Finnish Institute of Occupational Health

Biological monitoring – annual statistics 2012

Mirja Kiilunen

Finnish Institute of Occupational Health

Biological monitoring, annual statistics 2012

Mirja Kiilunen

Finnish Institute of Occupational Health
Helsinki 2013

Finnish Institute of Occupational Health
Chemical Safety
Topeliuksenkatu 41 a A
00250 Helsinki
www.ttl.fi

Editorial staff: Mirja Kiilunen
Illustrations: Mirja Kiilunen
Cover: Albert Hall Finland Oy Ltd

ISBN 978-952-261-357-8 (PDF)

ABSTRACT

Chemical exposure can be evaluated through industrial hygiene measurements or biomonitoring. Biomonitoring workers' exposure usually involves a blood or urine sample, from which the exposing substance, its metabolites or a physiological response are measured. Biological monitoring takes into account individual differences in exposure; absorption through all three routes: the skin, inhalation, and the gastrointestinal tract; and accumulation through both long-term and repeated exposure. Biomonitoring also makes it possible to determine the effectiveness of protection on a personal level. Total exposure is particularly important in the assessment of exposure and health risks posed by substances that are absorbed through the skin in significant quantities or that accumulate in the body through continuous and repeated exposure. The amount of analysis methods available for biomonitoring is quite limited. The best view of total exposure is obtained when both biological monitoring and industrial hygiene measurements take place at the same time. This book of statistics facilitates the comparability of chemical exposure in different workplaces and jobs, and helps reduce workers' further exposure to chemicals that are hazardous to health.

In 2012, the majority of biomonitoring analyses were carried out at the Helsinki office of the Finnish Institute of Occupational Health (FIOH). The Turku regional office studied exposure to isocyanates and the Kuopio regional office focused on the exposure assessment of mould and dust mites. FIOH's Client services is an accredited testing laboratory (T013), recognized by the Finnish Accreditation Services. A list of accredited analyses and fields of testing can be found on the website of the Centre for Metrology and Accreditation; www.mikes.fi.

In 2012, almost 24 500 samples were analysed, of which about 23 400 were service analyses. Quantitatively, the most significant biomonitoring analyses were those of urinary chromium and nickel, blood lead, urinary inorganic arsenic, urinary aluminium, urinary cobalt, and urinary mandelic and phenylglyoxylic acids, which are used for the assessment of styrene exposure.

Exposure to harmful chemicals is still common in Finland. Urinary chromium and nickel measurements most commonly exceeded the target level. About 27% (N = 106) of all measurements of cobalt exposure exceeded the biomonitoring action limit (BAL). The exceedances were in installation work, maintenance and grinding work, machining, hard metal work, the refining and manufacture of cobalt, zinc casting, and blade grinding. About 12.9% (N=13) of all measurements for carbon monoxide exposure exceeded the biomonitoring action limit. The greatest exceedances were in metal casting, among mould workers, founders and other foundry work, and in fire renovation. A total of 11.3% (N=35) of all pyrene exposure measurements were over the BAL. The most significant PAH exposures occurred in the creosote preservation of wood or in the treatment of creosote wood, and in the installation work of power lines. As regards styrene exposure, the number of exceedances of the BAL was only half of that in 2011: 9.9% (N=35) of measurements were over the BAL in 2012. This is on the same level as that in 2010.

All of the following also exceeded their BAL: aluminium exposure in aluminium welding, the installation of aluminium sheets; inorganic arsenic exposure in a variety of jobs;

benzene exposure in distillation of the oil; mercury exposure in the chlor-alkali industry; cadmium exposure in the blending of glass colours, the disposal of problem waste, soldering, cleaning, and smelting work; manganese exposure in the turning of manganese steels; and lead exposure in welding, machining, and casting work. As regards xylene exposure measured as urinary methylhippuric acid, the BAL was exceeded in painting.

These results prove that the need for biomonitoring remains indisputable. Biomonitoring is often the only way to reliably estimate exposure to chemicals that are absorbed through the skin.

