

**SCREENING
PROCEDURES FOR
DETECTING LEAD IN
EXISTING PAINT
FILMS:
A LITERATURE
REVIEW**

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ABSTRACT

Recent legislation required the U.S. Department of Housing and Urban Development (HUD) to establish procedures to eliminate, as far as practicable, the hazards of lead-based paint poisoning in any existing HUD-controlled housing. Thus, HUD promulgated a regulation which requires abatement to eliminate lead-based paint poisoning hazards in housing in which the concentration of lead in paint equals or exceeds 1 mg/cm^2 . The legislation also required HUD to review test methods for measuring lead in paint. The National Institute of Standards and Technology (NIST) was tasked with this requirement. The first phase of the task, the subject of this report, was to review the literature for screening methods for measuring or detecting lead in paint. To facilitate the review, criteria were developed for potential test methods. A test method must be: 1) capable of detecting lead concentrations of 1 mg/cm^2 but not concentrations less than 0.06%, 2) non-hazardous, 3) suitable for use as a nondestructive field method 4) suitable for use by non-technical personnel, and 5) sufficiently reliable and precise. No method reported in the reviewed literature met all of these requirements.

Key words: analysis; detection; detection limit; discrimination limit; housing; lead; literature review; measurement; paint; screening; x-ray fluorescence spectrometry

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1. INTRODUCTION

Recent legislation, an amendment to the Lead-Based Poisoning Prevention Act by Section 566 of the Housing and Community Development Act of 1987 (Public Law 100-242, approved February 5, 1988), requires the U.S. Department of Housing and Urban Development (HUD) to "establish procedures to eliminate as far as practicable the hazards of lead-based paint poisoning with respect to any existing housing which may present such hazards and which is covered by an application for mortgage insurance or housing assistance payments under a program administered by the Secretary." In response to this legislation, HUD promulgated a regulation which requires abatement to eliminate the lead-based paint poisoning hazards in housing in which the concentration of lead in paint equals or exceeds 1 mg/cm^2 [1]. In addition, the legislation requires HUD to periodically review and reduce the level below 1 mg/cm^2 to the extent that reliable technology makes feasible the detection of a lower level and medical evidence supports the imposition of a lower level.

Because of the large number of homes that may have lead-based paint, HUD would like a simple, fast screening method to detect the presence of lead in paint films as part of an overall measurement procedure. Thus, if lead were found in a screening test, the lead concentration would then be determined more precisely by an appropriate measurement procedure.

The National Institute of Standards and Technology (NIST, formerly NBS) has been asked by HUD to develop recommendations, based upon current laboratory and field data, on methods for use in the detection and measurement of lead in dry paint films at two levels. The first level is for rapid screening methods which are capable of determining, with reasonable certainty, if lead is present. The second level is for methods for quantitatively measuring the concentration of lead in paint. The key requirements at both levels are safety, reliability, accuracy, precision, detection sensitivity (both qualitative and quantitative), suitability for use in the field and in the laboratory, ease of use, and usability by non-technical personnel. This report describes the results of a literature survey on potential procedures for screening painted surfaces to detect the presence of lead.

2. CRITERIA FOR JUDGING SCREENING TESTS

The following criteria were judged essential for a screening test. They are that the test procedure be 1) capable of detecting lead concentrations of 1 mg/cm^2 but not concentrations of less than 0.06% by mass of a dry paint film, 2) non-hazardous, 3) suitable for use as a nondestructive, or minimally destructive, field method, 4) suitable for use by non-technical personnel, 5) sufficiently reliable, precise and accurate and 6) rapid.

These criteria require no further explanation, except for the first and fifth. The criterion that lead levels below 0.06% by mass of total solids (600 parts per million) not be detected, with some chosen degree of confidence, is included because it is the limit set forth in the Lead-Based Paint Poisoning and Prevention Act as amended by the National Consumer Health Information and Health Promotion Act of 1976, Public Law 94-317, promulgated by the Consumer Product Safety Commission (CPSC) regulation, Lead-Containing Paint [2], for lead in consumer paint (i.e., paint used for residential structures). Paints may be contaminated by very minor amounts of lead because of the presence of lead in water, air, and other parts of the environment.

