Portable X-ray Fluorescence Instruments for the Analysis of Lead in Paints

E. H. KAPLAN, M. D. LILLEY, R. F. SCHAEFER,
B. CADE, A. DESAI, A. PADVA, and H. G. ORBACH

PORTABLE X-RAY FLUORESCENCE instruments for the analysis of lead in paint have recently been tested by the Chicago Board of Health and the results compared with those obtained with atomic absorption spectrophotometry. A city ordinance requires that walls containing 1 mg or more of lead per square centimeter of surface area be covered over if there is a hazard to children's health. Therefore the board has been analyzing paint samples from interior building surfaces in a massive program designed to aid the Building Department of Chicago in enforcing the city's code.

Atomic absorption spectrophotometry is the method generally used for the determination of the lead in paint (1). It is convenient and accurate, but considerable time is required to complete a series of analyses even though the time per analysis is minimal. Also, it is frequently desirable to learn the lead content without destroying or defacing a surface area, and the sampling required in this method is destructive. To supplement this procedure and minimize the number of samples that must be ground, weighed, and ashed, the samples can first be screened with sodium sulfide. Sayre and Wilson suggested that squeeze dropper bottles of sodium sulfide be carried into the field for in situ testing (2). Such a procedure, however, does not seem desirable in view of the odor of the solution, and samples still must be gouged out of the walls to insure that all inner layers have been tested.

In the atomic absorption method, lead values are determined as a percentage by weight in the sample as received. Samples collected by inspectors in the field, however, are highly variable. Many contain large quan-

□ Dr. Kaplan is a toxicologist, and Mr. Schaefer, Mrs. Cade, Mr. Desai, and Mr. Padva are chemists in the Division of Laboratories, Chicago Board of Health. Dr. Orbach is director of the division. Mr. Lilley, who currently is a marine analytical chemist at the School of Oceanography, Oregon State University, Corvallis, at the time of the study was a toxicologist in the division.

Tearsheet requests to Dr. E. H. Kaplan, Toxicologist, Chicago Board of Health, Room LL 33, Chicago Civic Center, Chicago, Ill. 60602.

tities of plaster or other background material; others are almost pure surface paint. Obviously, the percentage of lead by weight in a sample with much plaster would be highly diluted. In addition, as King has pointed out (3), the amount of lead per unit of surface area of ingested paint particles is a better indicator of the hazard from ingestion than is the percentage by weight. The level of 0.03 mg of lead per square centimeter of surface area has been recommended as the permissible limit (3). Determinations by atomic absorption of the lead per unit area have been limited to surfaces that can be measured and cut precisely, or else have required assumptions as to the weight of paint per unit of surface area.

Subsequent to the experiments described in this paper, a surface area photometer (A) has been used in our laboratory to determine the surface areas of irregular paint chips based on the amount of light absorbed when they are placed in the path of a collimated light source. Samples to be analyzed by atomic absorption can thus be measured, and results can be calculated in milligrams per square centimeter.

With X-ray fluorescence, the milligrams of lead per square centimeter can be measured rapidly in situ. Lawrer and associates used this method to examine apartment walls in situ (4). The instrument they tested, however, was relatively bulky and required liquid nitrogen, so that it could only be used on vertical surfaces and not for monitoring window sills and ceilings. The advent of X-ray fluorescence spectrometers that were light in weight and portable led the Division of Laboratories of the Chicago Board of Health to test the results of lead analysis with these instruments.

Boltrop and associates have also recently tested an instrument similar to those we tested in Chicago, but their results with it did not correlate well with those from chemical analysis (5). Since our study has been completed, an extensive survey of methods for determination of lead in paint films has been published (6).

Methods

Three X-ray fluorescence instruments were chosen for study (B, C, and D), each from a different manufacturer.

All were light in weight, had the probe separate from the rest of the instrument, and could be used at room temperature on any fairly smooth surface at least 2 inches in diameter. An improved version (E) of one instrument (B) was also tested subsequently.

To compare the two methods of lead determination, we used a series of paint-coated card stock samples. After taking the X-ray fluorescence measurements, we cut out a selected area of each sample and analyzed the lead content by atomic absorption. At levels below 10 mg of lead per square centimeter, the results with X-ray fluorescence were relatively close to those obtained by atomic absorption. Finally, we determined the lead content of panels obtained from walls of condemned buildings both by X-ray fluorescence and by atomic absorption spectrophotometry. The samples chosen had in situ X-ray fluorescence readings within the linear range of the instrument being tested. There is a greater disparity in samples actually obtained from apartment surfaces. The discrepancies may result from variations in the matrix, as paints from different sources may differ considerably in composition, or from variations in the background, which may include paper, canvas, wood, or plaster, among other possibilities.

