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Comparisons among lead paint field screening test methods

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Abstract

Leaded paints are known to present a potential health risk if ingested. There are several field screening and laboratory methods to determine if walls are painted with lead-containing coatings. A common type of field screening method is a colorimetric chemical reaction with the painted surface which is intended to produce qualitative 'yes/no' results. This method results in some small damage to the coated surface. X-ray fluorescence is a nondestructive field screening device which can produce slightly more quantitative data although the results are often reported in reference to being above or below the HUD criteria. US Environmental Protection Agency (US EPA) laboratory methods to quantify lead in coated surfaces include atomic absorption (AA) and inductively coupled plasma (ICP).

Three series of tests were conducted to determine the capability and characteristics of four field screening devices (three colorimetric, one X-ray fluorescence) to detect lead content on painted walls. Laboratory analysis was used to determine base lead levels in the test paints. The first test series evaluated the apparent detection threshold of three colorimetric field screening kits using the manufacturers' definition of a positive result. The second series of tests examined the effect of multiple layers of leaded and nonleaded paints on the colorimetric and X-ray fluorescence detection methods. The third series of tests examined the qualitative effect of such things as paint color, application method, and surface preparation on three colorimetric test kits.

1. Introduction

Lead has a ubiquitous presence in the environment. Not only is it used by man to produce a variety of industrial and consumer products but it is also a naturally occurring element of the earth's crust that which is continuously replenished by the degradation of uranium and thorium [1]. The presence of lead in ingested materials is a concern based on the numerous health studies of lead exposure. The United States Environmental Protection Agency (US EPA) has found that exposure to lead is not healthful (i.e., produces no healthful effects) at any level of human exposure. For example, there is no maximum contaminant level (MCL) for lead in public water

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supplies. Rather, the US EPA has issued an action level of 15 ppb and a goal of zero in acknowledgement that no level was found to be healthful [2].

Regardless of the source (i.e., water, soil, paint, air), once lead enters the human body and is oxidized to its ionic form (Pb^{2+}), it is easily metabolized. Depending on the dosage and the length of exposure, adverse health effects can range from such common ailments as upset stomachs, irritability, and constipation to more serious manifestations as damage to organs, the central nervous system, and the brain. These adverse effects may be more severe in young children. Chronic exposure to high lead levels in both adults and children can be fatal.

This study explored the different field conditions that may present analytical challenges in determining the presence of lead in painted surfaces. As a starting point, it is necessary to define a lead-based paint. Two federal agencies have been charged with responsibilities under the Lead-Based Paint Poisoning Prevention Act (1978): the Department of Housing and Urban Development (HUD) and the Consumer Product Safety Commission (CPSC).

HUD issued a Lead-Based Paint Hazard Elimination regulation on 15 April, 1991, in response to its duties under the Lead-Based Paint Poisoning Prevention Act (Act). The goal of the federal law was to protect children in public and Indian housing units from lead poisoning originating from lead-based paint. HUD defined lead-based paint as: (i) paint having greater than or equal to 1.0 m of lead per cm^2 of paint or (ii) paint containing 0.5% lead by weight in a dry paint sample.

Once it is determined that lead-based paint is present in a public housing unit, certain abatement measures are mandated [3].

In 1978 the Consumer Product Safety Commission banned the sale of paints containing more than 0.06% lead (by weight, dry basis). This 0.06% level is regarded as a trace amount and is equivalent to 600 ppm lead. Leaded paints are still available for some commercial uses such as sign painting.

While HUD and CPSC have defined what is or is not considered a lead-based paint for public housing units and consumer products, many other types of buildings and structures could have interior surfaces coated with lead-based paints that may pose a health risk to building occupants under certain conditions. Some of these types of properties have been addressed under Title X of the Housing and Community Development Act – 'Residential Lead-Based Paint Hazard Reduction Act of 1992' [4]. It is anticipated that additional guidelines and regulations will be forthcoming from agencies such as: US EPA, HUD, NIOSH, and OSHA; and from other standards making groups [5].

