ARIZONA DEPARTMENT OF TRANSPORTATION

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SLOW SPEED WEIGH-IN-MOTION STUDY

Final Report

Prepared by:
Dr. Maralou De Nicholas
Center for Advanced Research in Transportation
College of Engineering & Applied Sciences
Arizona State University
Tempe, Arizona 85287

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Phoenix, Arizona 85007
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16. Abstract

This study was conducted to evaluate the performance of the Weighwrite slow-speed weigh-in-motion (SWIM) system installed at the eastbound Ehrenberg port of entry on Interstate 10. Tests were planned to closely coincide with those performed by Castle Rock Consultants in 1988.

System accuracy was assessed by means of a dynamic to static comparison. One hundred vehicles were selected for the random vehicle tests from truck traffic passing through the port. In addition, two test vehicles were measured repeatedly. Attempts were also made to assess the impact of altering the height of the SWIM scale's approach and exit.

Results indicate that the SWIM system is not performing well enough to meet current scale certification requirements in Arizona. This suggests that criteria which are used to certify static scales may be too stringent for SWIM applications.

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SLOW SPEED WEIGH-IN-MOTION STUDY

OVERVIEW

The Weighwrite slow-speed weigh-in-motion (SWIM) scale, installed at the eastbound Ehrenberg port of entry on I-10, was initally tested by Castle Rock Consultants in the first half of 1988 (1). The current study was undertaken to further evaluate the operating performance of the Ehrenberg SWIM system.

Tests were planned to coincide closely with those conducted in 1988. As was the case in the earlier investigation, system accuracy was assessed by means of a dynamic to static comparison. Testing was performed in February and March of 1989.

RANDOM VEHICLE TESTS

Method

One hundred and four vehicles were selected from truck traffic passing through the Ehrenberg port. Every effort was made to select vehicles at random, although vehicle selection was at times subject to queue and delay considerations.

Each vehicle was first weighed on the port's three-section platform scale, which was certified by Weights and Measures prior to testing. The vehicles were then guided over the SWIM scale at a constant speed not exceeding 5 mph.

Four vehicles were discarded from the sample when their drivers failed to follow directions. Thus, 100 vehicles with a total of 292 axle groups remained in the final sample for analysis.

Results

Measurement accuracy. In order to assess system accuracy, absolute error was first computed by subtracting static weight from SWIM weight. Percentage error was then calculated using the following formula:

$$\% \text{ Error} = \frac{\text{SWIM weight - static weight}}{\text{static weight}} \times 100$$

Means and standard deviations for absolute error and percent error were computed for axle groups and gross weights. The results are presented in Tables 1 and 2. Results from the previous study are included in these tables for ease of comparison.

Table 1. Measurement accuracy -- axle groups

Sample	Sample Size	Mean	Standard Deviation
January 1988	397	-1.7% (-264 lbs.)	1.4% (211 lbs.)
March 1988	458	-2.2% (-343 lbs.)	1.7% (255 lbs.)
June 1988	433	-2.4% (-419 lbs.)	1.5% (233 lbs.)
March 1989	**292**	**-0.4%** **(- 57 lbs.)**	**2.1%** **(326 lbs.)**

Table 2. Measurement accuracy -- gross weights

Sample	Sample Size	Mean	Standard Deviation
January 1988	132	-1.5% (-784 lbs.)	0.6% (339 lbs.)
March 1988	145	-1.9% (-1083 lbs.)	0.7% (381 lbs.)
June 1988	148	-2.3% (-1232 lbs.)	1.0% (363 lbs.)
March 1989	**100**	**-0.3%** **(-159 lbs.)**	**0.9%** **(463 lbs.)**

Statistical analyses on the March 1989 data failed to detect a difference between static and dynamic weights for axle groups ($F(1,582) < 1$, n.s.) or gross weights ($F(1,198) < 1$, n.s.). It appears that the average error is much lower in the current sample; however, the variation has increased substantially. Weights thus seem to be fluctuating quite a bit more, and while the system is more likely to underestimate weight, 37% of the axle groups weighed heavier on the SWIM scale. (Detailed analysis results are presented in Appendix A.)

Weight range analysis. Axle groups were then divided into three different weight ranges for analysis purposes. Means and standard deviations for absolute error and percent error were computed for axle groups within each weight range. The results are presented in Table 3, which also includes results from the previous study for comparison.

Table 3. Weight range analysis

Range	Sample Size	Mean	Standard Deviation
0-10,000 lbs.			
1/88	79	-199 lbs.	138 lbs.
3/88	90	-282 lbs.	155 lbs.
6/88	82	-306 lbs.	161 lbs.
3/89	**52**	**- 58 lbs.**	**260 lbs.**
10-20,000 lbs.			
1/88	156	-1.9% (-236 lbs.)	1.5% (174 lbs.)
3/88	168	-2.6% (-328 lbs.)	1.8% (208 lbs.)
6/88	153	-2.5% (-333 lbs.)	1.4% (193 lbs.)
3/89	**110**	**-0.6% (- 65 lbs.)**	**2.5% (306 lbs.)**
> 20,000 lbs.			
1/88	162	-1.2% (-325 lbs.)	1.0% (256 lbs.)
3/88	200	-1.4% (-380 lbs.)	1.1% (309 lbs.)
6/88	198	-1.8% (-532 lbs.)	0.9% (234 lbs.)
3/89	**130**	**-0.1% (- 51 lbs.)**	**1.3% (366 lbs.)**

Statistical analyses (shown in Appendix A) reveal a nonsignificant tendency for variation to increase for heavier axle groups. This is consistent with previous research, which indicates that the system is generally more accurate weighing heavier axle groups when the error is expressed as a percentage of axle group weight, although absolute error tends to increase with weight.

Frequency analysis. The percentage of vehicles which lie within limits of accuracy (specified as 2% - 6% in the previous investigation) was computed. Results are presented in Table 4. Previous computations are listed for comparison.

