Simple Quantitative On-Site Lead Testing

By Ivars Jaunakais

WQA Aquatech show

Friday, March 28th / 8 AM

www.sensafe.com / ivars@sensafe.com

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 1900's
- Regulation 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 minimum Lead thresholds.

Lead Levels Affects Humans

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

Lead F.Y.I.

- 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 cm^2
- Lead is soft, bendable, and easily cut with a knife
- Lead is present in most metal plumbing
- Most metal items we use each day may contain Lead

The Chemistry of Lead

- Oxidation states of Lead are 0, +2, and +4
- Organic and inorganic salt compounds of Lead are state +2
- 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

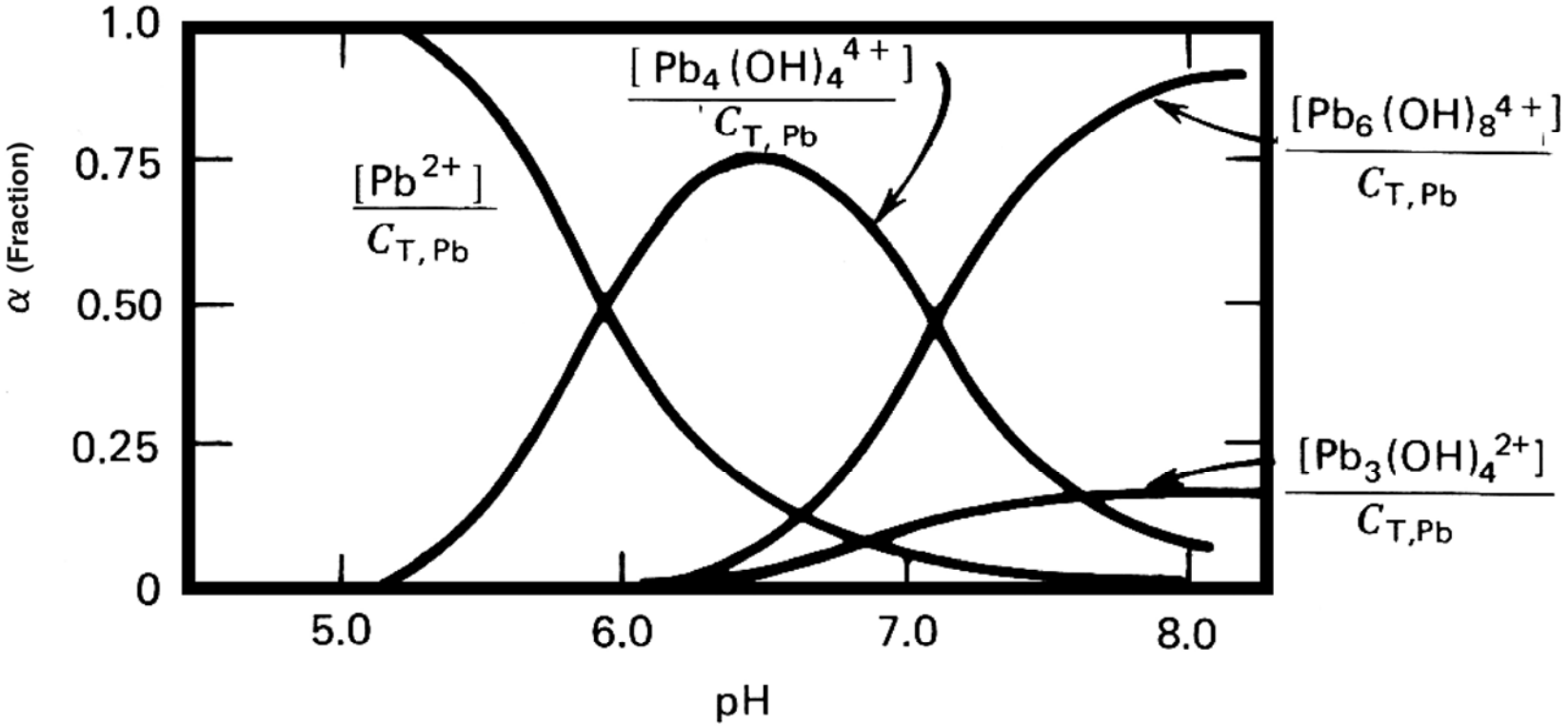


Fig. 1. Species distribution of lead in an aqueous Pb(II) solution $C_{T,PB}$ 0.04 M. by Olin A. Svensk Kim Tidskr., 73:482(1961).