Samples received in the laboratory for analysis by atomic absorption are screened on spot plates with approximately 0.1 molar sodium sulfide. A black color is considered to indicate the possible presence of lead in the paint. Schaefer and Cade, of our laboratory, found that about 1 percent of the paints containing lead give

Building inspector taking reading of lead content of building wall

Regression lines and 95 percent confidence intervals for X-ray fluorescence instruments

INSTRUMENT B

X-ray fluorescence, milligram Pb per square centimeter

INSTRUMENT C

X-ray fluorescence, milligram Pb per square centimeter
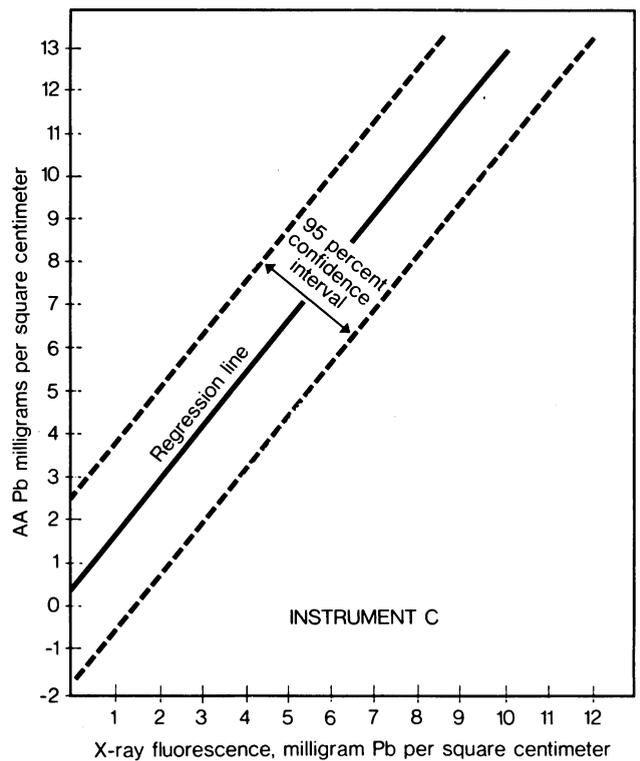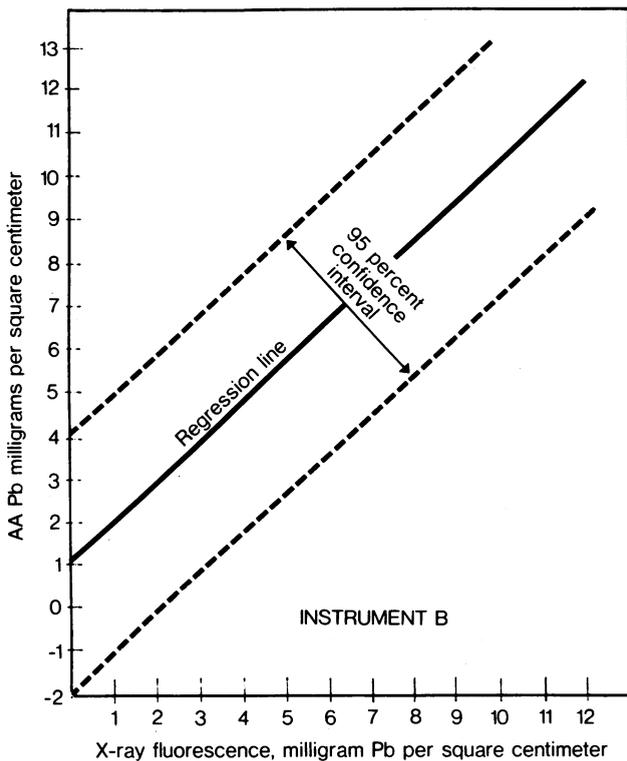
false-negative results by this procedure. In order to examine the maximum number of samples, this loss of positives is accepted. Samples that are negative by the sodium sulfide test are not analyzed by atomic absorption; positive and doubtful samples are analyzed.