Table 4. Frequency analysis -- gross weights

Sample	Proportion Within P% of Mean		
	P = 2%	P = 3%	P = 4%
January 1988	100%	100%	100%
March 1988	99.7%	100%	100%
June 1988	95.9%	100%	100%
March 1989	**96.7%**	**99.9%**	**100%**

As can be seen, results are very similar to those obtained in previous tests.

TEST VEHICLE TESTS

Method

Two vehicles were secured for testing -- one 2-axle (Federal class 3) and one 3-axle (class 4). The availability of these vehicles provided the opportunity to collect repeated measurements of the same weight.

Vehicles were weighed ten times each on the static and SWIM scales. The testing spanned a two-day period. Test vehicle measurements were taken approximately every 1/2 to 1 hour.

Results

Measurement accuracy. In order to assess system accuracy, absolute error and percentage error were calculated using the same methods employed with the random data. Means and standard deviations for absolute error and percent error were then computed for each test vehicle. The results are presented in Tables 5 and 6. Results from the previous study are included in these tables for ease of comparison.

Table 5. Measurement accuracy -- 2 axle test vehicle

Sample	Sample Size	Mean	Standard Deviation
Axle Weights			
1/88	48	-0.9% (-119 lbs.)	0.6% (65 lbs.)
3/89	**20**	**-0.8% (- 95 lbs.)**	**1.0% (143 lbs.)**
Gross Weights			
1/88	24	-1.0% (-281 lbs.)	0.2% (63 lbs.)
3/89	**10**	**-0.8% (-190 lbs.)**	**0.9% (216 lbs.)**

Table 6. Measurement accuracy -- 3 axle test vehicle

Sample	Sample Size	Mean	Standard Deviation
Axle Weights			
1/88	50	-1.1% (-218 lbs.)	0.3% (98 lbs.)
3/89	**20**	**-1.1% (-249 lbs.)**	**1.4% (301 lbs.)**
Gross Weights			
1/88	25	-1.0% (-434 lbs.)	0.2% (87 lbs.)
3/89	**10**	**-1.1% (-498 lbs.)**	**1.1% (509 lbs.)**

Once again, it is observed that while the average error is comparable, the variation has increased substantially. Similar results are obtained when data are broken down by axle type (Table 7). Inferential analyses failed to detect a difference between test vehicles for percent error of gross weight ($F(1,18) < 1$, n.s.) or axle groups ($F(1,38) < 1$, n.s.). Analysis tables are presented in Appendix B.

Table 7. Measurement accuracy by axle type -- 3 axle test vehicle

Axle Type	Sample Size	Mean	Standard Deviation
Single			
1/88	25	-1.1% (-138 lbs.)	0.3% (35 lbs.)
3/89	**10**	**-1.0% (-134 lbs.)**	**1.7% (229 lbs.)**
Tandem			
1/88	25	-1.0% (-298 lbs.)	0.3% (73 lbs.)
3/89	**10**	**-1.1% (-364 lbs.)**	**1.0% (332 lbs.)**

Temperature trends. Unfortunately, there was not sufficient variation in surface temperature during testing to afford meaningful comparisons. Thus, this analysis was not conducted.

PROFILE TESTS

It has been noted that the accuracy of the SWIM system is dependent upon the smoothness of the approach to the scale, and that great care was taken to ensure a level approach and exit (1). These tests were conducted to assess the impact of deliberately raising the approach and exit platforms of the scale.

Method

The two-axle and three-axle test vehicles were used to assess profile effects on the SWIM scale. The relative scale height was incrementally changed by placing plywood boards of varying thickness combinations on either the approach or exit platform of the scale. Test vehicles were driven over the scale at constant speeds; each vehicle was weighed four times per profile condition.

Results

Means and standard deviations of absolute and percent error were calculated for individual axle groups and gross weights for each level. The descriptive information is presented in Tables 8 and 9.

Table 8. Profile effects -- 2 axle test vehicle

Relative	Mean			Standard Deviation		
Scale Height	Axle 1	Axle 2	Gross	Axle 1	Axle 2	Gross
+3/8"	-65	-880	-945	50	125	106
	(-0.7%)	(-4.2%)	(-3.1%)	(0.5%)	(0.6%)	(0.3%)
+ 1/4"	-95	-815	-910	70	75	143
	(-1.0%)	(-3.9%)	(-3.0%)	(0.8%)	(0.4%)	(0.5%)
+ 1/8"	-40	-685	-725	26	19	41
	(-0.4%)	(-3.2%)	(-2.4%)	(0.3%)	(0.1%)	(0.1%)
+ 1/16"	-50	-365	-415	16	157	173
	(-0.6%)	(-1.7%)	(-1.4%)	(0.2%)	(0.7%)	(0.6%)
0"	-85	90	5	57	186	238
	(-0.9%)	(0.4%)	(0.0%)	(0.6%)	(0.9%)	(0.8%)
-1/16"	-70	-35	-105	69	144	80
	(-0.8%)	(-0.2%)	(-0.3%)	(0.8%)	(0.7%)	(0.3%)
-1/8"	-85	30	-55	57	123	158
	(-0.9%)	(0.1%)	(-0.2%)	(0.6%)	(0.6%)	(0.5%)
-1/4"	-65	35	-30	30	34	52
	(-0.7%)	(0.2%)	(-0.1%)	(0.3%)	(0.2%)	(0.2%)
-3/8"	-125	-165	-290	136	145	155
	(-1.4%)	(-0.8%)	(-0.9%)	(1.5%)	(0.7%)	(0.5%)

