NFPA Committee on Fire Apparatus
FIREFIGHTER TREAD PLATE SLIP RESISTANCE STUDY

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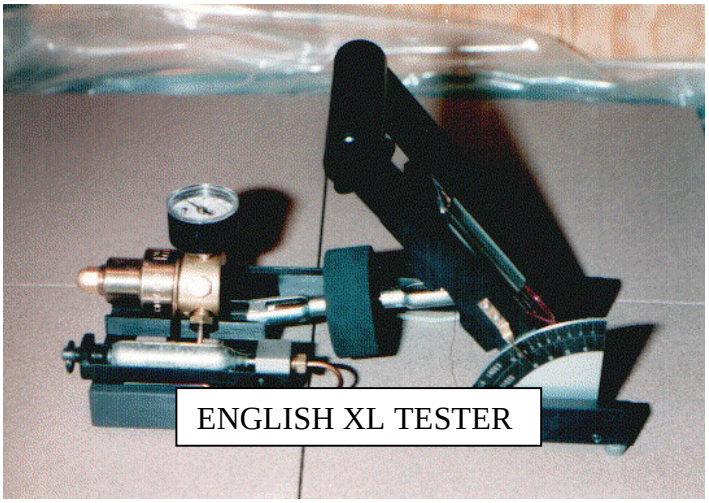
BACKGROUND

Continued concern for reducing the potential for slip and fall accident occurrence of fire truck apparatus has lead the National Fire Protection Association (NFPA) Committee on Fire Apparatus towards establishing a slip resistance criteria standard. Safety Officer Robert Tutterow, Chairman of the Safety Task Group of the NFPA 1901 Technical Committee on "Fire Apparatus", advises that the Charlotte Fire Department has estimated that one injury per week is attributed to an accident in or around fire apparatus. Concern for slip and fall accidents involving firefighters on fire truck apparatus led the Committee on Fire Apparatus to begin to study the slip resistance of various tread plate and walking surface materials presently used, as well as those proposed as improved surfaces for consideration for use on fire truck walking surfaces.

As safety consultant and researcher specialized in slip resistance, and chairman of the ASTM F13 Committee on "Safety and Traction for Footwear", I was contacted by the NFPA Safety Task Group for consultation. The NFPA Committee Safety Task Group, chaired by Safety Officer Robert Tutterow, was provided a demonstration of various slip testing devices which were considered to have potential for testing of wet surfaces at their San Jose Meeting on April 5, 1997. Both the English XL (VIT) (ASTM F1679) and the Brungraber Mark II (PIAST) (ASTM F1677) testers were illustrated for use due to their specific ability to be used for wet surface testing. These testers are recognized by ASTM Committee F13 to be suitable for use for wet testing, are portable, apply forces to the surface

when wet without "sticktion effects", and have ASTM F13 Standards associated with their use. The task group was advised that the precision and bias statements for the equipment had not yet been completed and was in process although the early tests were encouraging. Further it was explained that it was not known whether the testers would be helpful for evaluation of such coarse and aggressive surfaces as those considered for this application. In addition, the size of the sensor used by the slip tester on the surface would need to contact enough of the material area to get a representative sampling. (The Mark II tester uses a 3" x 3" square sensor and the English XL uses a 1-1/4" diameter, round sensor.)

The NFPA Safety Task Group, during their meeting in San Jose, had decided to proceed with a study in two phases. First, the tread surface materials of interest were to be evaluated with both of the recommended slip testing devices to measure the slip resistance associated with the materials. Then, the second phase of the study would obtain subjective firefighter evaluation of the surface materials to help determine what level of slip resistance would be considered safe for firefighter use. The evaluation of the surface materials was to involve actual firefighters, with footwear used in the field, to assess the tread surfaces by walking on the surfaces, subjectively rank ordering the surfaces from least to most slippery, and by then providing a subjective determination as to which surface represented a surface deemed adequately safe for use. It was contemplated that the corresponding slip resistance reading could then be specified in establishing a performance standard for the slip resistance of fire apparatus.


ENGLISH XL TESTER

This study was intended to be a cooperative effort which would involve firefighters from several departments. Many thanks to Dave Underwood, Ph.D. for his assistance in statistical analysis; Safety Officer Robert Tutterow; Captain Gary Pope; and the men and women firefighters who devoted their time and efforts towards assisting in this project.

