21st Century Paint Volume Solids Testing with DJH Designs PVS1

Simple, Fast and Accurate Paint Volume Solids (PVS) Measurement

Independent Evaluation of PVS1

Introduction

A fast, simple, and reliable instrument and method for paint volume solids (PVS) measurement has not been available so there is limited experience with accurate PVS data, especially at the plant quality control level.

The ASTM and ISO standard methods for measuring and calculating PVS are intricate, exacting, and require skilled human intervention leading to uncertainty in the results.

The goal of PVS1 is to change this status quo by introducing DJH Designs PVS1 paint volume solids instrument.

PVS is a fundamental property of paint that is especially useful for large consumers of paint. Unlike paint weight solids, PVS provides the true area coverage (litres per square metre).

Knowing the PVS of paint will:

- Allow determination of the volume of paint needed for a production run,
- Allow coater set up to target the correct dry film build, and
- Allow determination of the true cost of paint - $ per unit area.

This report illustrates the use and value of PVS data, and supplies results from three significant trials of DJH Designs PVS1 instrument. It demonstrates the value, ease of use, and accuracy of this method.

Simple Principle and Methodology for the PVS1 Instrument

PVS1 uses a fundamental approach involving measurement of the wet and the cured film of the same paint sample. Figure 1, below, shows a typical scan of a wet and a dry film sample.

Figure 1 –PVS1 scans of an SMP paint sample

The PVS1 method comprises the following steps:

1. Apply a drop of paint to the precisely engineered substrate that is about the size of a microscope slide,

2. Spread the drop into a narrow film using a special draw down tool.

3. Load the paint onto the sample holder; this is scanned before and after curing in the convection/IR oven.

Whilst simple in principle, high precision mechanisms and innovative software are used to achieve consistency and accuracy. Samples need to be prepared quickly to minimise solvent evaporation prior to measurement of the wet film. Mastering the procedure is accomplished quickly as evidenced by consistent results between different operators after as little as one hour of training and practice.

Comparison with Traditional Methods

ASTM, ISO and AS (Australian Standard) methods for paint volume solids measurement have three significant drawbacks compared to DJH Designs PVS1 as follows:

1. They do not cure the paint having an oven temperature in the order of 130 degrees centigrade. For this reason, the results are not directly comparable to coil paint line conditions.

2. These methods are complex and labour intensive, involving many measurements and calculations with considerable human intervention. Measurements include weighing samples to a high degree of precision both in air and immersed in water (to calculate the volume of the dry paint sample). Advanced knowledge of the density of solvents is required and skilled laboratory technicians are needed to carry out the method. Given all the steps and the subjectivity involved, results may be inaccurate and inconsistent from one lab to another, as we have seen in the trials reported here.

3. Furthermore, one test takes two hours to complete. Two tests are needed per sample and the results are then averaged; hence 4 hours is needed per paint sample.

The PVS1 Evaluation Trials

Industrial scale trials of DJH Designs PVS1 have focused on:

- Comparison of PVS1 results with those from ASTM and ISO standard tests,
- Consistency of PVS measurements using PVS1, and
- PVS1data correlation to paint-line usage and dry film thickness prediction for selected large volume paints.

The trials were undertaken in cooperation with 8 multi-national paint manufacturers and coil coaters. PVS1 was used to test a selection of the paints, and they were also tested independently. The results from three of these trials are reported here and summarised as follows:

Trial 1 - Trial of 7 high volume paints comparing line usage to predictions based on data from the DJH PVS1 and two independent labs using the ASTM method;

Trial 2 - Trial of 4 paints comparing DJH PVS1 results with two independent labs using the ISO method. One of the paints was tested 13 times to compare consistency of results

Trial 3 – A line trial of 5 paints in which PVS1 was used to predict dry film build based on wet film build measurement.

Trial 1 – Correlation of DJH PVS1 Results to Line Paint Usage

Seven high usage paints were selected including:

- three primers,
- two backers, and
- two topcoats.

