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H.M. MacLean and S.F. Hall
UFFI Assistance Program
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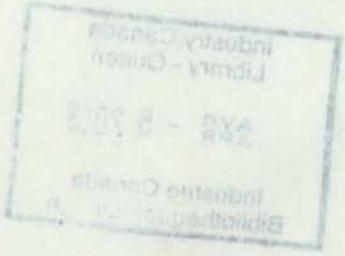

FINAL ANALYSES OF PRE- AND POST-CORRECTIVE MEASURES FORMALDEHYDE LEVELS IN UFFI HOMES

(36 pages)

from the Statistical Master of January 20, 1987

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Consumer and Corporate Affairs Canada
February 6, 1987

(replaces report dated December 1, 1986)

Approved for Release: S. Hall March 12/87
Release date:
File Number: 10305-30

FINAL ANALYSES OF PRE- AND POST-CORRECTIVE MEASURES FORMALDEHYDE LEVELS IN UFFI HOMES

From the Statistical Master of 20/01/87.

Room air and wall cavity formaldehyde levels were measured both prior to and after the completion of corrective measures. Time weighted average room air formaldehyde levels were obtained using the AQRI-PF1 passive formaldehyde monitor (referred to as dosimeter), whose limit of detection is 0.01 ppm. Wall cavity tests were performed with the Dräger 0.5/a formaldehyde detection tube whose range is from 0.5 to 10.0 ppm.

Formaldehyde levels prior to corrective measures were measured at a variety of testing stages in the UFFI Assistance Program. The first pre-corrective measures testing stage was a screening test (SCR), during which room air formaldehyde levels were determined. Based on these levels, participants in the program were then selected for either the Full Scale Test (FST) during which two room air formaldehyde tests and up to 120 wall cavity formaldehyde tests, were performed, or the Modified Remedial Information Procedure during which two wall cavity and two room air formaldehyde measurements were made.

Post-corrective measures formaldehyde levels were measured at the Audit Inspection stage (AI), where two wall cavity and two room air formaldehyde measurements were made, or at the Modified Audit Inspection (MAI) or Homeowner Audit (HOA) stages, where only the two room air formaldehyde tests were performed. These three stages are known collectively as PCM (post-corrective measures) testing.

An automated correlation between various variables and formaldehyde levels was attempted, but could not be carried out. Since the test run which was made on a minute subset of the data base was very expensive, the correlation on the entire data base would have been prohibitively expensive. Instead, the data were compiled in ranges and the mean values of the population in each of these ranges were used in all correlations but the one given on page 4. This method allowed trends to be identified. Further precision was not possible since the use of means could introduce error.

The results of these correlations are included in this and other reports.

The mean average SCR formaldehyde level for each home was 0.058 ppm $\pm$ 0.037550 (22,549 homes). In a graph of the frequency distribution of these SCR levels (Graph 1), the peak was at 0.035 ppm. A secondary peak at 0.134 ppm was found, but other than that, this distribution was a normal distribution. This secondary peak was the result of the increase in the sizes of ranges of formaldehyde levels examined. Below 0.120 ppm, means were given for 0.010 ppm ranges of formaldehyde (e.g., 0.021 - 0.030), but starting at 0.120 ppm, the ranges increased to 0.020 ppm and then to 0.050 ppm (i.e., 0.121 - 0.150, 0.151 - 0.200, $>$ 0.200). The curve did appear to be skewed, but this was an artifact caused by the limits of the dosimeters used. Since the dosimeters have a range of 0.010 ppm to 1.00 ppm and since the peak was at 0.035 ppm, a bell shaped curve could not possibly be observed. The curve was, however, quite symmetrical for 0.020 ppm about the peak of 0.035 ppm.

Slightly more than half of the homes, 51.7%, had SCR formaldehyde levels from 0.011 to 0.050 ppm inclusively and 90.3% had levels from 0.011 to 0.100 ppm, inclusively.

Full Scale Test (FST) dosimeter results were significantly lower than the SCR results at the 95% confidence level, the mean average FST formaldehyde level being 0.050 $\pm$ 0.031630 ppm. This is reflected in the distribution of formaldehyde levels (see Graph II). A greater percentage of homes, 61.1% at FST, had formaldehyde levels from 0.011 to 0.050 than did homes with SCR tests (51.7%). For the range of 0.011 to 0.100, 94.1% of homes with FST results were in this category versus 90.3% for SCR results. Thus, there were more FST results than SCR results in low formaldehyde level ranges.

The mean average MRIP room air formaldehyde level was 0.042 $\pm$ 0.023598 ppm. The peak of the frequency distribution was at 0.025 ppm, lower than for both SCR and FST, as can be seen in Graph III. As well, the secondary peak seen for SCR and FST was almost absent, a marginally small increase in frequency occurring at 0.130 ppm.

The maximum pre-corrective measures room air formaldehyde levels in homes having valid dosimeter results from two separate testing stages were examined. Those data are found in Table I, below.

Table I: Difference Between Formaldehyde Levels Prior to Corrective Measures

	Maximum SCR		Maximum FST		Time Interval
Count of Homes	Mean (ppm)	Standard Deviation	Mean (ppm)	Standard Deviation	Mean (days)
5504	0.074	0.046071	0.057	0.037646	196.51

	Maximum SCR		Maximum MRIP		Time Interval
Count of Homes	Mean (ppm)	Standard Deviation	Mean (ppm)	Standard Deviation	Mean (days)
1161	0.041	0.023999	0.045	0.026661	217.48

The mean maximum SCR formaldehyde level in homes having both valid SCR and MRIP results was 0.041 ppm, whereas the mean maximum MRIP result for the same homes was 0.045 ppm. Calculations which take into account the sample size and the standard deviations for these two means proved that at the 95% confidence level, the two means are significantly different; that is, the mean maximum MRIP formaldehyde level was significantly higher than the mean maximum SCR formaldehyde level.

In contrast, analyses of SCR and FST formaldehyde levels for homes having valid results for both testing stages established that at the 95% confidence level, the mean maximum FST formaldehyde level, 0.057 ppm, was significantly lower than the mean maximum SCR formaldehyde level, 0.074 ppm.

In comparing the two sets of data (SCR/MRIP and SCR/FST), it is quite clear that there are two very different populations. Those homes having both valid SCR and MRIP results have comparatively low formaldehyde levels, and the increase from SCR to MRIP, although certainly statistically significant, is not very large. The increase observed may be the result of an increase from a baseline level of formaldehyde, due to the introduction of new sources of formaldehyde. That these homes are at minimal formaldehyde levels is supported by the maximum levels of formaldehyde measured in wall cavities at MRIP, which are, on average, 2.18 ppm versus 4.29 ppm for the mean maximum FST wall cavity formaldehyde levels. Homes at a baseline level would be much more likely to have increases than decreases in formaldehyde levels.

The group of homes having both valid SCR and FST results had a mean SCR formaldehyde level of 0.074 ppm, a level almost twice as high as the SCR level for homes having both valid SCR and MRIP results. The mean maximum wall cavity formaldehyde levels for the SCR/FST group were approximately twice that of the SCR/MRIP group. Other studies have shown a direct relationship between dräger and dosimeter levels.

For homes with both valid SCR and FST formaldehyde levels, the mean time interval between the tests and the ratio of the SCR and FST levels for various ranges of ratios were compared. These data are given in Table II. It was determined that the larger the SCR/FST ratio was (that is, the greater the decrease from SCR to FST), the greater the time elapsed between tests. The relationship between the decrease in formaldehyde levels and the time elapsed was logarithmic, as shown in regression analyses and graph IV. The coefficient of determination, r, was equal to 0.66. Therefore, there is a trend towards decreased levels of formaldehyde with the time elapsed before corrective measures, for this group of houses.

A similar analysis of the SCR to MRIP ratios and the mean time elapsed between tests for each range of ratio was performed. These data are given in Table III. It was also a logarithmic relationship. The coefficient of determination, r, was 0.92 (see graph V). In this case, however, the smaller the time between tests was (minimum mean time interval was 154 days), the greater the increase from SCR to MRIP. Thus, it appeared as if this group of homes was more likely than not to have an increase in formaldehyde levels between tests, but that the longer the time span between tests, the less likely it was that an overall increase would be observed.

Table II: Mean Ratio of SCR to FST Levels and Time Elapsed

*Mean Ratio SCR/FST	Mean Time Elapsed (days)	Count of Homes	Cummulative Percent of Homes
>3.000	215.22	451	8.19
2.500	202.37	870	24.00
1.875	192.54	407	31.40
1.625	197.88	533	41.08
1.375	200.80	698	53.76
1.125	188.80	794	68.19
0.889	189.79	707	81.03
0.727	184.39	387	88.06
0.615	201.55	243	92.48
0.533	182.75	139	95.00
0.400	190.74	191	98.47
<0.333	217.13	84	100.00
total	196.51	5504	100.00

Table III: Mean Ratio of SCR to MRIP Levels and Time Elapsed

*Mean Ratio SCR/MRIP	Mean Time Elapsed (days)	Count of Homes	Cummulative Percent of Homes
>3.000	365.32	25	2.15
2.500	278.65	114	11.97
1.875	219.15	47	16.02
1.625	249.63	86	23.43
1.375	233.84	128	34.45
1.125	201.82	147	47.11
0.889	214.89	197	64.08
0.727	207.86	113	73.82
0.615	197.04	101	82.52
0.533	181.85	54	87.17
0.400	154.49	108	96.49
<0.333	195.10	41	100.00
total	217.48	1161	100.00

* Originally, ranges of ratios were provided. In order to calculate the correlation between the ratio and the mean time, it was necessary to convert the range to a number. The midpoint of the range was selected except for the ranges >3.000 and <0.333, where values of 3.001 and 0.332 were assumed, respectively.

Changes in pre-corrective measures formaldehyde levels have been studied by comparing formaldehyde levels in homes with varying ages of UFFI; that is, by attempting to correlate formaldehyde levels to the time elapsed between the installation of UFFI and the period of testing. It was found that there was a decreasing logarithmic relationship (see Graph VI and Table IV) with a coefficient of determination, r, equal to -0.971. This relationship should, however, be interpreted with caution. The magnitudes involved are very small. The levels of formaldehyde after 12 years are 0.026 ppm lower than after 2 years. This represents a difference of

0.0026 ppm per year. In comparison, a mean decrease of 0.022 ppm from SCR to PCM was observed for both UFFI removal and HRV installation. The mean time elapsed was 640 days. The difference of 0.026 ppm over 10 years would translate to 0.005 ppm over 560 days. Thus, any contribution which the time factor makes to the decrease observed with the implementation of corrective measures must be negligible.

Table IV: Mean Pre-Corrective Measures Formaldehyde Level versus the Age of UFFI

Mean Age of UFFI (days)	Mean Pre-Corrective Measures Formaldehyde	Count of Means
495.5	0.047	39
653.0	0.066	730
831.1	0.061	1197
1010.0	0.062	2431
1189.0	0.059	2794
1367.0	0.057	2705
1549.0	0.055	1977
1732.0	0.053	1742
1993.0	0.050	2048
2352.0	0.046	1092
2712.0	0.046	439
3073.0	0.042	141
3454.0	0.048	66
4782.0	0.043	93

Even if the difference was of a larger magnitude, there would be no way of knowing whether it really represented a decrease. It is an established fact that formaldehyde levels vary significantly from one UFFI home to another, due to numerous factors. Unless the comparisons of formaldehyde levels were made with the same UFFI at different ages rather than with different UFFI's of different ages, it would be impossible to determine whether the observed difference was due to age of UFFI or whether it was due to any or several of the other factors which differentiate one home from another.

As with the two series of pre-corrective measures tests, the maximum pre- and post-corrective measures results in homes having both valid pre- and post-corrective measures results were compared.

It was determined that for each of the pre-corrective measures test-types, there was a significant decrease from the pre- to the post-corrective measures testing, at the 95% confidence level. This held true for all corrective measures with sufficiently large sample sizes. Sealing and fresh air intake had sample sizes which were too low to be significant. See Table V below. It should be noted that the total measures data also include a few homes with "unknown other" corrective measures, so that the sum of the counts for removal, HRV, Fresh air intake, and sealing will not equal that of total measures.

Table V

Corrective Measures	Count of Homes	Maximum Screen		Maximum PCM		Time Interval
		Mean (ppm)	Standard Deviation	Mean (ppm)	Standard Deviation	Mean (days)
Removal	8407	0.068	0.046506	0.046	0.031489	608.61
HRV	2821	0.065	0.045058	0.043	0.028061	733.45
Fresh Air Intake	9	0.067	0.034241	0.038	0.019842	858.56
Sealing	44	0.071	0.046765	0.039	0.024417	679.64
Total Measures	11743	0.068	0.046655	0.046	0.030920	631.44

Corrective Measures	Count of Homes	Maximum FST		Maximum PCM		Time Interval
		Mean (ppm)	Standard Deviation	Mean (ppm)	Standard Deviation	Mean (days)
Removal	3815	0.059	0.036010	0.048	0.030941	503.64
HRV	2178	0.054	0.035276	0.043	0.027660	598.77
Fresh Air Intake	13	0.071	0.064161	0.048	0.027032	458.31
Sealing	32	0.051	0.029967	0.043	0.036538	580.72
Total Measures	6098	0.058	0.036248	0.046	0.029988	537.58

Corrective Measures	Count of Homes	Maximum MRIP		Maximum PCM		Time Interval
		Mean (ppm)	Standard Deviation	Mean (ppm)	Standard Deviation	Mean (days)
Removal	921	0.046	0.025013	0.041	0.027341	502.86
HRV	392	0.046	0.030149	0.038	0.022904	693.48
Fresh Air Intake	3	0.045	0.053426	0.037	0.034871	520.00
Sealing	12	0.045	0.017781	0.028	0.009403	486.00
Total Measures	1351	0.046	0.026600	0.040	0.025981	557.44

For homes having both SCR and PCM results, the mean maximum SCR formaldehyde level was 0.068 ppm, and the mean maximum PCM formaldehyde level was 0.046 ppm. Taking into account the precision range of the dosimeter ($\pm$25% for levels less than 0.025 ppm and $\pm$15% for levels greater than 0.025 ppm), and the fact that the ranges of formaldehyde

levels examined were in "blocks" of 25%, a rough estimate of the percent of homes having had a decrease, no change or an increase can be made. The breakdown utilized is as follows:

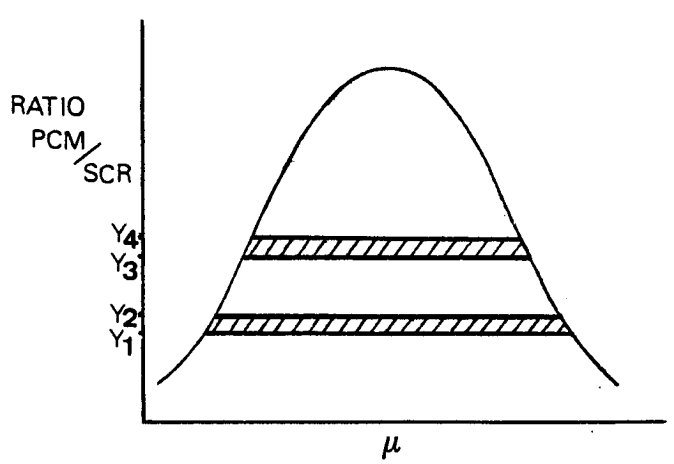
decrease ..... SCR is greater than 125% of PCM
no change ..... difference is less than or equal to 25%
increase ..... PCM is greater than 125% of SCR

Table VI

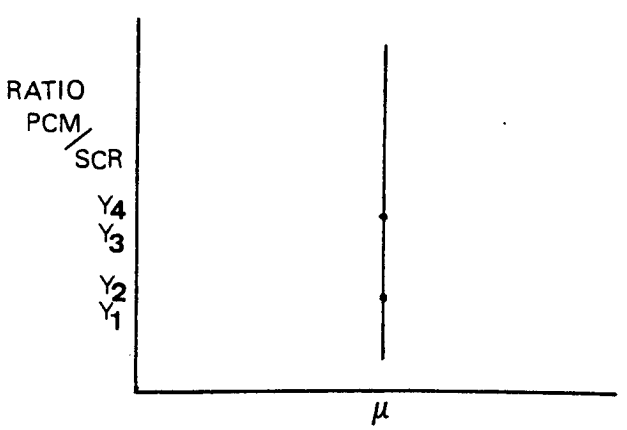
	Increase		No Change		Decrease	
Corrective Measure	Count	Percent	Count	Percent	Count	Percent
Removal	1393	16.6	2916	22.8	5098	60.4
HRV	495	17.6	585	20.7	1741	61.7
Other	72	15.6	107	23.2	283	61.3
Total Measures	1965	16.7	2616	22.3	7162	61.0

As can be seen in Table VI, there was very little difference between the corective measures shown (sealing and fresh air intake are excluded because of low sample size).

An examination of the mean time interval between the SCR and PCM tests and the relationship with the ratios of the PCM to SCR formaldehyde levels showed no correlation. The graphs of the ratio versus the mean time interval for each corrective measure had scattered points for measures with low sample sizes and, as the sample size increased, the points collapsed to form a vertical line. See Graphs VII through XI, attached. Since the x coordinate for each point for these graphs is actually the average time interval for a large number of homes with a given range of y (y is the ratio of PCM/SCR), the graphs representing a random situation would be a vertical line, not a normal curve as is often seen. This is illustrated below with a graph of the ratio and the time interval, and a second graph of the ratio and the mean time interval.



TIME INTERVAL



MEAN TIME INTERVAL

If the individual time intervals for the two ranges of y (y_1 to y_2 and y_3 to y_4) in the normal distribution above are averaged, two points are produced, both of which have the same x coordinate. These two points form a vertical line whose x coordinates are μ, the mean of the normal distribution.

Further analyses have shown some seasonal bias in the frequency of testing for SCR's versus PCM's. This bias, however, could not be responsible (wholely or in part) for the decrease observed for two reasons. The first is that for every month of a year, the mean average SCR formaldehyde levels from tests carried out in a month were higher than the mean average PCM formaldehyde levels from tests in the same month. Also, if the reason that the SCR levels were higher, overall, than the mean average PCM levels was that more SCR tests than PCM tests were conducted in the summer, then by re-calculating the mean average (overall) PCM level using the SCR frequency of testing as a weighting factor rather than the PCM frequency of testing, the "new" mean average PCM level would be significantly increased.

This was not the case. The "new" mean average PCM was 0.0428 ppm (versus 0.0414 ppm for the real mean average PCM) and was still significantly lower than the mean average SCR formaldehyde level. Thus, differences in seasonal testing frequencies were not a contributing factor in the decrease from SCR to PCM formaldehyde levels.

A similar analysis of those homes having both valid FST and PCM results was performed. Again, the mean maximum pre-corrective measures formaldehyde level, mean maximum FST level, 0.058 ppm, was significantly higher than the mean maximum PCM, 0.046 ppm, at the 95% confidence level.

There was no correlation between the decrease in formaldehyde levels from FST to PCM and the time elapsed between the tests. This was true for all corrective measures with sufficient sample size to warrant analysis (UFFI removal, HRV installation, and total measures). See Graphs XII to XIV.

The seasonal testing frequencies for FST and PCM were much closer than those of SCR and PCM testing, although there was still some bias to lower testing frequencies in the winter for FST versus PCM. A re-calculation of the mean average PCM using the FST frequency of testing resulted in no change in the mean average PCM level (0.0414 to 0.0412). Thus, the difference in testing frequencies by season was not the reason for the change in formaldehyde levels.

The same analyses for homes having had both valid MRIP and PCM dosimeter results were repeated. The results of these analyses were similar. The mean maximum MRIP, 0.046 ppm, was significantly higher , at the 95% confidence level, than the mean maximum PCM, 0.040 ppm. There was no correlation between the decrease in formaldehyde levels from MRIP to PCM and the time elapsed between these tests, for removal of UFFI, HRV installation, and for total measures). See Graphs XV to XVII attached.

In this case, there were more PCM tests conducted in spring and summer than were MRIP tests. In re-calculating the mean average PCM formaldehyde level using the MRIP frequency of testing, the mean average PCM level was found to decrease by 0.0032 ppm. Thus, the decrease from MRIP to PCM was a true one, which, if anything, was of a slightly lowered magnitude due to a preponderance of MRIP testing in winter.

Aside from the seasonal factor, the only other factor which could have caused the decrease in formaldehyde levels from pre- to post-corrective measures testing would be the laboratory analysis of the dosimeters.

Differences in homes would not be a factor because only those homes having both valid pre- and post-corrective measures formaldehyde levels were included in the statistical analyses of the data. The home itself could not be a factor since a consistent and significant decrease in formaldehyde levels related neither to time nor to UFFI corrective measures would necessitate the removal of a source of formaldehyde other than UFFI, in a majority of homes. In other words, only seasonal effects or laboratory analysis factors need to be considered.

Analyses of QA/QC data indicated a positive bias in formaldehyde levels measured in spiked dosimeters, early in the program. This bias in laboratory analysis could not be the cause of the decreases from pre-corrective measures testing (carried out early in the program) to PCM testing (carried out later in the program), since there was a signficant increase from SCR (early testing) to MRIP (later testing). Had this positive bias been significant, a consistent and significant decrease from SCR to MRIP would have been observed.

The significant and consistent decrease from pre- to post-corrective measures testing must, therefore, have been due to the implementation of corrective measures.

For AI and MRIP, each wall cavity measurement was made in the same room as one of the room air measurements, and for FST, two of the wall cavity measurements were each in a room which corresponded to one of the room air measurements. Choosing corresponding locations allowed the comparison of wall cavity to room air formaldehyde levels, before and after the implementation of corrective measures.

The levels of formaldehyde in the wall cavity after the removal of UFFI are reduced to < 0.5 ppm by neutralization with a sodium bisulphite solution. It should be noted that a value of 0.25 ppm is assigned to each reading of < 0.5 ppm, for the purpose of statistical calculations. Although room air levels are also reduced by the removal of UFFI, the reduction is of a lower magnitude than that of the wall cavity. Therefore the ratio of room air to wall cavity formaldehyde levels is increased by the removal of UFFI.

The opposite should occur with the installation of a Heat Recovery Ventilator (HRV). Room air formaldehyde levels should decrease and wall cavity levels remain relatively stable for an overall decrease in the ratio of room air to wall cavity formaldehyde levels.

Table VII below provides the ratios of room air to wall cavity formaldehyde levels at various testing stages. The breakdown is by corrective measures for post-corrective measures results only. These data are for all homes, not just those having both pre- and post-corrective measures results.

Table VII

Ratio of Dosimeter to Matching Dräger Level

	AUDIT			MRIP			FST		
Corrective Measure	Count of Ratios	Mean	Standard Deviation	Count of Ratios	Mean	Standard Deviation	Count of Ratios	Mean	Standard Deviation
Total	3568	0.1068	0.109733	3413	0.0848	0.089090	14,554	0.0630	0.084857
Removal	796	0.1690	0.142838						
HRV	2716	0.0879	0.088421						
Fresh Air Intake	8	0.0405	0.051818						
Sealing	29	0.1500	0.192060						

During FST, for a small percentage of homes, room air formaldehyde levels were determined not only by the use of dosimeters, but also by active sampling with oakridge device. The ratio of the oakridge to the dräger levels are given Table VIII.

Table VIII

Ratio of Oakridge to Dräger Levels - FST		
Count of Homes	Mean	Standard Deviation
1043	0.0681	0.136152

There was no significant difference at the 95% confidence level between the mean FST dosimeter to matching dräger ratio and the mean fST oakridge to dräger ratio. Further analyses have shown that there is good correspondence between FST dosimeter and oakridge levels.

The MRIP ratio was significantly higher than the FST ratio, at the 95% confidence level. This was due to the MRIP dräger levels which were used to calculate the ratio (mean = 1.510 ppm) being much lower than FST dräger levels used (mean = 2.278 ppm). The FST levels overall in the program, 4.29 ppm, were also higher than the overall MRIP dräger levels, 2.18 ppm.

As expected, the Audit Removal ratio was much higher at the 95% confidence level than either the MRIP or FST ratio, the reason for this being that these audit dräger levels were lower than MRIP dräger or FST dräger levels.

The Audit HRV ratio was higher than the FST and approximately equal to the MRIP ratios. The installation of an HRV had been expected to result in decreased room air formaldehyde levels and relatively unchanged wall cavity formaldehyde levels, and thus a lowered ratio. That this was not consistently observed, however, demonstrated that the picture was somewhat more complex than anticipated.

Further examination of the data, by region, revealed that Ontario and Quebec, the only two provinces with significant counts, had very different results. In Ontario, the ratio at Audit peaked at 0.029. Overall it was less than the MRIP ratio and not significantly different from the FST ratio. The Quebec Audit ratios, which peaked at 0.308, were higher than both the FST and MRIP ratios. See graph XVIII attached.

Since there was no seasonal bias in frequency of Audit testing for HRV installations in Ontario and in Quebec, the difference in the ratios must have been due to other factors.

The higher ratios in Quebec could have been caused by a problem with the HRV installation, performance, or use by homeowners, in that province.

Since, in Table VII, the homes included in the Audit ratio calculation are not the same ones as those included in the MRIP or the FST ratio calculations, it is possible that the unexpected behaviour is an artifact of the comparison of levels in different homes.

Thus, the ratios before and after corrective measures for HRV installation were examined (by province and for all of Canada) only in those homes where there was a ratio for both MRIP and Audit, or both FST and Audit. These data are given in the Tables below.

Table IX

		FST		AUDIT	
Region	Count	Mean Ratio	Standard Deviation	Mean Ratio	Standard Deviation
Canada	785	0.0603	0.082804	0.0863	0.082804
Quebec	280	0.0969	0.084467	0.1169	0.103815
Ontario	475	0.0530	0.079372	0.0699	0.071219

Table X

		MRIP		AUDIT	
Region	Count	Mean Ratio	Standard Deviation	Mean Ratio	Standard Deviation
Canada	175	0.0862	0.091953	0.0833	0.089790
Quebec	74	0.0940	0.078410	0.1006	0.119119
Ontario	97	0.0806	0.101878	0.0709	0.057670

The differences between MRIP ratios in Tables VII and X are not significant, whereas some of the differences between the FST ratios in Tables VII and IX are significantly different at the 95% confidence level. Specifically, those homes having both FST and Audit ratios in Quebec have significantly higher ratios at FST (Table IX) than do homes in Ontario (Table IX) and in Canada overall (both Tables VII and IX). Much of the increase in the ratio from FST to Audit, for all of Canada, is as a result of the very high Audit ratio in Quebec and of a higher proportion of the total number of homes at Audit being in Quebec (see Table IX).

In analyzing the data used to calculate the ratios, it was found that the Quebec homes were different from the others not only after corrective measures, but also before corrective measures. The difference lies particularly in the room air formaldehyde levels used to calculate the MRIP ratios (Table X) and the wall cavity formaldehyde levels used to calculate the FST ratios (Table IX).

The Quebec homes have higher room air formaldehyde levels and significantly lower wall cavity formaldehyde levels, especially at FST, than the other groups. It was also interesting to note that the FST Dräger levels for Quebec were so low that they were lower than the MRIP levels, even though the FST room air levels of formaldehyde are much higher than the MRIP levels. Also, the MRIP room air levels did not decrease from MRIP to Audit in Quebec, but did decrease significantly in Ontario.

The difference in room air levels could be attributable to decreased use of the HRV's by homeowners in Quebec. It has been noted that more HRV's in Quebec than elsewhere were turned off for very significant periods of time.

As can be seen in Table IX, the Audit ratio was significantly higher than the FST ratio, for Ontario. This was due to a large decrease in Dräger formaldehyde levels. It may be that these homes are part of the group of homes which do see a gradual decrease in formaldehyde levels with the passage of time. This was not the case for the homes in Table X which had a slight but not significant decrease in the ratio from MRIP to Audit, for Ontario. For these homes, the room air formaldehyde levels decreased significantly while the Dräger levels were relatively unchanged.

Thus, the unexpected changes in ratios of room air to Dräger formaldehyde levels after the installation of the HRV are related, in a large part, to the way in which Dräger levels change for different groups of homes. With the exception of Quebec homes in Table X, homes where HRV's were installed had a significant decrease in room air formaldehyde levels, and the lack of decrease in Quebec is attributable to the lack of use of HRV's by some homeowners.

The sample sizes for Fresh Air Intake and Sealing, as can be seen in Table VII, were too low to warrant analysis.

The cost effectiveness of corrective measures was examined by comparing average eligible costs, for homes having had both FST and PCM tests, with changes in room air formaldehyde levels from FST to PCM. These data are summarized in Table XI.