TEST PLATFORM & EQUIPMENT

The work began in Fairfax County, Virginia as Captain Gary Pope of the Fairfax County Fire and Rescue collected suitable tread surface materials, designed a custom welded platform rig suitable to mount the surfaces at step and platform heights, and was to begin a pilot test study with firefighters. Captain Pope's efforts completed two 10' x 24" platform rigs elevated at approximately 24 inches. Captain Pope installed two steps on the side of each rig, with a handrail, to provide step type use and firefighter evaluation of the test surface materials which were inserted into the frame. In addition, the rig was outfitted with automated spray heads for maintaining the surfaces wet while firefighters walked on various surfaces and evaluated the surfaces. Captain Pope designed the testers evaluation forms and provided sample tester instructions. After his use in a pilot study, he transported the rig and surfaces for further testing to Safety Officer Robert Tutterow, Occupational, Safety, and Health, Charlotte Fire Department.

Charlotte Fire Department provided a warehouse facility to set up the two platform rigs provided. The two rigged platforms were fitted with 10 test surfaces, five on each rig platform. The test surfaces provided included five solid and five perforated surfaces. The surfaces included aluminum, wood and steel materials. Polished diamond plate aluminum, was identified as test surface "B" in the study. A listing of the surface descriptions is provided in Table "A". Each platform test surface measured approximately 24" x 24". Smaller step surfaces of the same materials were inserted into the step frame which could be easily interchanged for an alternate test surface during testing. Each rig was leveled, the surfaces were scrubbed with a degreaser, and the surfaces were hosed clean.

CHARLOTTE EVALUATION

On December 2, 1997, Safety Officer Robert Tutterow set the rig up and prepared the surfaces with William Marletta who performed testing of the surfaces with the Mark II and English XL testers in both the dry and wet conditions with Neolite sensor material.

Subjective evaluation was performed using 16 fire fighters ranking of wet and dry surfaces. Fire fighters were all career fire fighters wearing Warrington Pro 14" pull on leather boots. Testing was performed on a sunny day with temperatures in the upper 40's and humidity around 70%. Firefighters were asked to rank order the materials from 1 to 10 with "1" being the most slip resistant.

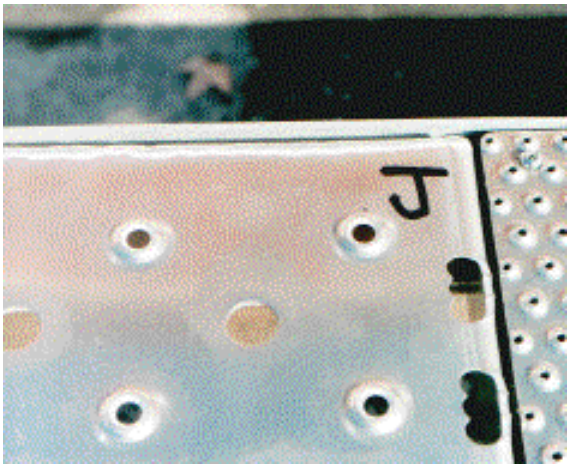
TABLE "A"
MATERIAL DESCRIPTION

DESIGNATION	MATERIAL COMPOSITION	DESCRIPTION
A	Wood	Gray Painted surface with sand additive
B	Aluminum	Polished Diamond Plate
C	Aluminum	Black Self adhesive Strips
D	Aluminum	Grip Strut
E	Aluminum	Milled Smooth Polished Flat
F	Synthetic Rubber	Rubber mat (pebble grain)
G	Aluminum	Gator Grip polished diamond plate with punch circles
H	Steel	Drainable morton cass, galvanized steel, circle holes large and small
I	Aluminum	Morton Treadgrip small raised circle design

J	Aluminum	Custom tread edge and pattern

Aluminum Gator Grip, a polished diamond plate, with punched circles, identified as material "G", appeared very abrasive; however, several firefighters commented that this material could cause tripping and expressed concern that a fall on this type of surface could cause serious injury. Surface "D" was identified as Aluminum Grip Strut, an expanded metal, open surface design.

