



3 µg/L Quick Detection of Lead in Water using new Photometric Method

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Wednesday, November 10th

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Lead In History

- It's been used by civilization from ancient times
- Georgius Agricola described Lead in the 16th century as a “pestilential and noxious metal
- Saturnism – the Greek name for the planet Saturn and the ancient symbol for Lead
- Saturnism disease symptoms included colic, delirium, and paralysis
- Plumb is a Latin word referring to Lead



Lead Regulations

- Government and industry accepted the dangers of Lead in the early 1900's
- USA Regulated lead use in gasoline (1975), paint (1978), and plumbing (1986)
- Average American blood Lead level has declined over the last 30 years
- Current research has not been able to identify safe minimum Lead exposure thresholds.



Lead Exposure Affects Humans

- Lowers I.Q.
- Elevates blood pressure
- Alters kidney function
- Measurable cognitive decline
- Increases violent behavior
- Death from high exposure



Lead Facts

- Lead is the element number 82 with an atomic mass of 207.19
- Lead is a heavy element with a density of 11.4 grams per cm³
- Lead is soft, bendable, and easily cut with a knife
- Lead is still present in most metal plumbing (USA allows 8% Lead content in pipes)
- Most metal items we use each day may contain some Lead



The Chemistry of Lead

- Oxidation states of Lead are 0, +2, and +4
- Organic and inorganic salt compounds of Lead are most frequently state +2 valence
- Inorganic salt compounds are only slightly soluble in water at or below 0.1 gram per Liter
- Below pH 6, Pb^{2+} is the major Lead-containing species
- At higher pH values the polymeric hydroxocomplexes predominate