Table 9. Profiie effects -- 3 axle test vehicle

Relative	Mean			Standard Deviation		
Scale Height	Axle 1	Axle 2	Gross	Axle 1	Axle 2	Gross
+3/8"	-30	-635	-665	71	153	201
	(-0.2%)	(-1.9%)	(-1.4%)	(0.5%)	(0.4%)	(0.4%)
+ 1/4"	-25	-365	-390	44	114	81
	(-0.2%)	(-1.1%)	(-0.8%)	(0.3%)	(0.3%)	(0.2%)
+ 1/8"	-110	-220	-330	33	121	114
	(-0.8%)	(-0.6%)	(-0.7%)	(0.2%)	(0.4%)	(0.2%)
+ 1/16"	-400	-905	-1305	247	704	939
	(-2.8%)	(-2.7%)	(-2.7%)	(1.7%)	(2.1%)	(2.0%)
0"	-175	-150	-325	55	214	233
	(-1.2%)	(-0.4%)	(-0.7%)	(0.4%)	(0.6%)	(0.5%)
-1/16"	-250	-190	-440	177	112	252
	(-1.7%)	(-0.6%)	(-0.9%)	(1.2%)	(0.3%)	(0.5%)
-1/8"	-75	-5	-80	81	81	161
	(-0.5%)	(0.0%)	(-0.2%)	(0.6%)	(0.2%)	(0.3%)
-1/4"	-160	-55	-215	101	118	148
	(-1.1%)	(-0.2%)	(-0.4%)	(0.7%)	(0.3%)	(0.3%)
-3/8"	-115	40	-75	81	222	223
	(-0.8%)	(0.1%)	(-0.2%)	(0.6%)	(0.7%)	(0.5%)

Mean error in pounds is depicted in Figures 1 through 4. It is immediately apparent that the SWIM system is much more subject to error when the height of the leading edge is altered. Curiously, it appears that error and variance are not at their lowest point when the scale height is at 0. Rather, closest estimates of static weight were obtained between -1/4" and -1/8" for both test vehicles.