As for the fifth criterion, the precision and bias of a measurement process determine the confidence one can place in the result, or in terms of a detection limit, the precision and bias of a blank, along with choices for false positive risk, α , and false negative risk, β , determine the detection limit of the measurement process [3].¹ In general terms, the detection limit is the smallest concentration that a particular measurement process can reliably detect. (Reliability is defined in terms of an acceptable α and β .) In determining the precision and bias of a measurement process, care must be taken to include the total measurement process. A total measurement process may include a standard procedure carried out on a variety of materials by different operators in different laboratories or in the field. The precision and bounds for bias of the total process will likely be greater than that of a limited part of the process.

Extensive literature on detection limits is available and it has recently been reviewed [4]. A brief, and necessarily simplified, discussion of detection limits is presented in this report. The many assumptions made in this discussion are pointed out. The assumptions are usually valid for the type of measurements being discussed, but there may be exceptions. Procedures for dealing with the exceptions are beyond the scope of this report. The assumptions used in this report present nearly best-case scenarios. (See, for example, the discussion by Saw et al. [5] on the use of the Chebyshev Inequality non-parametric technique, that is applicable to all distributions having a finite mean and variance. Such non-parametric detection limits are generally

¹Precision is usually associated with the random error of a measurement process and defined in terms of standard deviation, while bias is associated with systematic error. The uncertainty of a measured result associated with random error can be reduced by repeating the measurement, but that associated with bias is not reduced by repeating the measurement. Hence, these two types of error are treated separately in the discussion of detection limits below.

larger than when the functional form of the distribution is known.)

First, let us consider the technical meaning of the term, detection limit. Many definitions for detection limit have been used. Currie [4] lists four definitions related to current US regulatory practices. The definition used in this report follows the recommendations of the 1986 draft report of the International Union of Pure and Applied Chemistry (IUPAC) [6]. It is based upon hypothesis testing and recommends risk levels of 5 percent for false positive error, α , and for false negative error, β . However, the approach of hypothesis testing is general and has been developed independently of specific risk levels. Acceptance of the hypothesis-testing approach for defining detection limits is increasing and provides a means of reporting detection limits in rigorous, comparable ways [7].

According to Currie [4], "The keys to understanding the meaning of detection decisions and detection limits in matters of practical importance to science and society are: a) the existence of the two states which we wish to distinguish, b) a specified measurement process having an adequate DETECTION LIMIT, and c) a threshold or CRITICAL LEVEL for the measurement variable for making the Detection Decision. . . . Note that the detection decision is made by comparing an outcome or result of the measurement with the Critical Level." The "truth table" shown in table 1 illustrates these points. The two states that we wish to distinguish are: 1) the true concentration is zero and 2) the true concentration is L_b . The detection decision, either nd (not detected) or d (detected), is made by comparing an experimental outcome, \hat{C} , with the critical level, L_c , as shown in the table. If we accept a false positive risk of α and a false negative risk of β , then the probability of a correct decision when $\hat{C} \leq L_c$ is $(1 - \alpha)$ and the probability of a correct decision when $\hat{C} > L_c$ is $(1 - \beta)$. As stated above, risk levels of 0.05 or 5 percent are often chosen for both; however, socio-economic considerations may mandate other choices. The two risk levels need not be the same.

To illustrate the ideas expressed above, algebraic relations can be derived for the critical level and detection limit for a well-defined measurement process. Let us assume that the standard deviation of the measurement process is σ , its bias or associated systematic error is zero, and the distribution of experimental outcomes can be approximated by a normal distribution. Then, for a false positive risk of α , the critical level, L_c , becomes

$$L_c = z_{1-\alpha} \sigma_0$$

where z corresponds to the appropriate z statistic of the normal distribution and σ_0 is the standard deviation of the distribution having an expected mean value of zero, i.e., a null signal. σ_0 is related to the blank standard deviation, σ_b , by the

expression, $\sigma_o = \sigma_B(1+1/n)^{1/2}$ for measurements in which the net signal is determined by subtracting the blank from the gross signal measured once, and n is the number of measurements of the blank. When the number of replicate measurements of the gross signal is increased to m , the number of replicate measurements of the blank is n and the net signal is determined by subtracting the mean of the blank signal from the mean of the gross signal, the critical level is

$$L_c = z_{1-\alpha}\sigma_B(1/m + 1/n)^{1/2}$$

The detection limit, L_D , for the case in which the risk of a false negative is taken to be the same as that of a false positive, and σ for the distribution with a true concentration of L_D is the same as for the null signal, is twice that of the critical level, i.e., $L_D = 2L_c$. Note that, while the critical level is determined by σ_o and α , the detection level depends upon σ_o and both α and β . These concepts are illustrated in figure 1.