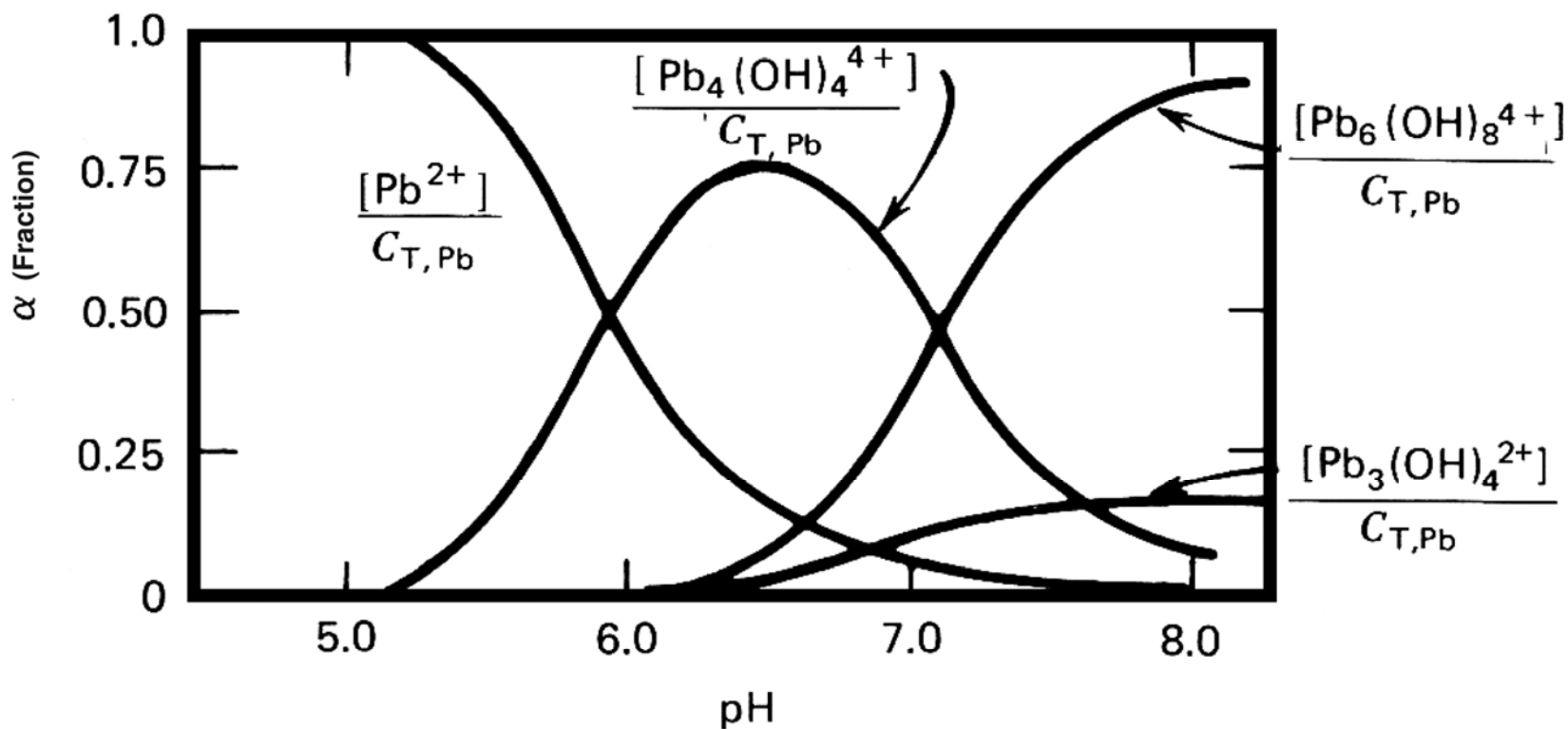


Fig. 1. Species distribution of lead in an aqueous Pb(II) solution $C_{T,Pb}$ 0.04 M.
by Olin A. Svensk Kim Tidskr., 73:482(1961).



Maximum Containment Level

- U.S.EPA maximum containment level allowed in drinking water is 15 PPB
- World Health Organization limit is 10µg/L
- Canada has a limit of 20µg/L
- Plumbing and fixtures must contain less than 8% Lead
- California regulation limits for faucet fixtures is very low for extraction “California Prop 65 and NSF.ANSI 61 lead-free”



Testing for Lead

- Most reliable method for testing is laboratory analysis by instrumentation but cost per test very expensive (over £20) and there is a delay in results
- Hazardous reagents in field kits and complicated test procedure may include extraction step
- Few field kits meet the detection requirements of 10 or 15 µg/L

LEADQuick™ Lead Test

- Uses eXact® LeadQuick™ photometer
- Test uses four reagents
- Only chemical hazard is a few drops of 25% Nitric Acid
- Easy on-site procedure
- Affordable
- Quick on-site results



LEADQuick™ Photometer Specifications

Menu	Tests for	Range	Resolution	+/- Accuracy	Limit*
PA1	Diluted Homogenized Paint Lead	.000 to 1.99	.001	.003 or 6%	—
PB2	Lead in Water (auto-zero)	1 - 500 µg/L	1 µg/L	3 µg/L or 6%	3 µg/L
HG3	Mercury in Water (auto-zero)	10 - 600 µg/L	1 µg/L	6 µg/L or 6%	10 µg/L
CD4	Cadmium in Water (auto-zero)	0.01 - 0.80 mg/L	.01 mg/L	.06 mg/L or 6%	.02 mg/L
AB5	Future or Custom Tests (Absorbance)	.000 - 1.99 abs	.001 abs	.002 or 2% abs	—
PB6	Lead in Water	1 - 500 µg/L	1 µg/L	3 µg/L or 6%	3 µg/L
PB2	Modified Test for Lead in Soil	18 - 3000 mg/kg 200 - 300,000	1 mg/kg 200	+ - 25% + - 40%	18 mg/kg 200 mg/kg
PB2	Lead extracted from Ceramic	1 - 500 µg/L	1 µg/L	3 µg/L or 6%	3 µg/L

*Limit is defined as the minimum reliable detection for that test. Any value below the limit should be considered inconclusive for that metal's presence.

LEADQuick™ Procedure

Step 1

Collect 50mL water sample in 50mL conical tube. Add three (3) drops of ACID-1 Reagent (25% Nitric Acid). Mix and allow to sit for about five (5) minutes. After this time, this TEST SAMPLE is ready for testing.



LEADQuick™ Procedure

Step 2

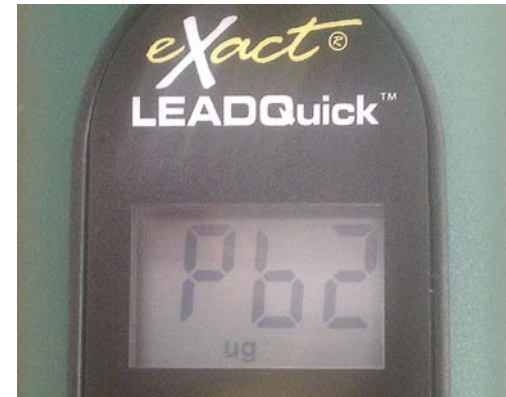
Press the ZERO/ON button to power the LEADQuick™ meter on; the display will show all annunciators, then the current MENU selection, followed by the last test reading.