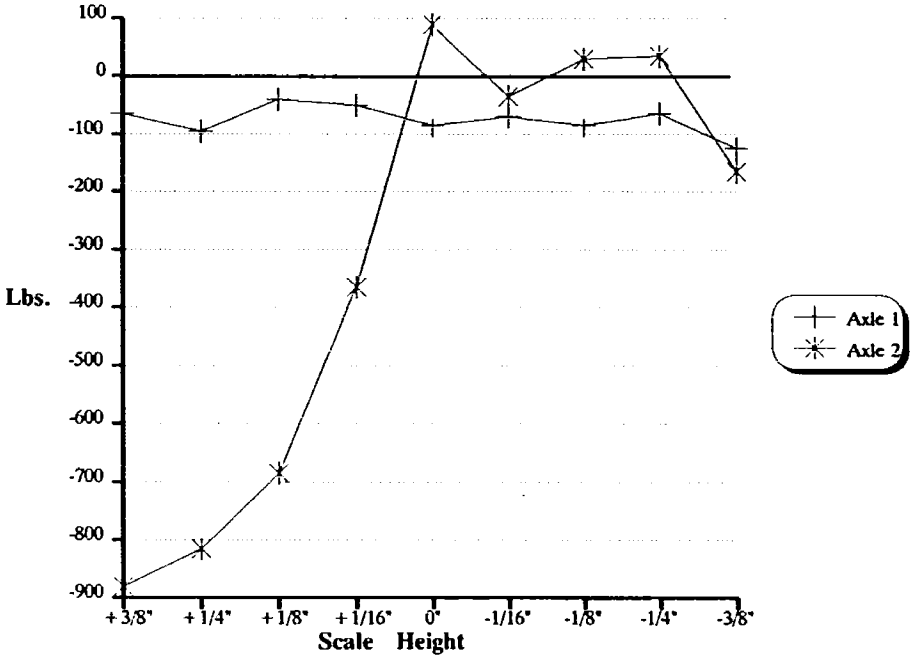

Figure 1. Profile effects by axle -- 2 axle test vehicle

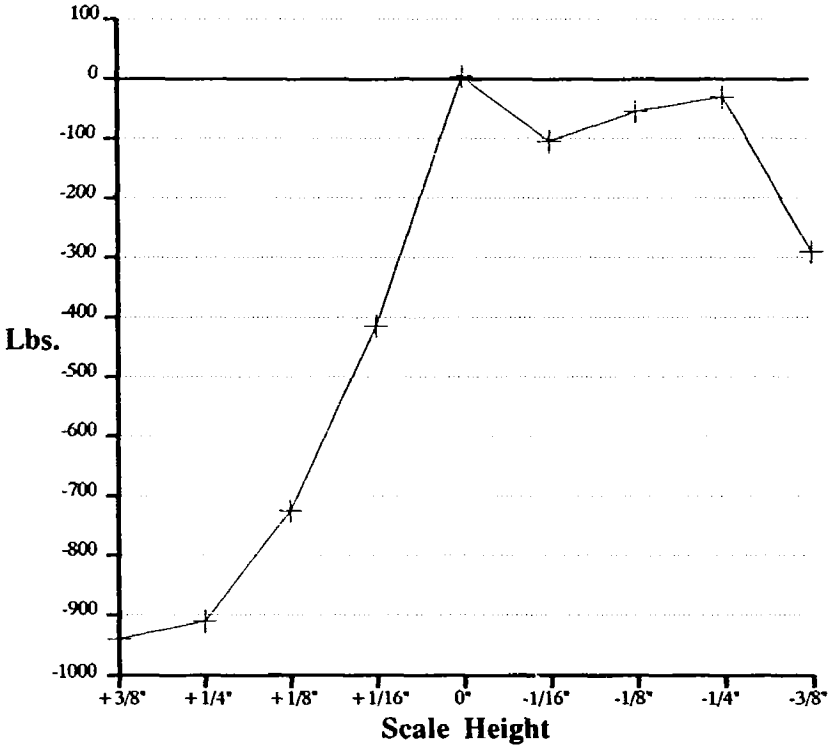

Figure 2. Profile effects (gross weight) -- 2 axle test vehicle

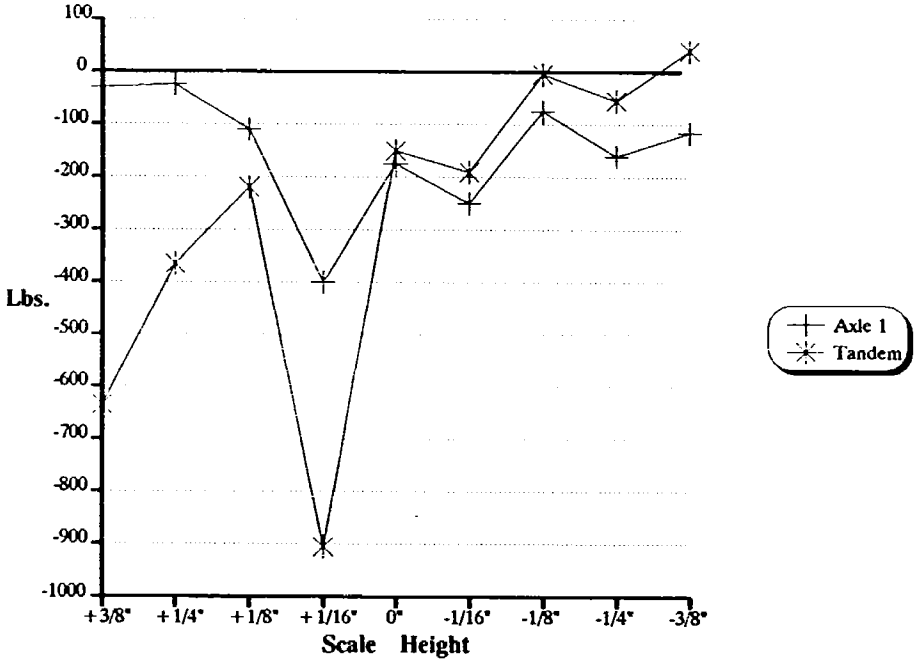

Figure 3. Profile effects by axle group -- 3 axle test vehicle

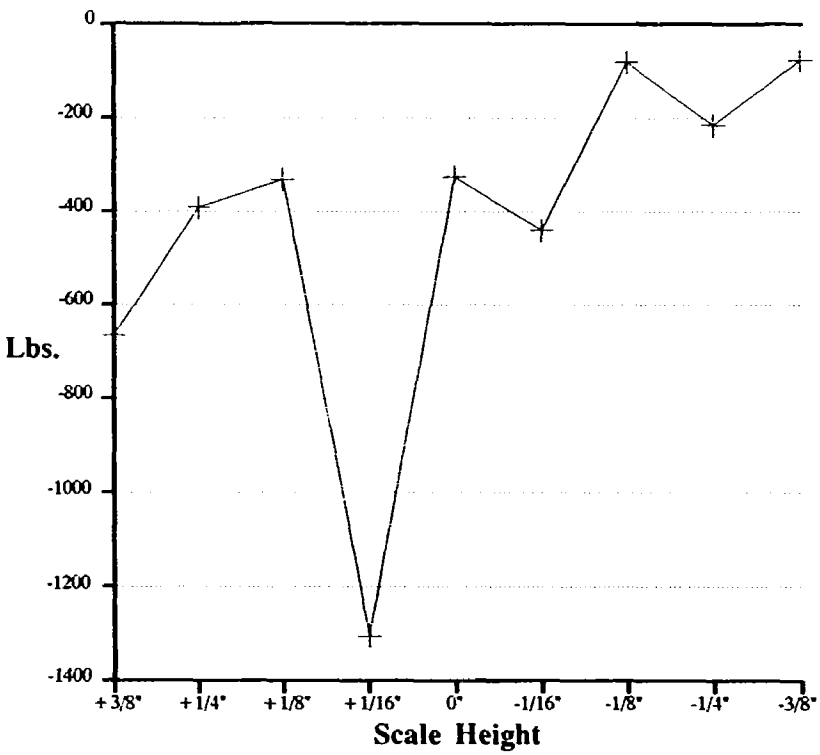

Figure 4. Profile effects (gross weight) -- 3 axle test vehicle

CONCLUSION

Taken together, these data suggest that the SWIM scale is not performing as well as it has in the past. The mean weight differences appear smaller than those previously reported, but the variation has increased substantially. On a case by case basis, it was observed that SWIM gross weights could deviate up to 10% from static weights, although only 4% of the gross weights in the random sample deviated from static weight by 5% or more.

Currently, the Arizona Department of Weights and Measures has no certification standard for weigh-in-motion scales. If the stringent criteria which are applied to static scales were used -- acceptance tolerance within .01% for new scales, maintenance tolerance within .02% for previously tested scales--these tests indicate that the Weighwrite SWIM scale at Ehrenberg would not fall within acceptable limits. Thus, as indicated in the Castle Rock report (1), this suggests that SWIM scales should be subjected to different certification criteria.

REFERENCE NOTES

(1) Castle Rock Consultants. **Port of Entry Weigh-in-Motion Feasibility Study: Draft Final Report.** Prepared for Arizona Department of Transportation, July 1988. HPR-PL-1-31 (702).

APPENDIX A

Statistical Analysis Tables
Random Vehicle Tests

ANALYSIS OF VARIANCE
Axle Groups--Random Vehicles

Cell Means and Standard Deviations

Variable .. WEIGHT

FACTOR	Mean	Std. Dev.	N
STATIC	19759.041	10391.034	292
SWIM	19701.644	10378.551	292
For entire sample	19730.342	10375.924	584

*** * ANALYSIS OF VARIANCE -- DESIGN 1 * ***

Tests of Significance for WEIGHT using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	62765182142	582	107843956		
CONSTANT	2.27343E + 11	1	2.273E + 11	2108.08	.000
SCALE	480989.04	1	480989.04	.00	.947

ANALYSIS OF VARIANCE
Gross Weights--Random Vehicles

Cell Means and Standard Deviations

Variable .. GROSS

FACTOR	Mean	Std. Dev.	N
STATIC	57687.400	18056.705	100
SWIM	57528.800	18004.447	100
For entire sample	57608.100	17985.410	200

*** * ANALYSIS OF VARIANCE -- DESIGN 1 * ***

Tests of Significance for GROSS using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	64370264780	198	325102347		
CONSTANT	6.63739E+11	1	6.637E+11	2041.63	.000
SCALE	1257698.00	1	1257698.0	.00	.950

WEIGHT RANGE ANALYSIS
Random Vehicles

Cell Means and Standard Deviations

Variable .. AXLE DIFFERENCE

FACTOR	Mean	Std. Dev.	N
0-10,000 lbs.	-58.462	260.432	52
10-20,000 lbs.	-64.545	305.805	110
> 20,000 lbs.	-50.923	365.845	130
For entire sample	-57.397	326.015	292