It should be noted that the corrective measures were prioritized because more than one measure is often applied. In order of decreasing priority, the corrective measure are: Removal, HRV installation, Fresh Air Intake, and Sealing. The usual combinations are: Removal and sealing, HRV installation and sealing, and Fresh Air Intake and sealing, though many other combinations are possible.

For Table XI, there is no change in formaldehyde levels if, for a home, the PCM levels fall in the same range as the FST levels. For example, if both the PCM and FST formaldehyde levels are in the range 0.041 to 0.050 ppm, then it is considered that there is no change.

Table XI

Corrective Measure	Difference Between FST and PCM Levels	Count	Percent	Average Eligible Cost
Removal	increase (PCM>FST)	711	19.5	$7672.10
	no change (PCM=FST)	980	26.8	$7799.00
	decrease (PCM<FST)	1963	53.7	$8325.94
	Total	3654	100	$8057.39
HRV	increase	510	28.8	$4817.97
	no change	317	18.7	$4799.72
	decrease	943	53.3	$4779.30
	Total	1770	100	$4794.10
Fresh Air Intake	increase	1	9.1	$2008.00
	no change	0	0.0	-
	decrease	10	90.9	$3230.00
	Total	11	100	$3118.91
Sealing	increase	5	17.2	$3348.60
	no change	3	10.3	$2517.67
	decrease	21	72.4	$3302.74
	Total	29	100	$3229.90
Total Measures	increase	1227	22.5	$6463.55
	no change	1300	23.8	$7055.45
	decrease	2937	53.8	$7133.93
	Total	5464	100	$6964.72

The sample sizes for Sealing and Fresh Air Intake were too low to be significant. It should be noted, however, that the costs for these measures appear to be high since the sealing performed included re-drywalling of the interior walls.

There was little difference between the percentages of homes where there were decreases, no change or increases from FST to PCM for removal and HRV installation. These figures closely resemble the comparison of SCR versus PCM results shown in Table VI. An analysis of overall PCM results showed no significant difference between PCM results for removal and HRV installation. The mean PCM for removal was 0.042 ppm and for HRV installation was 0.039 ppm. The difference in the two measures lies in the cost, removal being almost twice as costly, on average, as HRV installation.

In comparing mean average room air formaldehyde levels with the percentage of medical problems reported, it was found that the two were not really related. See Graphs XIX, XX, and XXI, attached.

For MRIP tests only 1.5% of homes had formaldehyde levels greater than 0.100 ppm so that only levels below 0.100 ppm were examined. For these levels, there was a power curve with r equal to 0.75 indicating an increasing relationship, but the increase in medical problems was only from 35.0% to 42.2% (a 7.2% increase) for the range of 0.01 to 0.100 ppm (a 900% increase in formaldehyde levels). This would indicate minimal increases over a very high baseline level of reported medical problems, as can been seen in Graph XIX.

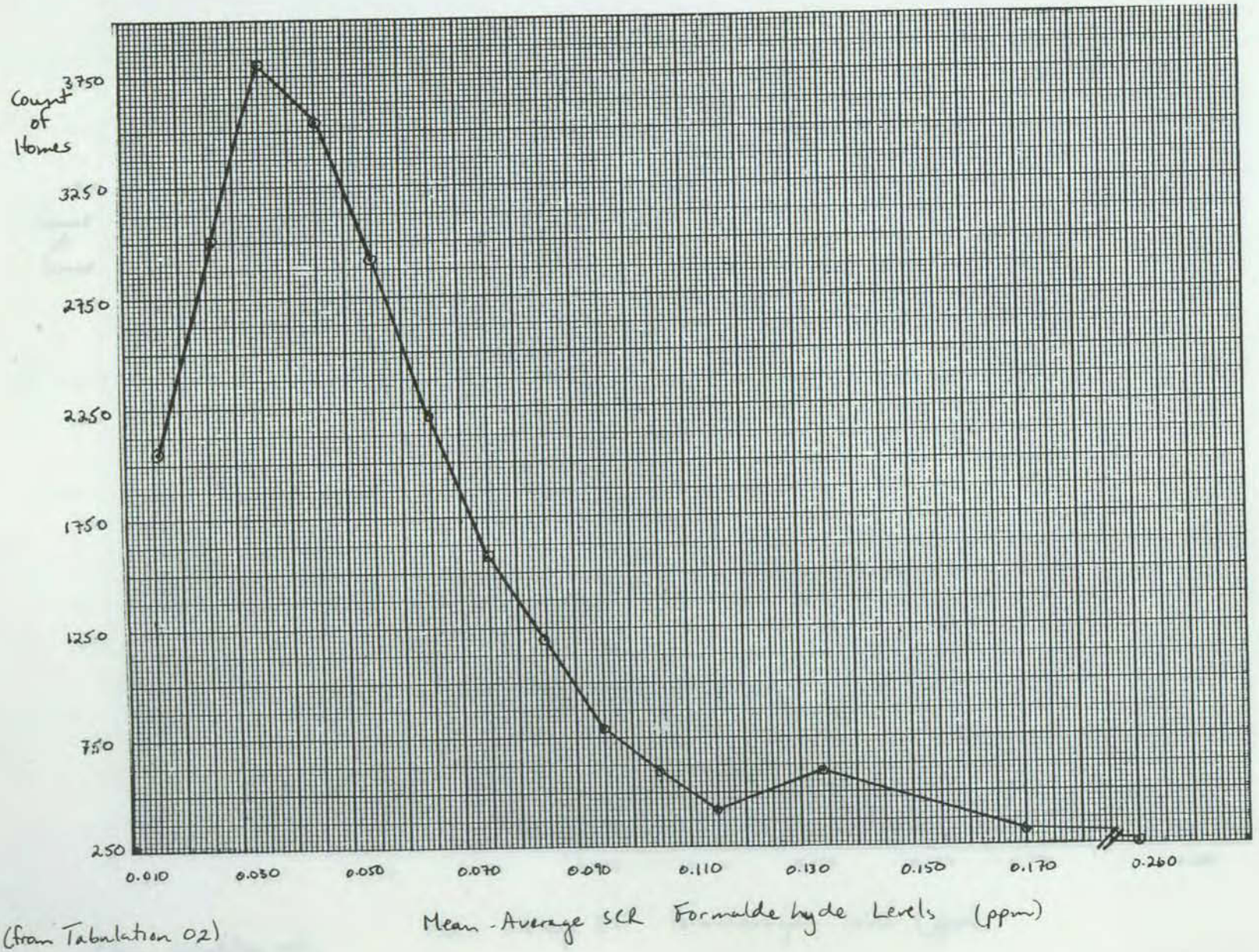
For FST and SCR, there were enough homes having levels above 0.100 ppm to warrant analysis over the full range of results. For FST, there was an exponential correlation, r being equal to 0.92, below 0.1 ppm but above that level, there was a decreasing relationship, as can been seen in Graph XX. That a decreasing relationship exists at higher formaldehyde levels indicates that there really is no relationship between the medical problems reported and the formaldehyde levels. For mean average SCR formaldehyde levels, there was no relationship above 0.100 ppm, and a power relationship below 0.100 ppm, with r equal to 0.91. There was very little increase in the percentage of medical problems reported. For the range 0.01 to 0.100 ppm, a 900% increase in formaldehyde levels, the increase in medical problems was only 3.6% (41.5% to 45.1%) (see Graph XXI). In all cases, the baseline level of medical problems was very high - 34.7% for FST and 41.5% for SCR.

Since there was no consistent relationship between room air formaldehyde levels and the percentage of homes where the occupants reported medical problems, and since there was a high percentage of medical problems reported even when formaldehyde levels were at the limit of detection, it can be concluded that there is no correlation between medical problems and formaldehyde levels before corrective measures.

It is interesting that the percentage of homes where the occupants reported medical problems was related to the choice of the corrective measure. The highest incidence of medical problems reported was with the pre-proclamation removals, at 55.9% of homes. Homes where removal was carried out after the proclamation had a 48.9% reporting rate, and 35.1% of homes where HRV's were installed had occupants reporting medical problems at the time of application. These percentages also correspond to the degree of media publicity at the times when homeowners chose corrective measures. At the time pre-proclamation homeowners removed UFFI, media publicity was at its highest. It was still somewhat high at the time of post-proclamation removals, but died off rapidly during that time. At the time where HRV installations started to become significant, UFFI had become a relative non-issue.

Graph I

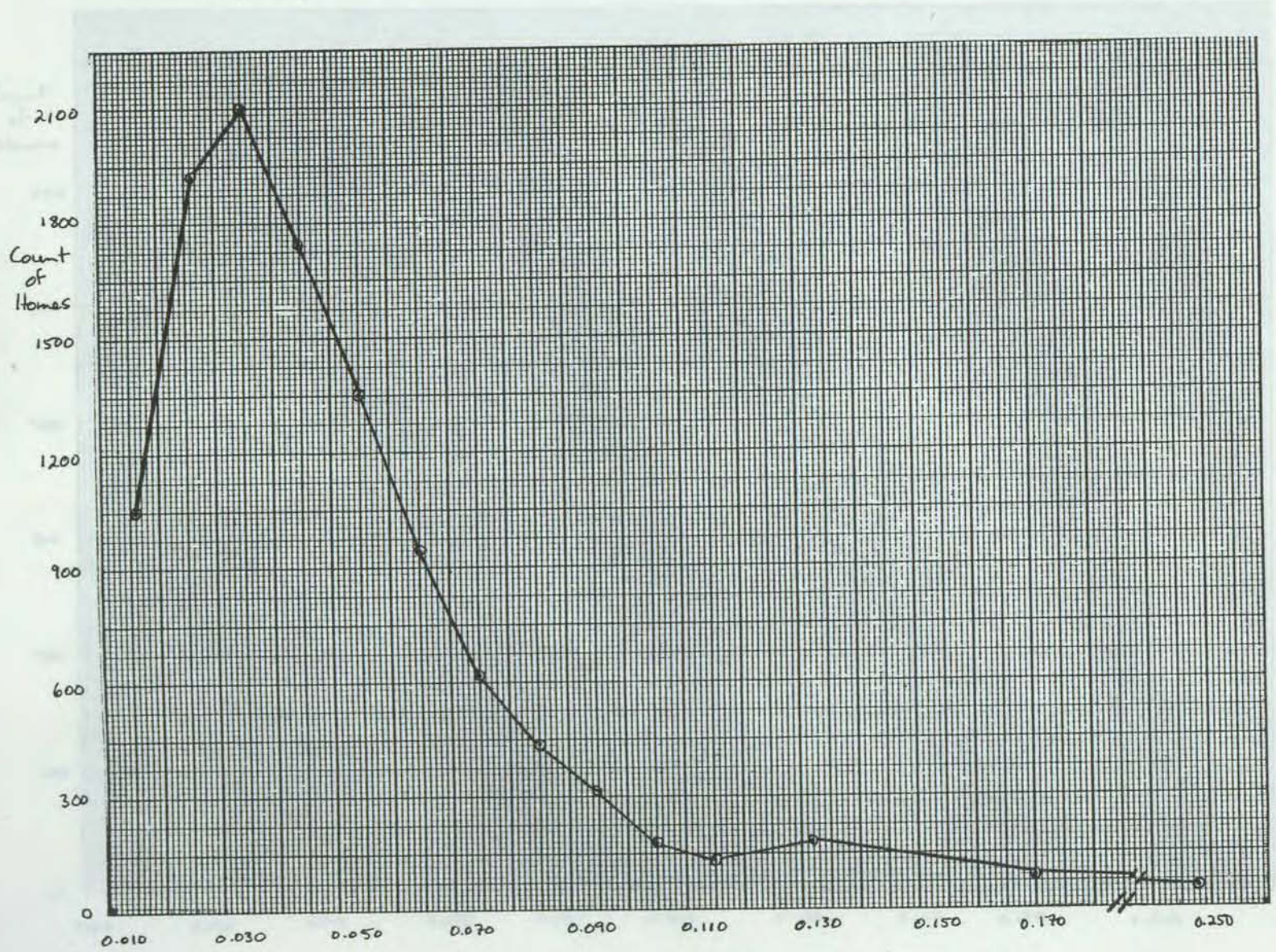
Frequency Distribution of Mean SCR Formaldehyde Levels



(from Tabulation 02)

Graph II

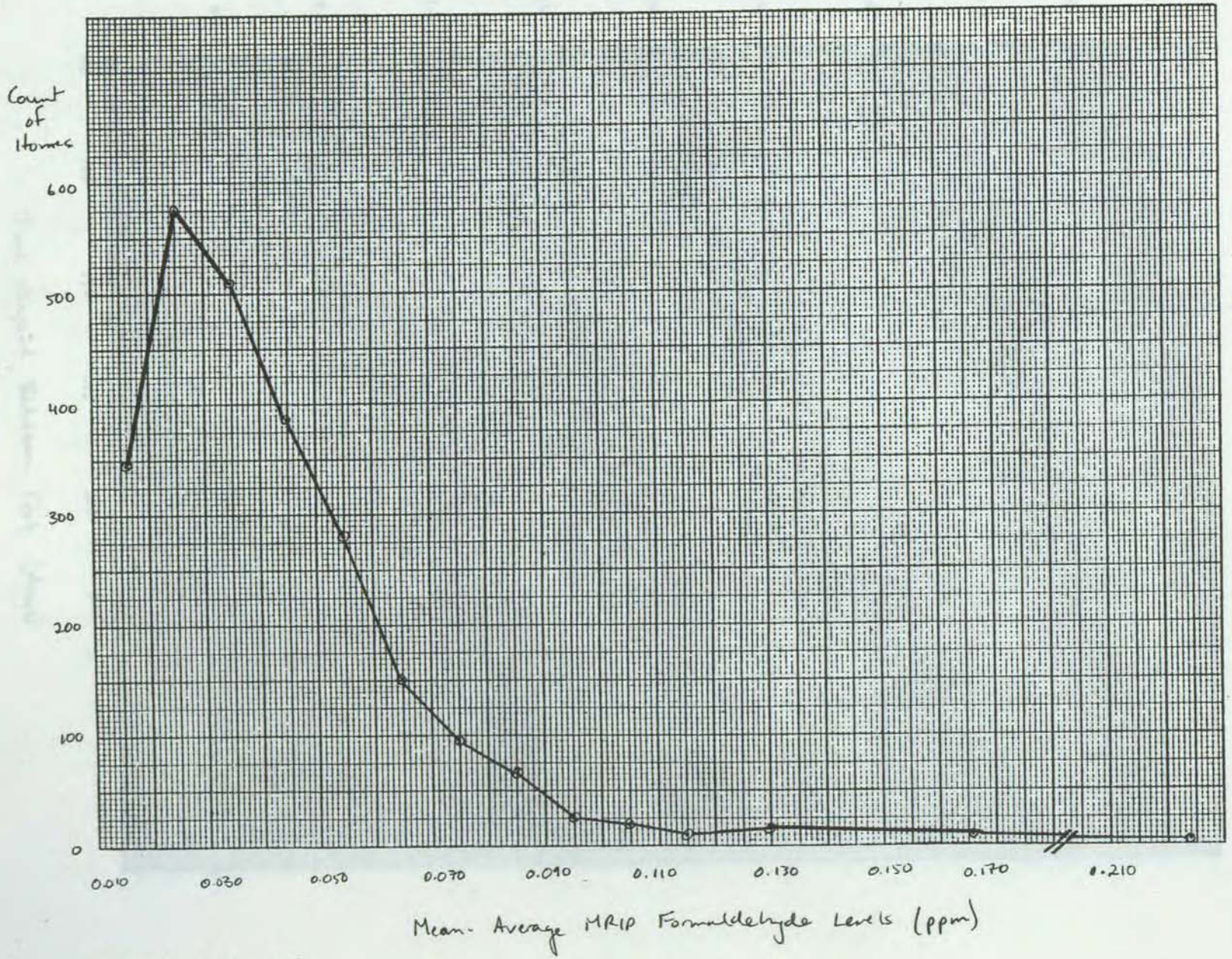
Frequency Distribution of Mean FST Formaldehyde Levels



