath at the same time and each set run in turn at the 1-hour, 1 day, 3 days and 6 day soak periods. The average (2) grams lost were plotted against soak time as shown in figure 3.

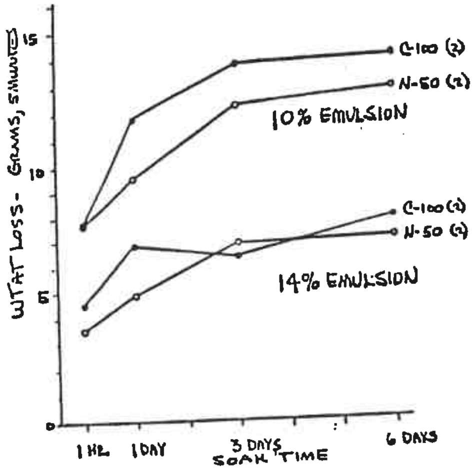

FIG. 3. EFFECT OF SOAKING TIME ON WTAT LOSS SERIES II

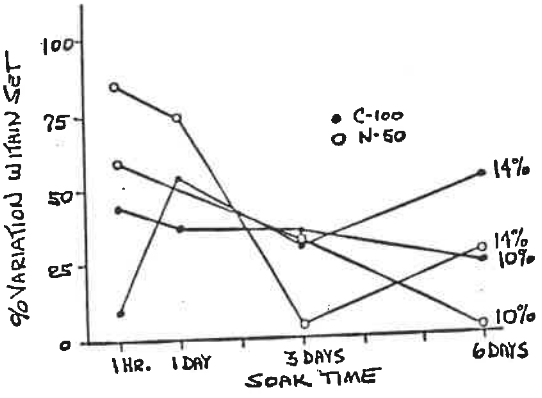

FIG. 4 PERCENT VARIATION WITHIN SET VS. SOAK TIME - SERIES II

The indication we see in figure 3 is that the rate of loss increase is decreased with soaking time and that perhaps 4 or 5 day's soaking time would be adaquate to show the effects of long term soaking. The N-50 and C-100 resulsts seem similar.

Figure 4 is a plot of the % variation at each soaking period and may indicate that there is less variation with longer soak times or it may simply indicate that lower losses yield greater variation than higher losses.

We then plotted our gram losses against the gram variation between the extremes of each set to evaluate the linearity and scatter we were getting in our first series I and series II.

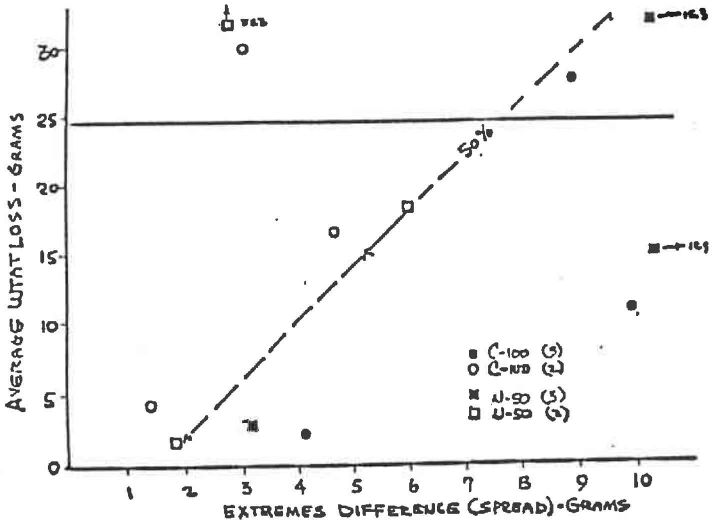

FIG 5a PRECISION/REPRODUCIBILITY - SERIES I

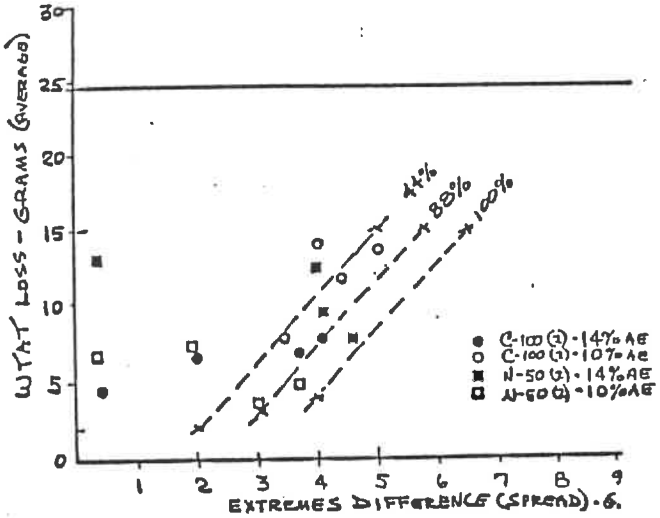

FIG 5b PRECISION/REPRODUCIBILITY - SERIES II

The series I plot, figure 5a shows clearly the scatter resulting from an inexperienced technician (which was the case) and suggests that the best 2 out of 3 results should be averaged rather than averaging all 3 results.

The series II plot; figure 5b shows improvement in scatter. In both cases there seems to be a trend toward greater percentage accuracy with larger numbers.

SERIES II SUMMARY (6-DAY SOAK)

	TOTAL WEIGHT LOSS, g.			N-50%, (C-100=100%)
	C-100 (8)	N-50 (8)		
10% AE	139.2	148.1		106.5%
14% AE	78.4	78.4		100%
TOTALS	217.6	226.5	avg.	104%

TABLE-2 - SERIES II SUMMARY (6-DAY SOAK)

1. Better accuracy with higher emulsion content and lower losses.
2. N-50 is slightly more accurate than the C-100.
3. The C-100 and N-50 give nearly the same results.

SERIES III

EFFECT OF SPECIMEN MASS, SPECIFIC GRAVITY, THICKNESS, COMPACTION, TEXTURE AND MACHINE TYPE.

16 sets of triplicate WTAT specimens were prepared using the Sandusky 0/#4, type 2 Dolomite and the performance CQS-1h. 16 specimen sets of 3 each were cast in 1/4" and 3/16" molds, 10 and 14% emulsion content, compacted and uncompacted for both the C-100 and N-50 machines (48 total). The 30-pound roofing felt substrate was preweighed and specific gravity predetermined. The net specimen air weight and water displacements determined. One set of each series was statically plate compacted with 2 tons or about 63 psi for 10 minutes total.

The sand patch area covered by 5 grams of 100/50 mesh silica sand was determined before soaking and abrading.

After abrasion loss determination the specimens were soaked for 72 hours and the saturated specific gravities determined.

SUMMARY RESULTS:

1. SPECIFIC GRAVITY. No correlation was found with the loss and either the saturated or unsaturated specific gravites. The specific gravities of the compacted specimens generally were greater than the uncompacted specimens and the losses were consequently lower.