Evaluation of the surfaces was conducted and several difficulties were encountered. Several of the surfaces were determined to have multiple areas of the tread with different pattern designs. For example, material "J" had raised circles, flat areas of polished aluminum, areas with circles cut out of the polished aluminum, and edge treatment. This made evaluation of the surface more difficult and it was decided that this material would be alleviated from future use in evaluation in the Fairfax trials to come.



Further, surface "D" was found difficult to set the test equipment on to obtain readings. Other surfaces were determined to have some degree of directional character or were otherwise inconsistent in their readings (H). It was identified that screw hole drillings, which often produce sharp, slip resistant edges, are often inconsistent as some holes are sharper than others even when new.

TABLE "B"
SLIP RESISTANCE MARK II DRY

MATERIAL	Test Data	Average Slip Resistance	Comments
A	Front .96; .96; Back .95, .96	.96	
B	Front .56, .56; Back .60, .62	.59	
C	Front 1.02, 1.04; Back 1.04, 1.02	1.03	
D	Front .78, .80; Back .79, .78 Front .80, .76; Back .86, .85	.79 .82	slide against short of oval slide against long of oval
E	Front .56, .55; Back .56, .55	.56	
F	Front .77, .79; Back .77, .79	.78	
G	Front 1.1, 1.1; Back 1.1, 1.1	1.10	
H	Front 1.1, 1.1 Back 1.1, 1.1	1.10	
I	Front .98, .96; Back .75, .80	.87	
J	Front .90, 1.1; Back 1.0, 1.0	1.00	Placement difficult erratic readings, top surface with hole only measured

TABLE "C"
SLIP RESISTANCE MARK II WET

MATERIAL	Test Data	Average Slip Resistance	Comments
A	Front .80; .77; Back .79, .76	.78	
B	Front .46, .47; Back .45, .49	.47	
C	Front .70, .74; Back .70, .70	.71	
D	Front .55, .65; Back .76, .72	.67	large hole makes machine balance difficult
E	.01, .01, .01, .01, .01	.01	
F	Front .48, .59; Back .47, .52	.52	
G	Front .74, .95; Back 1.1+, 92	.93	
H	Front 1.10+, 1.10 Back .76, 1.1+	1.02	inconsistent, overall steel holes perform well
I	Front .79, .78; Back .86, .85	.82	
J	not tested	NA	Flat area could not be tested due to large foot sensor

TABLE "D"
SLIP RESISTANCE English XL (VIT) DRY

MATERIAL	Test Data	Average Slip Resistance	Comments
A	Front 1.0+; 1.0+; Back .98, .98	.99	
B	Front .60, .59; Back .65, .64	.62	
C	Front 1.0+, 1.0+; Back 1.0+, 1.0+	1.0+	
D	Front .80, .75; Back .75, .76 Front .86, .90; Back .85, .85	.77 .87	slide against short of oval slide against long of oval
E	Front .58, .60; Back .62, .62	.61	
F	Front .76, .79; Back .79, .78	.78	
G	Front 1.0+, 1.0+; Back 1.0+, 1.0+	1.0+	
H	Front 1.0+, 1.0+; Back 1.0+, 1.0+	1.0+	
I	Front 1.0+, 1.0+; Back 1.0+, 1.0+	1.0+	
J	Front .55, .56; Back .54, .56 Front .62, .66; Back .62, .68 Front .76, .75; Back 1.0, 1.0	.55 .65 .88	Smooth surface area Raised circle surface area Difficult to test edge

TABLE "E"
SLIP RESISTANCE English XL (VIT) WET

MATERIAL	Test Data	Average Slip Resistance	Comments
A	Front .95, 94; Back .92, .94	.94	
B	Front .56, .58; Back .59, .58	.58	
C	Front 1.0+, 1.0+; Back 1.0+, 1.0+	1.0+	
D	Front .76, .70; Back .75, .70 Front .66, 62; Back .78, .80	.73 .72	slide against short of oval slide against long of oval
E	Front .10, .15; Back .10, .08	.11	
F	Front .8, .8; Back .8, .8	.68	
G	Front .55+, .56; Back .65+, .65 Front .96, .92; Back .95, .96	.60 .95	impact to flat surface areas impact to raised circle areas
H	Front 1.0+, 1.0+; Back 1.0+, 1.0+	1.0+	
I	Front .75, .68; Back .75, .65	.71	some areas noted with burrs on the holes others do not
J	Front .05, .10; Back .05, .06 Front .33, .30; Back .20, .30 Front .28, .32; Back .30, .45	.07 .28 .34	Smooth surface area Circle surface area, not raised Raised punched hole

Charlotte surface evaluations were tabulated for both dry and wet surface conditions for both the English XL and Mark II testers. After the surfaces were tested with the meters, the surfaces were subjectively rank order compared by the Charlotte firefighters. The results with comments and notes are shown in tables B, C, D, & E.