Tables 1 and 2 of this annual report contain information on the number of biomonitoring analyses carried out for service, research and quality control. Table 3 summarizes information regarding the different chemicals that exceeded their BAL in 2012. The separate chapters on the quantitatively most important chemicals include the distribution of measured concentrations, the most heavily exposed jobs, the main statistical values, and the follow-up of exposure in the last ten years. The statistical figures of the more rare analyses are presented in Table 4. The URL (upper reference limits) and the BAL of these are illustrated in Table 5. Table 6 shows the changes in URL for non-exposure, and the BAL in 2013. The most recent changes to the reference limits were made on 1st November. These have not been taken into account in data processing.

Helsinki 12.12.2013

Mirja Kiilunen

TABLE OF CONTENTS

1 2012 SUMMARY OF TABLES AND FIGURES

The total number of analyses by type in the following table is from 2003 to 2012. Table 2 presents these per analysis. The situation in 2012 is also shown as a diagram of the most common biomonitoring analyses and exceedances of the upper reference limits (URL) or of the target levels (TL).

Table 1. Biomonitoring analyses in 2003–2012

Year	Service Number of analyses	Research Number of analyses	Quality Number of analyses	All Number of analyses
2003	16172	2372	7422	25966
2004	14866	6154	6281	27301
2005*	12322	2773	905	16000
2006	12142	1171	539	13852
2007	13019	693	1236	14952
2008	13197	192	906	14210
2009	10569	492	1153	12164
2010	13498	100	879	14294
2011	17489	3377	453	21262
2012	23374	143	947	24456

* Since 2005, only the numbers of external quality assurance analyses have been taken into account in the quality of analysis.

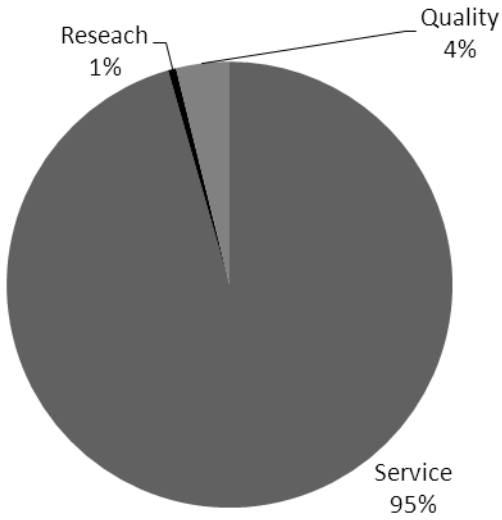


Figure 1. Biomonitoring analyses in 2012

Table 2. Biomonitoring analyses at the Finnish Institute of Occupational Health in 2012

Analysis	Service	Research	Quality	All
Synovial fluid				
Chromium	252			252
Cobalt	252			252
Serum /plasma				
Aluminium	4		3	6
Antibodies of mould dust	2429		532	2961
Antimony			1	1
Arsenic			1	1
Barium			1	1
Beryllium			1	1
Bismuth			1	1
Cadmium			1	1

Analysis	Service	Research	Quality	All
Serum / plasma				
Chromium			5	5
Cobalt			5	5
Copper	40		5	45
Lead			1	1
Manganese			5	5
Mercury			1	1
Mite antibodies	9			9
Molybdenum			1	1
Nickel			5	5
Platinum			3	3
Polychlorinated biphenyls	173		12	185
Selenium			5	5
Silver			1	1
Tellurium			1	1
Thallium			1	1
Thiocyanate	4			4
Thorium			1	1
Tin			1	1
Uranium			1	1
Vanadium			1	1
Zinc			5	5
Blood				
Mercury, inorganic	94		8	102
Mercury, organic	94			94
Cadmium	307		44	351
Carboxyhemoglobin in hemoglobin	106			106
Chromium	4369		3	4372
Cholinesterases	20	72	12	104
Cobalt	4360		3	4363
Lead	661		44	705