The above formula for the critical level is modified when the standard deviation of the distribution of the null signal is not known but is estimated from sample data. For the case in which n measurements are made of the blank, m measurements are made of the sample and the net signal is obtained as above, the critical level becomes

$$L_c = ts(1/m + 1/n)^{1/2}$$

where t is the appropriate student's t test statistic and s is an estimate of the population standard deviation of the blank. The detection limit cannot be explicitly defined in terms of the critical level for this case. An upper bound for the detection limit can be calculated from the bound for σ , given s and the number of degrees of freedom [4].

For the case in which the bounds for bias are not known and cannot be assumed to be zero, only an upper bound for the detection limit can be determined. Since a defined decision level is needed for decision-making purposes, the usual practice is to specify L_c and place the uncertainty in α [4]. That is, L_c is set such that the upper limit for α is 0.05 (or other chosen risk level) based upon the estimated bound for bias and the standard deviation of the blank. Thus, for the case in which the true concentration of analyte is zero, the critical level is increased by the absolute uncertainty of the bias, Δ , making $\alpha \leq 0.05$ (or other chosen risk level). Similarly, when the true concentration is L_D , an experimental outcome could be decreased by Δ . This results in the detection level being increased by two times the bounds for bias with α and $\beta \leq 0.05$. These ideas are illustrated in figure 2.

To tie this back to the criterion for detection limits, a satisfactory screening test for lead in paint must have a detection limit no greater than the regulation limit, or 1 mg/cm^2 or less. Since the detection limit is a characteristic of the measurement process and is determined by precision and bounds for bias, a regulation limit dictates the precision and bounds for bias required of a measurement process. A decisions as to whether an analyte is present is based upon an experimental outcome. The procedure for reporting data is to compare an experimental outcome with the critical level; that is, to report the analyte detected when \hat{C} is greater than L_c and not detected when the outcome is less than L_c . It is important to note that the practice of reporting the analyte not detected when \hat{C} is less than L_p , rather than L_c , corresponds to a 50% chance for a false negative and a false positive risk 10 times smaller than the false negative risk when $z = 1.64$ [4].

The other part of the fifth criterion deals with the lower limit. Although the situation is made difficult, in practice, by the use of two different units for expressing lead concentration, the procedure for using hypothesis testing in conjunction with a non-zero lower limit has been developed by Currie [4, p.40]. He has introduced the concept of a discrimination limit to cover this special case of an acceptable non-zero lower limit. Essentially, the objective of the measurement process is to discriminate low analyte concentrations from a fixed non-zero reference level. For a non-zero lower limit, in this case 0.06%, the critical level is increased by the amount of the lower limit [4]. Let us call this level, L_c^{ll} . Thus, when an experimental outcome exceeds L_c^{ll} , the analyte concentration is said to be greater than the lower limit (0.06% in this case) with a false positive risk $< \alpha$. Conversely, an experimental outcome is said to be less than the detection limit when the outcome does not exceed L_c^{ll} , with a false negative risk $< \beta$. The detection limit has also been increased by an amount corresponding to the lower limit. The risk of reporting a concentration greater than 0.06% when the true concentration is equal to 0.06% is, of course, α . If the true concentration is less than 0.06% then $\alpha < 0.05$.

In the following section, potential screening tests are reviewed and assessed using all the criteria presented above.

3. SCREENING TESTS

From the literature, it was determined that there are two general types of screening tests, 1) chemical spot tests and 2) tests carried out with portable testing equipment, e.g., portable x-ray fluorescence spectrometry (XRF).

3.1 Spot Tests

Before discussing specific spot tests for lead, two issues associated with their use will be discussed. The first issue is that the unit of detection of spot tests is usually in parts by mass, (e.g., percent); the unit of the regulation is mg/cm^2 - one is, essentially, in terms of amount per unit volume, and the other in terms of amount per unit area. The second issue is that most data on spot tests assume a homogeneous, reasonably well-characterized material. For leaded-paint films in old housing, lead may be localized in bottom layers and the availability of lead ions for detection by a spot test may depend upon the paint formulation, age and condition of the film. By making assumptions regarding density and thickness of paint films, relationships can be developed between the two units of measurement. Thus, the first issue cited above can probably be addressed in a reasonably straight-forward manner. The second issue of having to be able to deal with a non-uniform distribution of lead and differing availability of lead ions in a paint film is much more difficult to address. These issues will now be discussed in more detail.