2. TEXTURE and MASS. We theorized that coarser textured specimens would have relatively higher losses and that heavier specimens would have lower losses. A summary tabulation of net specimen weight and sand patch texture area vs. the relative loss within each set follows:

	N-50		C-100	
Thickness	Texture	Weight	Texture	Weight
1/4"	67%	42%	50%	75%
3/16"	83%	75%	42%	100%
x	75%	58%	46%	88%

TABLE 3 PERCENT CORRELATION, TEXTURE AND WEIGHT WITH LOSS

Texture affects the N-50 more than the C-100, while specimen weight affects the C-100 more than the N-50. Both texture and weight affect 3/16" specimens more than the 1/4" specimens.

3. EFFECT OF TEXTURE. Though the correlations are not story book, the sand patch area appears to be related to the WTAT loss, especially with the uncompacted specimens.

	UNCOMPACTED		COMPACTED	
C-100	CM2	Loss,g.	CM2	Loss,g.

1/4" - 10% AE	69.1	3.8	101.8	1.2
3/16" - 10%	72.9	4.3	91.2	3.8
1/4" - 10% AE	65.9	2.3	102.6	1.2
3/16" - 14% AE	62.6	2.9	89.4	1.0
N-50				

1/4" 10% AE	49.1	5.9	100.3	1.5
3/16" 10% AE	46.7	3.3	93.1	.9
1/4" 14% AE	56.4	4.7	102.4	1.3
3/6" 14% AE	71.7	2.7	107.2	1.7

TABLE 4 SERIES III AVERAGE LOSS VS AVERAGE SAND PATCH AREA.

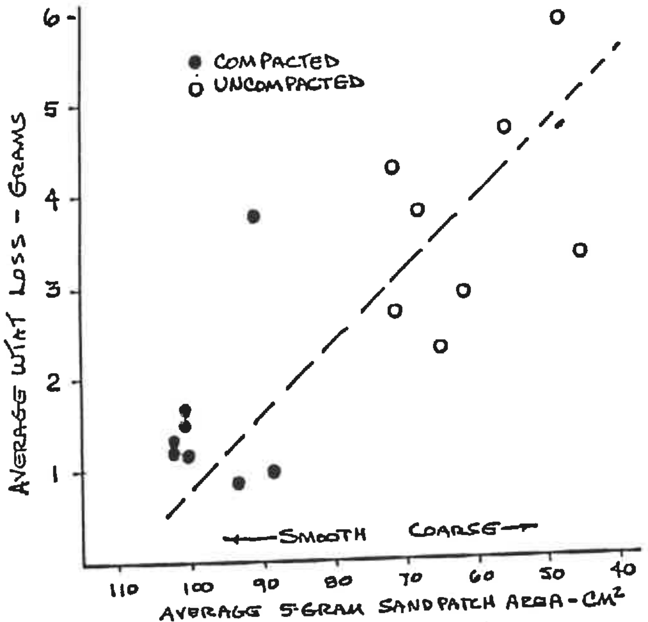

FIG. 6 EFFECT OF SAND PATCH TEXTURE AND COMPACTION ON WTAT LOSS SERIES III

FIGURE 6 Plot of Table 4 data. Average loss vs. average sand patch area.

4. COMPACTION. Static 9" diameter plate compaciton of 2, 5-minute cycles of 2 tons or 63 lbs/in2 reduces WTAT losses here by about 66%.

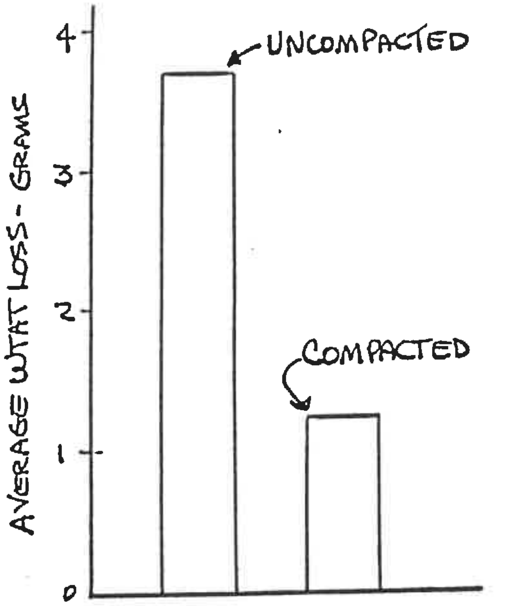

FIG. 7 EFFECT OF PLATE COMPACTION ON WTAT LOSS - SERIES III

Figure 7 d WTAT loss, Effect of Compaction, Average of all Series III Specimens.

5. THICKNESS. C-100 WTAT losses are greater with thinner samples while N-50 WTAT losses are reduced with thinner samples in this series.

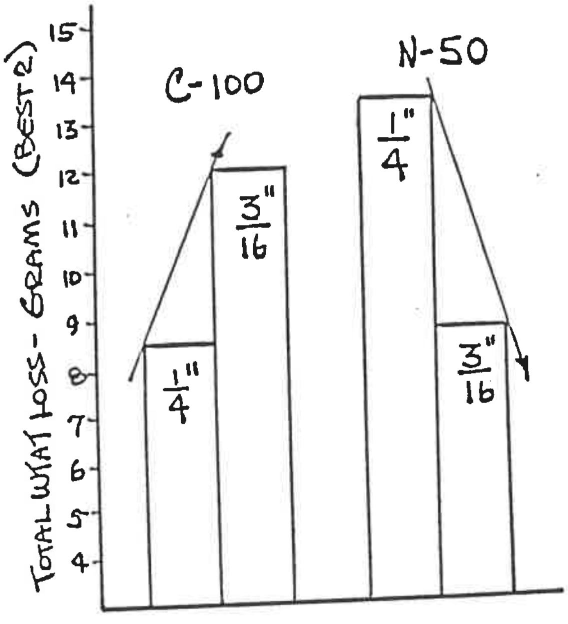

FIG. 8 EFFECT OF SPECIMEN THICKNESS ON WTAT LOSS - SERIES III

6. C-100, N-50 COMPARISON. Table 4 summarizes the average of all set total grams test in this series III.

	ALL (3)			BEST (2)		
AE%	N-50g	C-100g	N-50 % of C-100	N-50	C-100	N-50 % of C-100
10%	16.4g.	11.9	137.8%	11.6	15.0	77.3%
14%	10.1g.	7.7	131.2%	10.4	10.4	140.5%
TOTAL	26.5g.	19.6 avg	135.2%	22.0	22.4	avg. 98.2%

TABLE 4 SUMMARY SERIES III

7. COMMENT. In our opinion the WTAT loss values of this series are too low and consequently unrepresentative. The percentage losses are greater at low losses. However, the results in this series III are more consistent with fewer outliers than in #2 series as shown in figure 9.