When the percentage of lead by weight is to be determined in the laboratory by atomic absorption, the samples are analyzed in the condition in which they are received; no attempt is made to remove plaster, paper, or other foreign substances. After the samples are ground and mixed in a micro mill (F or G), 100 mg portions of the homogenized material are weighed into crucibles. If the samples are too small for instrument F or G or are not satisfactorily homogenized by either of these instruments, they are comminuted in instrument H. When the lead per square centimeter is to be determined by atomic absorption instead of as the percentage by weight, the paint samples are freed of as much adhering plaster as possible, and the surface area of a representative portion of each sample (approximately 1 square centimeter) is measured on the surface area photometer (A). This entire portion is then placed in a crucible. The contents of the crucibles in each case are then ashed 30 minutes at 500° to 600° C. After the contents have cooled, 5 to 7 ml portions of 7N HNO_3 are added, and the contents of the crucibles are heated to just below the boiling point on a hot plate in a fume hood until about half the original volume has evaporated. The contents of the crucibles are poured into 100 ml volumetric flasks, and the crucibles are rinsed with 5 to 10 ml portions of hot one-third saturated ammonium acetate solution, which are added to the volumetric flasks. The flasks are diluted to the mark with distilled water. Portions of the solutions are centrifuged, and the supernatants are then analyzed by atomic absorption spectrophotometry.

The radiation source for all the X-ray fluorescence spectrometers we tested (B, C, D, and E) is Co^{57}. Fluorescent radiation from the surface being measured is counted on a digital scaler. Readings are corrected for signals other than those from the K shell of lead by means of selective filters in the detector (B, D, and E) or by electronic energy discrimination (C). Instruments B and D require two operations: (a) the reading of the fluorescence from lead as well as of the back-scatter from the exciting radiation and (b) a correction for back-scatter, which is automatically deducted from the reading. Instruments C and E carry out both operations simultaneously. The scales of instruments B, C, and E are calibrated directly in milligrams of lead per square centimeter. The readings of instrument D are in the number of pulses. Instrument D was first calibrated against surfaces of known lead content, and then the lead values were interpolated on the calibration curve. Instrument C has a control to adjust the background reading to zero. For the other instruments, a background reading on plaster was subtracted from each reading. In every case readings were taken with the probe of the instrument placed firmly against a flat smooth surface at least 2 inches in diameter, so that the

Regression lines and 95 percent confidence intervals for X-ray fluorescence instruments

INSTRUMENT D

INSTRUMENT E
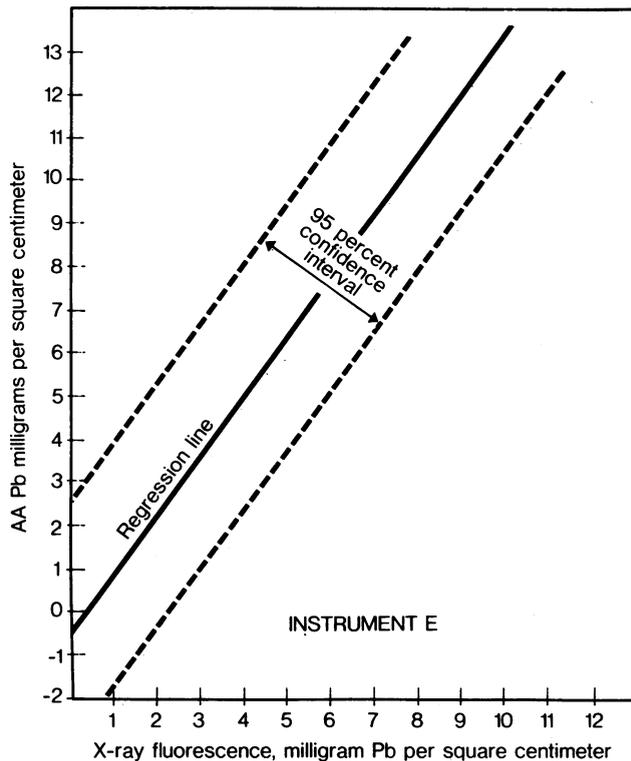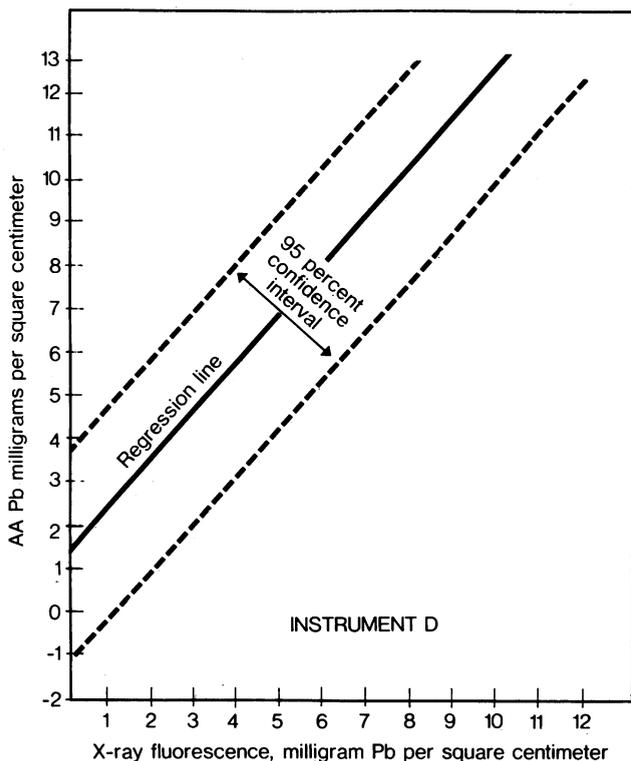
orifice of the probe was completely in contact with the surface. At least five readings were averaged.

