

MONSANTO CHEMICAL COMPANY

Texas City, Texas

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cc: H. K. Eckert
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To: Mr C. T. Murray

Statistical Analysis
VCM Data from 15 Tank Cars

This report is in answer to your letter of April 24, 1953. Data from the analysis of fifteen VCM tank cars was attached. You requested a statistical study of this data, to determine expected variations in analyses for polymerization-rate and chloroprene.

Samples

These tank car samples were divided into groups of four - titled First, Second, Third, and Fourth samples. There were fifteen samples in each of the first two groups, two samples in the third group, and four samples in the fourth group. The results on the Third Sample group were very low, however, and probably were erroneous. This group was eliminated from the statistical studies.

Although the samples were taken from different tank cars, the cars had all been loaded from the same sphere. They were treated, then, as several samples from the same tank. The groups titled First, Second, and Fourth Sample were the only ones considered.

For certain of the statistical studies, it was necessary to make some assumptions about the samples. Under each grouping there are either fifteen or four tank car samples. Each grouping, however, was considered as one statistical sample, out of which fifteen or four analyses had been run. For clarity in this report, these statistical groupings will be called "stat-samples" to differentiate between actual samples as drawn.

Statistical Studies

There were three general types of statistical procedures used for these studies. These are 1) analysis of variance, 2) charting of range and averages, 3) standard deviation.

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The various particular uses of the procedures are:

- 1) Analysis of variance - Stat-samples versus poly-rate analysis.
- 2) Analysis of variance - Analysts versus poly-rate analysis
- 3) Range and averages - Poly-rates
- 4) Standard deviation - Poly-rates
- 5) Analysis of variance - Stat-samples versus chloroprene analysis
- 6) Standard deviation - Chloroprene analysis

Stat-Samples Versus Poly-Rate Analysis

The purpose of this study was to determine which contributed more to the variations in the poly-rate, the samples or the analysis itself.

The results of this analysis of variance indicated that the major source of variation may be in the samples. By this is meant the whole range of errors possible in obtaining a sample. It includes sampling technique, bombs, homogeneity of tank-contents, differences in people taking the samples, and so forth.

However, while the results point toward the samples, no definite conclusion can be made. This is due, primarily, to the statistical assumptions about the samples necessary to set up the analysis of variance.

To reach any definite conclusions upon which future actions could be based, a statistically-controlled experiment would be necessary. A plan for such an experiment has been previously suggested. However, the pressure of the other work in the laboratory has made it impossible, up to now, to run such a controlled test.

Analysts Versus Poly-Rate Analysis

Differences in analysts is another variable to be considered in poly-rate variations. Therefore, to determine the effect different analysts might have on poly-rates, an analysis of variance was run on analysts versus the analysis itself.

The results in this study were very inconclusive. Primarily, because there was no cross-checking of the same sample by different analysts.

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The statistically-controlled test mentioned above would also measure the amount of variation due to analysts. It would show which variable - analysts, samples, or the analysis itself - is the most important factor in its effect on the poly-rate variations.

Range and Averages - Poly-Rates

This study was made to determine the precision of the poly-rate test on triplicate results from the same sample. And, also, the precision of the average of the triplicates from sample to sample of the same material lot. Samples here means samples as actually drawn from each tank car.

At 95% probability, the overall precision to be expected on the averages of triplicate results is plus-or-minus 2%, for samples from the same material lot. And for a triplicate analysis from the same sample, the range is 0 - 5%.

Standard Deviation - Poly-Rates

A standard deviation study was made to determine the overall precision of the individual poly-rates. This is a check of the precision from analyst to analyst, day to day, and test to test, on the same material lot.

The standard deviation found in this study is 2.75%. Therefore, at 95% probability, the overall precision to be expected on individual poly-rate analyses is plus-or-minus 5.5%, for samples from the same material lot.

I do not mean to infer by these limits, that they are the best possible. They are indications, rather, of the precision now being obtained on the poly-rate analysis.

Control Charts

No control charts are included with this report. Since the material being studied was of border-line specifications, and the average of all the analyses was 79.8% on the poly-rate, the charts would not be of much use. The limits of the test accuracy and precision, however, are valid and are independent of the quality of the material.

Stat-Samples Versus Chloroprene Analysis

Similar statistical studies to some of those made on the poly-rate test were made on the chloroprene test. This study was to determine the effect that samples and the analysis itself have on variations in the chloroprene results.

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This analysis of variance however, showed that the effect of both variables was not significant. Further tests are now being run in the control laboratory on the chloroprene analysis. These are discussed below.

Standard Deviation - Chloroprene

A standard deviation study was made to determine the precision of the chloroprene analysis. The average of all the results was 57 ppm chloroprene. This study showed that the standard deviation, using the control laboratory results, is 19 ppm (at 67% probability). Then, at 95% probability, the expected precision in the chloroprene analysis is plus-or-minus 38 ppm. There is no apparent explanation for this wide variation. (The maximum desirable operating limit is 30 ppm chloroprene.)

Control Tests - Chloroprene Analysis

A series of statistically-controlled tests are now being run in the control laboratory on the chloroprene analysis. An analysis of variance will be made on this data to determine the effect that analysts and samples have on variations in chloroprene results

A standard deviation study will also be made on this data. Another estimate of the precision to be expected in the chloroprene analysis will then be obtained.


L. E. Louraine

Summary

At a 95 per cent confidence level the VCM loaded from the one sphere into 15 tank cars was found to have the following variations:

- a. The chloroprene content ± 38 ppm
- b. The poly-rate between three portions of VCM from the same sample bomb $\pm 5.5 \%$
- c. The average poly-rate of the three portions of VCM from one sample bomb between the average poly-rate of three portions of VCM from another sample bomb $\pm 2.0 \%$
(Second sample from same or another tank car)

CTM:ldm
May 26, 1953

Gil: This is what we seem to
conclude from Lewis study of the
"Case of the 15 Tank Cars."

CTM

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