CLEANING LABORATORY EVALUATION SUMMARY

SCL #:	2006
DateRun:	07/16/2006
Experimenters:	Jason Marshall
ClientType:	Consultant
ProjectNumber:	Project #1
Substrates:	Wood
PartType:	Coupon
Contaminants:	Coatings
Cleaning Methods:	
Analytical Methods:	Performance Test
Purpose:	Summary Report
Experimental Procedure:	Solvent and Water Based Floor Coating Comparison

All procedures except drying times and gloss readings are based on ASTM D2394-83 (Revised 1993) Standard Methods for Simulated Service Testing on Wood and Wood-Base Finish Flooring. The methods in the ASTM standard cover procedures for measuring performance of finish flooring under several conditions (Not all tests may be required for any specific investigation.). The tests selected for evaluation were:

Loading Tests:
Floor Surface Indentation from small area loads
Falling-Ball Indentation
Rolling Load
Mechanical Tests:
Abrasion Resistance
Coefficient of Friction

Control of Moisture Content and Temperature
The moisture content at the time of testing will influence results due to the hydroscopic nature of the base materials. Therefore, efforts must be taken to ensure that the moisture content and temperature remain constant during the evaluation period. Ideally, the sample floor should be kept at 65+/-1% relative humidity and 68+/-6oF.

During laboratory testing, conditions were within the prescribed range for relative humidity, 68%, as was the temperature, 74oF.

Sample Preparation
The flooring material supplied was Hardwood flooring made from Red Oak. The boards were ¾” thick, 2 ¼” wide and cut into 8” sections. All of the flooring was sanded prior to making initial thickness readings using a 120 grit paper. With the boards cut into 8” coupons, three readings were made using a Brown & Sharpe Micrometer to measure each coupons initial board thickness. Each reading was made to 0.001” and the three values were averaged to give a baseline thickness for the coupons. In addition to the thickness baseline, baselines were established for Gloss, Coefficient of Friction, Impact, Small Area Loads. Procedures for each baseline measurements followed the procedures to be outlined.

Following the establishment of the baselines, three coupons were coated with a supplied floor finish according to the manufacturers’ specifications. The application of the floor coatings was performed using a graduated pipette to ensure the proper coating rate. The coatings were then spread over the panels following the grain of the wood using a 1” Pure Bristle 1500 paint brush. Each coating layer was allowed to sit for 2 hours prior to the application of the next coat. Completed coupons were allowed to sit for a minimum period of 24 hours before performance evaluations were conducted. Specific application procedures are listed in the table below.
An additional product that was tested previously was included in the summary tables for comparative purposes.

Table 1. Floor Coating Procedures
Current Practice
Sand and vacuum floor
Apply lacquer sealer at 250 sq ft per gallon
When lacquer sealer is dry abrade the surface and vacuum
Apply sanding sealer and let dry (overnight)
Apply polyurethane gloss
Harco Sanding Lacquer Sealer #1047
Harco Primer/Sanding Sealer #850
Capitol Polyurethane Gloss

Modified Current Practice
Sand floors using 100 grit paper
Apply lacquer sealer at 600 sq ft per gallon
Allow to dry 45-60 min before applying second coat

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Sand lightly in between coats
Apply Sanding sealer
Buff with 100 grit
Apply polyurethane gloss at 500-550 sq ft per gallon
5-6 hours between coats
24 hours before light traffic
Harco Sanding Lacquer Sealer #1047
Harco Primer/Sanding Sealer #850
Capitol Polyurethane Gloss

Bona Mfr, Oil Based
Sand floor with 80-100 grit
Apply sealer at 600-700 sq ft per gallon
Dry 1.5-2 hours
Abrade with 120 grit
Apply topcoat at 500-600 sq ft per gallon
Dry 2-3 hours
Abrade
Apply second coat
Light traffic in 24 hours
Final coat 48 hours before use
7 days for curing
Bona DriFast Sealer
Bona Mega – 2 coats

Bona Mfr, Water Based
Sand using 80 grit on unstained wood
Apply sealer at 500-600 sq ft per gallon
Dry 2 hours
Abrade with 120 grit
Apply topcoat at 500-600 sq ft per gallon
Dry 2-3 hours
Abrade
Apply second coat
Light traffic in 24 hours
Final coat 48 hours before use
7 days for curing
Bona Bonaseal
Bona Mega – 2 coats

Previously Tested Water Based
Sand floor
The finish was applied using a 1” Pure Bristle 1500 paint brush.
To ensure consistent coating application, the finish was leveled off using a 10 mils Precision Gage & Tool Co Dow Film Caster.
Pro Finisher Water Based Sanding Sealer – 1 coat
Pro Finisher Polyurethane – 2 coats

Results:

Drying Time
During the sample preparation with floor finish, drying times were monitored. Observations were made after the first coat at every 10 minutes until the finish was dry to the touch. The amount of drying completed during each time interval was visually estimated and recorded. Subsequent coats were analyzed in the same manner. Drying times for each finish were compared to each other and are in Tables 2-5.