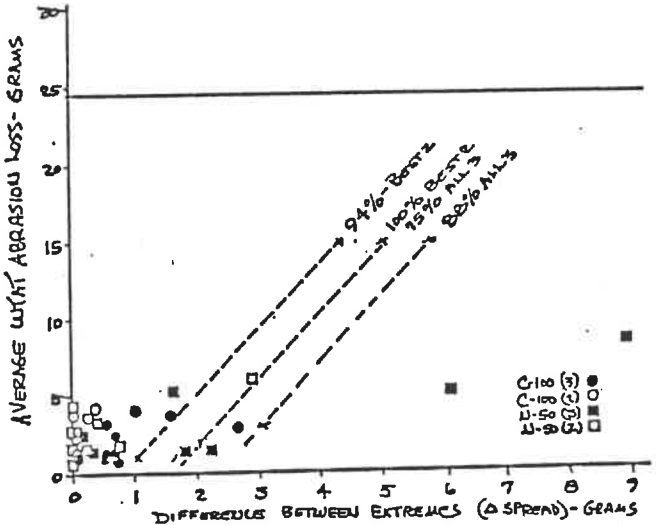

FIGURE 9 PRECISION/REPRODUCIBILITY- SERIES III SUMMARY

SERIES IV

EFFECT OF COMMODITY GRADE MATERIALS.

A commodity grade asphalt cement was emulsified with a commodity grade emulsifier. Four sets of triplicate specimens (12) were prepared with the Sandusky 0/#4 aggregate at 10% and 14% emulsion for the C-100 and N-50 machines.

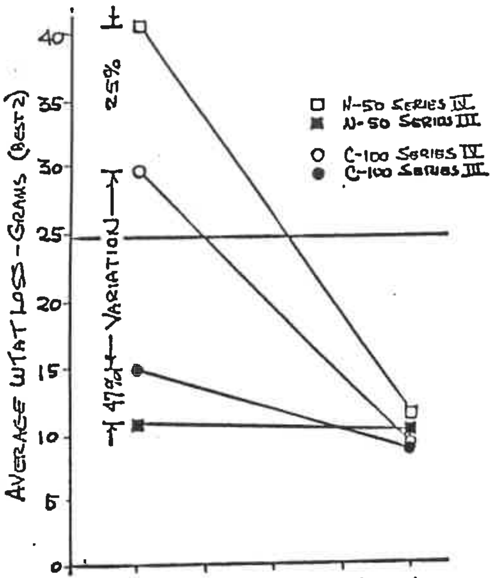

FIG 10 EFFECT OF MATERIALS QUALITY SERIES III & IV COMPARED

The loss increases were dramatic compared to the previous quality performance system at 10% AE content but were nearly the same at 14% AE content. Note the 25% variation between machines at high loss. The variation nearly doubles at low loss.

Table 5 shows larger correlation precentages with series IV than with the previous experiments:

	ALL (3)			BEST (2)		
AE%	N-50,g.	C-100,g.	N-50 % of C-100	N-50,g.	C-100,g.	N-50 % of C-100
10	41.8	26.8	156%	40.3	29.4	137%
14	19.0	9.1	209%	12.5	8.0	156%
TOTAL	60.8	35.9	avg.169%	52.8	37.4	avg.141%

TABLE 5

SERIES V

EFFECT OF PORTLAND CEMENT QUALITY

In Series II on the effect of soaking time we selected the emulsion contents of 10 and 14% to give larger losses as was indicated by the initial 5-point WTAT curve. As testing proceeded we found that something was amiss with our results; they were too good! On inquiry, we found that stale cement was used for the curves. We then repeated the WTAT curve with the fresh unhydrated cement which was used throughout these tests. The new results corresponded much more closely to the actual results we were getting.

The differences between the stale, partially hydrated cement and the fresh cement ranged from a 50 to 80% reduction in loss when the fresh cement was used!

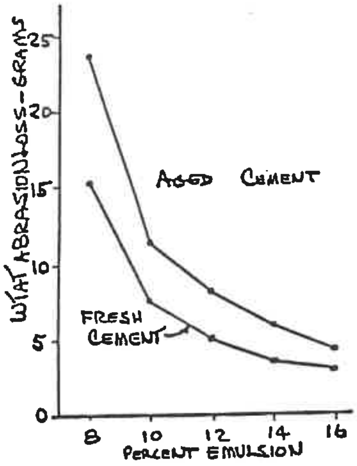

FIG. 11. WTAT CURVE - SERIES II
EFFECT OF PORTLAND
CEMENT AGE

Figure 11. Effect of cement age in WTAT loss.

SERIES VI

EFFECT OF MIXING TIME

The effect of mixing time (time vs shear) was even more dramatic. Two sets of duplicate specimens were prepared with the standard performance materials at 14% cement. One set was mixed for 30 to 40 seconds, then cast while the second set was mixed for 180 seconds before casting (there was still free unbroken emulsion present). There was much more than double loss due to the additional mixing time!

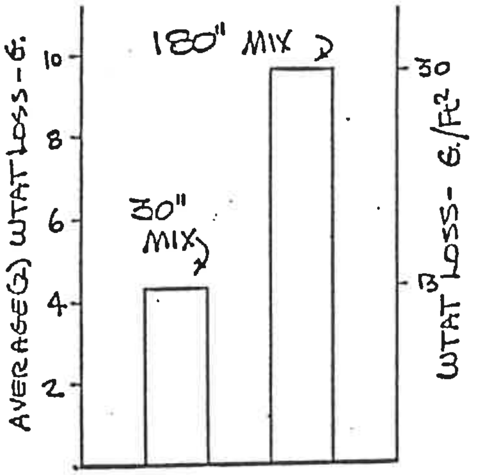

FIG. 12 EFFECT OF MIXING TIME ON WTAT LOSS

Figure 12 Effect of mixing time.

As time of mixing proceeds, the emulsion AC progressively coats or plates out on the aggregate, leaving less free emulsion for mat cohesion and substrate adhesion.

SERIES VII

EFFECT OF BITUMEN QUALITY AND EMULSIFIER QUALITY

Two bitumens, one a performance type (our #40) and the other a commodity type (our #37 river-grade), were separately emulsified with two emulsifiers, 320 and 311, performance and commodity types respectively.

The performance emulsifier, substantially improves the commodity grade asphalt while the commodity emulsifier destroys the performance asphalt. Note that the 311 emulsifier results are nearly identical with each asphalt. The WTAT results appear to be much more dependent on the emulsifier quality than on the bitumen quality.