LEADQuick™ Procedure

Step 3

Press and re-press the MENU button until the display shows the parameter PB2.



LEADQuick™ Procedure

Step 4

Using the TEST SAMPLE fill and empty the CELL four (4) times (this rinses cell). Finally, fill cell to capacity (4mL) with the TEST SAMPLE. Tilt meter forward to allow excess sample to flow out in order to make room for the Pb-2 Reagent addition in Step 5.



LEADQuick™ Procedure

Step 5

Add five (5) drops of eXact® Reagent Pb-2, (Alkali buffer pH 10.5). This adjusts solution pH between 9.0 to 9.9.





LEADQuick™ Procedure

Step 6

Dip the eXact® Strip Pb-3, (indicator strip) into the CELL and immediately press READ. This starts the 20 SECOND countdown timer. During this time move the strip in a gentle back and forth motion. Remove and discard the strip after “1” on the display disappears. The display will flash (- - -) and begin immediately counting up from 1 to 60. After the 60 seconds, the meter automatically reads the color developed and zeros the color (the cursor will move across the display followed by 0 µg [µg/L]).

LEADQuick™ Procedure

Step 6 dipping the indicator strip





LEADQuick™ Procedure

Step 7

Dip the eXact® Strip Pb-4, (EDTA Strip) into the CELL and immediately press READ. This starts the *20 SECOND* countdown timer. During this time move the strip in a gentle back and forth motion. Remove and discard the strip after “1” on the display disappears. The display will flash (- - -) and begin immediately counting up from 1 to 60. After the 60 seconds, the cursor will move across the display, informing you that it is about to measure the sample as μg ($\mu\text{g}/\text{L}$ of lead). Record result displayed (this result is automatically stored in PB2). After testing is complete discard sample and rinse cell at least three times with clean water.



Facts About LeadQuick™

- LEADQuick™ procedure uses TMPYP indicator and is U.S. Patented
- On-site results with optimum accuracy, best sensitivity and minimum manipulation
- The Lead Test Interference chart details what concentration of ions this test will tolerate



Interference Chart

Lead Test (PB2 & PB6 MENU) Interferences (Similar interferences can be expected for Mercury and Cadmium Tests.)			
Ion	Interference Level	Ion	Interference Level
Aluminum, Al ³⁺	2 mg/L	Magnesium, Mg ²⁺	200 mg/L
Barium, Ba ²⁺	3 mg/L	Manganese, Mn ²⁺	0.5 mg/L
Bromide, Br ⁻	20 mg/L	Mercury, Hg ²⁺	0.01 mg/L
Cadmium, Cd ²⁺	0.07 mg/L	Nickel, Ni ²⁺	1 mg/L
Calcium, Ca ²⁺	500 mg/L	Nitrogen, Ammonium, NH ₄ ⁺	40 mg/L
Chloride, Cl ⁻	150 mg/L	Nitrogen, Nitrate, NO ₃ ⁻	20 mg/L
Chromium, Cr ³⁺	0.1 mg/L	Nitrogen, Nitrite, NO ₂ ⁻	300mg/L
Cobalt, Co ²⁺	1 mg/L	Phosphate, PO ₄ ³⁻	100 mg/L
Copper, Cu ²⁺	5 mg/L	Sulfate, SO ₄ ²⁻	200 mg/L
Fluoride, F ⁻	40 mg/L	Tin, Sn ²⁺	0.2 mg/L
Iron, Fe ²⁺	0.2 mg/L	Zinc, Zn ²⁺	2 mg/L
Iron, Fe ³⁺	0.1 mg/L		Rev. 07/03/07



Interferences

- All interfering ions, except for Mercury and Cadmium, inhibit the TMPYP-Lead complex formation
- Mercury and Cadmium give similar color reaction with TMPYP
- Since Mercury is rarely found in tap water its interference can be typically ignored
- Cadmium performs best with TMPYP in HCl acid
- Hardness ions such as Calcium and Magnesium are tolerated with reasonable range