3.1.1 Unit of Measurement: Parts per million (ppm) or mg/cm^2

As stated above, the relationship between the two units for lead concentration depends on film density and thickness. Assuming the film to be uniform throughout its whole thickness, then the concentration in ppm lead can be obtained by multiplying the number of mg/cm^2 of lead by

$$10^4(1/\text{thickness in mm})(1/\text{film density in g/mL}).$$

Percent of lead can be obtained by dividing ppm lead by 10,000.

To illustrate possible relations between the two units, some examples based upon typical materials are considered. Densities can be estimated both for lead-based paint and typical currently-available products. From old Federal paint specifications (e.g., TT-W-251) and instructions for their use [8], we can estimate the following properties for a typical lead-based paint finish coat: nearly 100 percent solids and 20 lb/gal (2.4 kg/L). Hence, the dry-film density of such a paint film would be about 2.4 g/mL. The density of non-leaded paints is less, because the pigments are less dense. Although the densities of paints, both oil-based and latex, depend upon the pigment volume concentration [9], most are in the range of 1.5 to 2 g/mL.

The thickness of an existing paint film depends on many factors, including age of structure, and owner and occupant's maintenance practices. However, the assumption is often made for residential buildings that paint is applied every three to five years at a thickness of 50 to 75 micrometers (0.05 to 0.075 mm or 0.002 to

0.003 inch) per coat. If we assume that a structure is 40 years old, then an existing film thickness of 0.5 mm (20 mils) may be a reasonable estimate. Similar film thicknesses have been reported for residences [10]. Hence, using an average film density of 2 g/mL and a film thickness of 0.5 mm, 1 mg/cm² would correspond to about 10,000 ppm or 1 percent by mass lead, if the lead were distributed homogeneously throughout the paint film.

Based upon the ideas used to develop these relationships between the units, one can develop a graph showing the relationship between thickness, density and ppm lead for films having a lead concentration of 1 mg/cm², as shown in figure 3. If the problems associated with non-homogeneous distribution of lead throughout a film and differences in availability of lead ions can be overlooked, then it would be possible to develop detection limits for screening procedures based upon thickness and density of the film. For example, all points to the left of a density curve would correspond to films having less than 1 mg/cm² lead.

3.1.2 Distribution and Availability of Lead Ion

It is more difficult to determine boundaries for problems associated with non-homogeneous distribution of lead throughout a film and differences in availability of lead ions for chemical reactions in spot tests. No literature was found in which these problems were discussed specifically for paint films. It is expected that the detection limit for any spot test would be a function of paint composition, age and exposure history. Because of the many possibilities of film composition and condition, a conservative estimate of a detection limit that could apply to all films would undoubtedly be greater than for any specific film.

3.1.3 Sulfide Spot Tests for Lead

Two spot tests for lead in paint involving the coloring of white lead pigments with sulfide have been described. Lead sulfide is brown to black in color. Sayre reported on the use of sodium sulfide for detection of lead [11] and Vind, et al., [12] modified Sayre's test solution slightly (adding a thickener and a paint solvent to improve the availability of the lead ion) and provided a grey-level scale for percentage of lead present. Vind, et al., reported that, for freshly applied lead-containing paint films, concentrations of lead as low as 0.5 percent could be detected. Lead concentrations of 0.1 percent were not reliably detected. See figure 4 for an illustration of Vind et al.'s color scale for lead in freshly-applied paint films. Thioacetamide, in a water solution, has also been used to supply the sulfide ion for reaction with the lead.

In addition to the general issues discussed above for spot tests, limitations of sulfide spot tests include the instability of the

sulfide solution, possibility of interference by other metal ions, e.g., mercury, and inapplicability of this method for dark-colored films.

3.1.4 Other Spot Tests for Lead-Containing Solutions

Several spot tests have been developed to detect small quantities of lead ion in solution. Feigl [13] describes three such tests in detail. All of them require several steps. In one test, lead in the plus two oxidation state is oxidized to the plus four state by bromine, the excess hypobromite reduced by ammonia and, finally, benzidine solution is added. The benzidine is oxidized to benzidine blue. Ions which interfere that may be in paint include manganese and cobalt. In another test, a solution containing lead ions is treated with sodium rhodizonate. Violet or red lead precipitates are formed; the color depends on the pH of the solution. Although this test is reportedly sensitive enough to use with solid materials, barium, which may be in paints, interferes with this test. And, finally, in a dithizone test, a drop of carbon tetrachloride solution of dithizone is added to the test solution and the mixture is shaken vigorously. The green dithizone solution turns brick red. However, several heavy metal ions such as zinc and mercury interfere with the test for lead. The procedure recommended to mask the presence of the other ions, thereby making the test specific for lead (addition of considerable amounts of potassium cyanide), is unacceptable for a screening test for lead in paint.