Drying Results

Table 2. Drying Times – 1st Coat

Drying Times (minutes)	Observations % Dry - visual			
First Coat	10	20	30	40
Current Practice	100			
Modified Current Practice	100			
Bona - Oil	85	95	100	
Bona - Water	90	100		
Pro Finisher Water Based Sanding Sealer & Polyurethane	65	85	100	

Table 3 Drying Times 2nd Coat

Second Coat	10	20	30	40	50	60	70	80	90
Current Practice	5	10	30	40	60	65	75	85	90
	10	30	45	60	75	95	100		

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Modified Current Practice									
Bona - Oil	40	90	100						
Bona - Water	50	100							
Pro Finisher Water Based Sanding Sealer & Polyurethane	40	80	100						

Table 4. Drying Times – 3rd Coat

Third Coat	10	20	30	40	50	60	70
Current Practice	40	60	80	95	97	99	100
Modified Current Practice	30	40	45	65	85	95	100
Bona - Oil	30	60	100				
Bona - Water	45	90	100				
Pro Finisher Water Based Sanding Sealer & Polyurethane	30	40	85	95	100		

Table 5. Drying Times - Summary

Table 5. Drying Times - Summary	
	Total Drying Times
Current Practice	180
Modified Current Practice	150
Bona – Oil	90
Bona – Water	80
Pro Finisher Water Based Sanding Sealer & Polyurethane	110

Gloss Readings

To determine the amount of “shine” the floor finishes created, baseline gloss readings were made on the uncoated coupons. A SPER Scientific Light Meter 840021 measuring Foot Candles from the surface to represent gloss readings. Three readings were made for each coupon, in the middle, and at both ends. The three coupons that were to be coated with the same finish were then averaged and recorded as the product average baseline. The same procedure was followed to determine the finished coupon average after the three coats were applied and allowed to cure for 24 hours. The finished coupon average and the baseline average were then compared to determine the increase or decrease in gloss. Results for the Gloss readings were compared for the various floor finishes and are in table 6.

Gloss Results

Product	Average Levels		
CP	7.48	6.42	-1.06
MCP	7.23	6.41	-0.81
BO	7.27	6.35	-0.92
BW	7.62	7.01	-0.61
SSPUC	7.57	9.03	0.09
BW	7.57	7.67	0.09

Indentation from Small Area Loads

According to the ASTM method, coupons will be subjected to the indentation damage from small area loads to obtain a measure of the resistance to sharp-edged small area loadings. Results obtained from this test are qualitative in nature. Relative finish performance will be compared among the various tested products.

Testing deviated from the ASTM method for sample size and test directions. This was due to the quantity of wood coupons that would be needed for testing.

The small area load apparatus was constructed using a wooded rolling pin that was implanted with metal trim nails with a 0.15 inch head. The nails were placed 1” apart along an 8” line. Subsequent lines were off-set by ½” from the previous row of nails. The rows were spaced at ¾” around the rolling pin. See Figure 1 for the small area load apparatus.

Figure 1. Small Load Apparatus

Each coupon was clamped between two boards so that the coupon would be held in place during the small area load testing. The superimposed load was provided by the experimenter pushing with a uniform force onto the rolling pin (unknown level but approximately equal for all products). The small load apparatus was rolled across the surface of the coupon for 100 trips (50 cycles). At the end of the 100 trips, the damage to

the coupon was classified according to the ASTM method as having none-minor, moderate, severe and complete damage. In addition, two independent assessments were made by lab personnel to rank the finishes for its ability to withstand small area loading. Overall summary rankings are listed in table 7.