In view of the random nature of radioactive emissions, the observed count varies statistically from reading to reading. Samples with background emission therefore give about as many negative as positive readings. If the duration of the readings is long enough or if a sufficiently large number are taken, the average is very close to the actual background. Because, however, in practice only a limited number of readings can be taken and the time per reading is limited, approximately half the readings are negative. Furthermore, the scatter contribution from the wall substrate will vary with the nature of that substrate; some walls with lower background emission than that of the plaster that we used in determining the backgrounds of the instruments will give negative readings if lead is absent. Instrument E has a negative suppression jumper that causes the scaler to register negative readings as zero. The jumper was removed for our evaluation.

Readings with instrument B were taken on painted card stock panels prepared by the D. H. Litter Company, N.Y., for A. E. Organ and Peter Berry of Texas-Nuclear Instrument Division, Nuclear-Chicago. Several pieces of known surface area were then cut out of each panel, ashed, and analyzed by atomic absorption. The lead content was calculated as the milligrams of lead per square centimeter.

There are many layers of paint on the average surface in older buildings, and the lead-containing layer is not necessarily the top one; in fact, it is more likely to be one of the bottom layers. To see if there was any difference in results based on the relative position of the lead-containing layer, we stacked the card stock panels on top of one another in various sequences and measured them by X-ray fluorescence before cutting them up for analysis by atomic absorption. The true lead values were assumed to be the sums of the concentrations in milligrams per square centimeter in the individual panels as determined by atomic absorption.

By arrangement with Commissioner Joseph Fitzgerald and William Burke, City Building Department, sections of 43 walls were chopped from abandoned buildings and brought to the laboratory. The lead content of these sections was measured with instruments B, C, and D. Instrument D was not available when samples from 15 additional walls were measured. Subsequently, 92 wall sections were obtained for the evaluation of instrument E. Each wall section to be measured was marked. Experiments in our laboratory have indicated that lead is almost entirely confined to the layers of paint and that penetration into the plaster is minimal. Therefore, after the X-ray fluorescence measurements, a piece of known surface area was cut out of the marked portion of each wall section, freed of as much underlying plaster as possible without removing any paint, and then ashed and analyzed by atomic absorption. The results were calculated in milligrams of lead per square centimeter of surface area.

Finally, 100 panels from walls on which in situ measurements with instrument E indicated the absence of lead were brought to the laboratory. To evaluate the degree of confidence that could be placed in these readings, portions of the panels were analyzed for lead by atomic absorption as described.

Results

The correlation of X-ray fluorescence readings of painted card stock panels with the results of analysis of the panels by atomic absorption is shown in table 1.