Interferences In drinking water

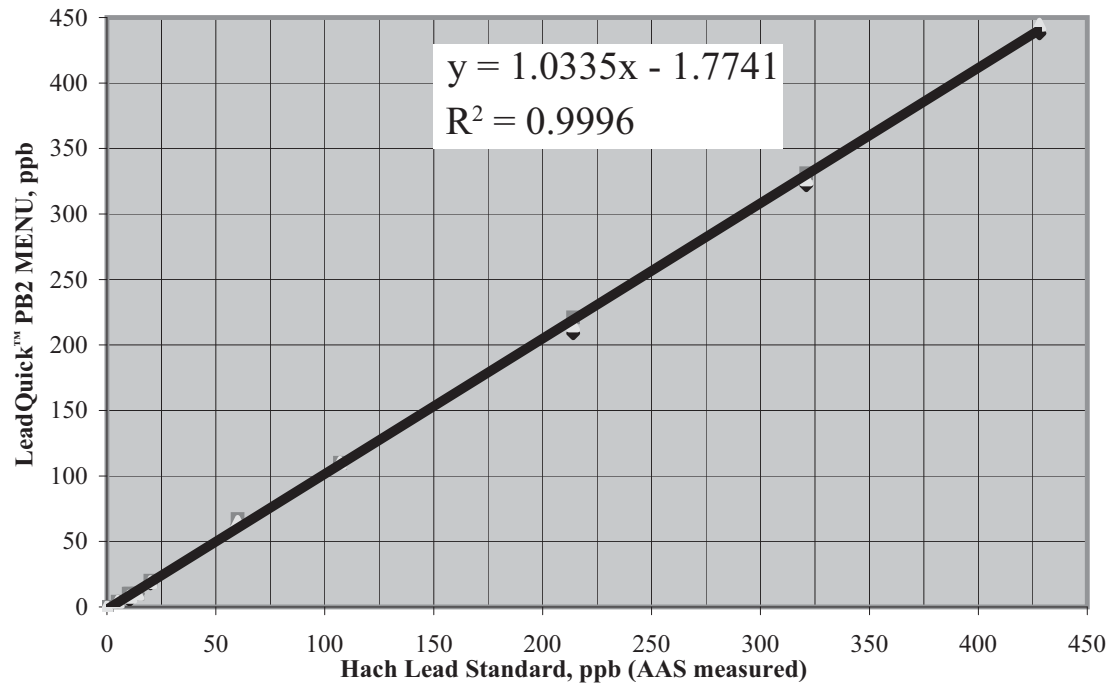
- Most potable, municipally treated water samples experience no interferences
- When using the LEADQuick™ with potable water samples use the “Standard Additions” or “spike” method to determine interferences
- For best results test on unpreserved, freshly drawn water samples

HACH® LeadTrak® System Comparison with eXact® LEADQuick™ System

Comparison	LEADQuick™ system	LeadTrak™ system
Detection range	3 to 500 $\mu\text{g/L}$	5 to 150 $\mu\text{g/L}$
Minimum detection	3 $\mu\text{g/L}$	5 $\mu\text{g/L}$
Number of kit components	4 reagents	6 reagents plus 1 Column
Cost of starter kit	\$399.99	\$525.00
Cost of replacement reagents	\$89.99 per 50 (\$1.80 per test)	\$179.00 per 20 (\$8.95 per test)
Time to run one test	Less than 10 minutes	Over 10 minutes
Number of steps to run test	7	22 (in colorimeter II 16 steps)
Waterproof	Yes	Yes (not battery compartment)
Handling of glass cells	No	Yes
Meter timer	Yes	No
Memory	Yes	Yes
Tests Lead in Water	Yes	Yes
Tests Lead in Soil	Yes	No
Tests Lead in Paint	Yes	No
Tests Mercury (Hg^{+2}) in Water	Yes	No
Tests Cadmium (Cd^{+2}) in Water	Yes	No

Detection profile for LEADQuick™ with HACH® Lead Standard

Detection of Lead in Water





Spiked Recovery Test Method

Or Standard Additions Method

- Add a known amount or concentration of Lead standard solution to the questionable sample.
- Add a Standard Solution amount that is at least equivalent to three times the minimum detectable limit of the test (10 ppb).
- This is the “spiked sample”



Spiked Recovery Test Method

Or Standard Additions Method

- Test the spiked and un-spiked (original) sample using the same reagents, instrument and technique or test method .
- The “spiked sample” should show an increase equal to the amount of standard added.
- The value obtained is called the Recovery. Ideally the % recovery is 100%.



Spiked Recovery Test Method

Or Standard Additions Method

- Results are acceptable if the % recovery is +/- 10%.
- If the recovery is not in the acceptable range there may be interferences .
- Dilute the sample with Lead free water past the point of interference, if the sample is within the detection limit of the test kit.