Two other tests have been used to detect lead in solutions made from paint. In both procedures, the paint was ashed, either wet or dry, the pigment dissolved in concentrated nitric acid, the pH was adjusted as appropriate and the test carried out [14]. In one, the potassium-copper-lead triple nitrite test, black rectangles of $K_2PbCu(NO_2)_6$ form when a drop of solution of $Cu(NO_3)_2$, mixed with the test solution, is dried and then wetted with a solution of KNO_2 in acetate buffer [15]. Crystal formation is observed under a microscope. In the other test, a potassium iodide crystal is added to the test solution, which has been diluted 1-1 with 6 M acetic acid. Yellow PbI_2 crystals are formed [16].

Several of these tests can be used to detect small quantities of lead in solution. Reported limits of detection are in the range of a microgram for small amounts of solution. However, interference by other ions that could be expected to be present in paint is possible for all of the tests. In addition, many of the chemicals would present potential hazards to the user, including the use of concentrated nitric acid for wet ashing of dry paint samples. Wet ashing would be a difficult field operation.

3.2 Portable Instruments

The only type of portable instrument for detecting lead in paint films nondestructively found referenced in the literature is an x-ray fluorescence (XRF) device. Unlike most of the spot tests, procedures for their use [17] and estimates of their precision (i.e., standard deviation of experimental outcomes) are available. The standard deviation of experimental outcomes of a blank, σ_B , of two commercial instruments now available is reported to be about 0.3 mg/cm^2 . An estimate of the bound for bias of $|0.5| \text{ mg/cm}^2$ was reported for an early model of one instrument [18] in going from substrate to substrate (the so-called substrate effect). To reduce the bias, manufacturers of these instruments recommend removing paint from a substrate to obtain a blank reading when measuring lead concentrations near 1 mg/cm^2 . However, for a screening test, this probably would not be acceptable since it would require removal of about 70 cm^2 of paint and will not be a part of the screening measurement method described below.

The following procedure will be assumed for a screening test using a portable XRF instrument: 1) follow the manufacturer's recommendations except for the number of replicate measurements to make at any one location and for the removal of paint, 2) make only one measurement in any location, and 3) do not remove paint for a blank measurement. It has been assumed that the measured result is from a normal distribution of experimental outcomes, n measurements have been made of the appropriate blank and that σ is constant for lead concentrations less than 1 mg/cm^2 . Thus, using one of the manufacturer's specifications for σ_B of 0.3 mg/cm^2 , and an estimate of the bounds for bias of $|0.5| \text{ mg/cm}^2$, we can determine the detection limit of this measurement procedure. For maximum risk levels of 5 percent, the critical level, L_c , is

$$L_c = 1.64\sigma_B(1 + 1/n)^{1/2} + 0.5 \text{ mg/cm}^2$$

or about 1 mg/cm^2 , and the detection limit, L_D , is twice the critical level or about 2 mg/cm^2 . When more than one measurement is made in any location and the net signal is obtained by subtracting the mean of the blank signals from the mean of the gross, the first term in the above expression for L_c becomes $1.64\sigma_B(1/n+1/m)^{1/2}$ where m is the number of measurements made of the unknown film. However, the bounds for bias is not a function of the number of measurements made in a location and, thus, is not reduced by making multiple measurements.

It must be kept in mind that these values for L_c and L_D are only applicable when the assumptions given above are true, that is, $\sigma_B = 0.3 \text{ mg/cm}^2$, bounds for bias = $|0.5| \text{ mg/cm}^2$, n measurements are made of the blank, one measurement is made in any sample location, $\alpha, \beta \leq 0.05$, and the distribution of experimental

outcomes is normal. These assumptions are based upon reported specifications and the literature. Further laboratory work is needed to determine whether they are valid. However, it is concluded that use of a portable XRF device having precision and bounds for bias equal or greater than the assumed values in a procedure in which only one measurement is made at any location and paint is not removed would not be an acceptable screening test. Making several measurements in a location and removing paint would take considerable time, making it unacceptable as a screening test.

4. CONCLUSIONS

1) Based upon the literature, no screening methods were found for detecting lead in paint that meet all the criteria listed in Section 2.