In the meantime, environmental professionals who are performing site assessments need to recognize and assess lead-based paints so they can minimize this source of lead exposure. If conditions of wear such as peeling and chipping are encountered during an inspection, this indicates a threat to young children who may ingest the material. If a major renovation or remodeling effort is planned for a property, construction workers and building occupants may need to be protected from lead dust. Even exterior surfaces and structures, such as house trim and bridges painted with lead-based paints, can be a concern to construction workers engaged in demolition and paint removal activities if they are not protected from lead dust inhalation. A recent interim final rule issued by OSHA limits construction workers to an exposure level of 50 μg/m^3 of air on an eight-hour time weighted average basis. This rule was promulgated in acknowledgement of the exposure risk to construction workers during demolition work, sanding, heat gun paint removal, cleanup and spraying operations [6].

2. Test objectives

The first step in evaluating the exposure potential from lead-based paint at any given property is simply to determine if lead-based paint is present. For the purposes of this testing work we give the following definitions: (i) Lead-based paint is defined as paint containing greater than or equal to 0.5% lead by weight on a dry basis. (ii) Nonlead paint is defined as paint containing less than 0.06% lead by weight on a dry basis. (iii) Lead-containing paints are paints that contain between 0.06% and 0.5% lead on a dry basis.

These definitions are based on HUD and CPSC criteria previously discussed [3, 4].

The following test series were performed to evaluate the performance characteristics of three field screening test kits.

Test series no. 1

To evaluate the apparent detection limit of three colorimetric lead screening methods, wall panels coated with progressively lower concentrations of lead-based and lead-containing paints were tested to determine threshold detection limits of three test kits. Actual lead concentrations in the painted surfaces were analyzed by inductively coupled plasma (ICP). A light golden paint was used to minimize color interference for the colorimetric tests.

Test series no. 2

This testing was conducted to evaluate the effects of multiple layers of leaded and nonleaded paints on detection capability. Wall panels were painted with various under layers and cover layers of both lead-based and nonlead paints and evaluated using X-ray fluorescence and colorimetric methods. ICP was used to determine lead levels in the paint.

Test series no. 3

Various color paints, application methods and surface preparation methods were employed to qualitatively check for their effects on colorimetric lead detection methods. ICP was used to determine lead levels in the paint.

3. General test procedures

The following general procedures were used for all tests. Three, 4 ft × 4 ft wall panels were constructed from commercially available plaster board. The lead-based and nonlead paints were analyzed to determine the baseline lead level being used for any given test.

Each wall panel was subsequently subdivided into a grid pattern consisting of test squares typically 10 in × 10 in. Each square was intended to be a unique paint test panel representative of one test condition.

The paints were well mixed prior to application and were evenly applied using a clean paint brush. Paint supplier's recommendations were followed in regard to mixing and paint application.

The same type of paint brush applicator was used in test series nos. 1, 2, and 3 to apply all layers of paint to any one test square and efforts were made to use approximately the same quantity of paint for each layer on any particular test square.

The wall panels were analyzed using up to three possible sample preparation methods and followed the various recommendations of the colorimetric test kit manufacturers.

– Sample preparation method one consisted of light abrasive sanding (***S***) of the painted surface by hand using 3M-413Q, 320SH1 grade extra fine sandpaper. This surface preparation consisted of approximately 30 s of light sanding in multiple directions until a soft, powdery surface was produced on the test panel.

– Sample preparation method two consisted of cutting (***C***) a 'V' notch in the painted surface using a clean razor blade. The notch was typically 1 inch long at each side and the two cuts intersected at about a 45° angle. The notch was repeatedly grooved until small paint chips could be seen at the surface.

– Sample preparation method three consisted of removing a chip(s) from the wall and crushing or grinding (***G***) it in a crucible and performing the leach and staining functions in the receptacle. This sample method was only used for series no. 3 testing, as it was found to be very erratic and unproductive during test series no. 1 and no. 2. Test wall no. 3 took a longer time to prepare and it was believed that a longer drying time might help the grinding method.

Each colorimetric test method used a chemical in liquid form that could be directed to the prepared painted surface or paint particles under investigation. Typically, the liquid was applied to the painted surface or particles using a swab type applicator. The basis for detection was a chemical reaction that would produce a visible color change. Two devices, Lead Check™ (LC) and Lead Alert™ (LA), produced a pink color change and one device, Lead Detective™ (LD), exhibited a black or gray color change for an affirmative result.

Below are the definitions of color changes used by the three colorimetric kit manufacturers:

LC "The appearance of any pink color on the swab indicates the presence of dangerous levels of lead ⋯" [7].