Charlotte rank order comparisons were also tabulated ranking the order of the firefighters preferences against the two meters for both wet and dry conditions. Although it should not be expected that the correlation between the firefighter subjective evaluation and that of the slip meters should be the same, it is apparent, based on the analysis that there is a high degree of correlation between the two testers and high degree of correlation between testers and the firefighters rank order comparison. Tables F & G illustrate the rank order comparison wet and dry.

TABLE "F"

Rank Order Comparison Dry

LETTER DESIGNATION	Firefighters Rank Order DRY	ENGLISH Rank Order Dry	MARK II Rank Order Dry
I	1	3	6
D	3	6	7
C	5	4	3
G	2	2	2
A	7	5	5
H	4	1	1
J	6	8	4
B	8	9	9
F	9	7	8
E	10	10	10

TABLE "G"

Rank Order Comparison Wet

LETTER DESIGNATION	Firefighters Rank Order WET	ENGLISH Rank Order WET	MARK II Rank Order Wet
I	1	6	3
D	2	5	6
C	3	2	5
G	4	3	2
A	5	4	4
H	6	1	1
J	7	deleted	deleted
B	8	8	8

F	9	7	7
E	10	9	9

Regarding the subjective evaluation of the firefighters, it is important to realize that the rank used for our comparison is an **average** of the 16 firefighters. For example, the total results of the firefighters rank order for milled smooth aluminum was reported as 1, 10, 10, 10, 10, 10, 10, 10, 9, 10, 10, 10, 10, 10, 10, 10, among the 16 firefighters. The average was a rank of 9.4 and the rank order was still 10 of 10 materials; however, clearly there was a question raised as to the first firefighters conclusion that the material was rank order #1, most slip resistant. Similarly, there is some variance raised in the firefighters rank order of the materials and some variances between firefighters are observed. However, overall there is a moderate to strong correlation between the testers and the firefighters.

TABLE "H"

Rank Order Wet Comparisons Graph Firefighter/ Tester

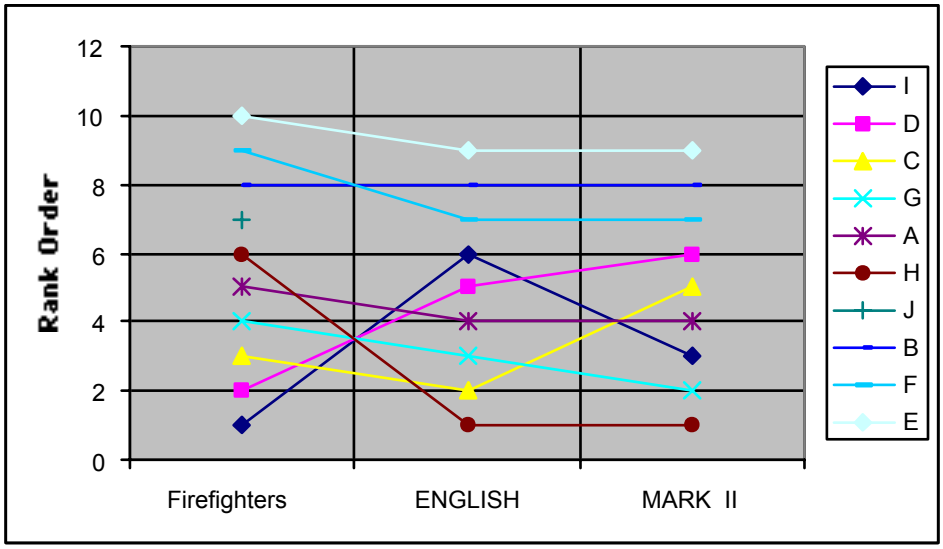


TABLE "I"