(From tabulation 02)

Graph III

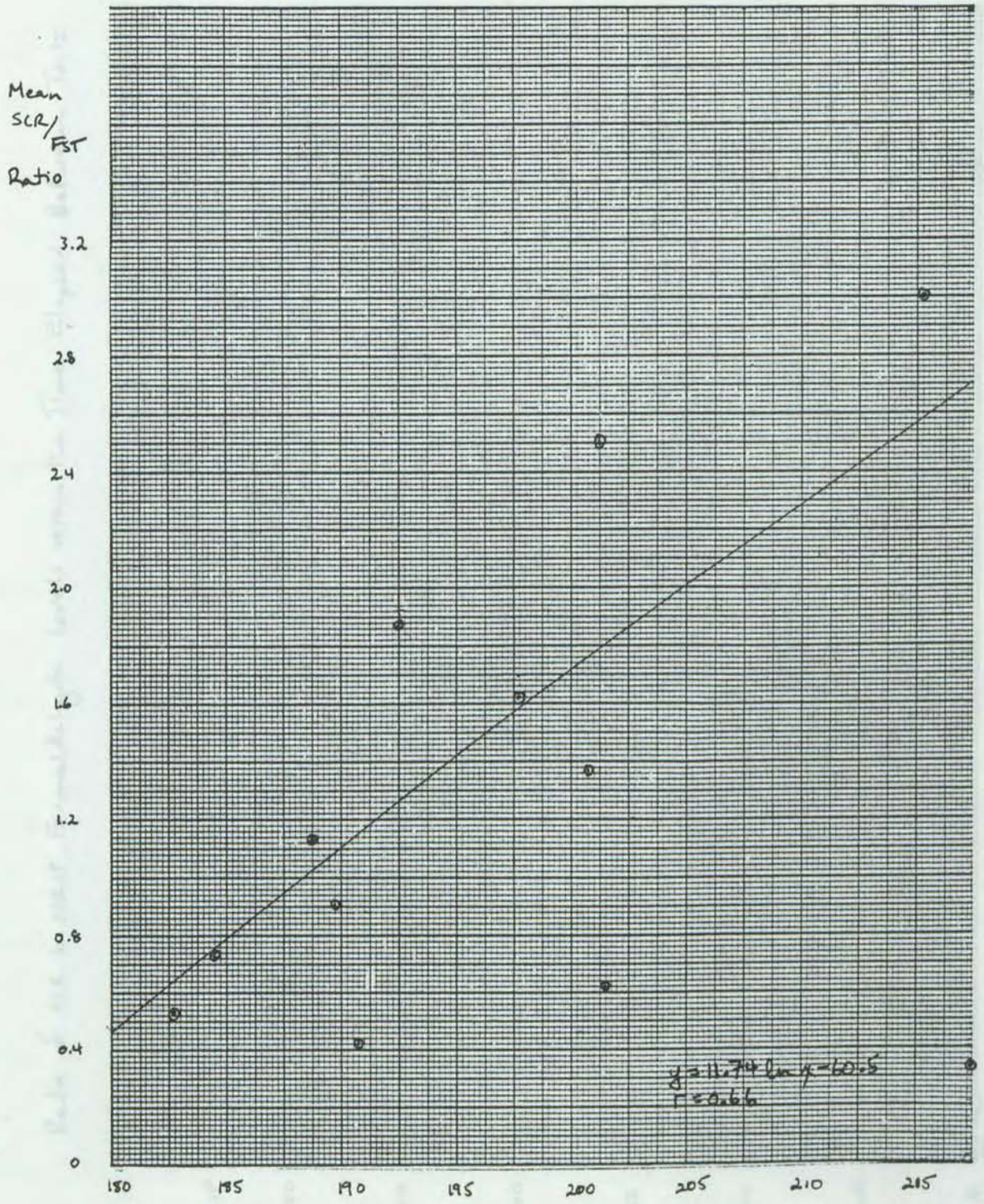
Frequency Distribution of Mean MRIP Formaldehyde Levels



(from tabulation 02)