Small Load Results
Table 7. Small Load Summary Rank

Product	Adjusted Rank
Current Process	5
Modified CP	1
Bona - Oil	4
Bona - Water	2
SSPUC	2
Blank	6

Falling-Ball Impact Indentation
This test is designed to obtain a measure of the resistance of a flooring finish to impacts from dropped objects. Four drops were made for each coupon for a total of twelve drops per finish. Each drop was made at a 6” intervals starting at 6” and ending at 72”. The ball used for the drops was a 440-C stainless steel 2” diameter ball, grade 100. The dropping apparatus used is shown in Figure 2. Carbon paper was placed on the coupon surface to assist in determining where the indentation was made.

Figure 2. Dropping Apparatus

The same Brown & Sharpe Micrometer was used to measure the indentations to the coated coupons. A plot was made of the height of drop and residual indentation and the slope of the best fit line was calculated. From the plots, the intercept of the height of drop at 72” was recorded as the index of indentation resistance. Results for each finish were compared each other. The lower the index was, the less the indentation would be and therefore the better the coating's resistance. Values are listed in table 8.

Uncoated		0.196	
Product	Slope of Best Fit Line	Index of Indentation Resistance	Rank
CP	1714.8	0.0420	4
MCP	1692.1	0.0426	3
BO	1791	0.0402	5
BW	1560.4	0.0461	2
Blank	2138	0.0337	1

Rolling Load
Measurements made during the rolling load will reveal damage to the coupon surface from repeated rolling forces, simulating heavy castor loads such as beds, desks and appliances. Coupons were placed into a holding device and clamped to restrict movement of the coupon. A load sled was constructed using a wood plank and three castor wheels. The round, hard wheels were 2” in diameter and 1” wide. The sled was loaded with 200 pounds. Figure 3 shows the sled passing over the surface of the finished coupon.

Figure 3. Rolling Load Apparatus

Ten passes (5 cycles) were completed and the three measurements were made along the path of the sled wheel. An additional 15 passes were made with three more measurements made. Following the 25 passes, another 25 passes were made with the deformation measurements. The averages for the three sets of passes were calculated. Any notable surface changes were recorded. The results for each floor finish were compared to the other finishes and are found in table 9.

Rolling Load Results
Table 9. Rolling Load Comparison

Floor Coating	10	25	50	Total Depression Depth
CP	0.0089	0.0036	0.0016	0.0141
MCP	0.0072	0.0024	0.0008	0.0104
BO	0.0086	0.0022	0.0012	0.0121
SSPUC	0.0041	0.0058	0.0084	0.0084
BW	0.0102	0.0022	0.0006	0.0130

Abrasion Resistance
The methodology used for this experiment uses little from the ASTM standard. The 80 grit aluminum oxide was used as sandpaper, the testing went for two, 100 cycles and the Navy-type Wear Tester instrument was replaced with the BYK Gardner Abrasion Tester (Figure 4).

Figure 4. Abrasion Tester Apparatus

Coupons were placed into the Abrasion tester and subjected to the 100 cycles with the 80 grit sandpaper. At the end of the first cycle, the coupons were wiped with a dry sponge to remove any dust that was generated. Three thickness measurements were made and recorded to determine the decrease in surface

thickness. The coupon was then subjected to the second 100 revolutions with the sandpaper. Measurements were made in the same manner as the first set. Averages for both sets were calculated and compared to the other floor finishes and are in table 10.

Abrasion Results

	Initial	Average Loss			
	Thickness	Cycle 1	Cycle 2	Total Loss	Beyond Coating
CP	0.0056	0.0040	0.0039	0.0079	0.0024
MCP	0.0061	0.0066	0.0027	0.0093	0.0032
BO	0.0061	0.0067	0.0031	0.0098	0.0037
BW	0.0055	0.0087	0.0023	0.0110	0.0055
Pro Finisher Water Based Sanding Sealer & Polyurethane	0.0073	0.002	0.004		
Blank	0.0000	0.0043	0.0021	0.0064	0.0064

Coefficient of Friction
The ASTM specified apparatus was replaced with an IMASS, Inc SP-102B-3M90 Slip/Peel Tester (Figure 5). Two types of friction coefficients were measured using this instrument. The first, Static CoF, was determined by obtaining the force required to move the specimen from a stationary position. The second, Sliding CoF (or Kinetic), was found by measuring the average force required to maintain movement at a certain rate. Measured forces will have peaks and valleys in the amount of force needed to keep moving. Average these values results and dividing by the weight of the object will result in the desired coefficient.