PVS was measured by 2 independent labs using the ISO method, and by DJH Designs-R&D using the PVS1 instrument. Paint usage data was collected during several weeks of production. Coated surface area, paint volume, and extensive thickness measurements were tracked to calculate paint line-based usage and baseline PVS results.

The PVS results from PVS1, the two labs, and from production are given in Table 1. Table 1 includes the error between predicted and actual paint consumption – (litres per square metre) for each method. This difference is expressed as a percentage.

Table 1 - PVS Results - Trial 1							
Paint	Top Coat	Top Coat	Backer	Primer	Backer	Primer	Primer
ID	1	2	3	4	5	6	7
A) Paint Volume Solids % (PVS)							
LAB 1	44.9	49.6	43.8	21.7	41.9	45.3	21.6
LAB 2	44.5	50.8	49.8	21.87	43.9	44.88	29.42
Line	44.5	44.4	45.1	23	37.4	42.2	24.5
PVS1	44.7	43.3	47.4	22.7	37.9	43.1	23.8
Nominal	46.9	48.7	46.5	26.9	46.9	46	26.9
B) Percentage Difference Between Predicted and Actual Paint Usage							
LAB 1	-1.0%	-11.6%	2.8%	5.6%	-11.9%	-7.4%	11.9%
LAB 2	0.0%	-14.4%	-10.4%	4.9%	-17.4%	-6.4%	-20.1%
Line	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PVS1	-0.4%	2.5%	-5.1%	1.3%	-1.3%	-2.1%	2.9%
Nominal	-5.4%	-9.7%	-3.1%	-17.0%	-25.4%	-9.0%	-9.8%

Figures 2 and 3 below respectively compare the lab with the line data, and the PVS1 with line PVS results.

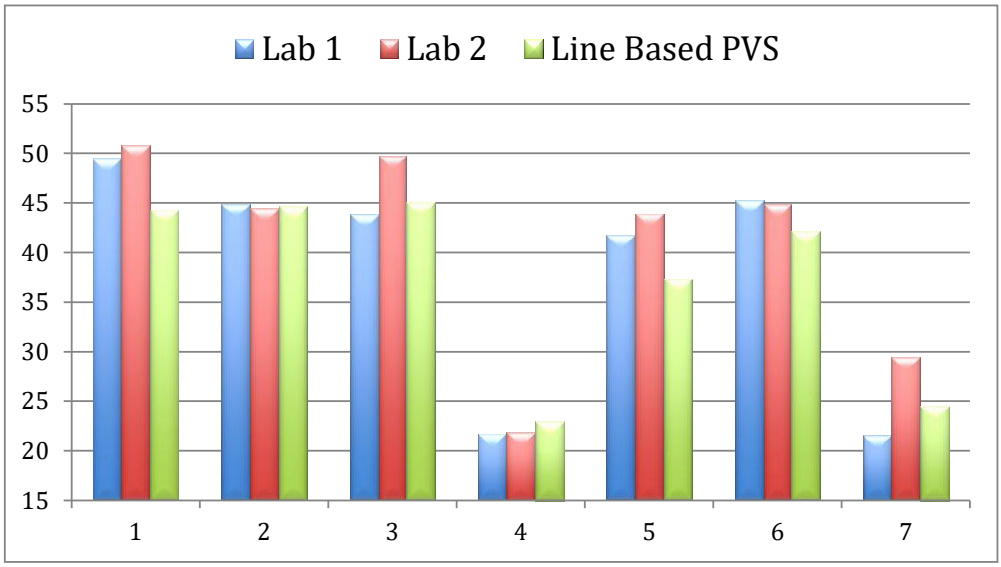

Figure 2 – % PVS Results for Labs 1 and 2 and for Line based PVS

Labs 1 and 2 showed agreement for 4 of the paints and showed a variance of 6% and 8% for paints 3 and 7 respectively.