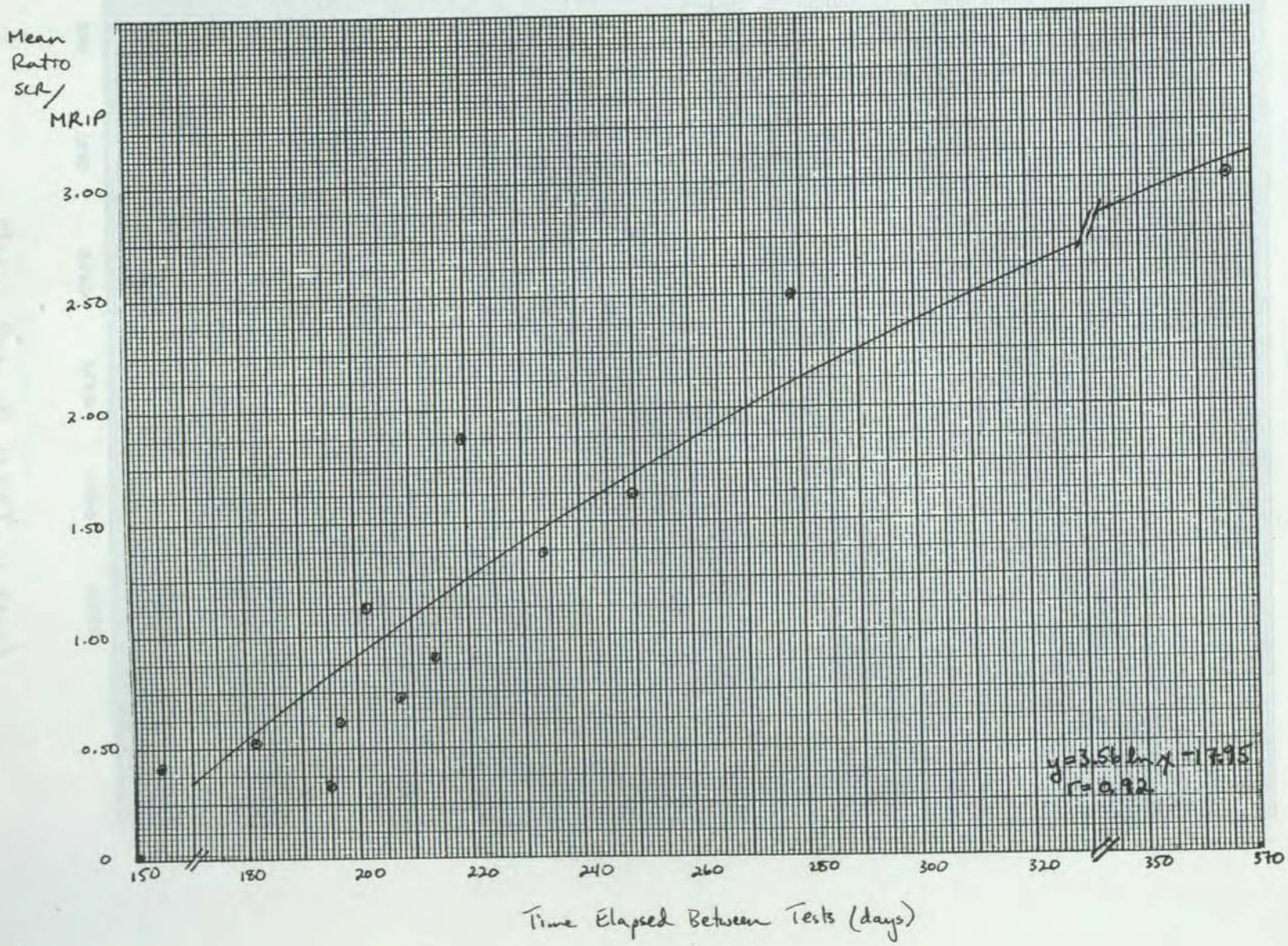
Graph IV

Ratio of SCR to FST Formaldehyde Levels versus the Time Elapsed Between Tests



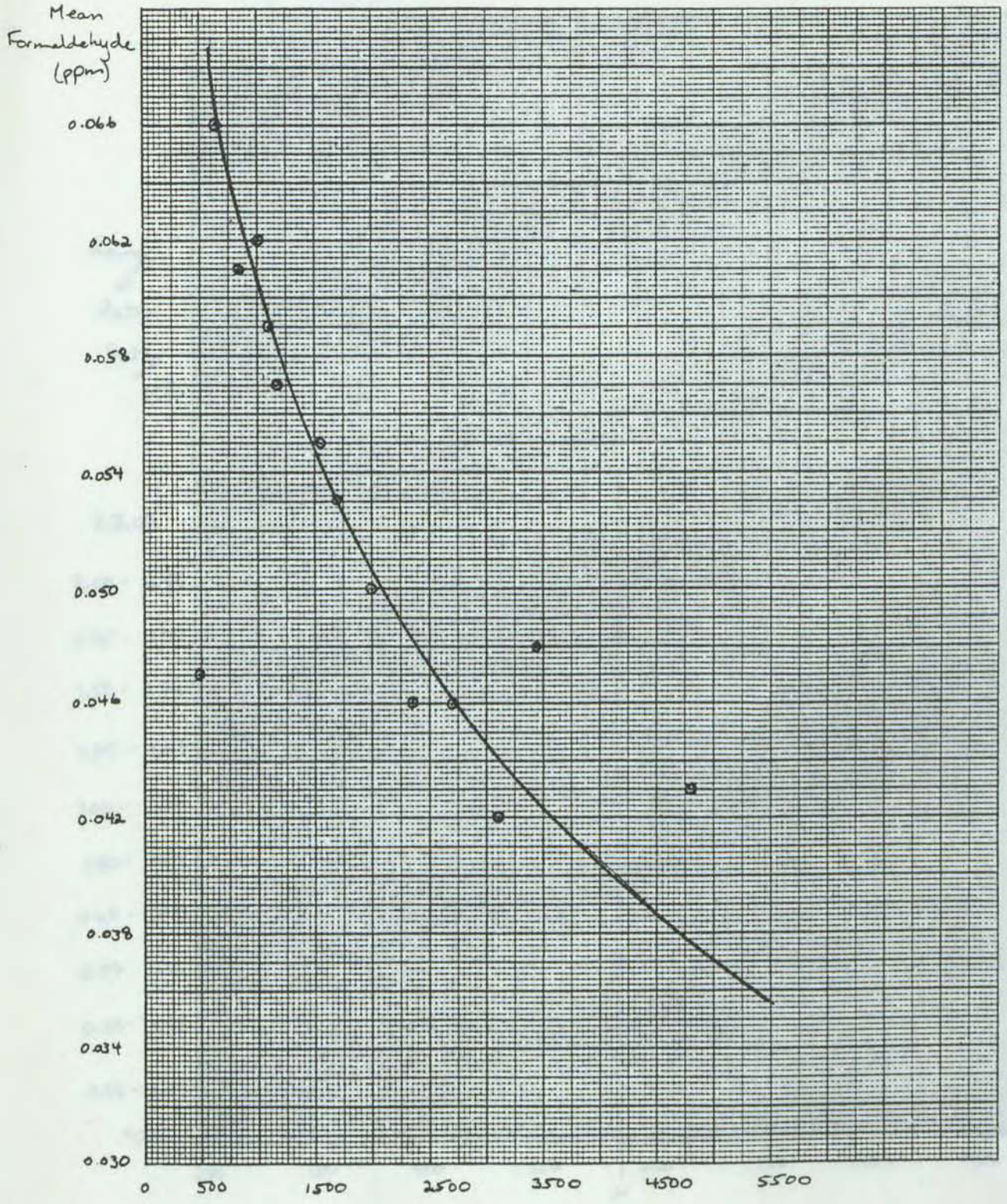
Graph V

Ratio of SCR to MRIP Formaldehyde Levels versus The Time Elapsed Between Tests



Graph VI

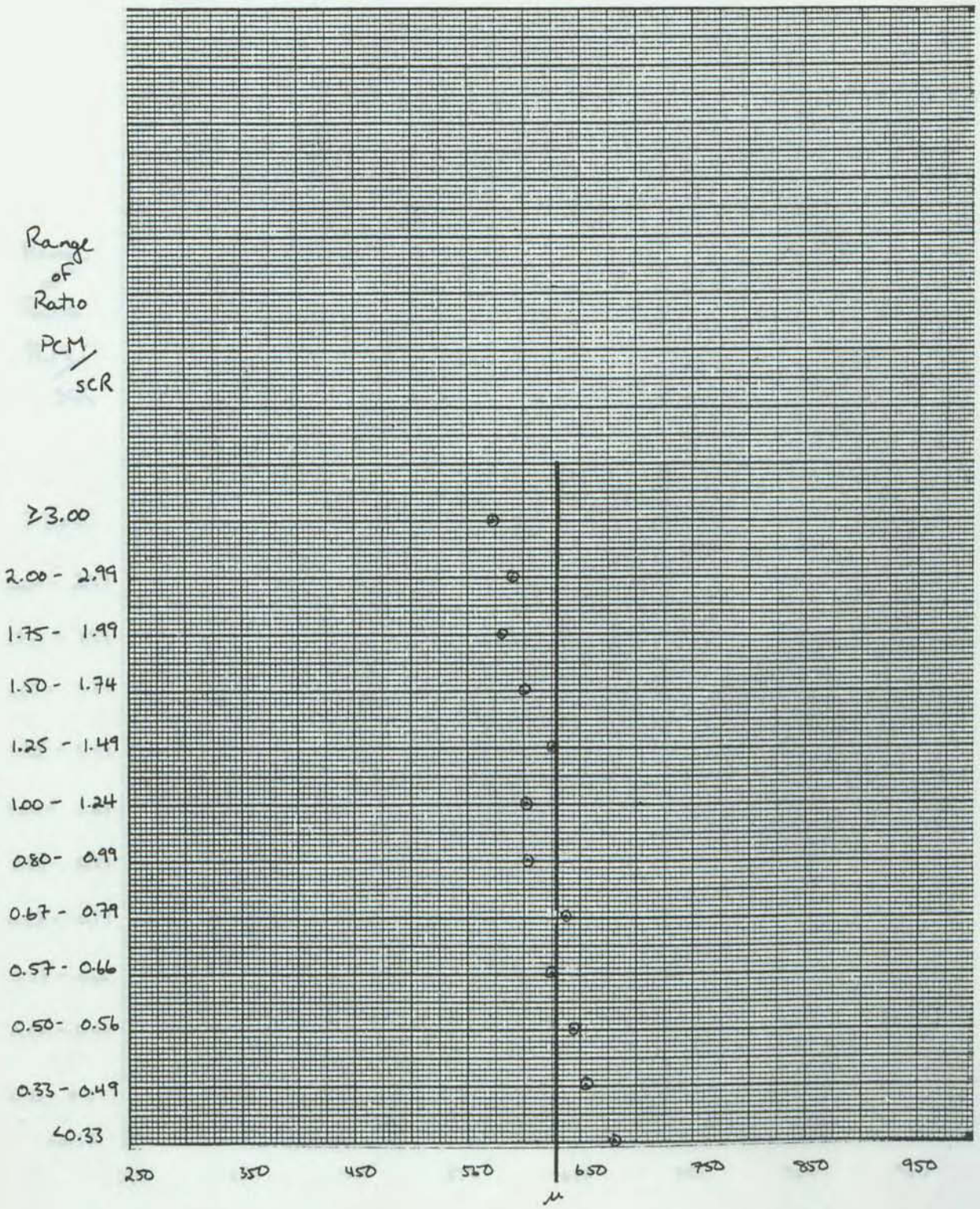
Distribution of Mean Average Pre-Corrective Measures Formaldehyde Levels by Mean Age of UFFI



Graph VII

Time Elapsed Between Tests versus the Ratio of PCM to SCR

Total Measures



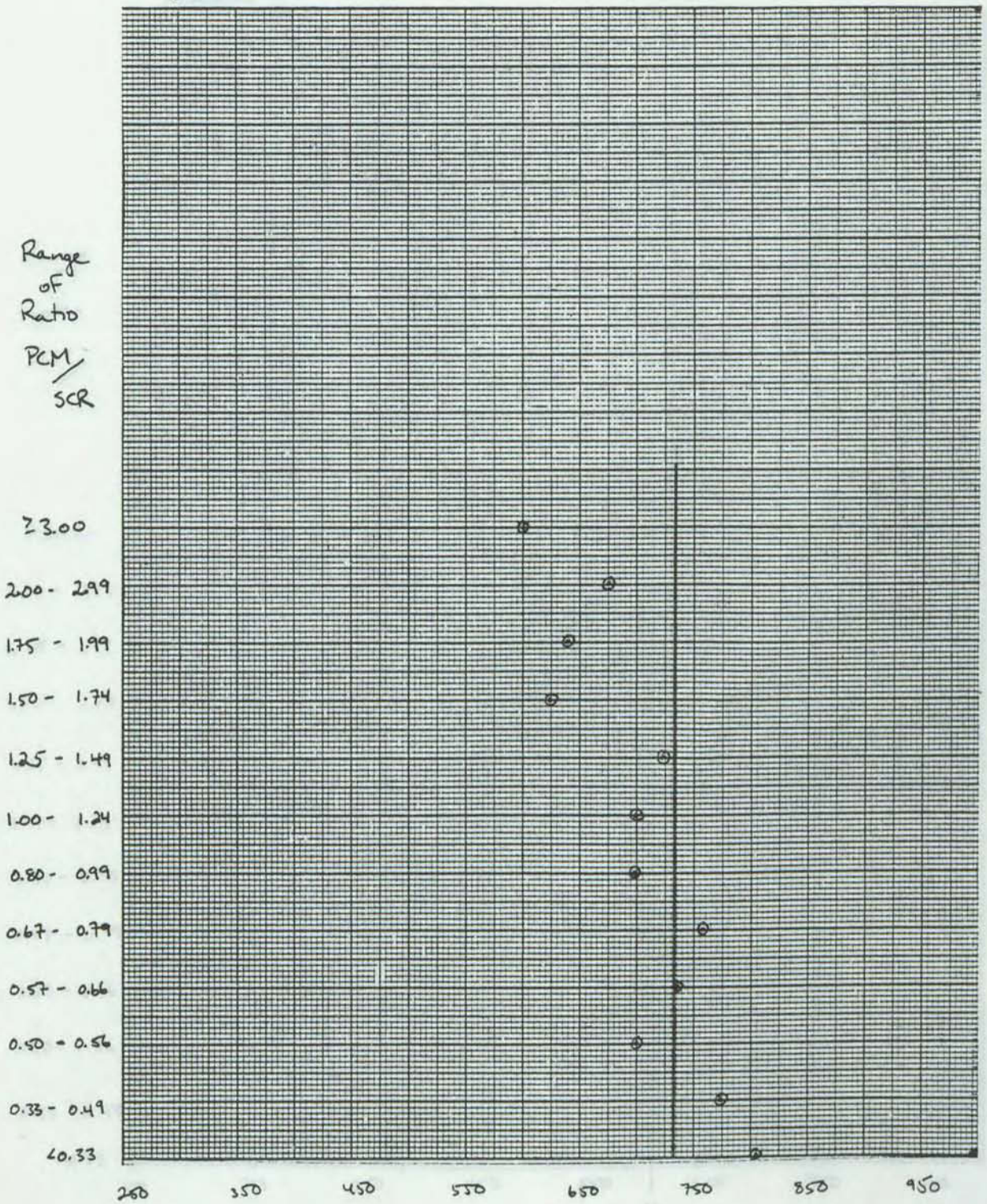
Time Between Tests (days)

$\mu = 631.44$, $n = 11,743$

Graph VIII

Time Elapsed Between Tests versus the Ratio of PCM to SCR

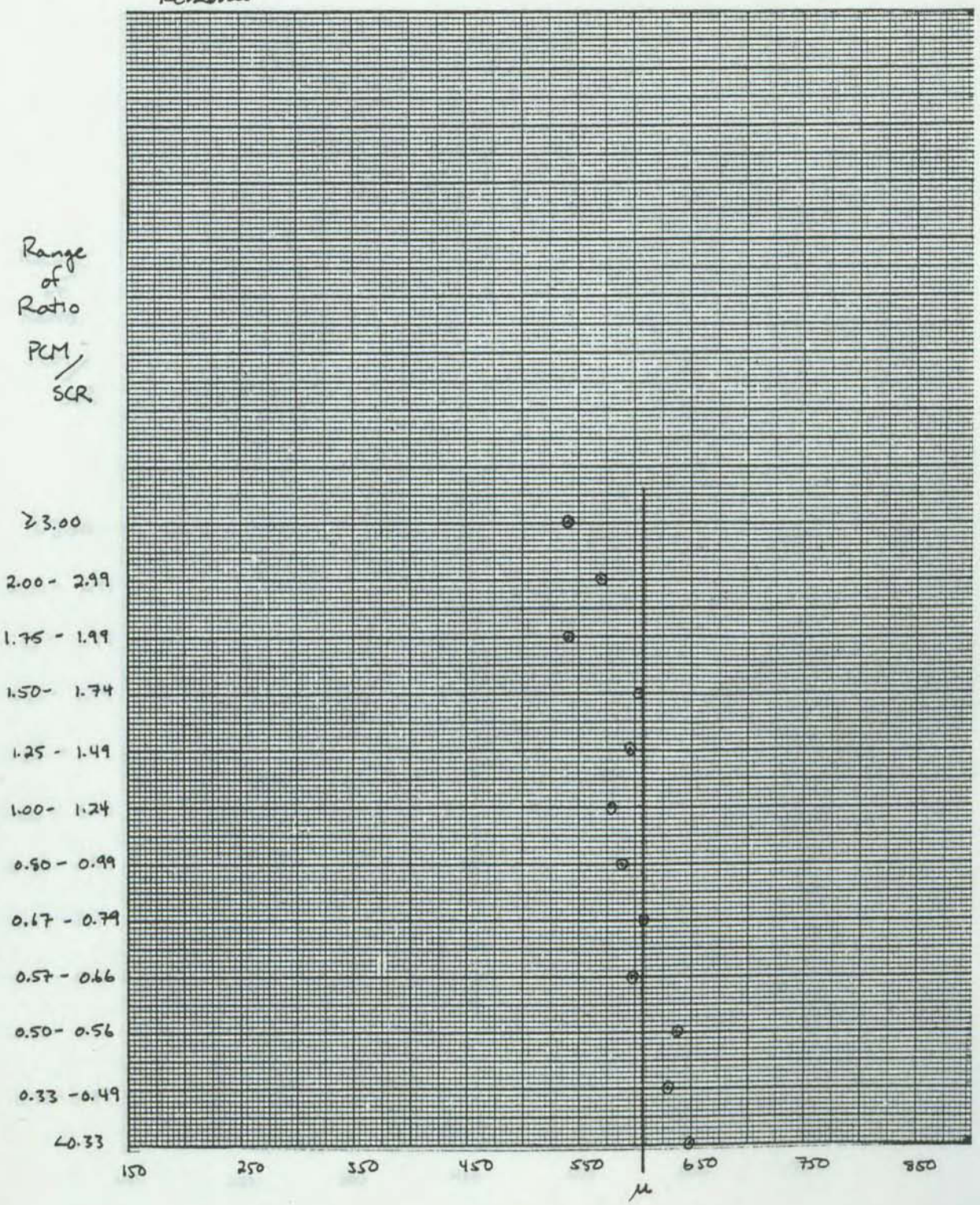
HRV Installation



$\mu = 733.45$, $n = 2821$

Graph IX

Time Elapsed Between Tests versus the Ratio of PCM to SCR Removal



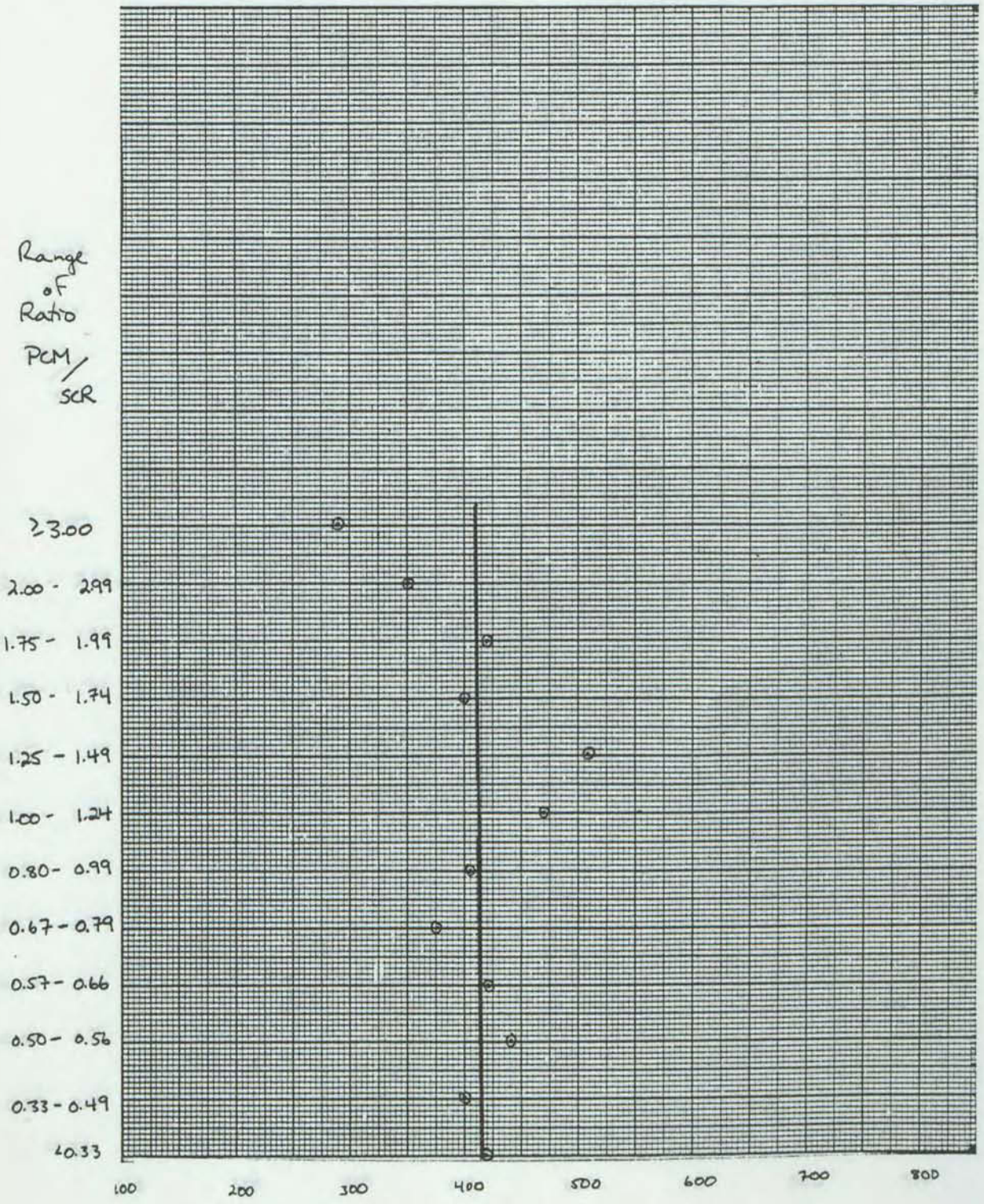
Time Between Tests (days)