*** * ANALYSIS OF VARIANCE -- DESIGN 1 * ***

Tests of Significance for AXLE DIFFERENCE using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	30918093.43	289	106983.02		
CONSTANT	839997.81	1	839997.81	7.85	.005
WEIGHT RANGE	11128.49	2	5564.25	.05	.949

APPENDIX B

Statistical Analysis Tables
Test Vehicle Tests

ANALYSIS OF VARIANCE
Gross Weights--Test Vehicles

Cell Means and Standard Deviations

Variable .. % GROSS DIFFERENCE

FACTOR	Mean	Std. Dev.	N
2 AXLE	-.757	.871	10
3 AXLE	-1.075	1.103	10
For entire sample	-.916	.981	20

*** * ANALYSIS OF VARIANCE -- DESIGN 1 * ***

Tests of Significance for % GROSS DIFFERENCE using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	17.78	18	.99		
CONSTANT	16.80	1	16.80	17.01	.001
TRUCK	.51	1	.51	.51	.484

ANALYSIS OF VARIANCE
Axle Groups--Test Vehicles

Cell Means and Standard Deviations

Variable .. % AXLE DIFFERENCE

FACTOR	Mean	Std. Dev.	N
2 AXLE	- .815	.986	20
3 AXLE	-1.057	1.380	20
For entire sample	- .936	1.190	40

*** * ANALYSIS OF VARIANCE -- DESIGN 1 * ***

Tests of Significance for % AXLE DIFFERENCE using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	54.66	38	1.44		
CONSTANT	35.06	1	35.06	24.37	.000
TRUCK	.58	1	.58	.41	.528

APPENDIX C

Raw Data

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/8/89

NO.	TRUCK ID	CLASS	TIME*	1ST AXLE 1	TANDEM 1 2	TANDEM 2 3	4	5	GROSS	OVERSPEED (Y/N)
✓1 static	JB HUNT	9	10:42	11380	21420	16680			49480	
SWIM				11500	21600	16900			50000	
✓2 static	WHITE	4	10:55	14300	34300				48600	
SWIM				14080	33100				47180	
✓3 static	AMERICAN MOVERS	9	11:00	8980	26160	20740			55880	
SWIM				9060	25460	20620			55140	
✓4 static	MAROON	9	11:15	11080	23780	25460			60320	
SWIM				11080	23160	25460			59700	
✓5 static	MILLIS TRANSFER	9	11:17	11540	28180	26120			65840	
SWIM				11740	27840	26360			65940	
✓6 static	NORTH AMERICAN	9	11:21	6200	23080	17500			46780	
SWIM				6200	23240	17500			46940	
✓7 static	WHITE TANKER	9	11:22	9100	12520	9580			31200	
SWIM				9280	12520	9860			31660	

* OF STATIC WEIGHT MEASUREMENT

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/8/89

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓8 static	PETROLEUM DELIVERY	9	11:26	12560	34020	33420			80000	
SWIM	TANKER			12520	33200	33660			79380	
✓9 static	AUTO CARRIERS INC	9	11:28	10300	27240	20420			57960	
SWIM				10360	27000	20400			57760	
✓10 static	GRAEBEL VAN LINES	9	11:32	9860	23280	21300			54440	
SWIM				10000	23080	21300			54380	
✓11 static	TUCKER	9	11:34	10200	33180	32920			76300	
SWIM				10080	32520	33460			76060	
X 12 static	TRANSNATIONAL WHITE FREIGHTLINER	9	11:38	10260	31920	31220			73400	NOT WEIGHED
SWIM				—NONE—					——	
✓13 static	WILLIAM HUNT TRANSPORTATON	9	11:39	10280	22460	15140			47880	
SWIM				10020	22380	15500			47900	
✓14 static	THRIFTY	251-2 10	11:40	10280	12860	32240			55380	
SWIM				9700	13220	31920			54840	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/8/89

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓15 static	NORTHERN AUTOMOTIVE	251-2	11:43	8600	11060	20240		.	39900	
SWIM		10		8780	10520	20280			39580	
✓16 static	MONT J. WILLIAMS	9	11:47	12360	34120	33840			80320	
SWIM				12120	34160	33900			80180	
✓17 static	JOSEPH LAND	9	12:33	10840	34580	30660			76080	
SWIM				10760	33580	31060			75400	
✓18 static	PARKWAY DISTRIBUTORS	9	12:35	11120	28300	25580			65000	
SWIM				11020	28280	25680			64980	
✓19 static	J & Y TRANSPORT	9	12:40	10180	22880	20240			53300	
SWIM				10040	22740	20040			52820	
✓20 static	BUILDERS EMPORIUM	10	12:40	9880	12940	29580			52400	
SWIM				9160	13520	29200			51880	
X21 static	VALLEY TRUCKING	9	12:41	10440	19540	17580			47560	(YES)
SWIM				— NONE —					—	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/8/89

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓22 static	WIND RIVER TRUCKING FLATBED	9	1:04	10840	21060	9400			41300	
SWIM				10860	20880	9360			41100	
✓23 static	WHITE	2D (3)	1:06	6320	7900				14220	
SWIM				6320	7960				14280	
✓24 static	DLB	9	1:10	11020	30220	25680			67120	
SWIM				11300	29560	26320			67180	
✓25 static	MERIT	9	1:15	10600	33040	31540			75180	
SWIM				10440	32760	32060			75260	
✓26 static	AZ RIVER TRANSPORT	6	1:17	8460	8040	5500			22000	
SWIM		2S1		8180	8360	5380			21920	
✓27 static	STANLEY TRUCKING	9	1:18	10740	33840	29760			74380	
SWIM				10100	33960	29720			73780	
✓28 static	CEMENT TRUCK	4 3D	1:30	13800	26000				39800	
SWIM				13740	25500				39240	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/8/89