2) Although some of the spot tests were reported to have low detection limits (where detection limit was defined in the appropriate references in several different ways), these tests were designed for lead ions in solution. The process for getting lead ions from a dried paint film into solution involves the use of concentrated acids and would not be readily accomplished in the field.

3) The spot test using sodium sulfide and scratching the paint film is capable of detecting lead in fresh paint films when the concentration is greater than 0.5 percent. The test is limited to white or light colored films, and it may not be satisfactory when a leaded paint layer is at the bottom of many layers. However, it may be possible to develop guidelines as to when this test could be used satisfactorily as a screening test.

4) The XRF instruments, using the manufacturers' specifications for precision and reported estimates of bias, are not acceptable for screening with only one measurement per location and without paint removal to correct for substrate effect for risk levels of 5 percent. The detection limit for this measurement procedure is not less than the regulation limit, 1 mg/cm^2 . If the bounds for bias can be sufficiently reduced by removing the paint, and more than one measurement is made in any one location, then the measurement process could be used to detect lead concentrations less than 1 mg/cm^2 . However, it may be too slow to be acceptable as a screening test.

5. ACKNOWLEDGEMENT

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Table 1. Truth Table

Actual (True) Concentration, C		
Decision	Blank (C = 0)	Detection Limit (C = L _b)
nd ($\hat{C} \leq L_c$)	1 - α	β
d ($\hat{C} > L_c$)	α	1 - β

Body of table gives decision probabilities, the critical level, L_c, is characterized by the false positive risk, α ; L_b is characterized by L_c and the false negative risk, β . [nd is not detected, d is detected and \hat{C} is an experimental outcome.]

¹ From Currie, L.A., "Detection and Quantitation in X-ray Fluorescence Spectrometry," in X-Ray Fluorescence Analysis of Environmental Samples, T. Dzubay, ed., Ann Arbor Science Publishers, Inc., (1977) p. 289. Minor changes in Currie's notation have been made to make the notation in the table consistent with that used in this report.

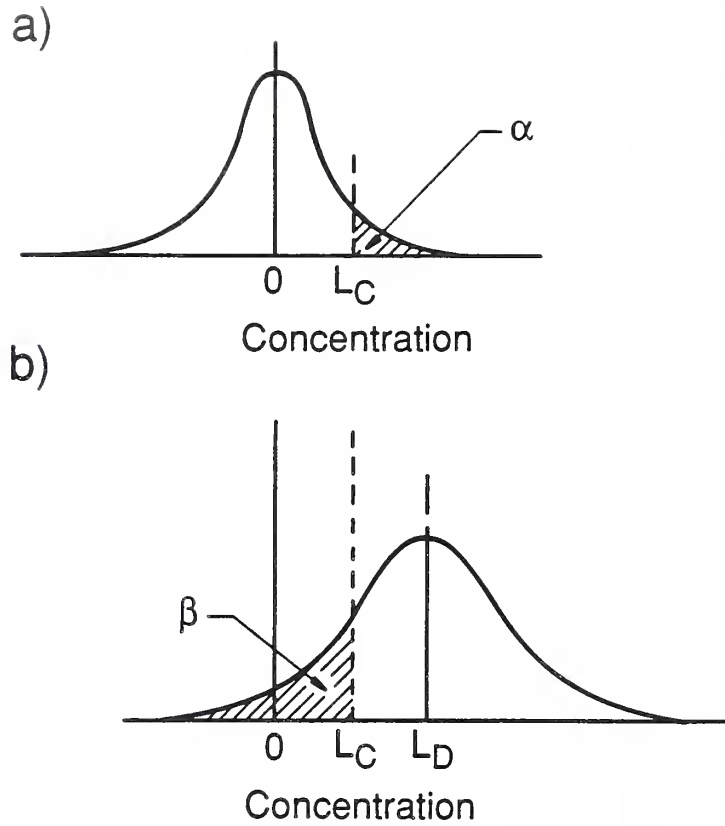


Figure 1. The risk of false decisions. The illustration shows the relationship between the critical level, L_C , detection limit, L_D , and the choices of risks for false positive decisions, α , and for false negative decisions, β , for the case in which there is no bias. Curve "a" represents the probability density function (pdf) of experimental outcomes when the true concentration is zero (the null signal), while curve "b" represents the pdf of outcomes when the true concentration is L_D .