Table 1. Lead content of painted card stock panels as determined by X-ray fluorescence instruments and by atomic absorption spectrophotometry

	Mg of lead per square centimeter	
Sample number	X-ray fluorescence	Atomic absorption
00001	0.1	0.02
00005	1.1	.02
00010	.6	.02
00015	1.0	.02
00020	.2	.02
00025	− .2	.02
07401	8.2	9.2
07405	5.7	4.7
07410	8.8 0.2	
07413	5.5	3.6, 4.0
07415	8.4	9.2
07420	5.2	4.5
07425	5.8	4.4
12401	5.7	5.6
12405	7.9	9.0
12410	6.5	4.7
12415	6.1	6.0
12420	6.3	6.4
12425	8.1	10.8
18601	11.8	16.4
18605	12.3	16.4
18610	12.5	16.8
18615	11.9	17.2
18620	12.0	17.2
18625	11.8	15.6

The averages of six analyses by atomic absorption are shown in the third column. At values of lead by atomic absorption spectrophotometry of less than 10 mg per square centimeter, the maximum deviation between the methods is 1.5 mg per square centimeter. Those panels, however, that gave values of about 16 mg per square centimeter when analyzed by atomic absorption gave readings of the order of 12 when analyzed by X-ray fluorescence. The results in table 1 were all obtained with instrument B. A spot check with instrument C gave similar results. This deviation from linear correspondence between the methods occurred at a lower level than was anticipated. To check on the reproducibility of the readings, we determined a series of five independent values on samples 00020 and 07413. Each value was the average of five readings on instrument B. The mean lead content of those panels was 0.5

mg per square centimeter for sample 00020 and 5.5 mg per square centimeter for sample 07413, with ranges of –0.1 to 0.8 mg per square centimeter for 07413 and 5.1 to 5.9 mg per square centimeter for 00020. The standard error of the mean was 0.037 for sample 00020 and 0.038 for sample 07413.

Table 2. Lead found in multiple painted card stock panels according to their position in relation to the surface

| Sample number[1] | Mg of lead per square centimeter | |
	X-ray fluorescence	Atomic absorption
00005, 07401	8.3, 8.4	9.2
00001, **00005**, 07401	9.2, 9.5	9.2
00005, **07401**, 00001	8.2	9.2
07401, **00005**, 00001	8.3	9.2
07405, 07401	12.9, 13.1	13.9
00001, **07401**, 07405	13.4	13.9
00001, **00005, 07401**, 07405	13.1	13.9
00001, **00010, 00015, 00005**, 07401	13.0	14.0
07410, 07425	13.5	13.6
07401, **07410**, 07425	17.5	22.6

[1]On each line, first number represents a top panel and last number, a bottom panel. Numbers in between (in boldface) represent middle panels, in order from top to bottom.

The results of our experiments to determine if there was any difference in the lead value depending on whether the paint layer containing lead was near the surface or under several layers of unleaded paint are given in table 2. We measured by X-ray fluorescence the lead content of the combinations of layers and compared the results with the sums of the individual values for the samples as determined by atomic absorption (table 1). Within the limits of accuracy deduced from table 1, the values are in agreement in all cases, regardless of the relative positions of the lead-containing layers (table 2). It is noteworthy that the correlation between the two methods of analysis persists up to about 13 mg of lead per square centimeter.

The data obtained from building walls are given in tables 3 and 4. The regression lines and the 95 percent confidence intervals for the atomic absorption values as compared with the readings from each of the instruments studied *(B, C, D,* and *E)* are shown in the chart. The atomic absorption results are regressed against the X-ray fluorescence results to show the most probable values for lead content by atomic absorption that correspond to the various instrument readings. The confidence limits (dotted lines) indicate the range of analyses to be expected with 95 percent confidence for any instrument reading. Although the confidence limits are hyperbolic, the deviation from linearity is negligible over the relatively short ranges of the curves. Thus, a sample for which instrument B gives a reading of 3.2 will most probably contain 4.0 mg of lead per square centimeter when analyzed by atomic absorption, and 95 percent of the samples giving that