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓29 static	31 FLAVORS	251-2	1:24	9840	17440	39900			67180	
SWIM		10		9720	17020	39780			66520	
✓30 static	DON'S TRUCKING	9	1:25	11260	14100	9020			34380	
SWIM				11200	13860	9540			34600	
✓31 static	JB HUNT	9	1:38	10660	33600	33100			77360	
SWIM				10580	33580	33040			77200	
✓32 static	TRAILBLAZER	9	1:39	11100	33700	34080			78880	
SWIM				10820	33580	34020			78420	
✓33 static	BOR-AIR NYCON	9	1:40	10660	22380	10980			44020	
SWIM				10600	22380	11220			44200	
✓34 static	MAY & SON	9	1:42	11500	34600	33460			79560	
SWIM				11160	34140	33540			78840	
35 static	ALMAS INTERNATIONAL	(3) 20	2:03	8540	17360				25900	
✓SWIM				8240	16840				25080	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/8/89

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
36 static	SWIFT	9	2:03	10660	12200	9540			32400	
SWIM				10580	12000	9940			32520	
37 static	HAGEN INC.	9	2:04	12000	28120	27000			67120	
SWIM				11880	27720	27760			67360	
38 static	AJF SOUTHWEST CANNING	9	2:10	10140	14000	14760			38900	
SWIM				9540	13120	14420			37080	
39 static	ROADWAY	251-2	2:11	9020	16400	32720			58140	
SWIM		10		8920	16060	32620			57600	
40 static	TRANSPORT COMMODITIES FLATBED	9	2:13	9860	32260	30860			72980	
SWIM				9260	32960	30780			73000	
41 static	RYDER	3 2D	2:17	3980	6840				10820	
SWIM				3940	6760				10700	
42 static	UNITED VAN LINES	9	2:19	10200	23880	24740			58820	
SWIM				10320	23500	24760			58580	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/9/89

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓43 static	ARCADIAN	9	9:56	11860	30640	25800			68300	
SWIM				11680	30480	25820			67980	
✓44 static	R.E. GARRISON	9	9:57	11500	34440	31720			77660	
SWIM				11400	34100	31920			77420	
✓45 static	CAROLINA	9	10:00	11040	21600	18320			50960	
SWIM				11260	21480	18420			51160	
✓46 static	SWIFT	3-2	10:01	12120	24540	30900			67560	
SWIM		99		12280	24160	30680			67120	
✓47 static	FALCON	3-2	10:03	11020	29980	34860			75860	
SWIM		99		10820	29480	34440			74740	
✓48 static	SELF-LEVELING LOAD PETROLANE (PROPANE)	2D	10:10	6880	18180				25060	
SWIM		3		6840	17980				24820	
✓49 static	ALANTON INC.	9	10:13	11220	21040	14520			46780	
SWIM				11220	20680	14640			46540	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/9/89

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓50 static	BUDWEISER	251 6	10:32	6660	13740	11840			32240	
SWIM				6600	13380	11740			31720	
✓51 static	LINDA LINES	9	10:33	10800	31320	25820			67940	
SWIM				10420	31300	25860			67580	
✓52 static	MERCADO LATINO	9	10:40	9340	24600	22540			56480	
SWIM				9160	24620	23160			56940	
✓53 static	UPS	251-2 10	10:41	10200	14200	26420			50820	
SWIM				9180	14840	26300			50320	
✓54 static	GREAT WESTERN MEAT	9	10:42	11740	28600	24240			64580	
SWIM				11660	28320	24340			64320	
✓55 static	MCINVALE	9	10:45	9300	19020	17220			45540	
SWIM				9120	19020	17200			45340	
✓56 static	REZZONICO	251-2 10	11:37	9340	16660	49780			75780	
SWIM				9020	17160	49300			75480	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