Rank Order Wet Comparisons Chart Firefighter/ Tester

MATERIAL	Firefighter Rank Order Wet	Avg. Mark II Wet Slip Resistance	Avg. English Wet Slip Resistance
A	5	.78	.94
B	8	.47	.58
C	3	.71	1.0+
D	2	.67	.73
E	10	.01	.11
F	9	.52	.80

G	4	.93	.78
H	6	1.02	1.0+
I	1	.82	.71
J	7	NA	.23

VIRGINIA BEACH

Further studies were conducted with the City of Virginia Beach Fire Department, and the assistance of Captain Gary Weidner, on May 14th and 15th, 1998. This study offered several refinements over the work done in Charlotte. Most importantly the subjective evaluation of the materials by the firefighters was now done blindfolded. Firefighters were blindfolded, guided to the platform and walked up the platform which was provided a guardrail enclosure on each side. Further, the equipment was provided water spray through spray head nozzles stationed at each material plate on the platform. Prior water application utilized hose nozzles. This study utilized 20 firefighters with eight materials as listed in Table J.

TABLE "J"
MATERIAL DESCRIPTION

DESIGNATION	MATERIAL COMPOSITION	DESCRIPTION
A	Wood	Gray Painted surface with sand additive
B	Aluminum	Polished Diamond Plate
C	Aluminum	Black Self adhesive Strips
D	Aluminum	Grip Strut
E	REMOVED	REMOVED
F	Synthetic Rubber	Rubber mat (pebble grain)
G	Aluminum	Gator Grip polished diamond plate with punch circles
H	NEW ADDED	Open saw tooth
I	Aluminum	Morton Treadgrip small raised circle design
J	REMOVED	REMOVED

TABLE "K"
Virginia Beach Blindfold
Wet Rank Order
20 Firefighters ranked 8 materials from least to most slippery

(Bold & Shaded Responses indicated materials which firefighter judged "unsafe")

Least Slippery

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	C	C	H	C	H	I	I	I	C	C	H	H	C	I	D	C	C	C	D	D
2	D	I	I	I	D	D	G	G	H	I	G	I	H	H	C	F	I	H	H	I
3	I	G	C	C	G	C	H	D	I	F	I	G	I	D	I	I	D	I	G	G
4	H	F	G	G	I	F	F	C	D	D	D	D	G	C	H	A	F	D	I	H
5	F	D	F	F	C	A	D	H	F	A	C	C	A	A	A	G	G	G	F	C
6	A	H	**A**	**B**	A	H	C	A	G	H	A	**A**	F	G	G	H	H	**A**	C	A
7	**G**	A	**D**	**G**	**F**	G	**A**	**B**	**A**	G	**B**	**F**	**D**	F	**F**	D	A	**F**	A	**F**
8	**B**	**B**	**B**	**H**	**B**	**B**	**B**	**F**	**B**	**B**	**F**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**

Most Slippery

What surfaces were judged the worst? Analysis of the 20 firefighters responses from this blindfold study concludes that the 100% of those surveyed felt that the polished diamond plate, material "B", was unsafe when wet. An additional seven firefighters (35%) in the survey felt that material "F", pebble textured rubber, was unsafe when wet. An additional five firefighters (25%) in the survey felt that material "A", paint with sand abrasive on wood, was unsafe when wet. Also noted, 2 respondents felt material "G" and 2 respondents felt material "D" was unsafe.

What surface materials were judged the best? Interestingly, 50% of those surveyed felt that material "C", 3M abrasive strips, used in the study were among rank 1 or 2 for least slippery. Similarly, 50% of those surveyed felt that the material "I", stainless steel Morton Grip, used in the study were among rank 1 or 2 for least slippery. In addition, material "D", grip strut, and material "G", Gator Grip polished diamond plate with punch circles ranked highly slip resistant. Eight respondents (40%) ranked material "G" within the top three slip resistant materials.

