

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

CONCORA TEST VARIABILITY

Project 1108-35

Report

to

TECHNICAL DIVISION

FOURDRINIER KRAFT BOARD INSTITUTE, INC.

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SUMMARY

A statistical analysis was carried out to compare the test variability associated with the three Concora conditioning procedures. The following results were obtained:

1. The average coefficients of variation and per cent standard error are shown below:

Conditioning Time	Coefficient of Variation	Per Cent Standard Error
5-8 sec.	5.57	1.76
30 min.	5.25	1.66
24 hr.	5.18	1.64

It appears that the conditioned Concora results exhibit slightly lower test variability on the average. For example, for five of the six mills, the highest coefficients of variation were obtained with the 5-8 sec. Concora procedure.

2. The 30 min. and 24 hr. procedures gave about equal coefficients of variation. The 30 min. procedure results exhibited the lowest coefficient of variation for three of the mills and the 24 hr. results gave the lowest variability for the other three mills.

3. The average 5% confidence limits for the percentage difference between two averages of ten specimens each are shown below:

Conditioning Time	5% Confidence Limits, %
5-8 sec.	5.2
30 min.	5.0
24 hr.	4.8

For example, a difference between two averages of 5.2% or more would be significant at the 5% level for the 5-8 sec. procedure. As may be noted, slightly lower limits are associated with the conditioned Concora results.

INTRODUCTION

At the last Technical Division meeting the results obtained on the Concora conditioning time study were summarized. In brief, the results indicated that:

1. The three Concora procedures correlated almost equally well with combined board flat crush. Flat crush predictions using the three procedures were also about equally good. This indicates that the deleterious effects which are claimed to occur during conditioning either do not occur or do not affect the relationship. By the same token, the unstable moisture condition associated with "immediate" testing did not adversely affect the relationships with combined board flat crush to any great degree.

2. The correlation coefficients for the individual plants and the composite correlation coefficients were appreciably lower than claimed by Long and Maltenfort, as shown below:

	Concora Conditioning Time		
	<u>5-8 Sec.</u>	<u>30 Min.</u>	<u>24 Hr.</u>
Mill Results:			
Maximum	0.779 (Mill E)	0.825 (Mill C)	0.774 (Mill C)
Minimum	0.600 (Mill B)	0.468 (Mill F)	0.508 (Mill D)
Composite	0.769	0.767	0.763
IPC Results:			
Maximum	0.838 (Mill F)	0.912 (Mill F)	0.873 (Mill F)
Minimum	0.445 (Mill D)	0.566 (Mill B)	0.613 (Mill A)
Composite	0.789	0.787	0.793

Thus, the manner of conditioning does not materially affect the magnitude of the correlation coefficient.

3. The 5-8 sec. tolerance for the time interval between the specimen emerging from the fluter and the beginning of loading seems unrealistically short. In this connection one participant found it necessary to use a tolerance of 10 - 13 sec.

After reviewing the above results, it was suggested that the test variability for the three methods be analyzed. The results obtained are summarized herein.

STATISTICAL PROCEDURES

Average variances were calculated for each mill using the procedure outlined by Davies (1).

1. The variance about each sample average was calculated as follows:

$$V = \frac{\sum x^2 - (\sum x)^2 / N}{N - 1} \quad (1)$$

where V = variance = standard deviation squared
 $\sum x^2$ = sum of squares of individual observations
 $(\sum x)$ = sum of individual observations
and N = number of observations = 10

Separate variance estimates were calculated for the mill and Institute results for each sample.

2. The average variance (\bar{V}) for each mill was calculated as follows:

$$\bar{V} = (V_1 + V_2 + \dots + V_k) / k$$

where V_1, V_2, \dots = individual sample variances for mill and
Institute results, respectively
and k = number of individual sample variances

3. Standard deviations, coefficients of variation and standard errors were calculated for each mill composite as follows:

$$\text{Standard deviation} = s = \sqrt{\bar{V}}$$

$$\text{Coefficient of variation} = (s/\bar{X})100$$

$$\text{Standard error} = s/\sqrt{10}$$

$$\text{Per cent standard error} = 100(s/\sqrt{10})/\bar{X}$$

where \bar{X} = average mill test value

4. Confidence limits for a significant difference at the 5% level between two averages of ten readings were calculated as shown below:

$$\bar{X}_1 - \bar{X}_2 = \pm t_{05} \quad 2 s / 10$$

where $t_{05} = 2.10$ for 18 degrees of freedom

DISCUSSION OF RESULTS

The results are shown in Table I. Because the "hot" Concora averages are at a higher level than the conditioned results, the comparisons of test variability should be made in terms of percentages -- i.e., coefficient of variation or per cent standard error. The differences in coefficient of variation or per cent standard error are not great; however, the "hot" Concora tests show the highest variability for five of the six mills. The 30 min. and 24 hr. procedures give slightly lower coefficients of variation than the "hot" Concora results on the average.