3/9/89

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓57 static	WATKINS	251-2	11:38	12020	17220	41680			70920	
SWIM		10		11920	16900	41660			70480	
✓58 static	NORTH AMERICAN	9	11:39	9120	17160	13040			39320	
SWIM				9300	17200	13220			39720	
✓59 static	GARRISON	9	11:42	9860	28120	27260			65240	
SWIM				TRAILER AXLES OFF SCALE					—	
✓60 static	BROWN TRANSPORT	351-2	11:43	10620	23880	42360			76860	
SWIM		12		9760	24600	42040			76400	
✓61 static	COPA FUEL	3-2	11:47	10620	33320	36500			80440	
SWIM		99 SALE		10900	33760	36300			80960	
✓62 static	SOUTHWEST TRANSPORTATION	9	11:48	10540	24840	16780			52160	
SWIM				10460	24560	17280			52300	
✓63 static	STIDHAM FLATBED	9	11:52	11820	32220	33080			77120	
SWIM				11700	31980	32980			76560	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓64 static	TEXAS AMERICAN EXPRESS	9	11:53	10500	30680	32920			74100	
SWIM				10140	30760	33240			74140	
✓65 static	LEICHT MAYFLOWER	9	11:55	9800	24200	20720			54720	
SWIM				10000	24020	20660			54680	
✓66 static	HERT TRUCKING	2S1-2 10	12:00	8360	19540	52100			80000	
SWIM				8280	19360	51760			79400	
✓67 static	CON-WAY WESTERN EXPRESS	2S1 6	12:01	7140	9140	5480			21760	
SWIM				7080	9160	5460			21700	
✓68 static	PST VANS	9	12:02	11560	21540	19920			52020	
SWIM				11280	22220	19480			52980	
✓69 static	BAGGETT	9	12:06	9960	20500	18180			48640	
SWIM				10000	20560	18320			48880	
✓70 static	SHAMROCK FOODS TANKER	9	12:07	11360	33460	34900			79720	
SWIM				11760	33280	35020			80060	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓ 71 static	SWIFT	9	12:08	9880	32220	33340			75440	
SWIM				9680	32400	33680			75760	
✓ 72 static	CAT PLUS	2D 3	12:10	3780	6360				10140	
SWIM				3740	6340				10080	
✓ 73 static	THRIFTY	251-2 10	12:11	9880	16220	31780			57880	
SWIM				9720	16500	31600			57820	
✓ 74 static	MC KELVEY TRUCKING	9	12:12	11380	31140	33060			75580	
SWIM				11400	31200	32960			75560	
X 75 static	RELIABLE	9	1:05	— NO STATIC WEIGHT —						
SWIM										
✓ 76 static	RYDER	9	1:05	11160	25380	33700			70240	
SWIM				11300	25720	33940			70960	
✓ 77 static	SOUTHWEST MOTOR FREIGHT	9	1:08	10300	20600	20400			51300	
SWIM				10180	20920	21060			52160	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
78 static	YELLOW	10	1:09	9660	16160	40940			66760	
SWIM				9720	15980	41120			66820	
79 static	NASHVILLE TRUCKING	9	1:12	9520	31160	19200			59880	
SWIM				9660	30700	19600			59960	
80 static	OAKLEY TANKER	9	1:14	12200	34300	33140			79640	
SWIM				12120	33540	33260			78920	
81 static	GIBSON	9	1:15	10300	32120	26000			68420	
SWIM				10340	32020	26520			68680	
82 static	R&A TRUCKING	9	1:16	10800	14760	31580			57140	
SWIM				10840	14420	31940			57200	
83 static	BINGHAM	2516	1:20	8840	11100	9720			29660	
SWIM				8520	11500	9560			29580	
84 static	MONKEM	9	1:21	11320	34160	33300			78780	
SWIM				11200	34160	33280			78640	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
85 static	CONSOLIDATED FREIGHT	2S1-2	1:22	10580	18580	42320			71480	
SWIM		10		10540	18440	42020			71000	
86 static	ARROW AIR SUSPENSION	9	1:27	10520	15060	40120			65700	
SWIM				10220	14860	39980			65060	
87 static	CANTLAY TANKER	5 AXLE 3-2	1:28	10000	32860	36680			79540	
SWIM		99		9500	33060	36600			79160	
88 static	GRADY SHRIVES TRUCKING	9	1:30	9480	26940	16400			52820	
SWIM				9500	26760	16680			52940	
89 static	ALLIED VAN LINES	9	1:32	11180	24620	26860			62660	
SWIM				11220	24160	26960			62340	
90 static	INTERNAT. TRANSPORT FLATBED	9	1:33	10800	26380	21620			58800	
SWIM				11200	26660	21480			59340	
91 static	INTERNAT TRANSPORT #569 FLATBED	9	1:34	10280	23400	16320			50000	
SWIM				9780	24020	16160			49960	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
92 static	CHEVRON	3D	1:37	12300	32440				44740	
SWIM		4		12200	32240				44440	
93 static	SUNDANCE	9	1:38	8800	33720	33360			75880	
SWIM				8720	33980	33680			76380	
94 static	LAURA SCUDDERS	251	1:39	9160	13580	12580			35320	
SWIM		6		8960	13600	12480			35040	
95 static	IRON HORSE TANKER	9	1:54	11160	33660	34320			79140	
SWIM				11020	33500	34960			79480	
96 static	TJ'S TRANSPORT	9	1:55	11280	13980	9460			34720	
SWIM				11240	14220	9900			35360	
97 static	INTERIOR TURF	251	1:56	8880	10560	11340			30780	
SWIM		6		8420	11160	10980			30560	
98 static	WESTERN HYWAY TANKER	3-2 99 5 AXLE	2:00	10300	32980	36000			79280	
SWIM				10200	32360	35240			78300	

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

RANDOM VEHICLE TEST

NO.	TRUCK ID	CLASS	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
99 static	JB HUNT	9	2:01	9140	16780	15880			41800	
SWIM				9340	16500	16300			42140	
100 static	WATKINS	251-2 10	2:02	9960	16500	42000			68460	
SWIM				9320	16780	41840			67940	
101 static	TNT BESTWAY	351-2 12	2:03	8360	20840	45560			74760	
SWIM				8060	21240	45040			74340	
102 static	NORTH AMERICAN	9	2:07	9520	25860	24460			59840	
SWIM				9720	25880	24700			60300	
103 static	E W EAST WEST	9	2:08	10160	24580	22500			57240	
SWIM				10120	24240	23100			57460	
104 static	HAY	251-2 10	2:09	9020	17040	48000			74060	
SWIM				8740	17060	47480			73280	
105 static										
SWIM										

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

TEST VEHICLE TEST

VEHICLE: ZD (03) 3/8/89

MEASUREMENT NO.	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓1 static	12:05	8640	16120				24760	
SWIM 12:15 710		8600	16540				25140	
✓2 static	12:55	8560	16540				25100	
SWIM 1:00 114		8460	16400				24860	
✓3 static	1:55	8600	16520				25120	
SWIM 116		8440	16420				24860	
✓4 static	2:27	8540	16460				25000	
SWIM ~~#6~~ 98		8500	16280				24780	3/9/89
✓5 static	9:46	8560	16500				25120	
SWIM 89		8400	16300				24700	
✓6 static	10:15	8540	16600				25140	
SWIM 96		8420	16460				24880	
7 static	11:25	8500	16440				24940	
SWIM 11:35 106		8500	16340				24840	

* OF STATIC WEIGHT MEASUREMENT

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

TEST VEHICLE TEST

VEHICLE: ZD (03) 3/8/89

MEASUREMENT NO.	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
8 static	12:18	8520	16400				24920	
SWIM 113		8380	16360				24740	
9 static	1:03	8540	16420				24960	
SWIM 114		8460	16200				24660	
10 static	1:47	8500	16360				24860	
SWIM 113		8480	16080				24560	
11 static								
SWIM								
12 static								
SWIM								
13 static								
SWIM								
14 static								
SWIM								

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

TEST VEHICLE TEST

VEHICLE: 3D (04) 3/8/89

MEASUREMENT NO.	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
✓ 1 static	12:05	13220	33280				46500	
SWIM 12:15		13180	33100				46280	
✓ 2 static	12:55	13180	33220				46400	
SWIM		13420	32880				46300	
✓ 3 static	1:55	13200	33280				46480	
SWIM		13200	32960				46160	
✓ 4 static	2:25	13240	33140				46380	
SWIM		13000	32820				45820	3/9/89
✓ 5 static	9:45	13200	33320				46520	
SWIM		12740	32940				45680	
✓ 6 static	10:15	13200	33140				46340	
SWIM		13140	32840				45980	
7 static	11:25	13140	33020				46160	
SWIM		13020	32600				45620	