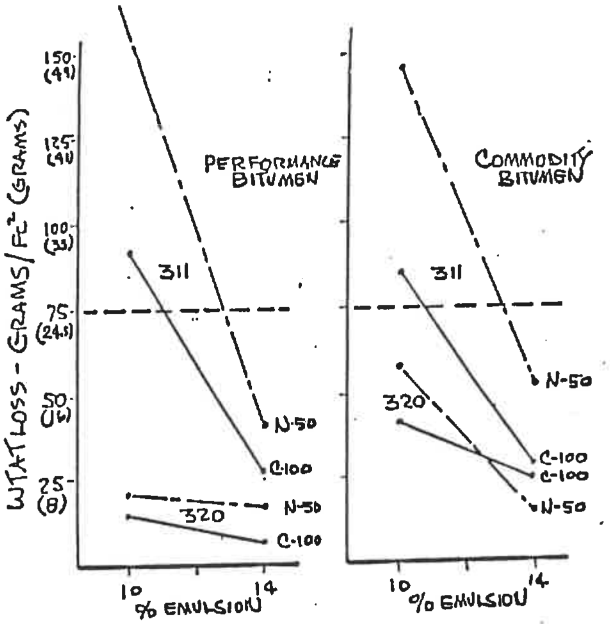

FIG.13 EFFECT OF BITUMEN QUALITY & EMULSIFIER QUALITY, SERIES VIII

Figure 13 Effect of Bitumen emulsifier quality.

SERIES VIII

EFFECT OF MIX WATER CONTENT

A commodity grade emulsion was mixed with the Sandusky 0/#4 aggreate 2 at 10% emulsion content and 3 different water contents. Only single specimens were run in this series.

Figure 14 clearly shows the rather large variation (24%) which occurs at only 4% difference in mix water content. It appears that even small variations in water contents can effect the precision of the WTAT results.

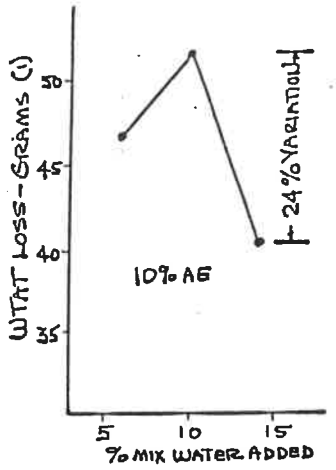

FIG 14 EFFECT OF WATER CONTENT ON WTAT LOSS

EFFECT OF LIMITED ADHESION, FREE BITUMEN, EXCESS AC, FLOATATION, INCOMPATIBILITY

During these experiments we were unable to find this effect. The first indication of this problem is the observation of free asphalt particles or free, unbound films of asphalt on the surface of the specimen. The second indication is free asphalt adhering to WTAT abrading hose which causes the third indication: AN INCREASE IN WTAT LOSS at higher levels of emulsion content.

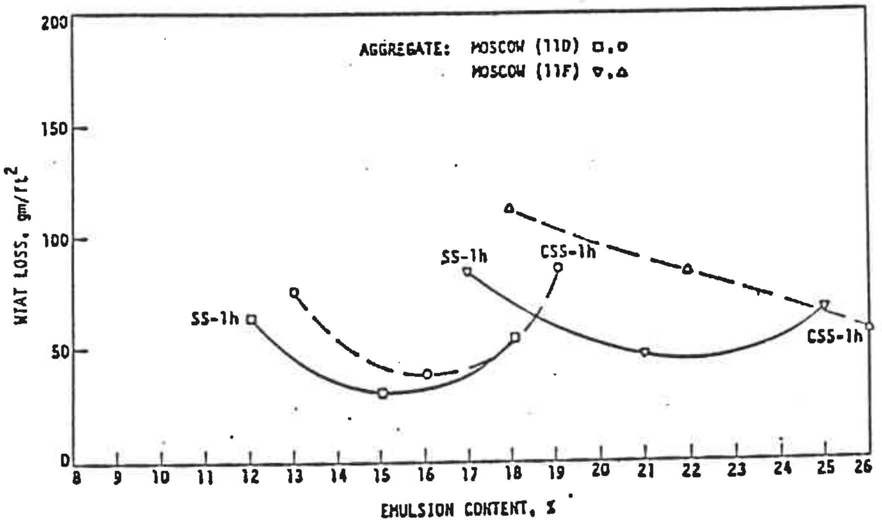

Fig. 15. WTAT loss vs emulsion content, Moscow (L_1D and L_1F).

Figure 15 taken from LEE's 1978 study shows an example of this phenomena. We have noted these effects at quite low emulsion contents. The effects can be a real source of variation at moderate to high emulsion contents. (This phenomenon is also related to greasy wheel tracks and flushing in our opinion).

EFFECT OF FILLER/FINES CONTENT AND GRADATION

Though we did not attempt to examine the effects of gradation, filler content and segregation, we include an example from our Geneva paper on the effects of fines/filler content on WTAT abrasion loss as another source of variability in test results.