The test procedures and conditions for ISO (and the ASTM) differ significantly compared with PVS1 test conditions. Unlike the ISO method, PVS1 has a short cure cycle and achieves a peak temperature of the paint that is equivalent to the on line cure temperature, that is, above the paints cross-linking temperature. These differences in curing conditions are significant and are sufficient to explain the difference seen between PVS1 and ISO or ASTM PVS results.

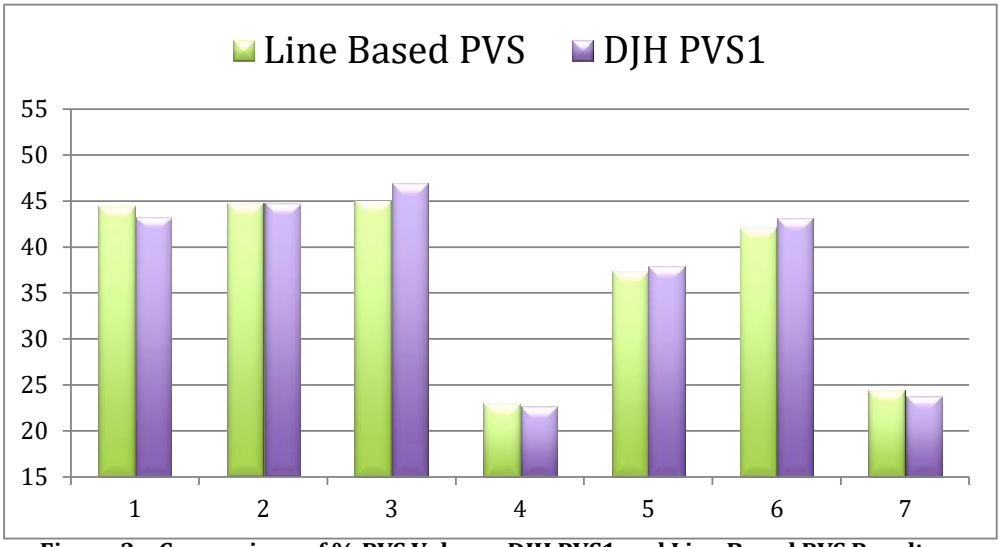

Figure 3 – Comparison of % PVS Values - DJH PVS1 and Line Based PVS Results

The average <u>absolute error</u> in predicting paint cover (or paint volume needed) across the seven paints was 7.4% and 10.5% for labs 1 and 2 respectively and 1.9% for PVS1.

Trial 2 – Comparison of the Consistency of PVS1 and ASTM Method Results

The purpose of this simple trial was to establish and compare the typical consistency of the test methods by conducting multiple tests on a few paints. Four topcoats comprising two polyesters, a fluorocarbon (PVDF), and an SMP were tested.

Testing for all paint samples using PVS1 was conducted in two sessions one week apart in order to compare the consistency of measurements.

Sample 4 was tested by PVS1 and by Lab B ten (10) times. The other three paints were tested twice by Labs A and B. Since the PVS1 test procedure is performed quickly, paint sample 1, 2 and 3 were tested 6 to 10 times each by this method.

All results are given in Appendix 1, and are summarized in Table 2.

Table 2 – Summary of Average PVS results including Standard Deviations

Sample & Analysis ID			Average PVS			Standard Deviation		% Differences in PVS		
Paint Sample	Session	Nominal PVS	PVS1	Lab A	Lab B	PVS1	Lab B	PVS1 vs. Lab A	PVS1 vs. Lab B	Lab A vs. Lab B
1	1	53	57.7	57.1	52.7	0.41		1.0	5.4	4.4
	2		58.4			0.31				
2	1	48	49.7	60.1	72.0	0.59		-1.4	-11.3	-9.9
	2		49.7			0.64				
3	1	51	56.0	58.4	53.7	0.77		-2.4	2.3	4.7
	2		56.0			0.81				
4	1	43	46.2	48.1	50.8	0.26	0.95	-1.8	-4.6	-2.8
	2		46.2			0.52				

Paint sample 4, tested thirteen times, showed PVS standard deviations of 0.95 and 0.38 for Lab B and for PVS1 respectively.