There appears to be little difference between the 30 min. and 24 hr. procedures in terms of variability. For three of the mills, the 30 min. procedure gave the lowest variability and the 24 hr. procedure gave the lowest variability for the other three mills.

It may be remarked that the above estimates of variability were obtained under relatively ideal sampling and test conditions. For example, all participants were to exercise special care to comply with the conditioning tolerances. This was true of the Institute's tests. In day-to-day testing, deviations from test procedure tolerances, test operator technique, etc., would probably increase test variability. Because of the short time involved in "hot" Concora testing, deviations from the 5-8 sec. tolerance could easily occur in routine testing which might give lower and more variable test results using the 5-8 sec. procedure. In this respect, deviations from the 30 ± 5 min. or 24 ± 2 hr. conditioning times may have less effect on test variability. In other words a small difference in absolute time at the 5-8 sec. level would have more effect than at the longer conditioning times.

TABLE I
 CONCORA TEST VARIABILITY

Plant	Conditioning Time	Average (\bar{X})	Variance (\bar{V})	Coefficient of Variation	Standard Deviation (s)	Standard Error (N=10)	Per Cent Standard Error	5% Confidence Limits for the Difference between Two Averages ^a			
								+ Confidence Limit	+ Percentage Limit	Upper Limit	
A	5-8 sec.	50.2	7.02	5.28	2.65	0.84	1.67	2.49	5.0	52.7	47.7
	30 min.	40.5	3.78	4.81	1.94	0.61	1.51	1.81	4.5	42.3	38.7
	24 hr.	41.3	4.33	5.04	2.08	0.66	1.60	1.96	4.7	42.9	39.7
B	5-8 sec.	44.1	4.53	4.82	2.13	0.67	1.52	1.99	4.5	46.1	42.1
	30 min.	34.7	2.45	4.51	1.57	0.50	1.44	1.48	4.3	36.2	33.2
	24 hr.	35.3	2.81	4.75	1.68	0.53	1.50	1.57	4.4	36.9	33.7
C	5-8 sec.	43.9	5.69	5.43	2.39	0.76	1.73	2.26	5.1	46.2	41.6
	30 min.	34.2	2.79	4.89	1.67	0.53	1.55	1.57	4.6	35.8	32.6
	24 hr.	35.0	3.02	4.96	1.74	0.55	1.57	1.63	4.7	36.6	33.4
D	5-8 sec.	40.4	6.06	6.09	2.46	0.78	1.93	2.32	5.7	42.7	38.1
	30 min.	32.5	3.79	5.99	1.95	0.62	1.91	1.84	5.7	34.3	30.7
	24 hr.	33.4	3.49	5.59	1.87	0.59	1.77	1.75	5.2	35.2	31.6
E	5-8 sec.	42.6	6.17	5.83	2.48	0.78	1.83	2.32	5.4	44.9	40.3
	30 min.	34.9	4.34	5.97	2.08	0.66	1.89	1.96	5.6	36.9	32.9
	24 hr.	35.4	3.98	5.63	1.99	0.63	1.78	1.87	5.3	37.3	33.5
F	5-8 sec.	43.1	6.63	5.97	2.57	0.81	1.88	2.41	5.6	45.5	40.7
	30 min.	36.8	3.83	5.32	1.96	0.62	1.68	1.84	5.0	38.6	35.0
	24 hr.	37.1	3.57	5.10	1.89	0.60	1.62	1.78	4.8	38.9	35.3
Av.	5-8 sec.	44.0	--	5.57	2.45	0.77	1.76	--	5.2	--	--
	30 min.	35.6	--	5.25	1.86	0.59	1.66	--	5.0	--	--
	24 hr.	36.2	--	5.18	1.88	0.59	1.64	--	4.8	--	--

^a Calculated as follows: $\bar{X}_1 - \bar{X}_2 = t_{0.05} \sqrt{2 s / N}$

Also shown in Table I are the 5% confidence limits for the difference between two averages of ten specimens each. For example, for Mill A, a difference of 2.49 p.s.i. (4.1 lb.) or more between two 5-8 sec. Concora averages would be significant at the 5% level. When converted to a percentage the confidence limits range from 4.5 to 5.7% for the 5-8 sec. tests, from 4.3 to 5.7% for the 30 min. procedure, and from 4.4 to 5.3% for the 24 hr. procedure. On the average the conditioned Concora results give lower confidence limits.

Literature Cited

1. Davies, O. L. Statistical methods in research and production. Hafner Publishing Co., New York (1958). Third Edition.