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 below 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 must allow for a delay in results
- Hazardous reagents in field kits and complicated test procedure may include extraction step
- Field kits don't meet EPA detection requirement of 15 µg/L

LEADQuick™ Lead Test

- Uses a Hach® LeadTrak Pocket Colorimeter II
- Four minute test uses four reagents
- Minimum chemical hazard (0.5m Nitric Acid)
- Easy on-site procedure
- Affordable ($2 per test)

LEADQuick™ Chemistry

Step 1

Collect a 10 mL water sample in clean sample cell.

LEADQuick™ Chemistry

Step 2

Lead solubilized to Pb^{2+} by the addition of five drops of Pb-1 Acid reagent, followed by a swirl to mix sample, and a two minute wait.

LEADQuick™ Chemistry

Step 3

While waiting, wipe the cell and place into the Hach LeadTrak colorimeter II. Turn meter on and select “abs” mode.

LEADQuick™ Chemistry

Step 4

Ten (10) drops of Pb-2 Buffer is added to make the solution alkali (about pH 9).

LEADQuick™ Chemistry

Step 5

Dip an eXact® Strip Pb-3 for 20 seconds with gentle back and forth motion which adds the porphyrin indicator and mixes the solution

LEADQuick™ Chemistry

Step 6

Wait one minute to allow the porphyrin and Lead hydroxocomplex, $Pb_6(OH)_8^{4+}$ to form a colorimetric complex in the cell; At the end of the one minute the meter is zeroed in the “abs” mode

LEADQuick™ Chemistry

Step 7

eXact® Strip Pb-4 is dipped into the cell sample for twenty seconds with gentle motion. This releases EDTA which breaks up the colorimetric porphyrin-Lead complex.

LEADQuick™ Chemistry

Step 8

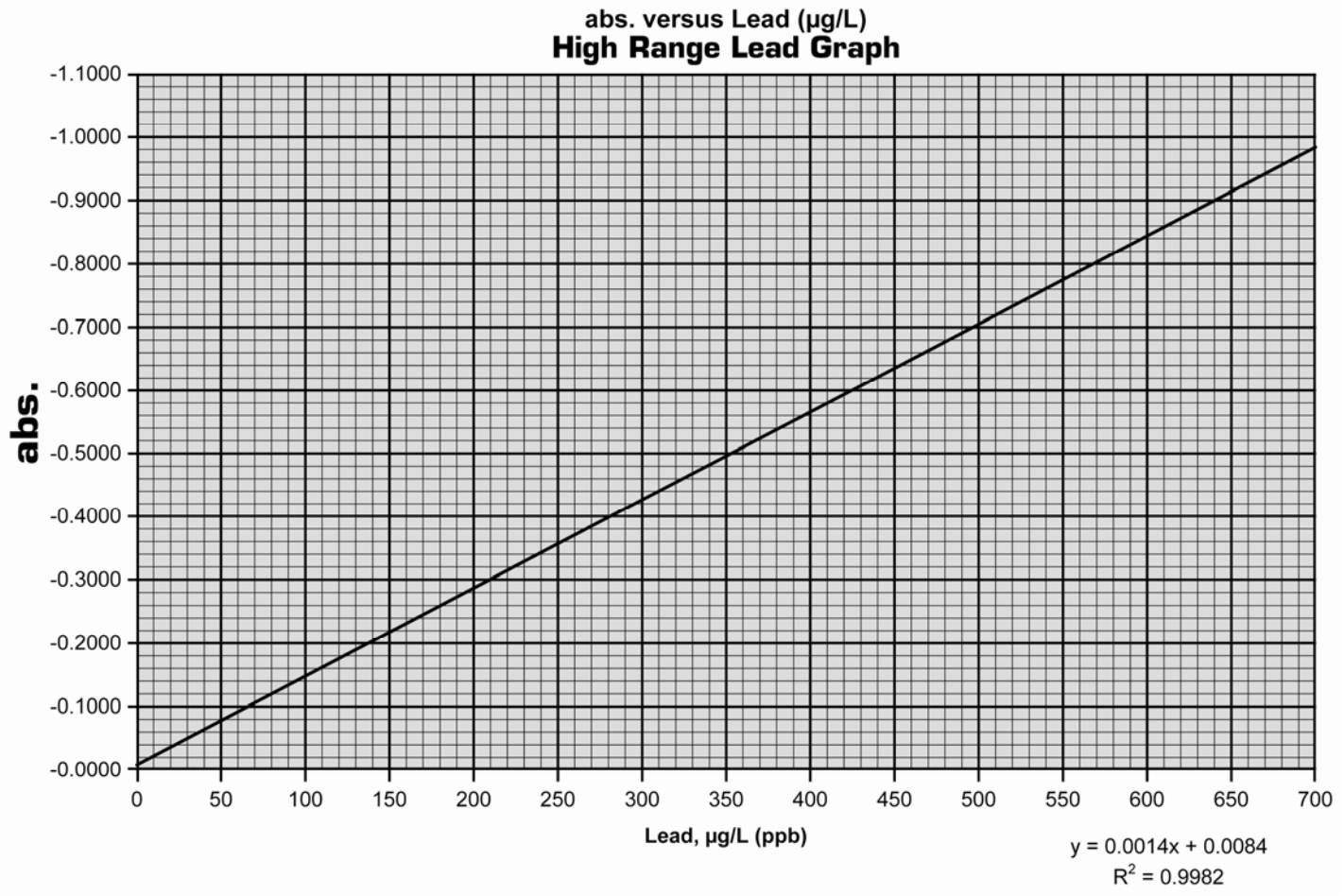
Press the read key and record the “abs” value. The value will be negative if Lead is present. The larger the negative reading the higher the Lead concentration.