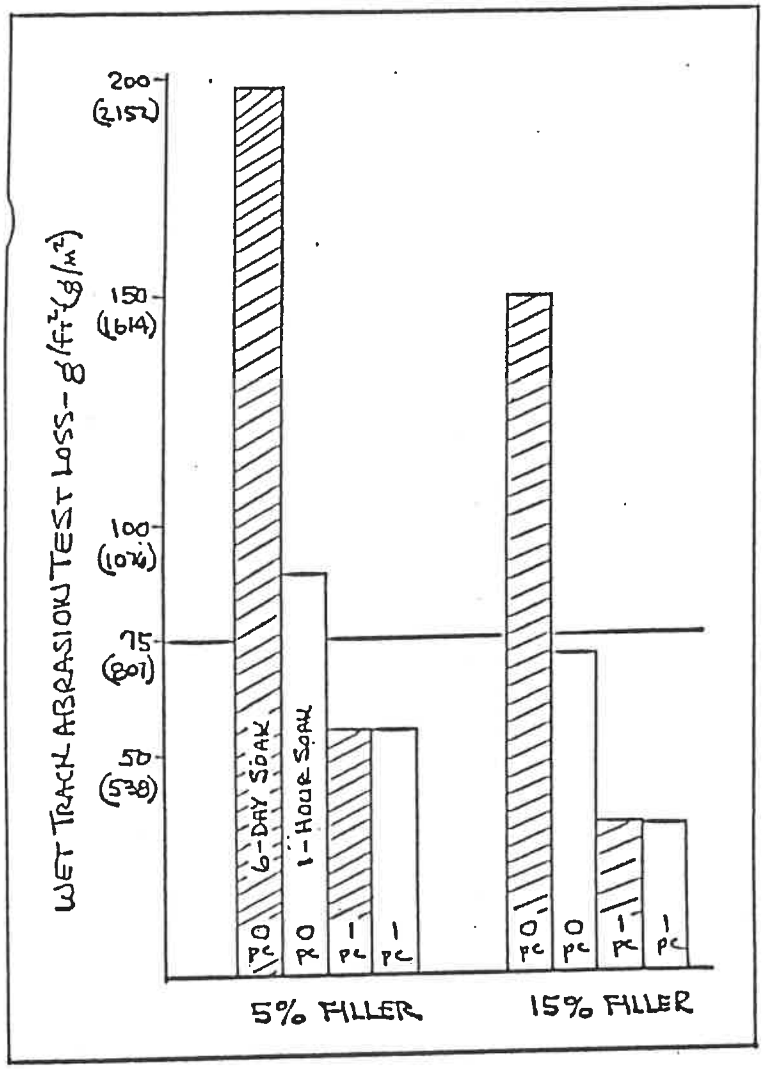

FIG. 16. EFFECT OF FILLER & CEMENT CONTENT ON 1-HOUR & 6-DAY SOAK WET TRACK ABRASION TEST LOSS – 12% EMULSION

FIGURE 16 THE PRESENCE (OR ABSENCE) OF CEMENT DRAMATICALLY AFFECTS BOTH THE ONE HOUR AND SIX-DAY SOAK WET TRACK ABRASION TESTS.

IN ALL CASES, INCREASED FILLER IMPROVES THE WTAT. CEMENT PRESENCE AT LOW OR HIGH FILLER CONTENTS MARKEDLY IMPROVES THE TEST RESULTS.

THESE SPECIMENS WERE FIRST RUN AT THE ONE-HOUR SOAK PERIOD, OVEN DRIED FOR 18 HOURS AT 60C, COOLED AND WEIGHED TO DETERMINE THE LOSS. TO CONSERVE MATERIALS, THE SAME SPECIMENS WERE USED FOR THE SIX-DAY SOAK TEST.

MECHANICAL VARIABLES

A. EFFECT OF SUBSTRATE MOISTURE.

Half of our results were less than 5 grams while one-fourth were less than 2 grams. Small errors can greatly distort percentage losses. (A thin dime weighs only 2.4 grams!) 55% of the Ng-Jones data is less than 5 grams while 28% is less than 2 grams loss. Errors in weighing may be critical in the precision of the test especially at the very low losses we are experiencing here.

To investigate the part that normal moisture content of the 30-pound roofing felt substrate we "dried" 2, 11 inch circles of the felt for 18 hours at 60C. The results were:

SAMPLE NO.	1	2
Weight as rec'd	65.37	65.56
After drying	64.11	63.88
Moisture loss	1.26	1.68 grams

TABLE 6a.

After drying, the circles were saturated for 72 hours in a water bath and then thoroughly dried to a saturated, surface dry condition. The results were:

SAMPLE NO.	1	2
Wt., Saturated	83.03	82.67
Wt., Dry	64.11	63.88
Moisture Absorbtion	18.92	18.79 grams

TABLE 6b.

Obviously, saturated roofing felt is not water proof! Part of the initial loss may be attributed to asphalt oxidation loss. Technicians should consider the potential for error in the water absorbtion of the felt substrate.

B. MACHINE CHARACTERISTICS - ABRASION AREA

Figure 17 shows the dimensions of the C-100 and N-50 abrasion patterns. Because the C-100 has a larger pattern there is a center over-lap diameter of 2.25" while the smaller N-50 has an 2.75" center overlap. There is also less edge space for abraded aggregate to escape on the N-50. Additionally, more aggregate will be abraded in the center of the N-50 and will be retained longer than on the C-100.

Abrasion begets abrasion; i.e., the more abrasion there is the more loose particles on the specimen surface that are available to increase the abrasion. This may explain the greater relative losses with N-50 when the overall losses are high. This fact also explains the typical non linear WTAT curves we usually see.

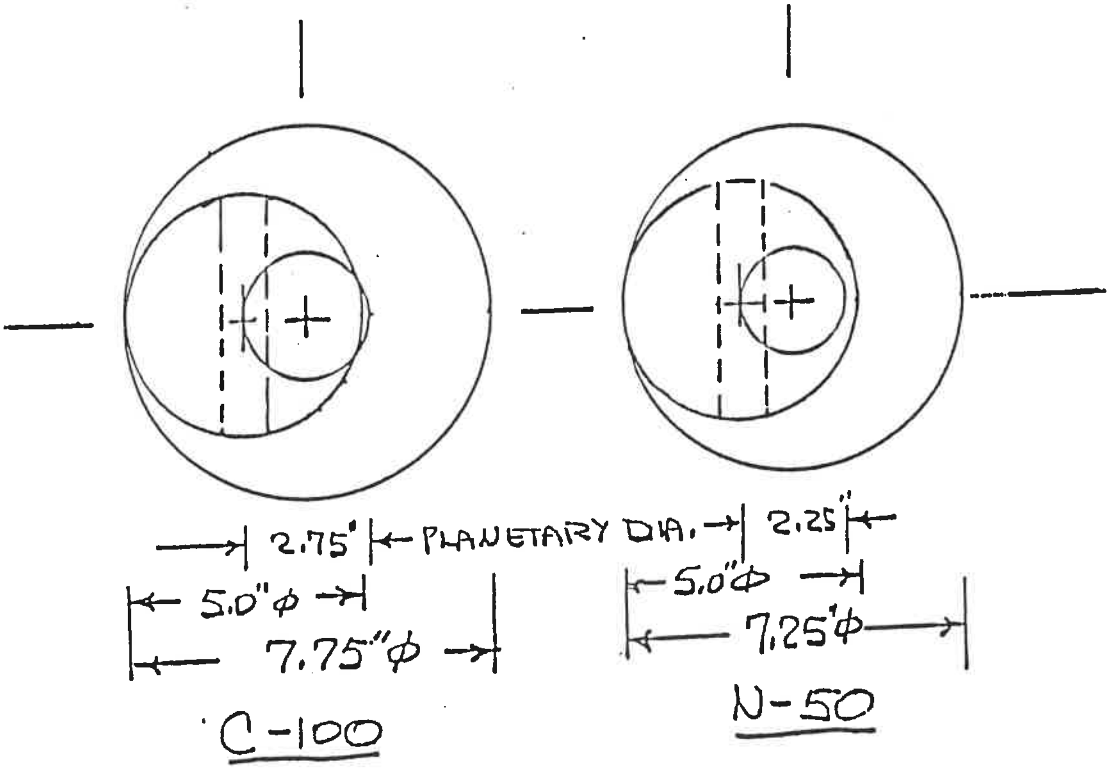

FIGURE 17 C-100 & N-50 ABRASION PATTERNS

C. DRIVE SHAFT DIMENSIONS AND TOLERANCES

Figure 18 is a schematic crossection of the abrading head drive line. The "slop angle" varies greatly with the past length, diameter slip tolerance and pin pivot vertical and horizontal position. The lowest "slop angle" produces a much smoother running test than the highest angle.