$\mu = 608.61$, $n = 8407$

Graph X

Time Elapsed Between Tests versus the Ratio of PCM to SCR

Other Measures

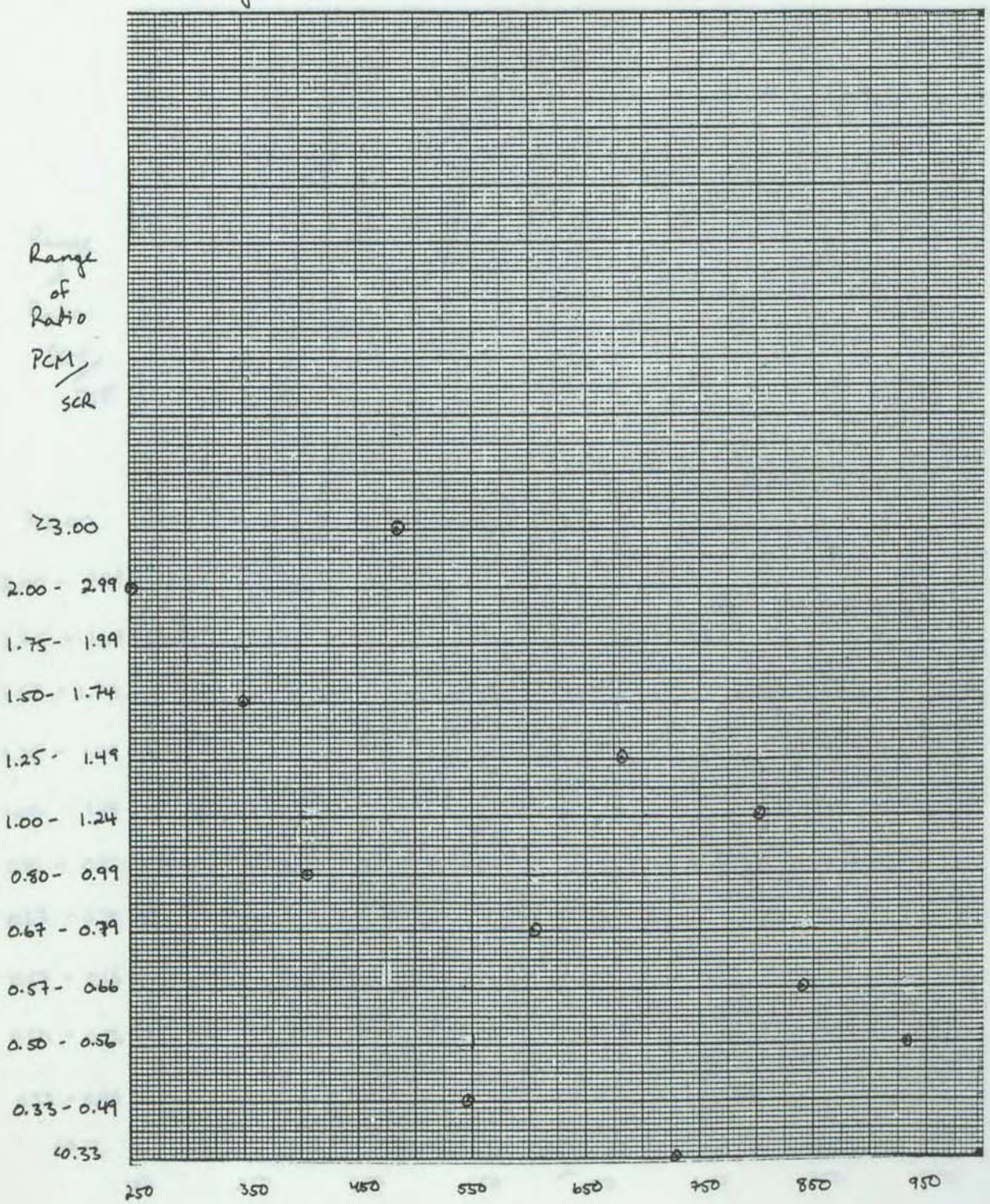


$\mu = 414.91$, $n = 462$

Graph XI

Time Elapsed Between Tests versus the Ratio of PCM to SCR

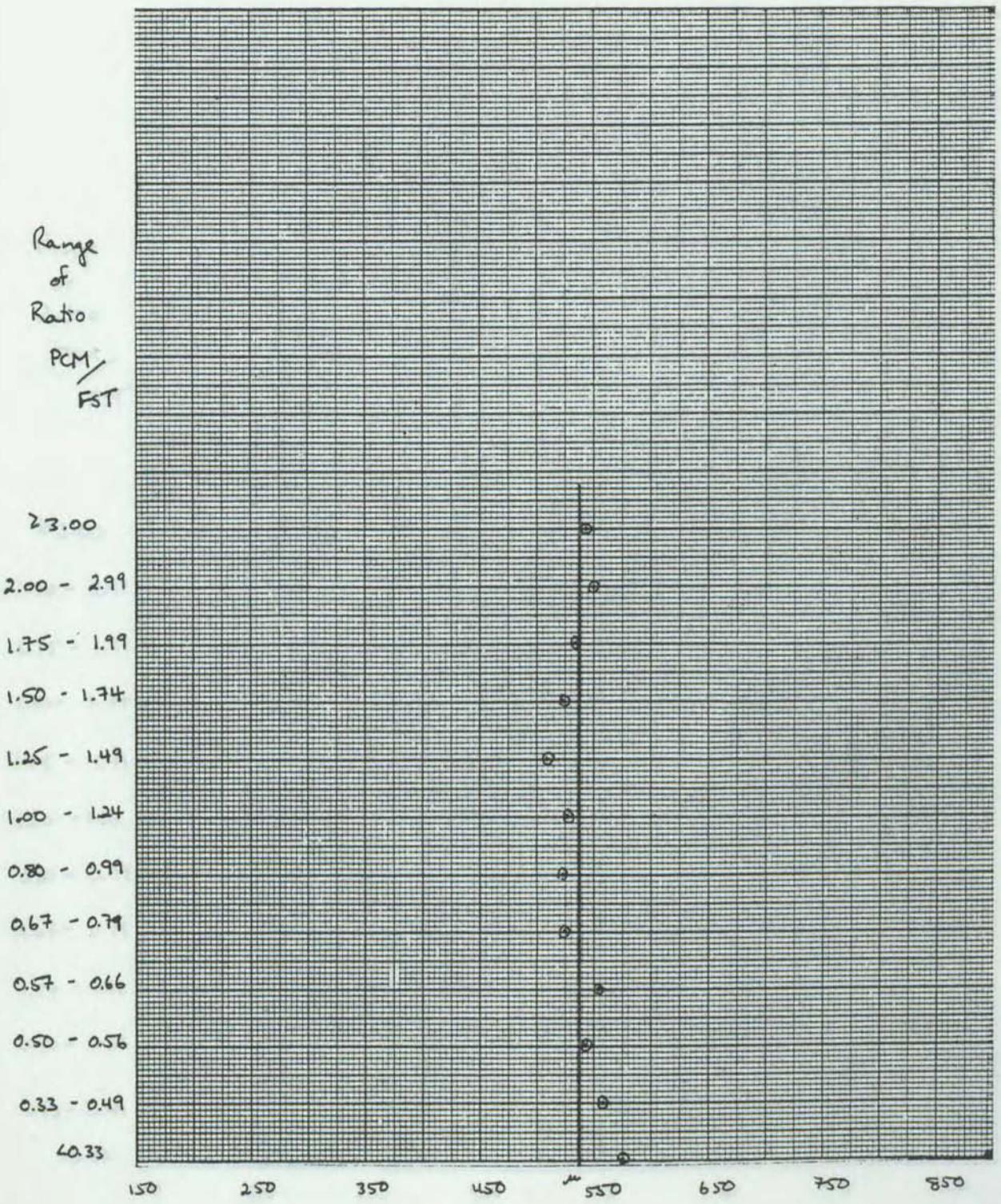
Scaling



$\mu = 679.64$, $n = 44$

Graph XII

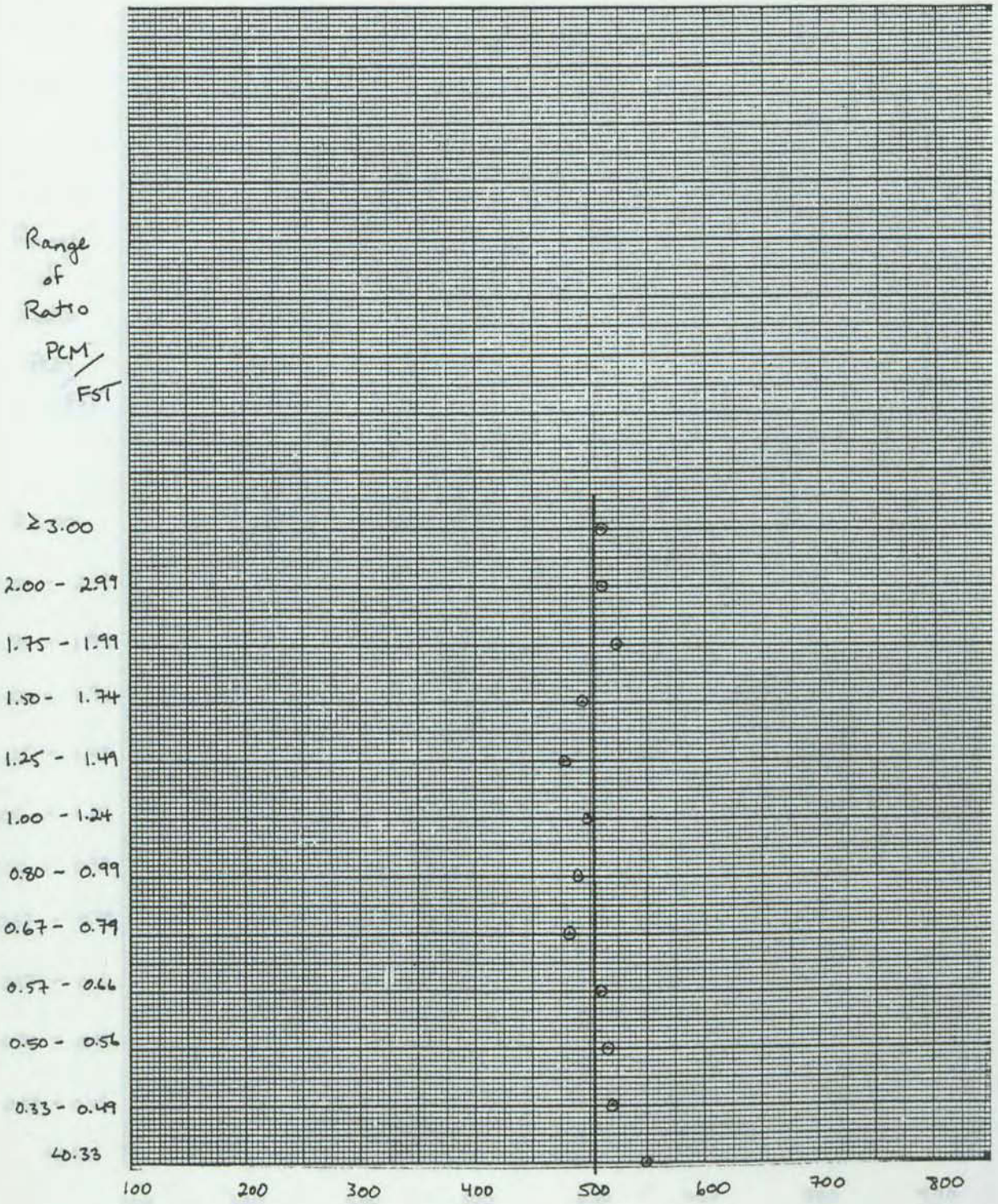
Time Elapsed Between Tests versus the Ratio of PCM to FST Total Measures