TABLE "L"
Virginia Beach Blindfold Study
Firefighters Rank Order Computations

Material	DESCRIPTION	Sum	Average	Rank Order
A	Gray Painted surface with sand additive	115	5.75	7
B	Polished Diamond Plate	156	7.80	8
C	Black Self adhesive Strips	57	2.85	2
D	Grip Strut	72	3.60	3
E	REMOVED	NA	NA	NA
F	Rubber mat (pebble grain)	110	5.50	6
G	Gator Grip polished diamond plate with punch circles	90	4.50	5
H	Open saw tooth	72	3.60	4
I	Morton Treadgrip small raised circle design	47	2.35	1

TABLE "M"
Virginia Beach Blindfold Study
Firefighter/ Tester Order Comparison
Wet

Rank Order	Material	DESCRIPTION	English XL	Mark II
1	**I**	Morton Treadgrip small raised circle design	.71	.82
2	**C**	Black Self adhesive Strips	1.0+	.71
3	**D**	Grip Strut	.73	.67
4	**H**	Open saw tooth	.58	.65
5	**G**	Gator Grip polished diamond plate with punch circles	.95	.93
6	**F**	Rubber mat (pebble grain)	.68	.52
7	**A**	Gray Painted surface with sand additive	.94	.78
8	**B**	Polished Diamond Plate	.58	.47

It should be noted that the gray abrasive surface material "A" was tested for slip resistance while in Charlotte. It is possible based upon what we have measured, that the surface had worn down in Virginia Beach study and no longer provides the slip resistance levels

measured in Charlotte. This would account for the relatively high .94 and .78 readings. It is recommended that this surface be rechecked.

ANALYSIS

(Assistance in statistical analysis was kindly provided by Dave Underwood Ph.D.)

Question #1. How do the Charlotte and Va. Beach (blindfolded) firefighter results compare with each other?

To evaluate how the two groups compared, we looked at the surfaces that were tested by both groups and used comparisons of evaluations common to both groups as illustrated in the table below, (eliminating some of the testing conducted). In comparing Charlotte fireman rankings with Va. Beach blindfold rankings, we use A,B,C, D, F, G and I.

TABLE N
COMPARISON OF CHARLOTTE with VIRGINIA BEACH

Designation	Composition	Description	Va. Beach
A	wood	gray painted, sand additive	
B	aluminum	polished diamond plate	
C	aluminum	black self adhesive strips	
D	aluminum	grip strut	
~~E~~	~~aluminum~~	~~milled smooth polished flat~~	~~removed~~
F	Synthetic .rubber	rubber mat (pebble grain)	
G	aluminum	gator grip polished diamond plate with punch circle	
~~H~~	~~steel~~	~~Drainable morton cass, galvanized steel, circles lg. and small~~	~~changed for Va. .Beach~~
I	aluminum	Morton tread grip small raised circles	
~~J~~	~~aluminum~~	~~custom tread edge and pattern~~	~~eliminated~~

Do the Charlotte and Virginia Beach firefighters agree on the slipperiness of the wet surfaces? Based on the analysis, Yes.

Evaluation used non-parametric analysis, to compare rank orders. Using Spearman's r_s correlation coefficient for rank-ordered pairs. The calculations are given in Table O.

The value for the correlation coefficient between the two sets of firefighters is 0.86, where a zero indicates no correlation and a 1 indicates perfect correlation. Using a table to look up the confidence level associated with this correlation coefficient, we find we are more than 95% confident the agreement didn't happen by chance. The correlation coefficient between Firefighter rankings on wet surfaces 0.86 providing a Confidence level of 95+%.

Table "O"

Calculations for Charlotte & Va. Beach wet comparisons

- Spearman's r_s correlation coefficient.

sample	Charlotte	blindfold	d	d^2
I	1	1	0	0
D	2	3	-1	1
C	3	2	1	1
G	4	4	0	0
A	5	6	-1	1
B	6	7	-1	1
F	7	5	2	4
			sum	8
		# comparisons		7
		Spearman	r_s	0.86
one-tailed value at 95% confidence:				0.71
	Significant at 95% confidence level			

2. The second question evuluated was "Do the Charlotte and Virginia Beach firefighters agree on the slipperiness of the dry surfaces?"

Again, yes. This is calculated similarly as above and summarized in Table P. The value for the correlation coefficient is 0.73, where a zero indicates no correlation and a 1 indicates perfect correlation. We again use a table to look up the confidence level. For this value of correlation coefficient, we are 95% confident the agreement didn't happen by chance.