Comparing results from the tests conducted 1 week apart (session 1 vs. session 2) showed that the PVS1 data was consistent.

Trial 3 – Predicting Dry Film Thickness from Wet Film and PVS1 Measurements
This trial was conducted on a coil coating line in Australia. PVS1 was used to measure PVS, and wet film thickness was measured using WFM1 prior to production.

Predicting dry film thickness also requires incorporation of other criteria such as paint transfer efficiency. To explain - reverse coating exhibits a phenomenon known as 'leakage' between the applicator roll and the strip. This results in a transfer efficiency factor that was estimated by our R&D from previous studies on this coater using WFM1 technology (WFM1 is described at www.djh.com).

The results of this trial are given in Table 3.

Table 3 – Prediction of DFT Using PVS1 Measurements

Paint Run	PVS1 Data	Measured WFT (mils)	Predicted DFT (mils)	Measured DFT (mils)	Predicted to Measured Variance (mils)
1	1.7	1.9	0.8	0.8	0.04
2	1.8	2.0	0.9	0.9	0.00
3	1.9	1.8	0.8	0.8	0.02
4	1.7	2.0	0.8	0.8	0.00
5	1.5	2.1	0.8	0.8	0.04

The trial demonstrated the capability of estimating DFT within 0.04 mils variance, and within an average of 0.o2 mils.

Whilst the results of this trial are impressive, the capability has been confirmed on a customer's high-capacity coil coating line in the USA. Use of PVS1 on this line resulted in an immediate improvement in film thickness management and a payback period of under three months.

Summary and Conclusion

DJH Designs PVS1 provides:

1. Accurate and consistent PVS data and ease of use,
2. The true cost of paint on an applied area basis,
3. Ease of operation and an analysis cycle of 5 minutes,
4. The ability to predict paint consumption for production, and
5. The ability to predict dry film build.

ASTM, ISO, and Australian Standard methods for PVS measurement are time consuming, do not replicate line conditions, nor do they provide good repeatability and accuracy.

DJH Designs PVS1 is the first instrument suitable for in plant use, and the first instrument to measure paint volume solids in under 6 minutes.

This instrument, more than any other, will provide a fast payback by delivering fundamental useful paint data necessary for the efficient operation of a coil paint line.

APPENDIX 1 - ALL RESULTS FROM TRIAL 2					
Analysis Session	**Paint Sample**	**Colour**	**PVS1 PVS**	**Lab A PVS**	**Lab B PVS**
1	1	Cream	57.9	56.5	53.2
1	1	Cream	57.4	57.7	52.2
1	1	Cream	58.2		
1	1	Cream	57.4		
2	1	Cream	58.8		
2	1	Cream	58.1		
2	1	Cream	58.4		
1	2	Grey	49.3	50.6	59.9
1	2	Grey	50.4	51.7	62.1
1	2	Grey	49.5		
2	2	Grey	49.4		
2	2	Grey	49.2		
2	2	Grey	50.4		
1	3	Beige	55.4	57.9	54.3
1	3	Beige	56.5	59	53.2
1	3	Beige	56.8		
1	3	Beige	55.4		
2	3	Beige	56.8		
2	3	Beige	54.6		
2	3	Beige	56.2		
2	3	Beige	56		
2	3	Beige	55.9		
2	3	Beige	56.8		
1	4	Primrose	46.2	47.3	51.5
1	4	Primrose	46.4	48.8	49.7
1	4	Primrose	46.4		49.2
1	4	Primrose	45.8		50
1	4	Primrose	46.4		50.8
2	4	Primrose	47.1		50.8
2	4	Primrose	46.3		50.9
2	4	Primrose	45.9		51.9
2	4	Primrose	45.8		51.7
2	4	Primrose	46.1		51.9