$\mu = 537.58$, $n = 6098$

Graph XIII

Time Elapsed Between Tests versus the Ratio of PCM to FST Removal

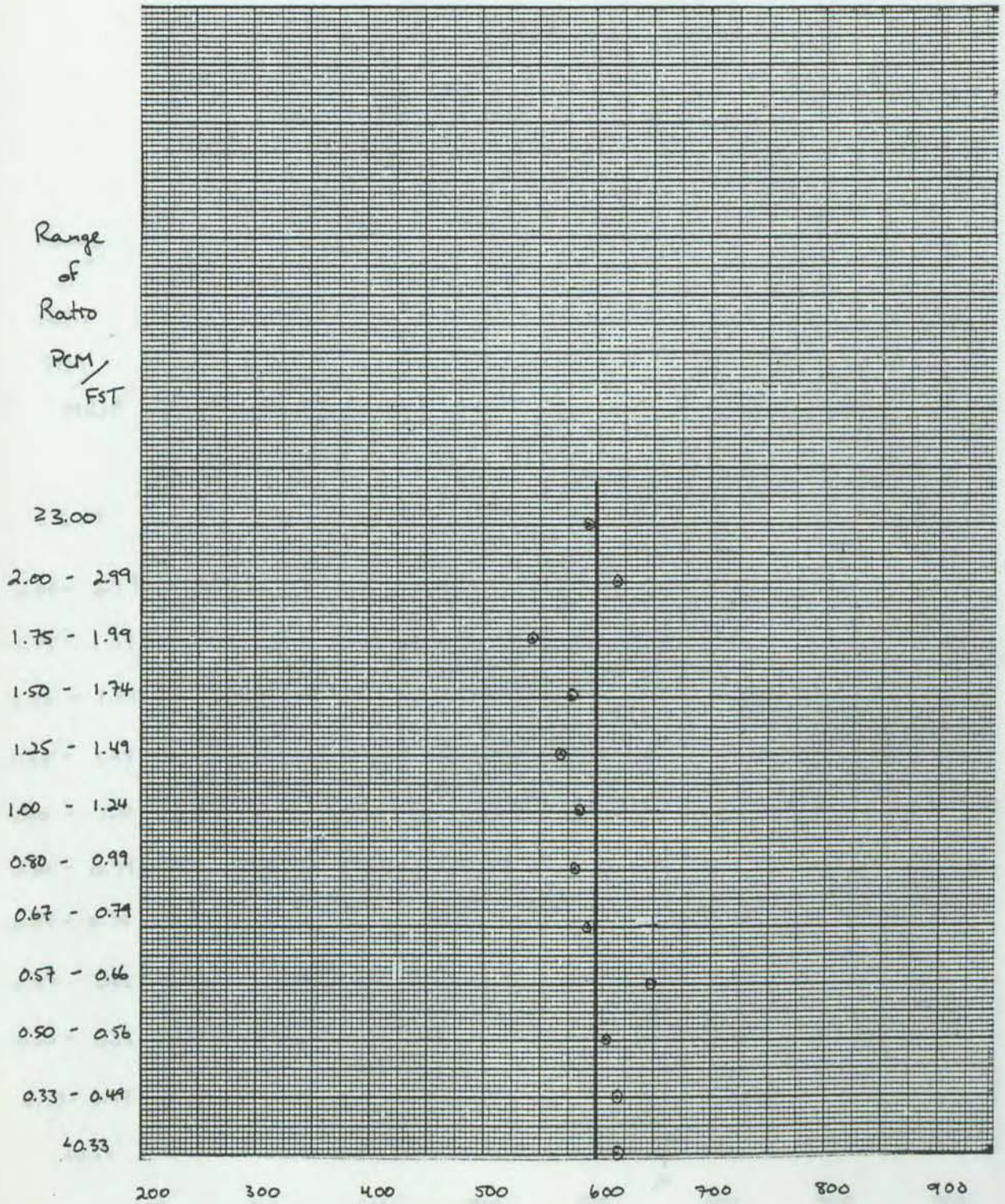


$\mu = 503.64$, $n = 3815$

Graph XIV

Time Elapsed Between Tests versus the Ratio of PCM to FST

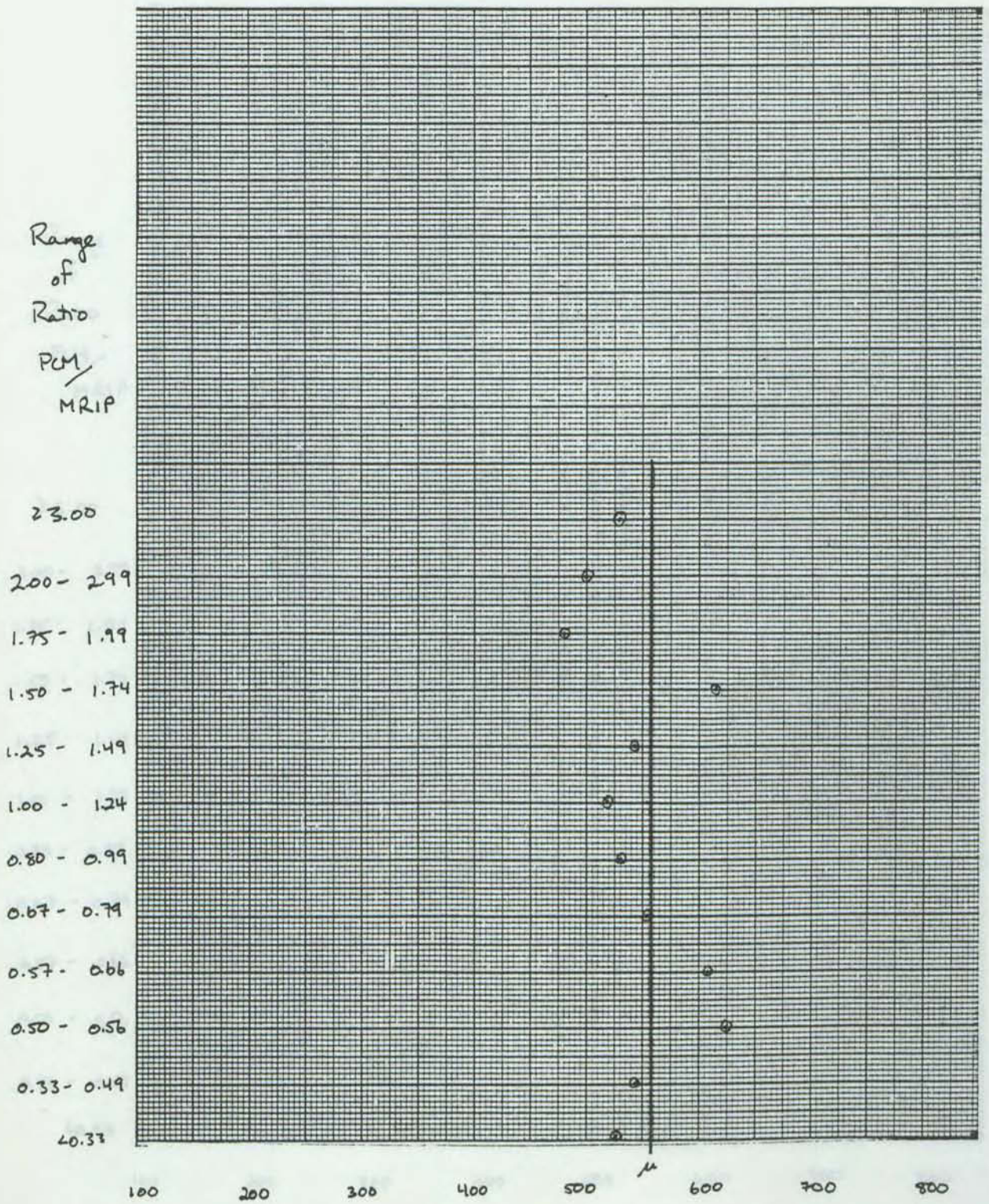
HRV Installation



$\mu = 598.77$, $n = 2178$

Graph XV

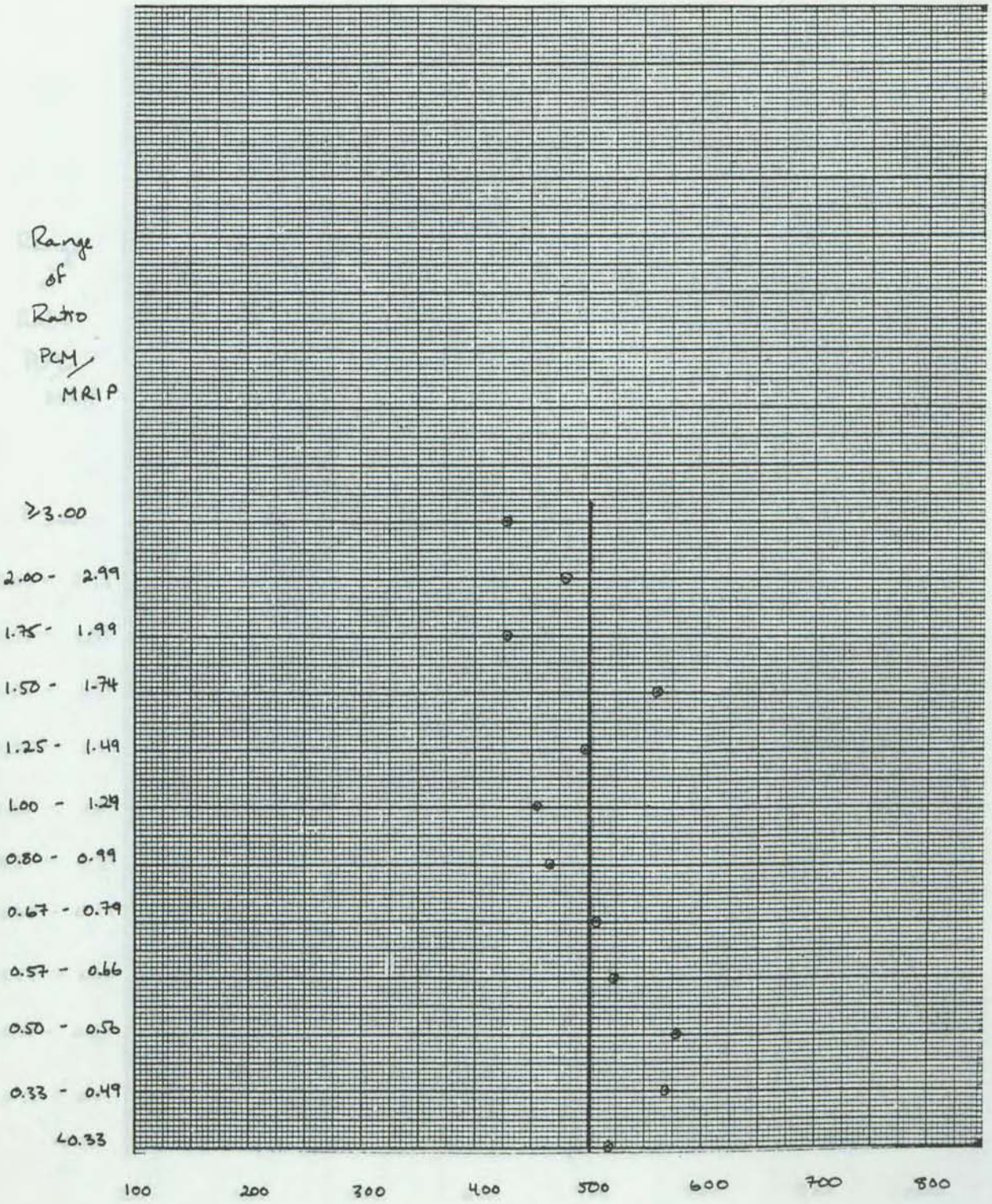
Time Elapsed Between Tests versus the Ratio of PCM to MRIP Total Measures



$\mu = 557.44$, $n = 1351$

Graph XVI

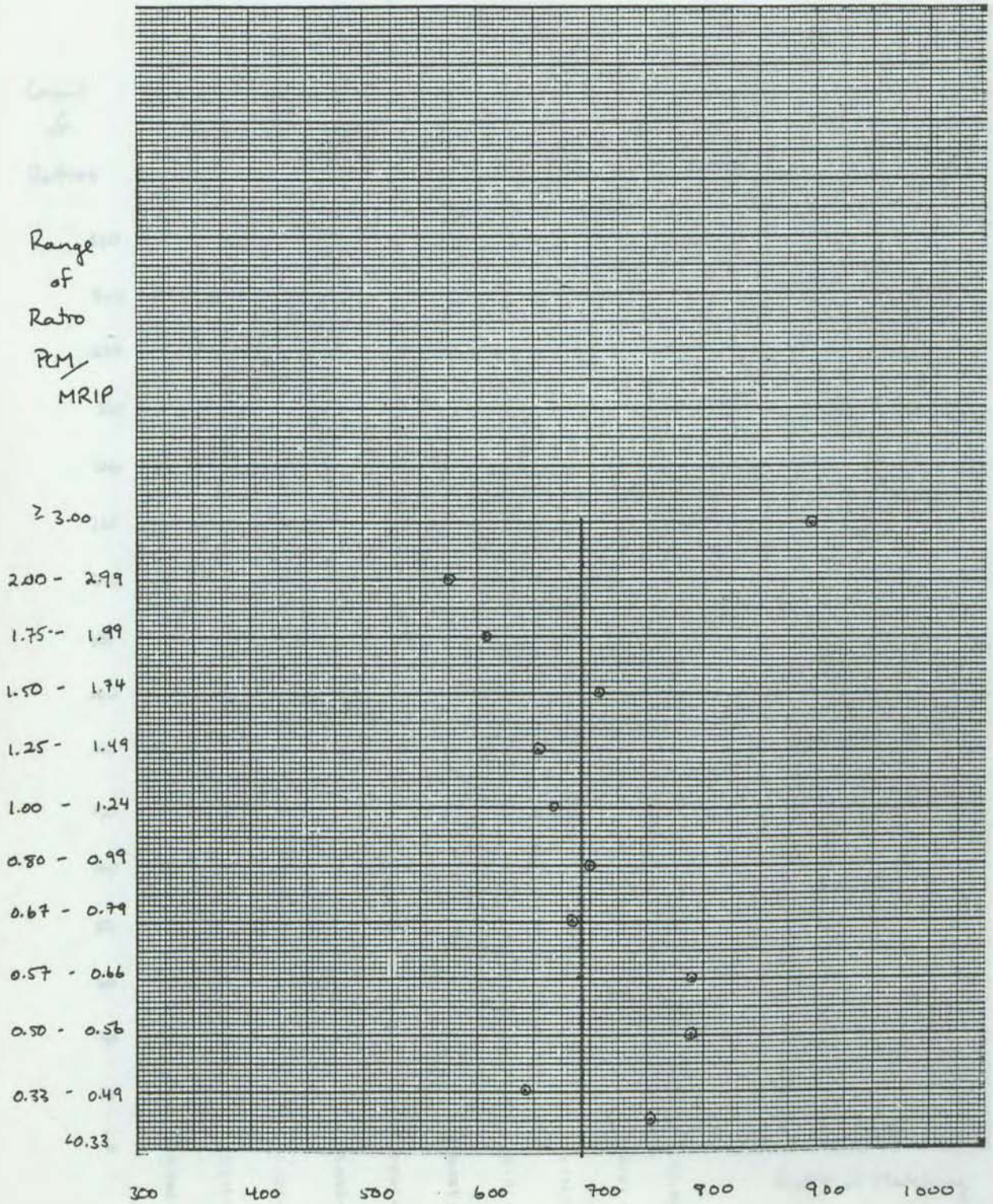
Time Elapsed Between Tests versus the Ratio of PCM to MRIP Removal