Table P

Calculations for Charlotte & Va. Beach dry comparisons

- Spearman's r_s correlation coefficient

Sample	Charlotte	Blindfold	d	d^2
I	1	1	1	1
D	3	3	0	0
C	4	2	2	4
G	2	4	-2	4
A	5	6	-1	1
B	6	7	-1	1
F	7	5	2	4
			sum	15
			# comps	7

			r_s	0.73
one-tailed value at 95% confidence:				0.71
	Significant at 95% confidence level			

In summary, the correlation coefficient between Firefighter rankings on wet surfaces was calculated at 0.73 with a confidence level of 95%.

Question 3. How do the VIT and Mark II results compare with each other?

A. Do the tribometers agree on wet surfaces?

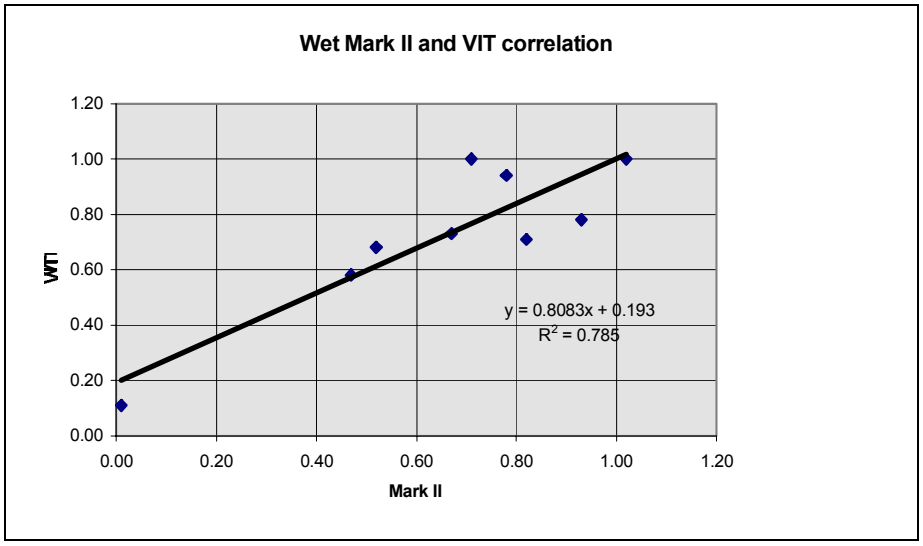
Yes. The statistical data is summarized in table Q. All the data from the Charlotte evaluation except for surface J, was used due to the possibility that there was an inability to measure that surface accurately.

Table "Q"
Wet Mark II and VIT Correlation.

Surface	Mk II	VIT
A	**0.78**	**0.94**
B	0.47	0.58
C	0.71	1.00
D	0.67	0.73
E	0.01	0.11
F	0.52	0.68
G	0.93	0.78
H	1.02	1.00
I	0.82	0.71

Pearson's correlation coefficient was calculated as 0.89. From a table lookup, this means we are 99% sure the agreement didn't happen by chance. If you square Pearson's correlation coefficient, you get a coefficient of determination of 0.79. This essentially means that about 79% of the information you get from using the Mark II is predicted by the VIT measurements.

Table "R"



B. Do the tribometers agree with each other on dry surfaces?

Again, yes. The numbers evaluated are summarized in table "S" entitled "Dry Mark II and VIT Correlation".

Table "S"
Dry Mark II and VIT Correlation

Surface	Mk II	VIT
A	0.96	0.99
B	0.59	0.62
C	1.03	1.00
D	0.81	0.83
E	0.56	0.61
F	0.78	0.78
G	1.10	1.00
H	1.10	1.00
I	0.87	1.00

The correlation coefficient is 0.93. From a table lookup, this means we are 99% confident the agreement didn't happen by chance. The coefficient of determination is 0.88, meaning about 88% of the information you get from using the Mark II is predicted by the VIT measurements for dry conditions. Therefore, the analysis supports that the correlation between the VIT and Mark II is better for dry conditions than wet conditions. This can be explained by observing the difference in operation between the two testers. The English XL impacts the surface with a slight angle as the circular foot is mounted on a spring which creates impact at a slight angle as it contacts the heel and then slaps down to the

surface – much like humans function during normal human walking. The English XL functions to squeeze water from the surface. The Mark II tester sensor impacts the surface flat and is, in my opinion, much more likely to produce hydroplaning typing effects.

Question #3. Do the tribometers agree with the firemen?