Analysis	Service	Research	Quality	All
Blood				
Manganese	1053		7	1060
Molybdenum	73		2	75
Tetrachloroethene	44		2	46
Titanium	353			353
Toluene	53		2	55
Urine				
Aluminium	443		7	450
Aniline	3			3
Arsenic, inorganic	628		17	645
Arsenic +3			4	4
Arsenic +5			4	4
Arsenic MMA	628		4	632
Arsenic DMA	628		4	632
Antimony	41		7	48
Barium			3	3
Beryllium	22		7	29
Bismuth			2	2
Diisocyanate metabolites	27	71		98
Fluoride	14		4	18
Formic acid	87			87
Hexane-2,5-dione	8			8
Cadmium	147		11	158
Cobalt	476		7	483
Chromium	1746		11	1757
Copper	21		7	28
Lead	32		7	41
Manganese	110		3	113
Mandelic and phenylglyoxylic acids	354		6	360
Mandelic acid	16		2	18
Mercury	204		11	215

Analysis	Service	Research	Quality	All
Urine				
2 - (2-Methoxyethoxy) acetic acid	6			6
Methyl ethyl ketone	2			2
Methyl hippuric acid	106		4	110
Molybdenum	75		3	78
Muconic acid	196		4	200
1-Naphtol	50		2	52
2-Naphtol	220		2	222
Nickel	1512		11	1523
Nitrous oxide	3			3
Phenol	79		4	83
Phenoxybenzoic acid	30			30
Platinum	1		4	5
1-Pyrenol	339		4	343
Retinol binding protein	3			3
Selenium	51		7	58
Sevoflurane	4			4
Silver			3	3
Thallium	1		7	8
Tellurium			3	3
Tert. butyl alcohol	8			8
Thorium			3	3
Tin			3	3
Titanium	70			70
Thiocyanate	22			22
2-Thiothiazolidine-4-carboxylic acid	98		4	102
Triethylamine	2			2
Trichloroacetic acid	7		2	9
Tungsten			4	4
Uranium	30		3	33
Vanadium			7	7
Zinc	6		7	13

Analysis	Service	Research	Quality	All
Daily urine				
Copper	38			38
Sundries				
Aluminium in water	19			19
Cadmium in water	1			1
Lead in Biological Material	1			1
All	**17489**	**3377**	**453**	**21262**

In addition, a 430 urinary creatinine assay and 5644 urinary relative density measurement analyses were carried out for the standardization of the results.

