

35

October 21, 1975

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Results of the most recent (9-12-75) collaborative tests on the vinyl chloride charcoal tubes are presented in Table I below. This series of tubes, VC-C-1 thru VC-C-4, contained duplicate samples at the 111.5 microgram and 37.2 microgram level of vinyl chloride. A statistical evaluation of the results is also included to show the accuracy and precision of each Plant.

Table I
Interplant Vinyl Chloride Results

Standards	VC-C-1 VC-C-4	VC-C-2 VC-C-3
	111.5 ug	37.2 ug
Niagara Falls	99.0	34.0
	94.0	32.0
North Chicago	128.0	42.5
	122.5	42.0
Plaquemine	118.0	25.0
	79.0	28.0
Akron Research	111.1	37.5
	113.5	37.5

Direct comparison of the results reveals that Niagara Falls and Plaquemine were generally on the low side of the standards, whereas North Chicago was on the high side. Akron Research was very close to the actual standards. From these results the percent relative accuracy (percent difference from standard) was calculated and is shown in Table II. Example: $\frac{99.0 - 111.5}{111.5} \times 100 = -11.2\%$

Table II
Percent Relative Accuracy

	VC-C-1 VC-C-4	VC-C-2 VC-C-3	<u>Average</u>
Niagara Falls	-11.2 -15.7	-8.6 -14.0	-12.4
North Chicago	14.8 9.9	14.2 12.9	13.0
Plaquemine	5.8 -29.1	-32.8 -24.7	-20.2
Akron Research	-0.4 1.8	0.8 0.8	0.75

The overall accuracy achieved by Akron Research, <1%, is outstanding.

To analyze the precision within each plant, the range of duplicate samples must be determined from the percentage data in Table II. Example:

North Chicago	VC-C-1	14.8%
	VC-C-4	9.9%

14.8 - 9.9 gives a range of 4.9.

The smaller the value of the range of duplicates, the greater is the precision within a particular lab. After the range of duplicates is determined for each plant, an average range value for all the plants, $\bar{R}$, is obtained and an upper control limit calculated. Any range value that exceeds the upper control limit (2 $\bar{R}$) is considered to be an outlier, and is omitted from subsequent calculations. Table III gives the values for the ranges of duplicates.

Table III
Ranges of Duplicates

	VC-C-1 VC-C-4	VC-C-2 VC-C-3
Niagara Falls	4.5	5.4
North Chicago	4.9	1.3
Plaquemine	34.9	8.1
Akron Research	2.2	0

Average range, $\bar{R}$ = 7.66

To calculate a 2σ (95% confidence) upper control limit for 8 subgroups with 2 observations per subgroup, the following formula is used:

$$\begin{aligned}
 UCL_2 &= \bar{R} + 2/3 [(D^* \cdot \bar{R}) - \bar{R}] \\
 &= 7.66 + 2/3 [(4.87 \cdot 7.66) - 7.66] \\
 &= 7.66 + 2/3 [37.30 - 7.66] \\
 &= 7.66 + 2/3 [29.64] \\
 &= 7.66 + 19.76 \\
 &= 27.42
 \end{aligned}$$

Taking 27.4 as the 2σ upper control limit, it can be seen that Plaquemine's range of duplicates (34.9), exceeds the upper control limit. By analyzing Plaquemine's results, 79 μ g can be considered an outlier and omitted from further calculations. Plaquemine should review their analytical procedure to determine possible causes for the discrepancy in results at the 111.5 microgram level. The fact that the ranges of duplicates for the other plants do not significantly approach the upper control limit demonstrates good precision.

While the ranges of duplicates gives an indication of the precision within each lab (intralab), the standard deviation (σ), which is the deviation from the mean, indicates precision among the labs (interlab). Table IV gives the standard deviation for the 111.5 microgram level.

Table IV
Interplant Data For 111.5 Microgram Level

x	$\bar{x}$	$(x - \bar{x})$	$(x - \bar{x})^2$	$\sum (x - \bar{x})^2$	n	σ
99.0	112.3	13.3	176.89	897.45	7*	12.23
94.0		18.3	334.89			
128.0		15.7	246.49			
122.5		10.2	104.04			
118.0		5.7	32.49			
111.1		1.1	1.21			
113.5		1.2	1.44			

* Plaquemine outlier of 79 μ g omitted from calculation of σ .

For charcoal tubes containing 111.5 micrograms, interplant analysis found a mean value of 112.3 micrograms with a standard deviation of 12.2 micrograms. The % relative standard deviation is 10.9%.

Table V
Interplant Data For 37.2 Microgram Level

X	$\bar{X}$	$(X - \bar{X})$	$(X - \bar{X})^2$	$\sum (X - \bar{X})^2$	n	σ
34.0	34.8	0.8	0.64	276.47	8	6.28
32.0		2.8	7.84			
42.5		7.7	59.29			
42.0		7.2	51.84			
25.0		9.8	96.04			
28.0		6.8	46.24			
37.5		2.7	7.29			
37.5		2.7	7.29			

For charcoal tubes containing 37.2 microgram of vinyl chloride, interplant analysis found a mean value of 34.8 micrograms with a standard deviation of 6.3 micrograms. The % relative standard deviation is 18.1%.

The smaller the relative standard deviation, the greater is the precision among labs. The % relative standard deviation values of 10.9% at the 111.5 microgram level and 18.1% at the 37.2 microgram level indicate that the precision among labs is not as good as it should be and further collaborative tests will be conducted. The results reported by Akron Research prove that excellent precision and accuracy are obtainable.

The help of L.A. Bedford, Division Manager, Quality Control, Chemicals, with the statistical work involved in this report is greatly appreciated.

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