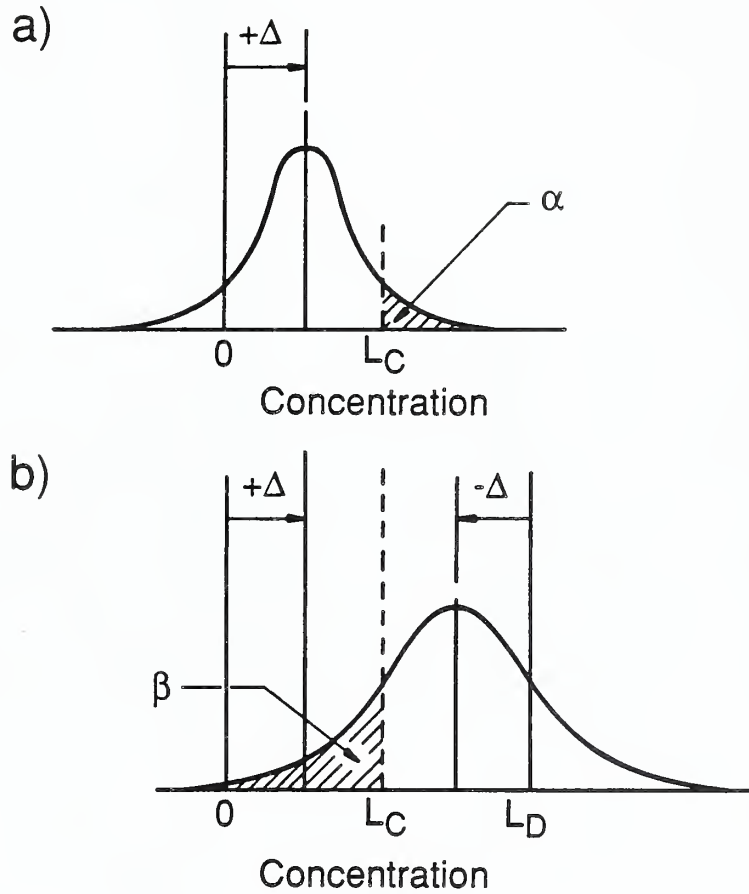


Figure 2. Effect of bounds for bias Δ , on detection limits. If the uncertainty in the bounds for bias is placed in α and β (e.g., α and $\beta \leq 0.05$), L_c and L_D can be specified.