"Slop" is necessary to accomodate irregular surfaces and the jamming effects of loose abraded aggregate. The degree or amount of slop however can effect the precision of the test. ASTM D 3910 does not specify these critical dimensions.

Lubrication of the bearing surfaces should also be specified.

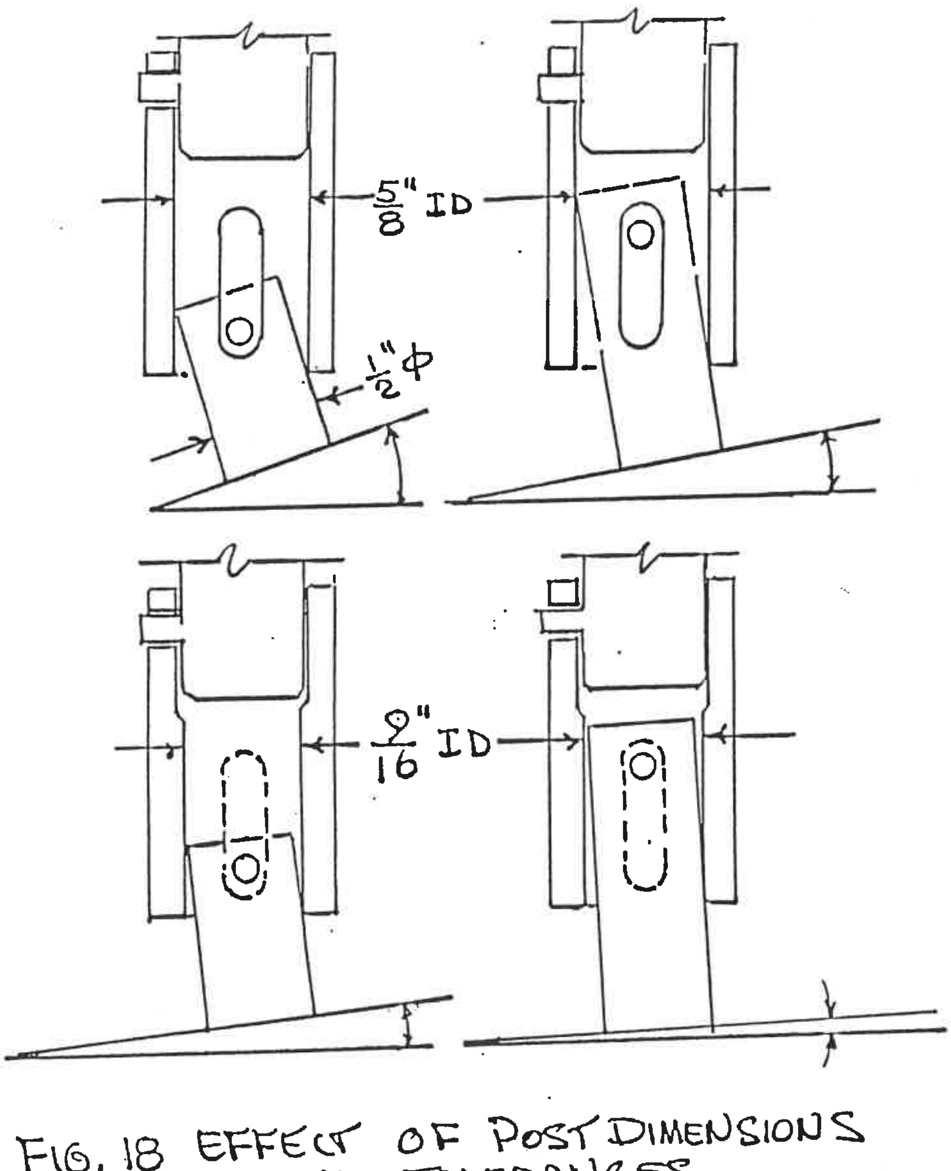

FIG. 18 EFFECT OF POST DIMENSIONS AND TOLERANCES

D. ALIGNMENT, PARALLELICITY AND WATER DEPTH

Among the most critical of the variables is the alignment of all contact surfaces. Gouging or complete misses caused by irregular thickness or curvatures, either convex or concave, or the mounting platform out of square and plumb, or excessive slop angle contributes to lack of precision. Water levels can vary from 1/2" to 0" and vary the washing effect of the water depth. All surfaces must be in the same, parallel plane if these variables are to be avoided.

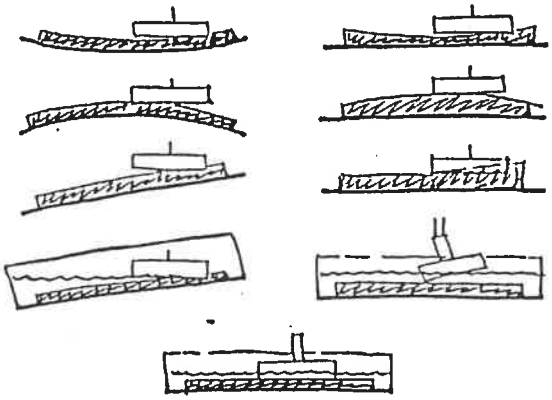

FIG. 19 ALIGNMENT, PARALLELICITY

E. HOSE WEAR PATERNS

The hose wear patterns shown in figure 20 are typical. The variations are due to hose curvature relative to their installation position in the abrading head. Essentially, there is a variable abrading area initialy very small but increasing to much larger areas at the end of the abrading period. Care in installation of the hose and use of a laterally guided hose bracket reduces the variation in wear patterns but not completely.

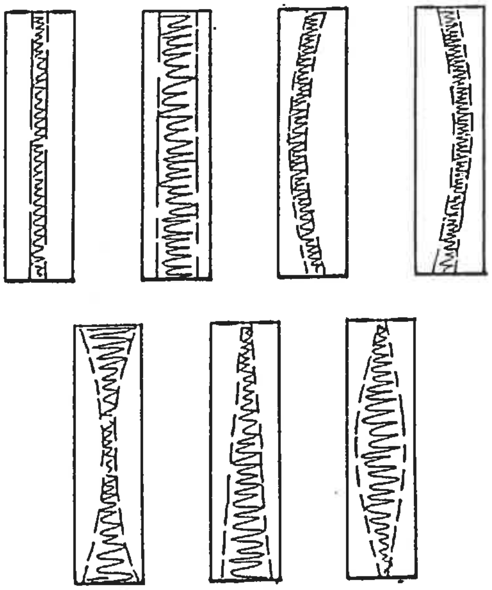

FIGURE 20. WTAT ABRASION HOSE WEAR PATTERNS

SERIES IX

EFFECT OF A CONSTANT AREA ABRADING SURFACE

Because of the variety of hose wear patterns due to hose curvature and the variable hose wear area (the greater the loss the greater the area), we performed this series of experiments to compare the effect of a constant area abrading surface with the standard hose.