LA "Positive result. The appearance of pinkish to rose/red color" [8].

LD "The black color indicates the formation of lead sulfate and is a positive test for the presence of lead above 4%" [9].

Wall panels for test series no. 1 were prepared using leaded paints in the range 5–15% so the paint could be diluted with nonlead paints to create a desired range of lead concentrations on a dry basis. A golden color was chosen to be diluted with white latex so that light tones would be evaluated. Light colors were perceived as resulting in the most obvious color changes when using these kits.

Wall panels for test series no. 2 were painted with a white paint in the lead range 0.1–1% to maximize their ability to produce a recognizable color change at the low end of the detection range.

The X-ray fluorescence method used a PGT XK-3 analyzer manufactured by Princeton Gamma-Tech., Inc. The device was configured like a hand-held lunch box. The method of detection was based on energizing the lead molecules in the paint with radiation from a cobalt-57 source in the 'lunch box' and detecting the unique fluorescent radiant energy given off by the energized lead.

The results of this analysis were displayed on the instrument's digital display; and, based on prior calibration, the results were reported as 'above', 'below', or 'uncertain' in regards to the HUD action level.

The following three test series were performed as part of this evaluation.

4. Threshold for detection using three colorimetric screening tests (test series no. 1)

'Sign Painters' 1 Shot Lettering Enamel' 191-L (gold), a lead-based paint, manufactured by Consumers Paint Factory, Inc. was blended with Benjamin Moore's 'Ceiling White' vinyl acrylic latex, a nonlead, flat paint to produce seven lead-based and lead-containing paint concentrations ranging from approximately 0.1% to 4.0%. Prior to calculating the formulation weights of the two paints, each was analyzed by an independent laboratory using the ICP method for lead content on a dry basis and percent solids (Table 1). Test blend concentrations were formulated to yield seven incrementally different percentages of lead-based paints on a dry basis that were expected to traverse the HUD lead based paint criteria. The seven blended paints were applied to produce seven vertical columns on the wall panel. Each vertical column was horizontally subdivided to produce three test squares. The top horizontal row of test squares only received a single layer of leaded paint; the second row of horizontal test squares also received two additional overcoats of nonlead 'ceiling white'; and the last horizontal row of wall panels received five overcoats of nonlead 'ceiling white'. Fig. 1(a) and (b) depict this configuration, along with notations as to the type of tests that were performed in each panel.

Table 1
Analytical results lead content (ppm) dry weight basis

Paint designation	Inductively coupled plasma	Total solids (%)
For test series no. 1		
Sign painter's 1 Shot 191-L	79,700	74
Ceiling White	< 10.4	48
For test series no. 2		
Sign Painter's 1 Shot 101-L	1937[a]	
Ace Five Star Flat Latex 184A120 White	Not analyzed	

[a] Average of three numbers, see Table 3.

(a)

TEST SERIES 1

			PERCENTAGE OF LEAD IN THE BASE LAYER (DRY BASIS)																				
			0.1%			0.2%			0.4%			0.5%**			0.6%			1%			4%		
			LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA
ROW 1	0 OVERCOATS, ONLY BASE LAYER	C	–	–	–	–	–	–	+	–	+	+	–	+	+	–	+	+	–	+	+	+	+
		S	+	–	+	+	–	+	+	–	+	+	–	+	+	–	+	+	+	+	+	+	+
ROW 2	2 OVERCOATS OF NO-LEAD PAINT	C	–	–	–	–	–	–	–	+	–	–	+	–	–	+	+	–	+	+	+	+	+
		S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	+	+
ROW 3	5 OVERCOATS OF NO-LEAD PAINT	C	–	–	–	–	–	–	–	+	–	–	+	–	–	+	–	–	+	–	+	+	–
		S	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	–	+	+	–

C - CUTTING S - SANDING LC - LEAD CHECK™ SWABS LD - LEAD DETECTIVE™ LA - LEAD ALERT™

LC (+) SWAB TURNED A DISTINCT SHADE OF PINK

LD (+) BLACK COLOR CHANGE OR GRAY TO BLACK

LA (+) SWAB TURNED PINK*

* FOR LEAD ALERT™, A POSITIVE COLOR CHANGE WAS VERY FAINT FOR ALL BUT THE 4% TEST.