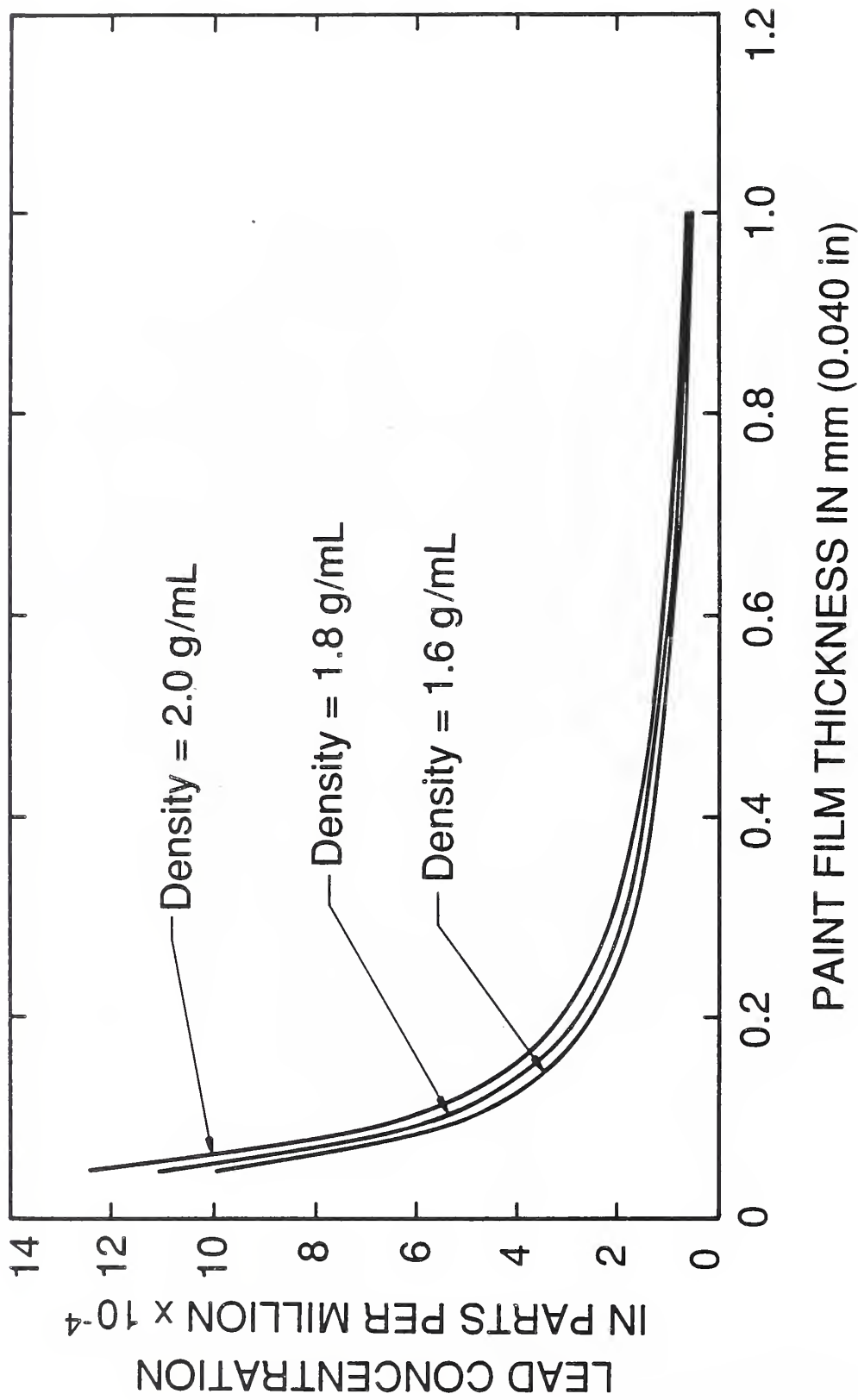


Figure 3. Relationship between lead concentration expressed in parts per million and paint film thickness for a lead film concentration of 1 mg/cm^2 for three assumed paint film densities. Note that the region to the left of the curves corresponds to lead concentrations less than 1 mg/cm^2 .

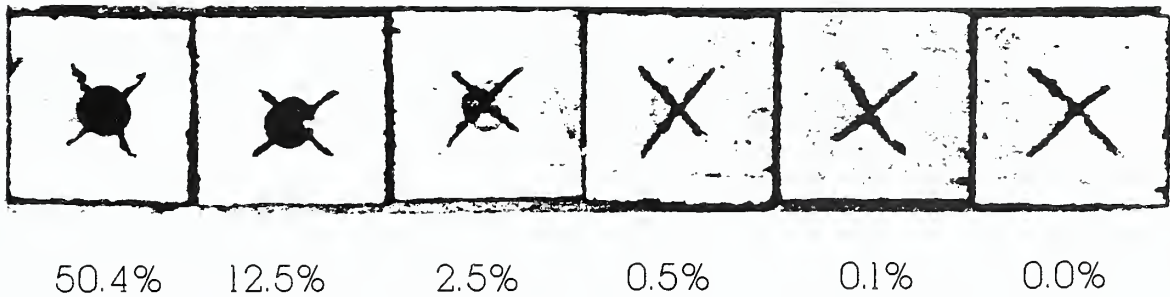


Figure 4. Grey-level scale for lead in paint for a sodium sulfide test. (from Vind, H.P., Mathews, C.W., Alumbaugh, R.L., and Hamilton, G.W., "Implementation of the lead-based paint poisoning prevention act at Navy activities," TN No. N-1533, Naval Civil Engineering Laboratory, Port Hueneme, CA 93043, 1978)

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11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

Recent legislation required the U.S. Department of Housing and Urban Development (HUD) to establish procedures to eliminate, as far as practicable, the hazards of lead-based paint poisoning in any existing HUD-controlled housing. Thus, HUD promulgated a regulation which requires abatement to eliminate lead-based paint poisoning hazards in housing in which the concentration of lead in paint equals or exceeds 1 mg/cm^2 . The legislation also required HUD to review test methods for measuring lead in paint. The National Institute of Standards and Technology (NIST) was tasked with this requirement. The first phase of the task, the subject of this report, was to review the literature for screening methods for measuring or detecting lead in paint. To facilitate the review, criteria were developed for potential test methods. A test method must be: 1) capable of detecting lead concentrations of 1 mg/cm^2 but not concentrations less than 0.06%, 2) non-hazardous, 3) suitable for use as a nondestructive field method 4) suitable for use by non-technical personnel, and 5) sufficiently reliable and precise. No method reported in the reviewed literature met all of these requirements.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

Key words: analysis; detection; detection limit; discrimination limit; housing; lead; literature review; measurement; paint; screening; x-ray fluorescence spectrometry

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