Determine the Lead concentration from the “abs” value chart.

Lead (Pb^{2+}) "abs" vs µg/L or ppb							
"abs"	µg/L	"abs"	µg/L	"abs"	µg/L	"abs"	µg/L
-.001	<3	-.031	22	-.061	40	-.091	56
-.002	<3	-.032	22	-.062	40	-.092	57
-.003	<3	-.033	23	-.063	41	-.093	57
-.004	<3	-.034	23	-.064	41	-.094	58
-.005	3	-.035	24	-.065	42	-.095	59
-.006	4	-.036	25	-.066	42	-.096	60
-.007	5	-.037	25	-.067	43	-.097	60
-.008	5	-.038	26	-.068	43	-.098	61
-.009	6	-.039	27	-.069	44	-.099	62
-.010	7	-.040	27	-.070	45	-.100	62
-.011	8	-.041	28	-.071	45	-.101	63
-.012	9	-.042	28	-.072	46	-.102	63
-.013	10	-.043	29	-.073	46	-.103	64
-.014	11	-.044	30	-.074	47	-.104	65
-.015	12	-.045	30	-.075	47	-.105	65
-.016	13	-.046	31	-.076	48	-.106	66
-.017	14	-.047	31	-.077	48	-.107	67
-.018	15	-.048	32	-.078	49	-.108	67
-.019	15	-.049	33	-.079	49	-.109	68
-.020	16	-.050	33	-.080	50	-.110	68
-.021	16	-.051	34	-.081	50	-.111	69
-.022	17	-.052	34	-.082	51	-.112	69
-.023	17	-.053	35	-.083	51	-.113	70
-.024	18	-.054	36	-.084	52	-.114	70
-.025	18	-.055	37	-.085	53	-.115	71
-.026	19	-.056	37	-.086	53	-.116	72
-.027	20	-.057	38	-.087	54	-.117	73
-.028	20	-.058	38	-.088	54	-.118	74
-.029	21	-.059	39	-.089	55	-.119	75
-.030	21	-.060	39	-.090	56	-.120	75
							Rev. 03/20/08

"abs" value chart

LEADQuick™ Graph



Facts About LeadQuick™

- LEADQuick™ modified procedure uses TMPYP and is U.S. Patented
- It delivers optimum accuracy and best sensitivity using minimum manipulation
- The Lead Test Interference chart details what concentration of ions this test will tolerate

Interference Chart

Lead Test Interferences			
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
- Mercury is rarely found in tap water above 0.005 mg/L
- Hardness ions such as Calcium and Magnesium are tolerated