According to British Standard BS 434, a solid 70 durometer neoprene strip 12.5 mm X 20 mm clamped to protrude 12.5 mm and weighted to 2200 grams (our 5 lbs = 2273g) or about 1.4 grams/mm2 is used. At the same time we increased the drive post length and reduced the drive shaft tolerance from 1/8" to 1/16".

Four sets of duplicate specimens were made at 10 and 14% emulsion content for both the C-100 and N-50 machines.

Our initial results are shown in Table 8:

N-50/C-100 as 100%

P-290 Hose Only:	92.4%
Neoprene Strip Only:	114.2%

Neoprene/Hose as 100%

	10% AE	14% AE
C-100	184%	144%
N-50	216%	176%

Average (All): 187%

TABLE 8 SOLID NEOPRENE AND HOSE COMPARED

It is quite obvious that the 12.5 mm solid neoprene strip of a constant area abrades much more than the hose (about +87%). Figure 21 shows rather dramatically the loss differences between the ASTM/ISSA Standard P-290 Hose and the BS 434 solid neoprene strip.

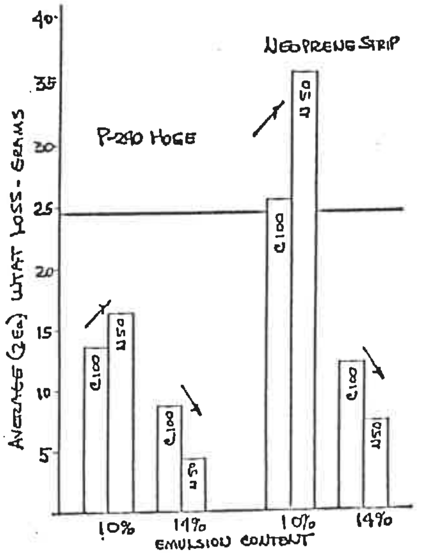

FIG.21 VARIABLE AREA HOSE SURFACE COMPARED WITH CONSTANT AREA NEOPRENE STRIP.

SUMMARY OF RESULTS AND CONCLUSION

Appendix C records a summary of our Series I, II, III & IV C-100 and N-50 average of best 2 results. They are arranged in 4 loss groups:

	N-50/C-100
20+	131.4%
10-20	99.5%
5-10	93.5%
0-5	100.8%

AVERAGE OF ALL SERIES

	N-50	C-100	N-50 % of C-100
Total all series	188.7	179.2	
Number of sets	21	20	
Average all series	9.44	8.53	
			110.6%
Average, less 20+ group	6.12	6.29	
			97.3%

Based on the results of this work we offer the tentative conclusion that the overall correlation indicates that, over a complete range of loss at 10 and 14% emulsion contents, the N-50 produces 10.6% (11.0%) more loss than the C-100 and at lower losses the N-50 produces 2.7% (3.0% less loss than the C-100).

All tests included were performed with standard head and hose and 5 minutes abrasion time.

It is our opinion that when the magnitude of the variables are reduced, the N-50 and C-100 machines will be substantially equal at less than 24.5 grams loss (75g/ft2 C-100 loss).

CONCLUSIONS AND RECOMMENDATIONS

Our data presented here is scattered more than we like due to the variables introduced. Our results, we believe, are rather typical of those found by other testing laboratories.

We believe that by refining and standardizing the test, particularly the mechanical aspects that much greater precision and reproducibility will be possible.

We believe that the WTAT does define rather well a minimum bitumen content requirement and that Kari and Coynes' original maximum loss of 75 grams per square foot (C-100, 5-minute loss of 24.5 grams) remains a solid number.

The WTAT, however, does NOT establish an OPTIMUM BITUMEN CONTENT. The test is most useful as a comparative tool...A SYSTEM EVALUATOR.

We recommend:

1. That reporting the loss per unit area be abandoned in favor of simply reporting the grams last for a given mchine and time; e.g., "5-minute C-100 loss of x grams" etc.

2. That specific test geometeries be precisely delineated; e.g., leveling of the machine and support platform, parallelness of the specimen surfaces, abrading head plane and water level and depth as well as hose orientation.

3. That the replacement of the standard abrading hose with a solid rubber strip be investigated to improve precision.

4. That extended soak time before abrasion such as 4 or 6 days be included as a note for optional procedure.

5. That precision limits or limits of variation among identical specimens be established.

   We suggest that for design report purposes that at least triplicate set specimens be run at 3 levels of emulsion content and that results larger than the follwing slope variations be rejected:

Average loss g.	Variation between extremes	Tolerance from average
2.0	2.0	+/- 1.0
15.0	5.0	+/- 2.5

6. That a liason be established between ISSA and ASTM D 04.03 Committee on surface treatments.

Figure 22 is a plot of the above appendix C data while figure 23 is a plot of the Ng-Jones data.