** HUD CRITERIA LEVEL FOR LEAD-BASED PAINT

(b)

TEST SERIES

			PERCENTAGE OF LEAD IN THE BASE LAYER (DRY BASIS)																				
			0.1%			0.2%			0.4%			0.5%*			0.6%			1%			4%		
			LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA
ROW 1	0 OVERCOATS, ONLY BASE LAYER	C	–	+	–	–	+	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		S	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ROW 2	2 OVERCOATS OF NO-LEAD PAINT	C	–	+	–	–	+	–	–	+	–	–	+	–	–	+	+	–	+	+	+	+	+
		S	–	+	–	–	+	–	–	+	–	–	+	–	–	+	–	+	+	–	+	+	+
ROW 3	5 OVERCOATS OF NO-LEAD PAINT	C	–	–	–	–	–	–	–	+	–	–	+	–	–	+	–	–	+	–	+	+	–
		S	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	–	+	+	–

C - CUTTING S - SANDING LC - LEAD CHECK SWABS LD - LEAD DETECTIVE LA - LEAD ALERT

LC (+) SWAB TURNED A SHADE OF PINK

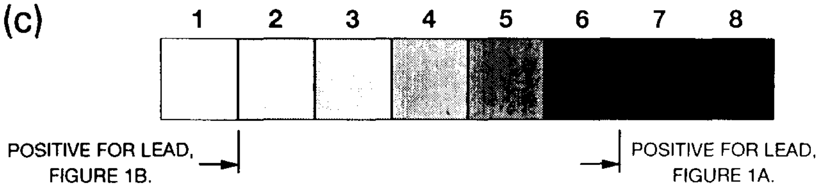
LD (+) WALL TURNED A SHADE OF GRAY

LA (+) SWAB TURNED PINK

* HUD CRITERIA LEVEL FOR LEAD-BASED PAINT

Fig. 1. (a) Positive identification for lead based on manufacturer's definition of color change (test series no. 1). (b) Positive identification for lead based on *any* color change to gray or shade of pink (test series no. 1). (c) Shading chart for Lead Detective™ kit.

(c)



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1 - 0% SHADING
2 - 10% SHADING
3 - 20% SHADING
4 - 30% SHADING
5 - 40% SHADING
6 - 60% SHADING
7 - 80% SHADING
8 - 100% SHADING

Fig. 1. Continued.

Only colorimetric tests using the three test kits were performed. An attempt was made to characterize the shade of gray color change observed using the LD kit in the field by comparing the color change on the wall to a shading chart shown in Fig. 1(c). The kits producing a pink color change were evaluated based on the presence of any perceptible pink color in the test square.

4.1. Test series no. 1: observations and discussion

Using the manufacturer's definition of positive detection of lead above the HUD criteria (see Section 3), each of the three calorimetric kits performed as expected indicating the presence of lead across the first row for a single layer of leaded paint. At and above 1% lead, it was relatively easy to detect a noticeable color change. Below 1%, the Lead Check™ (LC) kit and the Lead Detective™ (LD) kit were able to produce a noticeable color change but in increasingly fainter shades. The Lead Alert™ (LA) kit produced a faint pink color change for all but the 4% lead wall test panel which was a distinct pink color change. Detection of lead became very subjective below the 1% lead level for the appearance of pink color by the LA kit. The color change required an interpretation by the evaluator as to whether or not a 'distinct' pink color change had taken place.

Sanding was a slightly more effective surface preparation technique than the cutting method reported in row 1, with no overcoat (Fig. 1(b)), simply because more surface area was exposed to the leaching chemicals provided in the kit. All three colorimetric test methods exhibited a gradual lightening of the expected color change as the concentration of lead in the paint diminished. It was slightly easier to detect a black or gray shade color change on the test squares than it was to see a pink color change. This observation may be influenced by the color of the paint being examined. It may be possible to create a reference color chart for each method that could be used in the field to help identify the possible range of lead in field samples or as reference to the threshold of a distinct color change.

For the rows on the wall panel with multiple layers of white overcoats, only the LD kit produced a noticeable gray color change below 0.5% lead content. In general, the 'V' cut surface preparation technique was more effective for the LD and the LA kits; sanding seemed to work best with the LC kit.