Table 3. Lead content of paint samples from building walls as determined by X-ray fluorescence instruments B, C, and D and by atomic absorption spectrophotometry

| Sample number | Mg of lead per square centimeter | | | |
	Instrument B	Instrument C	Instrument D	Atomic absorption
100	– 0.4	0.7	– 1.3	0.3
101	– .3	– .2	– 1.3	.04
102	.1	.3	– .9	.3
103	– .8	– .1	– 1.4	.3
105	– 1.9	– .6	....	.04
106	– 1.9	– .4	....	.3
107	– 1.3	.4	....	.3
108	– 1.4	– 1.1	....	.04
109	– 1.9	– 1.0	....	.07
110	– 1.9	.4	....	.3
112	8.1	7.8	....	11.1
113	10.1	9.8	....	11.2
114	13.4	13.2	11.2	16.8
115	11.2	9.8	9.4	13.0
116	8.6	7.5	7.0	10.8
117	11.1	10.9	9.9	10.3
118	8.4	10.1	....	13.9
119	10.8	10.6	....	15.8
120	9.9	9.1	8.0	11.0
121	9.9	9.2	7.7	8.7
123	2.8	1.6	....	2.0
124	1.5	1.1	....	1.4
125	2.2	1.5	....	1.6
126	2.0	2.1	....	2.0
127	1.9	1.8	....	1.8
128	1.8	1.4	.2	2.6
137	10.3	7.5	7.9	11.7
138	1.4	.4	– .8	.4
139	– .4	.0	– .1	.5
140	.0	.4	.1	.5
141	– .5	.4	.3	.5
142	.0	.0	.0	.4
143	– .5	.0	– .8	.4
144	3.8	2.4	4.0	5.0
145	3.6	2.6	2.4	4.2
146	4.6	2.1	2.4	3.3
147	5.2	3.2	2.9	3.4
148	2.6	3.1	2.5	3.5
149	3.1	2.5	3.3	4.1
150	5.8	4.4	3.9	5.0
151	4.8	4.2	4.3	5.8
152	3.0	2.2	3.1	3.8
153	1.4	1.2	1.2	1.8
154	2.4	1.9	1.3	2.4
155	.7	1.1	.1	1.6
156	2.3	1.6	.7	2.4
157	1.8	1.7	.0	1.9
158	3.1	1.7	1.2	2.6
159	3.8	3.1	2.7	3.8
160	4.2	3.6	1.8	4.6
161	4.1	3.7	3.3	4.4
162	3.2	2.8	2.7	5.3
163	4.0	3.2	3.8	5.3
164	5.0	3.6	3.1	5.8
165	4.9	3.7	4.2	6.6
166	4.2	3.2	3.6	5.1
167	9.6	6.4	7.2	10.1
168	10.2	6.0	9.0	7.3

reading will contain between 1.0 and 7.0 mg of lead per square centimeter. Approximately half the samples with analyses by atomic absorption that are outside the 95 percent confidence limits will probably be higher and half will be lower. We can therefore conclude that an instrument reading of 3.2 will give a lead content by atomic absorption of greater than 1.0 mg per square centimeter with 97.5 percent confidence.

The correlation coefficient was 0.84 for instrument B, 0.97 for instrument C, 0.96 for instrument D, and 0.96

for instrument E. We have calculated by standard statistical methods that X-ray fluorescence readings of 3.2 or greater on instrument B, 2.2 or greater on instrument C, 2.0 or greater on instrument D, and 3.1 or greater on instrument E would indicate at least 1.0 mg of lead per square centimeter with 97.5 percent confidence. The corresponding readings at the 99.5 percent confidence level are 4.3, 2.7, 2.6, and 3.7, respectively. It is noteworthy that in the case of instrument E, the elimination of sample 615 would change the minimum

Table 4. Lead content of paint samples from building walls as determined by X-ray fluorescence instrument E and by atomic absorption spectrophotometry