$\mu = 502.86$, $n = 921$

Graph XVII

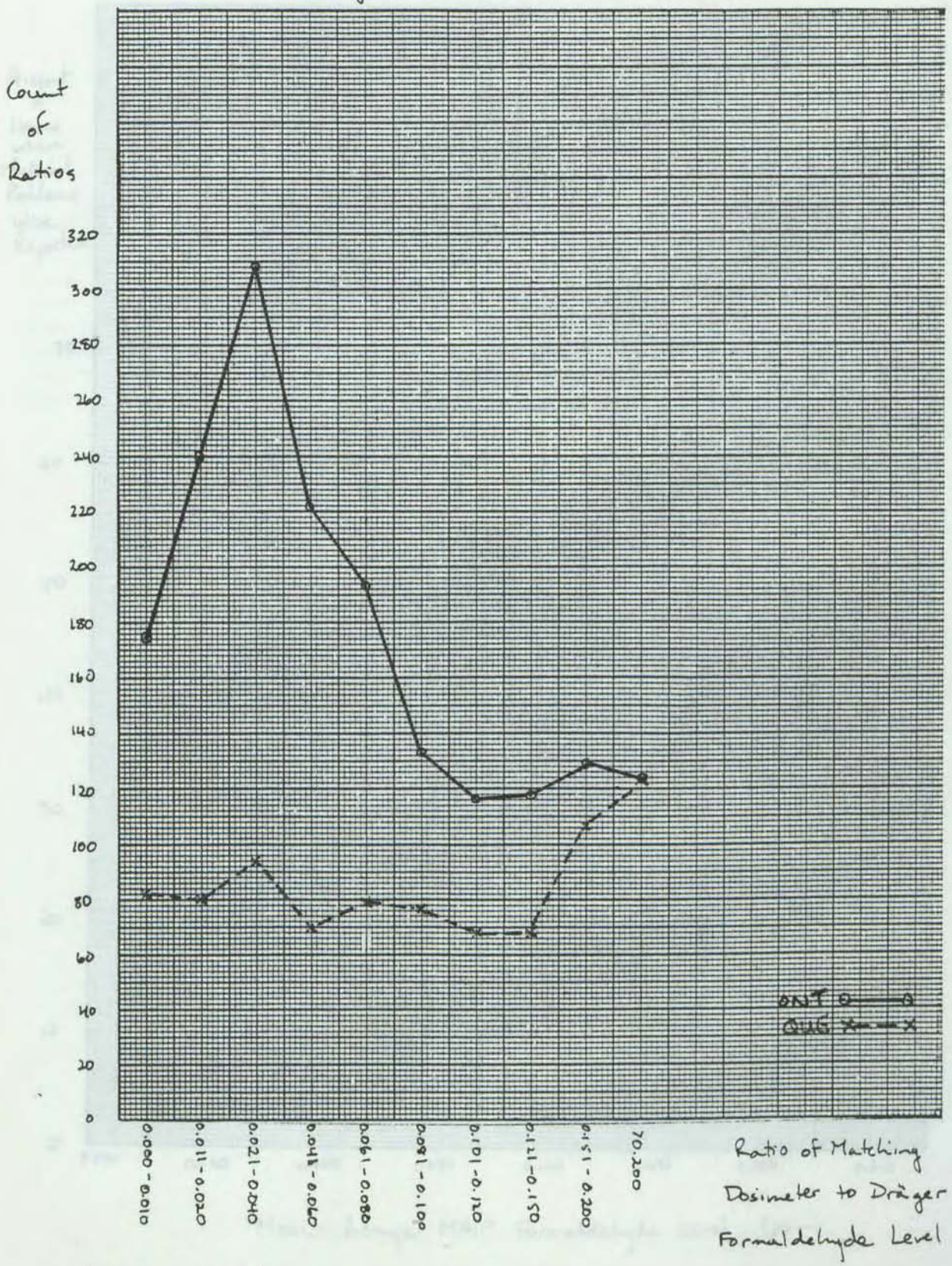
Time Elapsed Between Tests versus the Ratio of PCM to MRIP HRV Installation



$\mu = 693.48$, $n = 392$

Graph XVIII

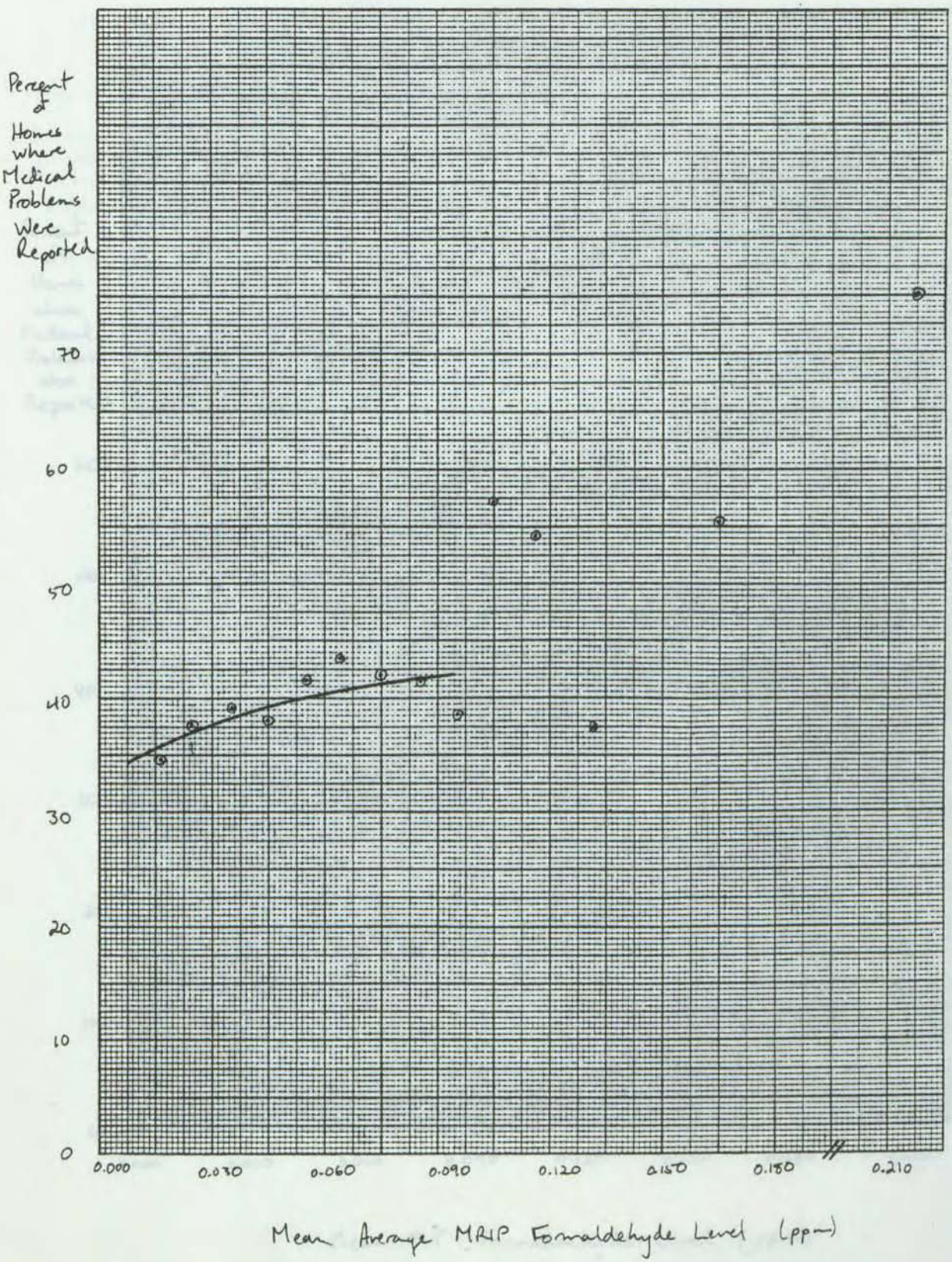
Frequency Distribution of the Ratios of Audit Dosimeters to Dräger, For Ontario and Quebec, HRV Installation



(From tabulation 8)

Graph XIX

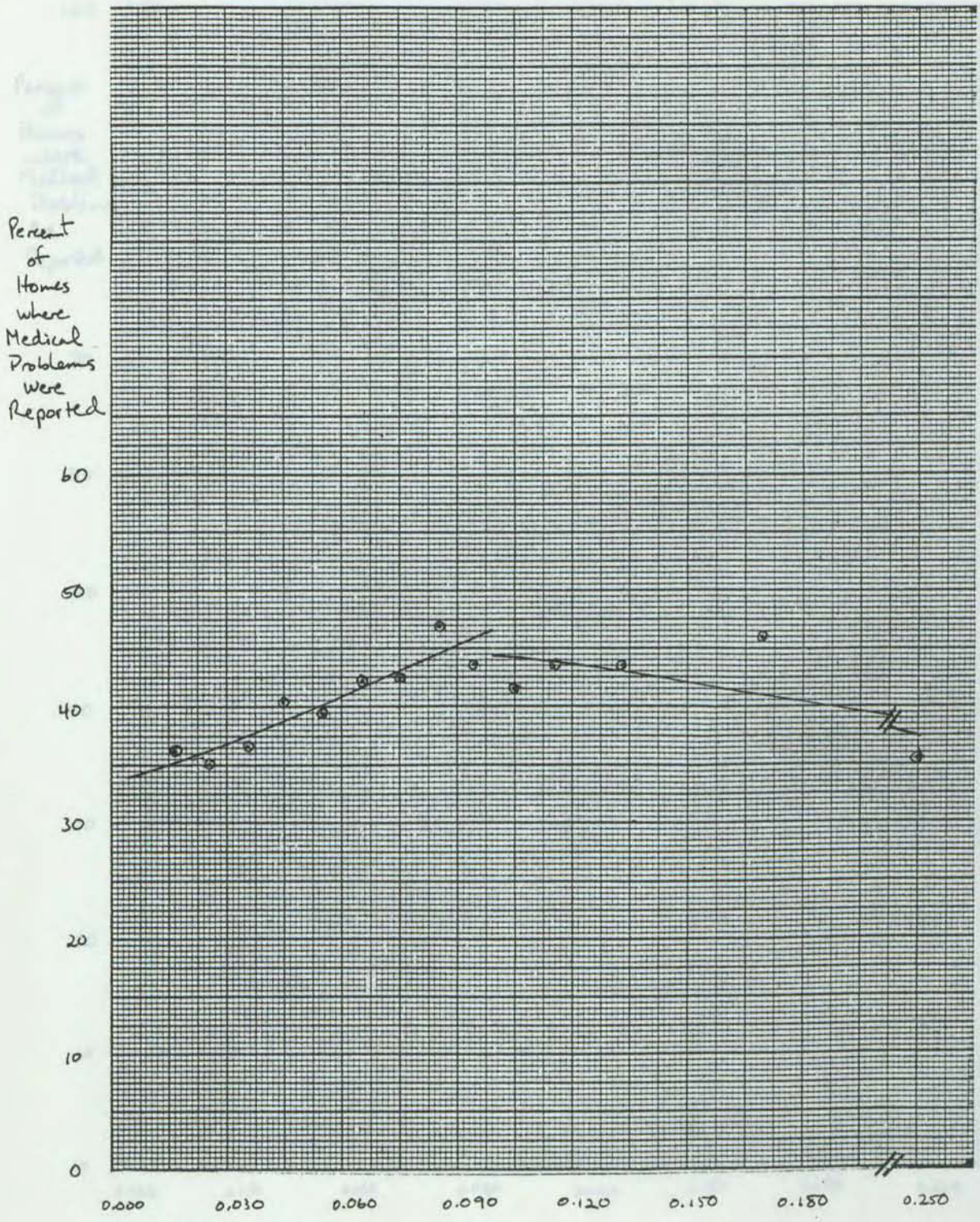
Mean MRIP Formaldehyde Levels versus Percent of Homes Where Medical Problems Were Reported



(from Tabulation 02)

Graph XX

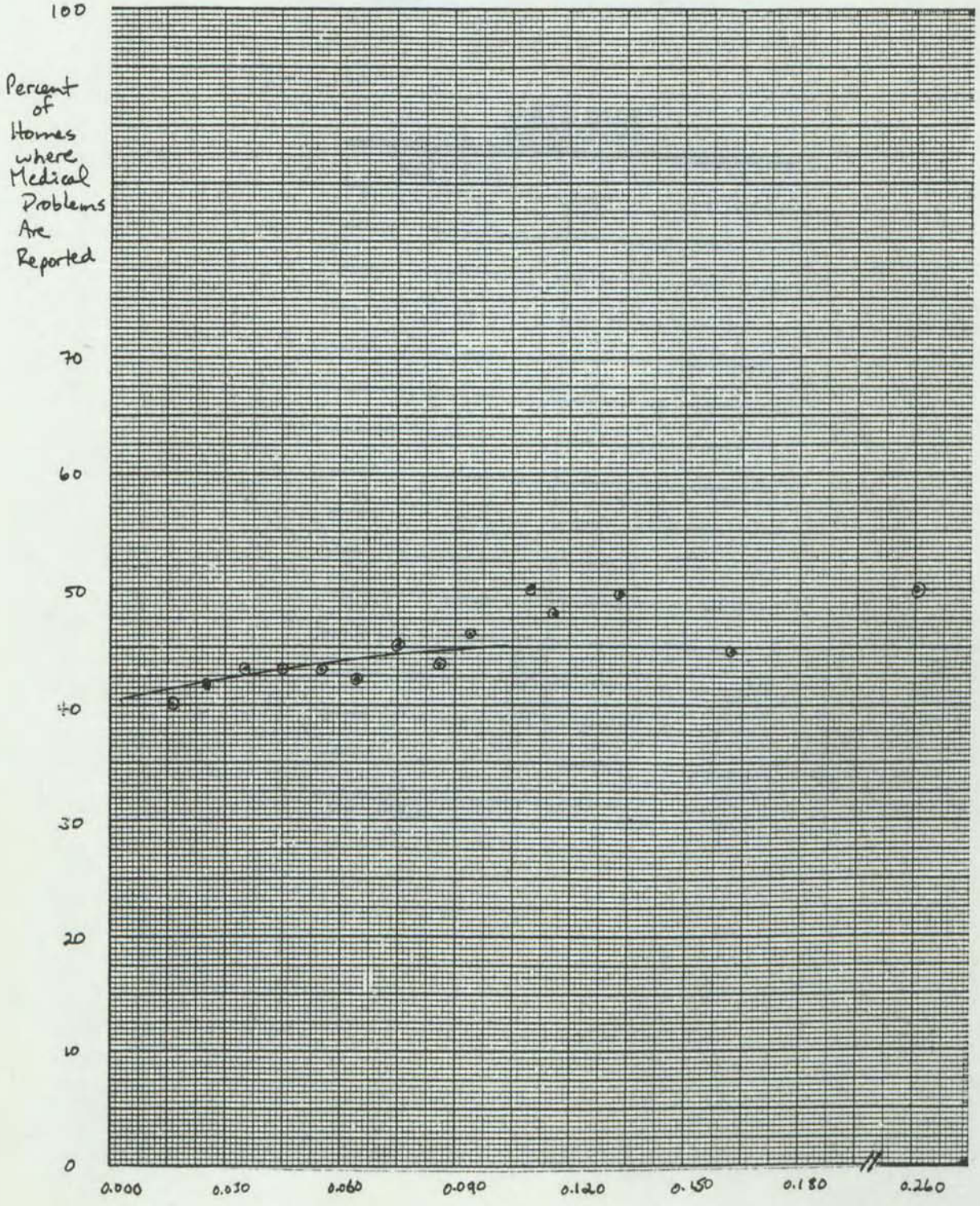
Mean FST Formaldehyde Levels versus Percent of Homes where Medical Problems Were Reported



(from Tabulation 02)

Graph XXI

Mean SCR Formaldehyde Levels versus Percent of Homes Where Medical Problems Were Reported



(from Tabulation 02)