5. The effect of multiple layers of leaded and nonleaded paints using the colorimetric and X-ray fluorescence methods (test series no. 2)

A wall panel as generally described in Section 3 was used for this testing. Fig. 2 indicates the specific paint application levels and traversed individual panels which contained only lead-based paint to those that contained only nonlead paint. This allowed for wall panels which had the same ratio of layers of lead-based to nonlead paint, but with differing total numbers of layers of paint. The downward diagonal in Fig. 2, for example, would represent this constant ratio condition with progressively increasing layers of paint. In all cases the lead-based paint (Sign Painter's 1 Shot 101-L) was applied first and the nonlead paint (Ace Five Star Flat Latex 184A120) was applied as an upper layer(s).

Based on laboratory results, a single layer of Sign Painter's 1 Shot 101-L had an average lead concentration of 1937 ppm. This level is below the HUD criteria, but was selected for testing purposes to augment the data from the higher concentration range discussed in test series no. 1, and because this concentration appeared to traverse the expected detection thresholds for these devices.

5.1. Test series no. 2: observations and discussion

It is apparent from Fig. 2 that two of the colorimetric methods for the most part resulted in negative values, whereas the remaining LD colorimetric method produced mostly positive results. A positive result from the LD kit for this test series was defined as a color change to any discernible gray shade. This is different from the manufacturer's definition of a positive lead reading which requires a color change to black and which was the criteria for test series no. 1. It was assumed that since the lead content of the paint was known, any discernible gray color would be due to this metal. Fig. 1c shows the gray scale used to identify a gray hue.

The X-ray fluorescent detector performed as expected on the test panels, in that multiple layers of leaded paints with an average lead concentration of 1937 ppm did not produce a positive result in the instrument, which was calibrated for 1 mg of Pb/cm^2.

For low levels of detection at or below the HUD criteria it may be possible to use colorimetric methods (based on weight percent lead in a dry paint sample) in conjunction with a color chart for screening purposes. The X-ray fluorescent method

Number of lead paint layers (0.1 - 0.25% lead)	Number of non-lead paint layers →	0			1			2			3			5		
		LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA	LC	LD	LA
1	S	−	+	+	−	+	−	−	+	−	−	+	−	−	+	−
1	C	−	+	−	−	+	−	−	+	−	−	+	−	−	+	−
2	S				−	+	−	−	+	−	−	+	−	−	+	−
2	C				−	+	−	−	+	−	−	+	−	−	+	−
3	S				−	+	−	−	+	−	−	+	−	−	−	−
3	C				−	+	−	−	+	−	−	+	−	−	+	−
5	S				−	+	−	−	+	−	−	+	−	−	+	−
5	C				−	+	−	−	+	−	−	+	−	−	+	−

S - SANDING
C - CUTTING
LD - LEAD DETECTIVE
LC - LEAD CHECK
LA - LEAD ALERT

(+) POSITIVE IDENTIFICATION FOR LEAD BASED OR A RECOGNIZABLE COLOR CHANGE TO GRAY OR PINK

(−) NO LEAD DETECTED, NO COLOR CHANGE SEEN

PAINT USED IN BASE LAYER CONTAINED AN AVERAGE 1,937 PPM LEAD ON A DRY BASIS.

DIAGONAL INDICATES PANELS OF CONSTANT RATIO: LEAD PAINT/NON-LEAD PAINT LAYERS

Fig. 2. Low-level lead detection results (test series no. 2).

employs a device that is set by the manufacturer to detect 1.0 $\pm$ .5 mg of Pb/cm^2 of paint. Although at the low concentrations correction for substrate interferences becomes very important.

The weight percent basis and the weight per area basis are not equivalent; however, they can be related to each other under controlled conditions. The following is a calculation method that could be used to relate the X-ray fluorescent criteria to a lead-containing paint criteria.

5.2. Example calculations

Test square: 100 in^2 or 645 cm^2,

Lead-containing paint: 1937 ppm or 1937 mg Pb/1000 g paint,

Typical paint layer: 50 g paint/645 cm^2 (based on field observation of good paint coverage); 1937 mg Pb/1000 gm paint = 97 mg Pb/50 g paint (50 g paint covers 645 cm^2 area); therefore, 97 mg Pb/645 cm^2 = 0.15 mg Pb/cm^2 for one layer of this paint.