Sample number	Mg of lead per square centimeter		Sample number	Mg of Lead per square centimeter	
	X-ray fluorescence instrument E	Atomic absorption		X-ray fluorescence instrument E	Atomic absorption
116	7.6	12.0	502	− .2	.02
129	7.1	12.8	504	.0	.05
137	8.5	12.5	505	− .1	.03
144	2.7	3.0	506	6.5	9.6
145	3.1	4.8	507	− .3	.04
146	2.8	3.9	508	.3	.2
147	3.1	4.3	509	.0	.1
148	4.0	4.5	510	.6	.1
149	1.8	4.6	511	.7	.05
151	4.2	5.8	512	11.6	12.4
152	3.1	4.6	513	2.9	3.0
159	3.5	6.1	514	2.8	2.4
161	3.8	6.1	515	.4	.2
163	3.2	6.2	516	.5	.2
164	4.3	5.4	517	.4	.2
165	3.9	6.0	518	.8	.1
166	4.5	6.3	519	.8	.1
167	7.6	11.1	520	5.5	4.4
168	8.2	11.7	521	.8	.1
169	8.3	13.6	522	.7	.1
240	− .2	.05	600	.6	.6
241	.5	.03	601	.8	.1
243	.4	.1	602	.5	.2
244	.6	1.3	603	.5	.1
245	.3	.03	604	1.1	.1
247	.3	.4	605	2.2	1.9
248	.5	.8	608	.9	.3
251	.5	.03	609	.9	.3
253	.3	.07	610	1.3	.6
254	.5	.05	611	6.3	9.7
255	.3	.07	612	5.9	9.7
256	1.6	.7	615	11.4	6.0
258	.4	.02	617	12.0	16.4
259	.1	.1	619	11.5	17.0
261	.9	.5	620	− .1	.2
262	2.7	2.7	621	11.6	17.2
263	.6	.1	622	2.5	1.9
264	.4	.2	623	2.1	1.7
265	.4	.06	624	5.5	6.3
266	.6	.03	625	.0	.02
267	.2	.02	626	.8	.04
271	.6	.4	627	.0	.1
273	− .2	.08	628	2.8	3.2
274	.3	.05	629	.7	.04
500	2.0	1.6	630	1.3	.2
501	.1	.1	631	2.2	2.8

reading to give 1.0 mg of lead per square centimeter with 97.5 percent confidence to 2.3. The corresponding value with 99.5 percent confidence for more than 1.0 mg of lead per square centimeter would be 2.9. Since the X-ray fluorescence readings and the atomic absorption values were not changed when they were rechecked on the same sample, they have not been eliminated. Under the circumstances, however, it is

Table 5. Lead content as determined by atomic absorption spectrophotometry for paint samples in which no lead was found by X-ray fluorescence analysis

Sample number	Mg of lead per square centimeter	Sample number	Mg of lead per square centimeter
26327	0.2	34251	.4
26328	.2	38041	.4
26329	.2	38043	.3
26330	< .1	38044	.3
26331	.2	38045	.6
36332	.6	38046	.3
36333	< .1	38047	.4
26334	1.3	38048	.6
26335	.3	38049	.3
33622	.1	38050	.4
33623	< .1	38051	.4
33624	.1	38052	.4
33637	.0	38053	.4
33638	< .1	38054	.4
34006	.0	38055	.4
34007	.0	38056	.6
34008	< .1	38057	.5
34009	< .1	38058	.6
34011	.5	38059	.6
34012	.5	38060	.3
34013	.4	38061	.1
34016	.6	38062	< .1
34018	< .1	38064	< .1
34020	< .1	38066	.0
34023	< .1	38067	.0
34025	.2	38068	< .1
34027	.2	38069	.9
34029	.2	38070	< .1
34030	< .1	38071	.6
34053	.3	38072	.4
34055	.2	38073	.3
34057	< .1	38074	.2
34060	.6	38075	.2
34062	.1	38076	1.9
34063	.6	38077	< .1
34210	.5	38078	.0
34211	.4	38079	.0
34213	.2	38080	< .1
34216	< .1	38081	< .1
34218	.0	38084	< .1
34220	<0.1	38086	< .1
34222	< .1	38087	< .1
34225	< .1	38088	.2
34227	< .1	38089	.2
34229	< .1	38090	.1
34232	< .1	38091	< .1
34233	.1	38092	.3
34238	< .1	38095	< .1
34240	.0	38096	.2
34241	< .1	38097	.1

1. *Surface area of paint samples is determined on surface area photometer; samples are then placed in crucibles for ashing.* 2. *Ashed samples are dissolved in nitric acid, diluted in volumetric flasks.* 3. *Lead concentrations of solutions are determined on atomic absorption spectrophotometer.*

doubtful that the differences in confidence limits between instruments are significant.

We were interested in determining the reliability of instrument readings that indicated the absence of lead in situ. Of the 100 panels from walls for which instrument E indicated the absence of lead (zero readings with the instrument set so that negatives read zero), only 2 contained more than 1.0 mg of lead per square centimeter (table 5). Therefore, it seems safe to predict that readings of zero lead on this instrument will indicate the absence of lead with better than 95 percent confidence and that instrument E can be used to screen out most samples that are negative for lead.