A. Wet surfaces.

Fireman and tribometer rankings agree at about the 93% confidence level. The calculations are attached in table "V". Our calculation, compared the tribometer slip resistance values to rankings for the 7 samples that the firemen looked at. Number 1 was used to designate most slip-resistant.

Table "T"

Wet results - Average Fireman Ranking

Sample	Charlotte firemen rank	Blindfold firemen rank	Total	Average firemen rank
A	5	6	11	5
B	6	7	13	7
C	4	2	3	2.5
D	3	3	6	4
F	7	5	12	6
G	2	4	3	2.5
I	1	1	2	1

Table "U"

Wet results - Average Tribometer Rankings

surface	Mk II	Mk II rank	VIT	VIT rank	total (Mk II + VIT)	average tribometer rank
A	0.78	3	0.94	2	5	2.5
B	0.47	7	0.58	7	14	7
C	0.71	4	1.00	1	5	2.5
D	0.67	5	0.73	4	9	5
F	0.52	6	0.68	6	12	6
G	0.93	1	0.78	3	4	1
I	0.82	2	0.71	5	7	4

Table "V"

Tribometers vs. Firemen,
Dry Spearman correlation coefficient calculations

Sample	Tribometers	Firemen	d	d**2
A	2.5	5	-2.5	6.25
B	7	7	0	0
C	2.5	2.5	0	0
D	5	4	1	0
F	6	6	0	0
G	1	2.5	-1.5	2.25
I	4	1	3	9
			sum	17.5
			# comps	7

			r_s	0.69
one-tailed value for 95% confidence:			0.71	

B. How do the Firemen and tribometers agree on dry surfaces?

Unfortunately, analysis of the data for dry comparison does not permit meaningful evaluation. Since the VIT was out of range on C, G and I when dry, we are only left with 4 surfaces, not enough for meaningful comparisons. (This is not particularly important as dry slip resistance isn't the problem.)

CONCLUSION

In conclusion, analysis of the data supports that Charlotte and Va. Beach (blindfolded) firefighter results compare well with each other. The value for the correlation coefficient between the two sets of firefighters for wet testing is 0.86, where a zero indicates no correlation and a 1 indicates perfect correlation. Based on the analysis we are more than 95% confident the agreement didn't happen by chance. The value for the correlation coefficient between the two sets of firefighters is 0.73 for dry testing, where a zero indicates no correlation and a 1 indicates perfect correlation. We again use a table to look up the confidence level. For this value of correlation coefficient, we are 95% confident the agreement didn't happen by chance.

Further, the measurement of slip resistance of the VIT and Mark II results compare well with each other. Evaluation of the dry testing determined that Pearson's correlation coefficient = 0.89 indicating that there we are 99% sure the agreement didn't happen by chance. If you square Pearson's correlation coefficient, you get a coefficient of determination of 0.79. This essentially means that about 79% of the information you get from using the Mark II is predicted by the VIT measurements.

In addition, research supports that the tribometers agree with the firemen's evaluation of wet testing. Fireman and tribometer rankings agree at about the 93% confidence level. Unfortunately, analysis of the data for dry comparison does not permit meaningful evaluation (This is not particularly important as dry slip resistance isn't the problem.)

This data continues to be analyzed; however, based on this study, it would appear that if a criteria level were to be set to rule out surface "B", polished diamond plate, then it would need to set a standard of higher than .58 with the English XL tester and/ or higher than .47 with the Mark II tester for wet conditions on non draining surfaces. It should be recognized that this level contemplates new diamond plate steel, which may not be a problem material until it is sufficiently worn. Further, if a criteria level were also to be set to rule out surface "F", pebble texture rubber, a standard level of a minimum of .68 with the English XL and a minimum of .52 with the Mark II tester should be set for wet conditions on non draining surfaces.

Further, based on this data, if we wish to rule out flat metal but permit the use for diamond plate aluminum for dry conditions then the data suggests that a suitable criteria would be to require that the material provide a minimum level of .62 with the English XL, or .58 with the Mark II tester, when tested dry with Neolite®.

Based on this data, if we wish to rule out diamond plate aluminum, smooth metal, and the pebble grain synthetic rubber for wet use, then the data suggests that a suitable criteria would be to require that the material provide a minimum level of .68 with the English XL tester, or .52 with the Mark II tester, when tested wet with Neolite®.

Submitted by,

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