Five layers of this low level lead paint (e.g., 5 × 0.15 mg Pb/cm^2 = 0.75 mg Pb/cm^2) may not be detected as a lead-based paint on an instrument calibrated for 1 ± 0.5 mg Pb/cm^2.

6. Qualitative effect of paint color and application method on three colorimetric test methods (test series no. 3)

A third wall panel was constructed in the fashion described in Section 3, but in this test series various colors, application methods and sample preparation methods were employed to obtain some qualitative information about these variables on the ability of these devices to detect lead in coatings. Table 2 designates the paints used for the testing.

Fig. 3 contains the configuration for test series no. 3. A single layer of white low lead paint (Control panels 1A and 1B) and a single layer of yellow high lead striping spray paint (Control 2) comprise row 1. Rows 2 and 3 were prepared with white low lead paint covered with four layers of multicolored no lead paints as described in Table 2. All panels were analyzed three times by the same laboratory using ICP and the results are shown in Table 3.

6.1. Test series no. 3: observations and discussion

For the control panels containing a single layer of lead-containing paint in the low concentration range (1610–2300 ppm), sanding the surface seemed to produce better results than 'V' notch cutting. 'V' notch cutting and sanding worked well on the high concentration range leaded paint (55,500-102,000 ppm); however, the bright yellow color of the base paint masked any color change that may have been present on the LA kit.

Of the two test panels that contained five layers of nonleaded paint, only the LD kit caused a discernible gray color change. The wall panel that contained four layers of white nonleaded paint over a single layer of white lead-containing paint tested negative using all kits and all surface preparation techniques. And lastly, a discernible gray color change was observed using the LD kit on panels that contained multiple layers of pink, white, and black paint layers over a single layer of lead-containing paint.

The values in Table 3 indicate the range of results using ICP for multiple analysis of samples from the same test panel. Other research has reported that an expected

Table 2
For test series no. 3

Control No.	Name	Lead content (ICP), ppm
Leaded paints		
Control 1A	Sign painters' 1 Shot 101-L Lettering White[a]	(1610–2300)
Control 1B	Sign Painters' 1 Shot 101-L Lettering White[a]	(1030–1900)
Control 2	Aervoe Striping Paint Yellow Spray Paint	(55 500–102 000)
Nonlead-containing paints		
3	Ace Five Star Flat Latex 18A120 (off white)	
4	Pratt & Lambert Vitra-Lite Alkyd enamel, no. E30772 Sunset Fog (pink)	
5	Ace Seven Acrylic Semi-Gloss Latex Enamel, 186A105 (black)	

[a] These two paints were from different lots.

difference in lead content between the actual value and the value attained after analysis is $\pm 10\%$ [10]. A higher variance between the actual lead value in a paint chip and the value reported by a laboratory may be a combination of laboratory technique, sampling technique, paint application uniformity, and paint homogeneity. For the purposes of test series no. 3, knowing the exact lead content in the Sign Painter's One Shot 101-L was not critical. What was needed was a verification that the paint contained less than the HUD low threshold of 5000 ppm.

7. General findings/conclusions

It is apparent that screening methods used on surfaces painted with low level lead-containing paints can produce variable results. Factors that contribute to these variations are: (i) choice of surface preparation technique; (ii) color of the paint layers being analyzed; (iii) choice of screening method; (iv) limitations of laboratory analysis methods.

When analyzing multiple layers of paint, it appears that a 'V' notch cutting technique may expose underlying layers of paint better than a surface sanding technique. However, when analyzing a single layer of paint or one to two layers, sanding may expose more surface area to test chemicals and produce a more discernible color change. Some paint colors (black, pink, yellow) may produce mixed results with colorimetric methods. Multiple samples may need to be submitted to a laboratory for verifications as even these test results show variation. Since the painted surfaces tested were freshly painted and in good condition, grinding a sample chip was not very successful. Perhaps on older, more friable paint chips, the grinding method would be more effective.