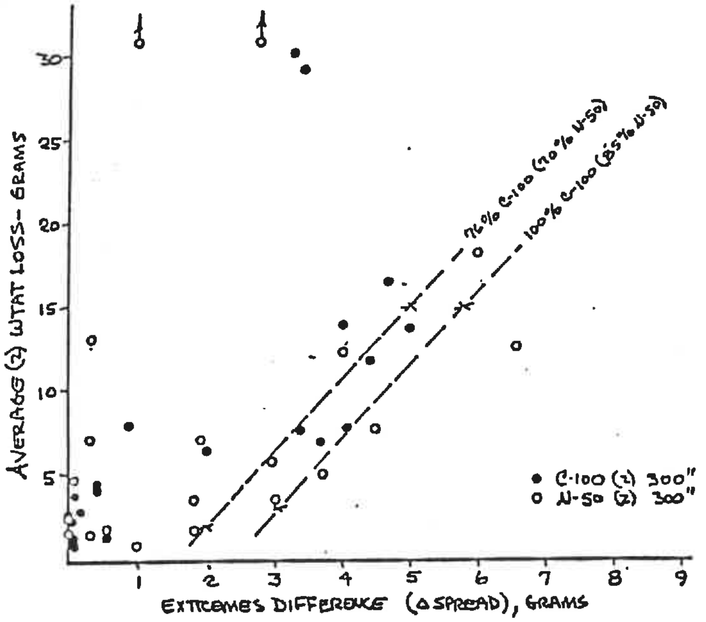

FIGURE 22 PRECISION/REPRODUCIBILITY – 41 SETS, BEST 2
SERIES I, II, III, IV

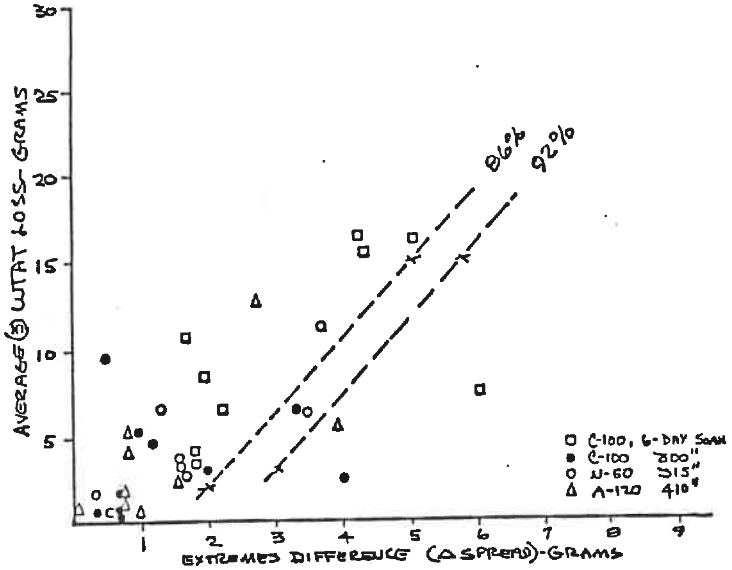

FIGURE 23 PRECISION/REPRODUCIBILITY- 36 SETS OF 3
NG-JONES DATA 12/87

APPENDIX A. Hobart Standards

APPENDIX B. Dimensional Tabulations

APPENDIX C. Summary Tablulation of average grams loss and spread or variation in extremes Series 1, 2, 3, & 4.

BIBLIOGRAPHY:

Kari & Coyne	AAPT 1964
Gerry Rose	ca. 1968
John Skog	1970
Lee	1978
Ordenin	1982
Benedict	1985
Kim	1987
Ng-Jones	1988
ASTM	D3910
ISSA	DTB-78-T-100

HOBART

ENGINEERING STANDARDS

TECHNICAL DATA

MIXER SPEEDS (RPM)

N50 60HZ

	1 st	2 nd	3 rd	4 th
Planetary	60	124	255	
Beater	136	281	580	
Attach.	60	124	124	

N50 50HZ

	1 st	2 nd	3 rd	4 th
Planetary	58	121	249	
Beater	132	274	566	
Attach.	58	121	249	

C100 60HZ

	1 st	2 nd	3 rd	4 th
Planetary	60	109	190	
Beater	142	258	450	
Attach.	60	109	190	

C100 50HZ

	1 st	2 nd	3 rd	4 th
Planetary	60	108	189	
Beater	142	256	447	
Attach.	60	108	189	

A120 50HZ & 60HZ

	1 st	2 nd	3 rd	4 th
Planetary	46	84	154	
Beater	104	194	353	
Attach.	60	111	203	

A200 50HZ & 60HZ

	1 st	2 nd	3 rd	4 th
Planetary	46	86	156	
Beater	107	198	361	
Attach.	61	113	205	

-SINGLE SPEED MOTOR

	C-100	N-50	A120
PLANETARY DIAMETER, in	2.75	2.25	3.125
CIRC" 5-INCH HOSE/HEAD ABRADED DIAMETER"	7.75"	7.25	8.125
ABRADED AREA in^2	47.15	41.26	51.82
ABRADED AREA ft^2	.327	.287	.360
CORRECTION FACTOR (MULTIPLIER TO CORRECT TO ft^2)	3.06	3.48	2.78
CENTER OVERLAP DIAMETER in	2.25"	2.75"	0.875"
CENTER OVERLAP AREA in^2	3.97	5.94	0.60
SHAFT RPM, 1st GEAR	61	61	47
ABRASION ~~HEAD~~ RPM	144	136	104
TOTAL RPM	205	197	151
? TIP SPEED (TRAVEL) ft/min	371.93	337.78	282.73
? EQUIVALENT TIME (C-100=300")	300 5'	330 5'30"	395 6'-35"
PLANETARY CIRCUMFERENCE in	8.64	7.07	9.85
PLANETARY TRAVEL/MINUTE in	1244	962	1024
EQUIVALENT TIME	300" 5.0"	388" 6'-28"	364" 6'-4"

APPENDIX C

SUMMARY - SERIES 1, 2, 3, 4

	C-100 (6)			N-50 (2)		
	$\bar{x}$	Δ		$\bar{x}$	Δ	
	30.3	3.0		38.3	2.7	
	29.4	3.2	$\bar{x}$ Δ	40.3	1.0	
	59.7	6.2	$\bar{x}$ 29.9/3.10	78.6	3.7	$\frac{39.3}{29.9}$/1.85 = 131.4%
	16.6	4.7		18.1	6.0	
	11.8	4.4		12.3	4.0	
	13.8	5.0		13.0	.3	
[illegible] x 3.06 = 41.5	14.0	4.0		12.5	6.6	
14.1 x 3.06 43.1	56.2	18.1	14.05/4.53	55.9	16.9	$\frac{13.98}{14.05}$/4.23 = 99.5%
2.6 x 3.06 8.0	1.4	.6		1.8	1.8	
7.4 x 3.06 22.6	4.5	.4		3.5	3.0	
$\frac{165.2}{4}$ = 41.3	3.8	0		5.0	3.7	
	1.2	.1		1.7	.0	
$\frac{41.3}{3.06}$ = 13.5 gar	2.3	.1		4.7	.1	
	1.2	.1		1.3	.3	
~ 7.38	4.3	.3		3.3	1.8	
	3.8	1.0		.7	1.0	
	2.1	.2		2.7	.0	
	1.0	.1		1.7	.6	
	26.4	2.9	2.64/.29	26.6	12.3	$\frac{2.66}{2.64}$/1.23 = 100.8%
	7.7	3.4		7.7	4.6	
	6.9	3.7		7.0	.3	
	6.4	2.0		7.0	1.9	
	7.9	4.1		5.9	2.9	
	8.0	.9	20	27.6	9.7	
4	$\frac{36.9}{5}$	14.1	= 7.38/2.82	6.90	/2.43	6.90/2.43
						$\frac{6.9}{7.38}$ = 93.5%

179.2/21 = 8.53

$\frac{315}{300}$ = 105% x 97.3 = 102.2%

$$\frac{\begin{array}{r}179.2\\-\ 59.7\\\hline 119.5\end{array}}{19} = 6.287$$

188.7/20 = $\frac{9.4}{8.53}$ = 110.6%

$$\frac{\begin{array}{r}188.7\\-\ 78.6\\\hline 110.1\end{array}}{18} = \frac{6.117}{6.287} = 97.3\%$$