Spiked Recovery Test Method

Or Standard Additions Method

The percent recovery formula is as follows:

$$\% \text{ Recovery} = \frac{100(\text{Cs}-\text{Cu})}{\text{K}}$$

Where:

Cs = concentration found through testing of the spiked sample

Cu = concentration found through testing of the unspiked sample

(NOTE: result should be adjusted for the dilution of the spike volume if volume change is more than 5%)

K = concentration of the spike added to the sample



Lead Recovery In Samples

Water Origin	Water Type	Water Sample	Spiked		Spiked	
		µg/L	20ppb (ug/L)	% Recovery	50ppb (ug/L)	% Recovery
Vienna, Austria	M	0	21	105	52	104
repeated		0	19	95	51	102
Munich, Germany	M	0	21	105	54	108
repeated		0	19	95	46	92
Kusnacht, Switzerland	M	0	20	100	51	102
repeated		0	19	95	54	108
Paris, France	M	0	19	95	50	100
repeated		0	20	100	45	90
Washington, DC	M	0	23	119	52	104
repeated		0	20	100	49	98
Philadelphia, PA	M	0	17	85	45	90
repeated		0	23	119	43	86
Phoenix, AZ	M	0	20	100	47	94
repeated		0	21	105	47	94
Edgewater, MD	W	0	22	110	50	100
repeated		0	16	80	46	92
Highland, NC	W	0	15	75	36	72
repeated		0	15	75	37	74
Rockwell, NC	W	0	22	110	51	102
repeated		0	23	119	50	100
Las Vegas, NV	M	0	19	95	52	104
repeated		0	17	85	49	98
Chicago, IL	M	0	21	105	51	102
repeated		0	16	80	52	104
Rock Hill, SC	W	0	18	90	47	94
repeated		0	17	85	46	92
Melbourne, Australia	M	0	20	100	47	94
repeated		0	19	95	45	90
Rock Hill, SC (exposed to lead)	M	5	25	100	56	102
repeated		5	26	104	52	95
Weaverville, NC	M	0	16	80	52	104
repeated		0	20	100	46	92
Anaheim, CA	M	0	19	95	53	106
repeated		0	21	105	47	94
Seattle, WA	M	0	16	80	45	90
repeated		0	16	80	42	84
Kilowna, BC, Canada	M	0	19	95	51	102
repeated		0	21	105	53	106

*M = Municipal, W = Well

Lead in Tap Water

- I've measured Lead levels throughout the world for the last 24 months.
- Recent publication by Triantafyllidou *et al* ("Lead Particles in potable water," Journal AWWA, June 2007) prompted me to test aerator filters and nozzles for lead particles and presence of lead in the aerator/nozzle fixture.



Lead in Tap Water

World-wide water samples

Sink and Tap Location	Extracted Lead in Water ug/L	Extracted Lead in Particles ug/L	Extracted Lead in Nozzle ug/L
Business Men's Room	< 3	190	135
Business Women's Room	< 3	19	90
Business Lunch Room	< 3	52	195
My Home Guest Bathroom	< 3	15	80
My Home Bathroom	< 3	11	115
Daughter's Home Bathroom	< 3	< 3	230
Associate's Home Bathroom	59	< 3*	430
Banff, Canada Hotel Bathroom	< 3	25	NT
Edmonton, Canada Hotel Bathroom	< 3	63	NT
Barcelona, Spain #1Hotel Bathroom	<3	12	163
Barcelona, Spain #2Hotel Bathroom	<3	104	28
Nozzle/Aerator bought in USA	NA	<3	125
Nozzle/Aerator bought in Spain	NA	<3	420
Deionised water (Blank control)	< 3	NA	NA
Lead Free Fixture (nozzle)	NA	NA	< 3

*interference suspected since precipitate appeared during testing; but test reported below detection level of Lead (< 3)

Table 2. Samples tested by Ivars Jaunakais over the last few months and his results.



Lead In Tap Water

- 7 of 9 sediment samples contained lead.
- (POU) point-of-use filtering devices are important.
- Brand new nozzles were positive for lead.
- Stainless steel filter screens tested negative.



Lead In Tap Water - Conclusions

- Exposure to lead may be more common than we think.
- Shocking that store-bought tap nozzles still contain lead.
- The tap that – “meets California prop 65 and NSF.ANSI 61 lead-free standards” was free of lead.