Row	Column	Sample	Method	LD	LA	LC
1	1	*Control 1A brush*	C	+	–	–
			S	+	+	+
			G	x	x	x
1	2	*Control 1B brush*	C	+	–	–
			S	+	+	+
			G	x	x	x
1	3	*Control 2 yellow spray paint*	C	+	–	+
			S	+	–	+
			G	x	x	x
2	1	*Five layers of #5 no-lead paint black*	C	+	–	–
			S	+	–	–
			G	x	–	x
2	2	*Four layers of #4 no-lead over 1A pink*	C	+	+	–
			S	+	–	–
			G	x	–	x
2	3	*Four layers of #3 no-lead over 1B white*	C	–	–	–
			S	–	–	–
			G	x	–	x
3	1	*#3, #4, 2x #5 over 1A black***	C	+	–	–
			S	+	–	+
			G	x	–	–
3	2	*Five layers of #4 no-lead paint pink*	C	+	+	–
			S	–	–	–
			G	x	x	–

(+) NOTICEABLE COLOR CHANGE TO PINK OR GRAY

(–) NO NOTICEABLE COLOR CHANGE TO PINK OR GRAY

(x) NOT TESTED

S - SANDING
C - CUTTING
G - GRINDING CHIP IN A CRUCIBLE
LD - LEAD DETECTIVE
LC - LEAD CHECK
LA - LEAD ALERT

** SQUARE KEY

BASE LAYER:	1A LEAD-CONTAINING PAINT
SECOND LAYER:	#3 WHITE NONLEAD PAINT
THIRD LAYER:	#4 PINK NONLEAD PAINT
FOURTH LAYER:	#5 BLACK NONLEAD PAINT
FIFTH LAYER:	#5 BLACK NONLEAD PAINT

TOP LAYER IS BLACK

Fig. 3. Qualitative effect of paint color on three colorimetric test methods.

8. Closing statement

Lead-based and lead-containing paints will be an increasing concern to environmental professionals. In the future, the HUD definition of lead-based paints may be used in some fashion as a level for evaluating nonpublic housing properties. It is important for property owners to understand that health and property contamination issues associated with lead-based paints will become an ever increasing concern. Environmental professionals can assist in minimizing exposure to this source of lead in the environment. Field screening of multiple samples coupled with laboratory

Table 3
ICP analytical results for test series no. 3 (ICP Method 6010)

Paint designation	Lead, ppm			Average ppm
	Sample 1	Sample 2	Sample 3	
Control 1A 1 Shot 101-L	1610	1900	2300	1937
Control 1B 1 Shot 101L	1030	1690	1900	1540
Control 2 Yellow Spray	55,500	102,000	77,800	78,433
Panel 2, 3[a]	690	455	567	571
Panel 3, 1	660	600	560	607
Panel 3, 2	45	49	46	47

[a] Row and column numbers on Fig. 3.

analysis or X-ray fluorescence are the best options at this time for detecting lead-based paints above an action level.

References

[1] R.J. Lewis, Hawley's Condensed Chemical Dictionary, 12th edn., Van Nostrand Reinhold, New York, 1993, p. 686.
[2] Code of Federal Regulations, 40 CFR Part 141, National Primary Drinking Water Regulations, 1992 edn., p. 684.
[3] Lead-Based Paint Hazard Elimination, 56 Fed. Reg. 15170 (1991) (to be codified 24 CFR Parts 35, 905, 941, 965, and 968) p. 15,172.
[4] Housing and Community Development Act, Public Law 102-550, Title X. Residential Lead-Based Paint Hazard Reduction Act of 1992, 42 U.S.C. 4851, pp. 3897–3924.
[5] M. McKnight and K. Ashley, ASTM Standards for addressing lead-based paint in buildings, ASTM Standardization News, December 1993, pp. 32–39.
[6] Code of Federal Regulations, 29 CFR Part 1926.62, Lead Exposure in Construction, 1993 edn., pp. 186–223.
[7] Lead Check™ Swabs Lead Test Kit Instruction Manual, HybriVet Systems, Inc., 1992.
[8] Sensidyne Lead Alert™ Easy to Use Professional All-in-One Test Kit, Sensidyne, 1993.
[9] The Lead Detective™ Lead Paint Detective Kit, Innovative Synthesis Corporation, 1988, 1991.
[10] J.N. Driscoll, C. Wood, T. Powell and J. Scott Askew, An extractive X-ray fluorescence method for field screening lead paint sites, Appl. Occupational Environ. Hygiene, 9 (3) (1994) 206–211.