Figure 5. IMASS Slip/Peel Tester

The Slip/Peel tester was first adjusted to ensure that the device was properly calibrated for the sled weight being used. A coupon was then placed and clamped onto the bed of the device. The speed of the bed was set to 45”/min. The instrument records two values, the peak, the valley and calculates the average. The device was run three times per coupon for measuring the Static CoF and three times to measure the Kinetic CoF. Each coupon’s value was averaged and then the values for each finish (three coupon averages) were averaged to get one value for the Static Coefficient of Friction and one value for the Kinetic Coefficient of Friction. These values for coated samples were compared to the CoF for the same uncoated coupons. Summary values are in table 11.

Calculating Coefficient of Friction
Ratio of tractive (pulling) force to the normal force (sled weight)
CoF = F/N = (Tractive force)/(Normal Force) = (meter reading)/(sled weight)

Coefficient of Friction Results
Table 11. Coefficient of Friction Average Differences

Cof F Difference						
	Static			Kinetic		
Product	Peak	Valley	Average	Peak	Valley	Average
CP	434	360	375	389	370	395
MCP	257	266	270	236	245	262
BO	-55	-45	-9	-2	-11	15
BW	45	41	71	103	36	67
Blank	-12	11	11	24	22	25

Summary:

Conclusion:

Summary of Findings
The scope of this investigation was to compare water-based floor finishes with an oil-based floor finish. Products were evaluated for seven performance criteria. The testing followed ASTM D2394-83 (Revised 1993) Standard Methods for Simulated Service Testing on Wood and Wood-Base Finish Flooring. Testing was modified to incorporate available laboratory equipment and existing procedures.

Drying
Water based floor coatings required less overall drying time than the solvent-based floor coating. However, the initial drying of the first coating for the current practice and modified current practice took 10 minutes. For the second coat, the two Bona products took less than 30 minutes to dry. When the times were added up for drying, the solvent-based coating took 60 to 100 minutes longer than the two Bona products. The average drying times for the water-based coating was 85 minutes and the current practice and modified current practice solvent-based coating averaged 170 minutes. The previously tested product needed just over 100 minutes for drying.

Gloss
The gloss readings signify the amount of shine the coatings provided to the floorboards. Negative numbers indicate that the floor was either darker than or not as reflective as it was to start with. Only the previously tested water-based product increased the shine of the coupons. The current practice darkened the coupons more than any other coating matrix did.

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Small Load
The modified current practice performed the best, resulting in the least damage to the coated coupons. The water-based Bona product and the previously tested water-based product both almost as effect as the modified practice. All coated coupons had less damage than the uncoated boards.

Impact
The uncoated boards resulted in the least amount of impact from the falling ball. The Bona water-based product showed the most resistance to indention for the coated boards. The modified current practice was the second most resistant coating matrix. The previously tested water-based product was the least protective.

Rolling Load
The previously tested water-based coating matrix had the least amount of indention resulting from the 200-pound sled whereas the current coating matrix had the greatest indentation from the rolling load.

Abrasion
The previously tested water-based coating matrix was the only product that did not lose all of the coating during the two abrasion cycles. The current practice was the next most resistant matrix. All products performed better than the untreated boards.

Coefficient of Friction
A higher coefficient implies that the floor would be easier to walk on, gripping footwear and reducing the chance of slipping or falling. The current practice matrix had the greatest increase in friction, followed by the modified current practice and the previously tested water-based product. The Bona oil matrix resulted in a lower static coefficient of friction.

Overall Comparison
When comparing all of the performance tests to determine how the products compared overall, the modified current practice matrix and the previously tested water-based matrix were the top performers. The Bona water-based matrix was next followed by the current practice. The Bona oil matrix had the lowest overall ranking of the coated coupons.

The relative ranking was based on the average of the eight performance criteria (coefficient of friction was broken into two categories, static and kinetic). Product summaries are listed in table 12 below.

Table 12. Floor Coating Summary of Results

Product	Average Rank	Drying	Gloss	Abrasion	Impact	Small load	Rolling Load	Static CoF	Kinetic CoF	Relative Rank
Current Practice	3.50	5	5	2	4	5	5	1	1	4
Modified Current Practice	2.50	4	3	3	3	1	2	2	2	2
Bona – Oil	4.25	2	4	4	5	4	3	6	6	5
Bona – Water	3.00	1	2	5	2	2	4	4	4	3
Pro Finisher Water Based Sanding Sealer & Polyurethane	2.50	3	1	1	6	2	1	3	3	1
Uncoated coupons	4.60	--	--	6	1	6	--	5	5	6