* OF STATIC WEIGHT MEASUREMENT

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) TEST
JANUARY, 1989

TEST VEHICLE TEST

VEHICLE: 3D (04) 3/8/89

MEASUREMENT NO.	TIME*	1	2	3	4	5	GROSS	OVERSPEED (Y/N)
8 static	12:18	13200	33000				46200	
SWIM		12680	31780				44460	
9 static	1:03	13160	32940				46100	
SWIM		12980	32700				45680	
10 static	1:47	13220	32920				46140	
SWIM		13260	33000				46260	
11 static								
SWIM								
12 static								
SWIM								
13 static								
SWIM								
14 static								
SWIM								

#1

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) STUDY

JANUARY, 1989

PROFILE TEST

VEHICLE: 2D (3)

LEADING EDGE (ENTRANCE)	STEERING AXLE	TANDEM	GROSS
0	9080	21500	30580
+1/16" 1	9020	20560	29580
+1/8" 2	9020	20420	29440
+1/4" 3	9080	20380	29460
+3/8" 4	9040	20280	29320

TRAILING EDGE (EXIT)	STEERING AXLE	TANDEM	GROSS
- 1/16" -1	9120	20880	30000
-1/8" -2	9080	21160	30240
-1/4" -3	9060	21160	30220
-3/8" -4	9100	20760	29860

#2

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) STUDY

JANUARY, 1989

PROFILE TEST

VEHICLE: 2D(3)

LEADING EDGE (ENTRANCE)	STEERING AXLE	TANDEM	GROSS
0	9020	21120	30140
+1/16"	9040	20760	29800
+1/8"	9040	20460	29500
+1/4"	8960	20260	29220
+3/8"	9020	20380	29400

TRAILING EDGE (EXIT)	STEERING AXLE	TANDEM	GROSS
- 1/16"	8960	21160	30120
-1/8"	9020	21320	30340
-1/4"	9000	21180	30180
-3/8"	8780	20980	29760

#3

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) STUDY

JANUARY, 1989

PROFILE TEST

VEHICLE: 2D (3)

LEADING EDGE (ENTRANCE)	STEERING AXLE	TANDEM	GROSS
0	8960	21120	30080
+1/16"	9060	20940	30000
+1/8"	9080	20460	29540
+1/4"	9020	20380	29400
+3/8"	9080	20080	29160

TRAILING EDGE (EXIT)	STEERING AXLE	TANDEM	GROSS
- 1/16"	9000	21180	30180
-1/8"	8960	21020	29980
-1/4"	9000	21120	30120
-3/8"	8960	21020	29980

#4

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) STUDY

JANUARY, 1989

PROFILE TEST

VEHICLE: 2D(3)

LEADING EDGE (ENTRANCE)	STEERING AXLE	TANDEM	GROSS
0	8960	21140	30100
+1/16"	9040	20800	29840
+1/8"	9060	20440	29500
+1/4"	8920	20240	29160
+3/8"	8960	20260	29220

TRAILING EDGE (EXIT)	STEERING AXLE	TANDEM	GROSS
- 1/16"	9000	21160	30160
-1/8"	8960	21140	30100
-1/4"	9040	21200	30240
-3/8"	9020	21100	30120

#1

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) STUDY

JANUARY, 1989

PROFILE TEST

VEHICLE: 3D (4)

LEADING EDGE (ENTRANCE)	STEERING AXLE	TANDEM	GROSS
0	14080	33240	47320
+1/16"	13840	32840	46680
+1/8"	14180	33300	47480
+1/4"	14220	33360	47580
+3/8"	14200	32840	47040

TRAILING EDGE (EXIT)	STEERING AXLE	TANDEM	GROSS
- 1/16"	13800	33460	47260
-1/8"	14300	33780	48080
-1/4"	14100	33800	47900
-3/8"	14220	34000	48220

#2

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) STUDY

JANUARY, 1989

PROFILE TEST

VEHICLE: 3D(4)

LEADING EDGE (ENTRANCE)	STEERING AXLE	TANDEM	GROSS
0	14180	33510	47720
+1/16"	13660	32300	45960
+1/8"	14220	33480	47700
+1/4"	14280	33360	47640
+3/8"	14300	33200	47500

TRAILING EDGE (EXIT)	STEERING AXLE	TANDEM	GROSS
- 1/16"	14220	33580	47800
-1/8"	14120	33600	47720
-1/4"	14280	33600	47880
-3/8"	14180	33570	47700

#3

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) STUDY

JANUARY, 1989

PROFILE TEST

VEHICLE: 3D(4)

LEADING EDGE (ENTRANCE)	STEERING AXLE	TANDEM	GROSS
0	14140	33720	47860
+1/16"	14240	33760	48000
+1/8"	14180	33520	47700
+1/4"	14320	33160	47480
+3/8"	14340	33080	47420

TRAILING EDGE (EXIT)	STEERING AXLE	TANDEM	GROSS
- 1/16"	14100	33600	47700
-1/8"	14260	33720	47980
-1/4"	14060	33620	47680
-3/8"	14060	33820	47880

#4

EHRENBERG PORT OF ENTRY SLOW SPEED WEIGH-IN-MOTION (SWIM) STUDY

JANUARY, 1989

PROFILE TEST

VEHICLE: 3D(4)

LEADING EDGE (ENTRANCE)	STEERING AXLE	TANDEM	GROSS
0	14060	33660	47720
+1/16"	13820	32240	46060
+1/8"	14140	33580	47720
+1/4"	14240	33420	47660
+3/8"	14200	33100	47300

TRAILING EDGE (EXIT)	STEERING AXLE	TANDEM	GROSS
- 1/16"	14040	33360	47400
-1/8"	14180	33640	47820
-1/4"	14080	33520	47600
-3/8"	14240	33580	47820