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

Lead Recovery In Samples

Water Origin	Water Type*	Water Sample abs.	20µg/L spike abs.	**Equivalent ppb (ug/L)	% Recovery	50µg/L spike abs.	Equivalent ppb (ug/L)	% Recovery
Vienna, Austria	M	0.003	-.035	21	105	-.093	52	104
repeated		0.003	-.032	19	95	-.090	51	102
Munich, Germany	M	0.004	-.035	21	105	-.098	54	108
repeated		0.005	-.032	19	95	-.082	46	92
Kusnacht, Switzerland	M	0.004	-.034	20	100	-.091	51	102
repeated		0.006	-.031	19	95	-.097	54	108
Paris, France	M	0.004	-.032	19	95	-.088	50	100
repeated		0.000	-.033	20	100	-.080	45	90
Washington, DC	M	0.002	-.038	23	119	-.093	52	104
repeated		0.003	-.034	20	100	-.086	49	98
Philadelphia, PA	M	0.005	-.029	17	85	-.079	45	90
repeated		0.003	-.038	23	119	-.077	43	86
Phoenix, AZ	M	0.003	-.033	20	100	-.084	47	94
repeated		0.004	-.036	21	105	-.084	47	94
Edgewater, MD	W	0.003	-.037	22	110	-.089	50	100
repeated		-.001	-.027	16	80	-.081	46	92
Highland, NC	W	0.001	-.025	15	75	-.063	36	72
repeated		0.001	-.025	15	75	-.065	37	74
Rockwell, NC	W	0.002	-.037	22	110	-.091	51	102

*M = Municipal, W = Well ** from Conversion Chart

Lead Recovery In Samples

Water Origin	Water Type*	Water Sample abs.	20ug/L spike abs.	**Equivalent ppb (ug/L)	% Recovery	50ug/L spike abs.	Equivalent ppb (ug/L)	% Recovery
Las Vegas, NV	M	-.001	-.031	19	95	-.093	52	104
repeated		0.005	-.029	17	85	-.086	49	98
Chicago, IL	M	0.002	-.036	21	105	-.090	51	102
repeated		0.006	-.028	16	80	-.094	52	104
Rock Hill, SC	W	0.004	-.030	18	90	-.084	47	94
repeated		0.005	-.029	17	85	-.081	46	92
Melbourne, Australia	M	0.004	-.033	20	100	-.084	47	94
repeated		0.005	-.031	19	95	-.079	45	90
Rock Hill SC (exposed to lead)	M	-.008	-.043	25	100	-.102	56	102
repeated		-.011	-.044	26	104	-.094	52	95
Weaverville, NC	M	-.006	-.028	16	80	-.093	52	104
repeated		0.010	-.033	20	100	-.081	46	92
Anaheim, CA	M	-.005	-.032	19	95	-.096	53	106
repeated		0.006	-.035	21	105	-.083	47	94
Seattle, WA	M	0.002	-.027	16	80	-.080	45	90
repeated		0.006	-.027	16	80	-.074	42	84
Kilowna, BC, Canada	M	0.006	-.031	19	95	-.090	51	102
repeated		0.005	-.036	21	105	-.095	53	106

*M = Municipal, W = Well ** from Conversion Chart

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:

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

Where:

Cs = concentration found through testing of the spiked sample

Cu = concentration found through testing of the un-spiked sample

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

K = concentration of the spike added to the sample

Lead in Tap Water

- I've measured Lead levels throughout the world for the last 6 months.
- Latest publication by Triantafyllidou *et al* ("Lead Particles in potable water," Journal AWWA, June 2007) prompted me to test aerator filters and nozzles.

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

- Only 1 of 11 samples contained Lead above 15 µg/L USEPA level or 10 µg/L WHO level.
- High sample taken from first 100 mL water drawn from tap after 12 hour stagnation.
- Appropriate flushing and discarding of stagnant water avoids high Lead.

Lead In Tap Water

- Only 2 of 9 sediment samples were free of lead.
- (POU) point-of-use filtering devices are important.
- New brand new nozzles were positive for lead.
- Stainless steel filter screens tested negative.

Lead In Tap Water - Conclusions

- We are exposed to more lead in our environment that we think.
- Shocking that store-bought tap nozzles contained lead.
- Only one control tap – “meets California prop 65 and NSF.ANSI 61 lead-free standards” was free of any lead.

My Life-style Changes

- Drink only micro-filtered tap water.
- Use a charcoal filter.
- Don’t allow children to drink directly from the tap nozzle.

Questions?