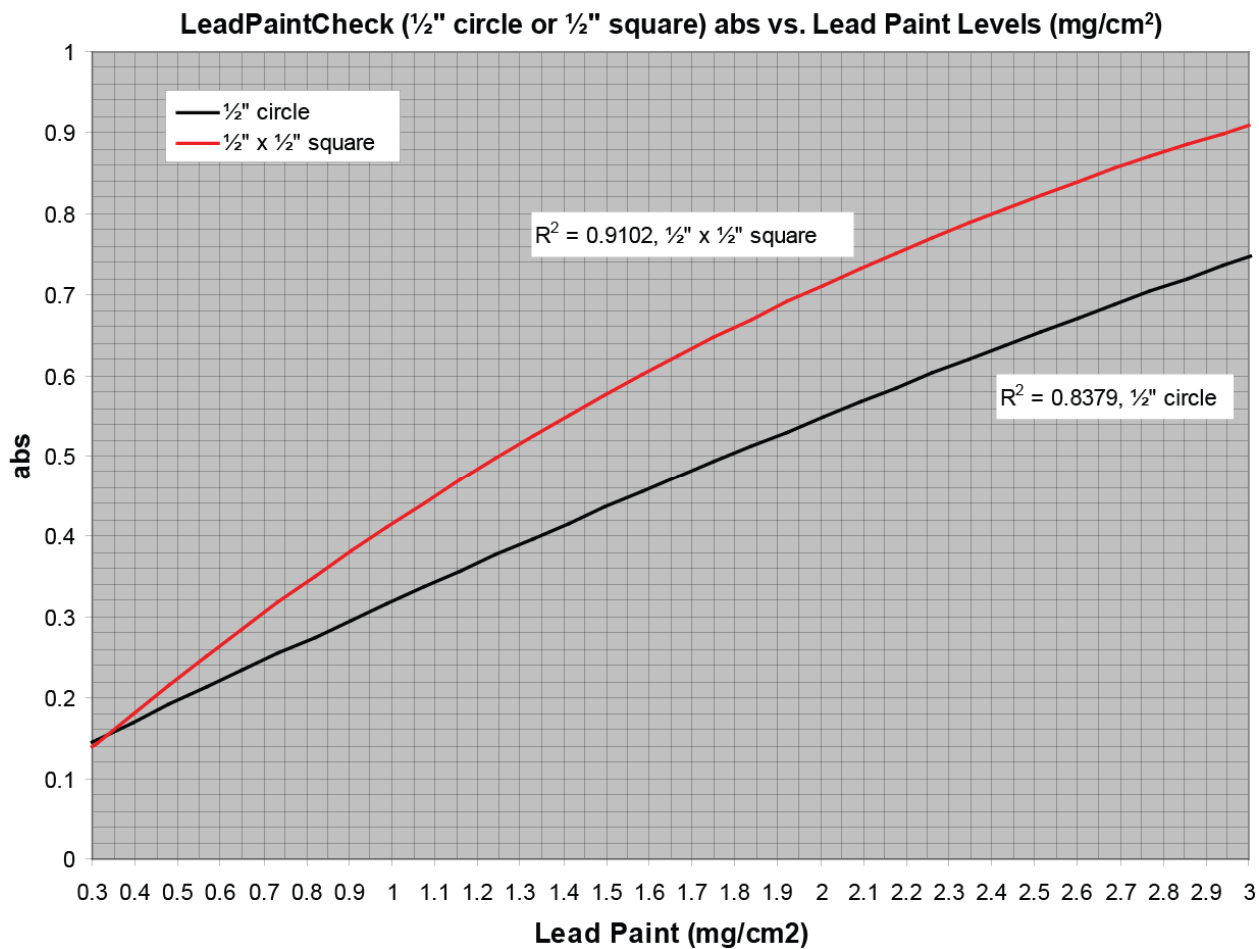
Lead Paint Check II



www.leadpaintcheck.com



Lead Paint Check II Profile





Modified LEADQuick method for lead in soil

- 0.1 mL volume (0.14 grams) of soil sample is extracted with 20 drops of 5% Nitric Acid in 50 mL conical tube.
- After 1 minute test can be performed on the soil extracted sample with modification supplied with meter.
- Detects 18 – 300,000 mg lead /Kg soil
- US regulation allows maximum 1,000 mg lead /Kg soil

Lead Quick Test Kit Promises

- Quick results.
- On-Site testing convenience.
- Economical.
- Easy test procedure.