Conclusion

Our study results suggest that it will be advantageous to measure the lead content of most intact wall panels in situ. All walls that give readings for lead of 3.2 mg per square centimeter or greater can be cited as violating the permissible level of less than 1 mg of lead per square centimeter. All walls that give zero or negative readings can be considered to be negative for lead. Only the relatively few samples that fall in the intermediate range will have to be tested by atomic absorption spectrophotometry. The cost and time for analysis will thus be lessened, and the intact walls that will have to be broken up and the samples that will have to be transported to the laboratory for analysis will be reduced to a manageable minimum.

References

1. Searle, B., Chan, W., Jensen, C., and Davidow, B.: Determination of the lead in paint scrapings by atomic absorption. Atomic Absorp Newsletter 8: 126−127 (1969).

2. Sayre, J. W., and Wilson, D. J.: A spot test for detecting lead in paint. Pediatrics 46: 783−785 (1970).

3. King, B. G.: Criteria for evaluating lead hazard of painted surfaces. Bureau of Community Environmental Management, Health Services and Mental Health Administration, Public Health Service, Cincinnati, Ohio, May 1971.

4. Lawrer, G. R., Kneip, T. J., Albert, R. E., and Kent, F. S.: X-ray fluorescence: Detection of lead in wall paint. Science 172: 466−468 (1971).

5. Bartltrop, D., Harford, C. L., and Killala, N. J. P.: The determination of lead in paint films with a portable isotope fluorescence analyzer. Bull Environ Contam Toxicol 6: 502−508 (1971).

6. Paabo, M.: Analytical methods for the detection of toxic elements in dry paint matrices—A literature survey. National Bureau of Standards Internal Report No. 73-251, July 1973. NTIS Accession No. PB224688. National Technical Information Service, U.S. Department of Commerce, Springfield, Va.

Equipment References

A. Surface area photometer. Laser Optics, Inc., Danbury, Conn.

B. X-ray fluorescent instrument. Model 9200 series. Texas-Nuclear, Austin (division of Nuclear-Chicago).

C. Lead detector. Model XK-2. Princeton Gamma-Tech, Princeton, N.J.

D. Manufacturer has not given permission to divulge identity of instrument.

E. Lead analyzer. Model PB-3. Texas-Nuclear, Austin (division of Nuclear-Chicago).

F. Micro mill. Model 4300. Cole-Parmer Instrument Co., Chicago, Ill.

G. Micro mill. Catalog No. 7875/602. Chemical Rubber Co., Cleveland, Ohio.

H. Micro mill. Wig-L-Bug Model 6. Crescent Manufacturing Co., Lyons, Ill.

SYNOPSIS

KAPLAN, E. H. (Chicago Board of Health), LILLEY, M. D., SCHAEFER, R. F., CADE, B., DESAI, A., PAVDA, A., and ORBACH, H. G.: *Portable X-ray fluorescence instruments for the analysis of lead in paints. Public Health Reports, Vol. 90, May-June 1975, pp. 223−230.*

In a study in the laboratories of the Chicago Board of Health, the results from determination of lead in paint films by X-ray fluorescence were compared with results from determination by atomic absorption. Portable instruments of three suppliers were used for X-ray fluorescence measurements. An improved version of one of these instruments was also tested.

The results of X-ray fluorescence readings on painted card stock panels with one of these instruments compared satisfactorily with the results as determined by the atomic absorption method at levels below 10 mg of lead per square centimeter. Readings on multiple layers of these panels were additive and independent of the order of these panels. All four instruments were tested in the laboratory on painted surfaces from the walls of condemned buildings. The most recent version of each instrument gave a correlation coefficient of 0.96 or better for the linear regression of lead values in milligrams per square centimeter by atomic absorption against instrument readings.

It was calculated that a reading of 3.2 or greater on any of the instruments would indicate with greater than 95 percent confidence that 1 mg or more of lead per square centimeter would be found when a sample of the paint was analyzed by atomic absorption. When the readings of one of the instruments showed lead to be absent, that result would indicate with better than 95 percent confidence that less than 1 mg of lead per square centimeter would be found by the atomic absorption method.

Portable X-ray fluorescence instruments can be used in situ to determine whether the walls of a building give readings for lead above the range of 0 to 3.2. Walls with readings above this range can be considered to have 1 mg or more of lead per square centimeter and would not be in conformance with the code of the City of Chicago. Samples would need to be taken for analysis in the laboratory by atomic absorption only from those walls with readings within the range of 0 to 3.2.