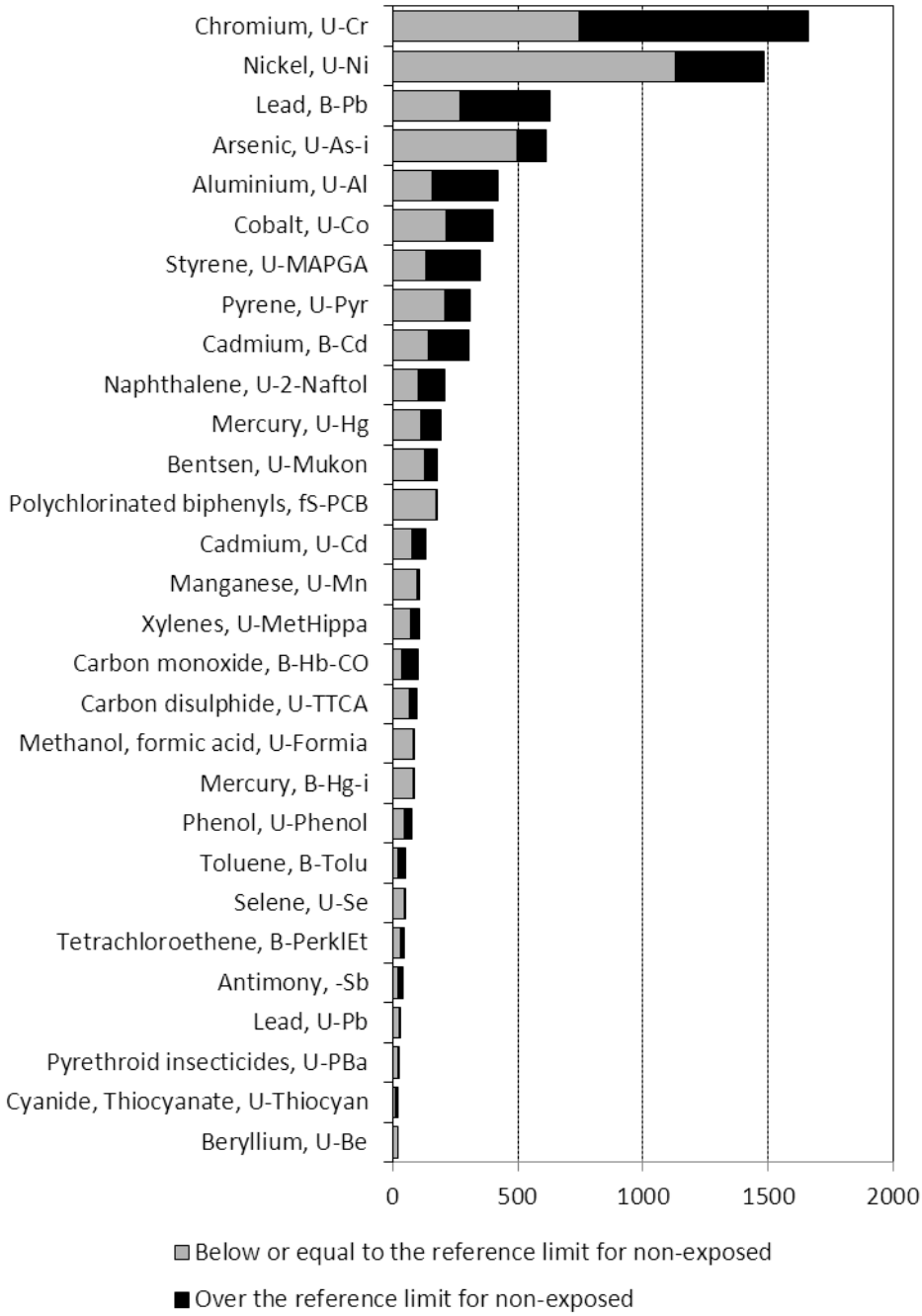


Figure 2. Number of most common biomonitoring analyses and number of exceedances of URL in 2012

Table 3. Measurements over the biomonitoring action limits (BAL) and target levels (TL) and associated occupations and tasks in 2012

Exposure / Analysis	Number of samples	BAL, TL	Exceed-ances / number of persons	Job titles, tasks, occupa-tions
Aluminium U-Al	421	6.0 µmol/l 3.0 µmol/l*	3 19	Assembly and welding work, installation, welding and foundry work
Arsenic inorganic U-As-i	612	70 nmol/l	27	Installation, maintenance, laboratory, process, cleaning, melting down and repair work in the production of metals (Cu, Ni) and in the manufac-ture of sulphuric acid, and in various consultancy and advi-sory work. The tasks of seven people were unknown.
Benzene U-Mukon	176	14 µmol/l	2	Operator
Carbon mon-oxide B-Hb-CO	101	0.050 (=5.0 %)	13	Metal casting, mould workers, founders, foundry work, fire renovation
Cadmium B-Cd U-Cd	 302 133	 50 nmol/l 40 nmol/l	 3 4	(B-Cd) glass colour blending, hazardous waste treatment (U-Cd), soldering, cleaning and melting work
Cobalt U-Co	401	130 nmol/l	106	Installation, maintenance and grinding work, machining, hard metal work, refining and manufacture of cobalt, zinc casting, grinding blades
Chromium U-Cr	1663	0.01 µmol/l Target level	920	Various occupations in the metal industry: e.g. installers, grinders, welders, founders, maintenance and repair work-ers, gas cutters, plasma cut-ters and flame cutters, polish-ers, machinists, chrome plat-ing workers, surface treat-ment workers and hangers, laboratory technicians, laser cutters, sheet metal workers

Exposure / Analysis	Number of samples	BAL, TL	Exceed-ances / number of persons	Job titles, tasks, occupa-tions
Chromium U-Cr continued	1663	0.01 µmol/l Target level	920	and welders, platers, plumb-ers, painters and spray paint-ers, various metal workers, metal sprayers, cleaners, construction workers
Lead B-Pb	630	1.4 µmol/l	15	Welding, machining and foundry work. The tasks of five people were unknown.
Manganese U-Mn	109	50 nmol/l	1	Turning work
Mercury U-Hg	192	140 nmol/l	4	Installation, making cells. One person's task was unknown.
Nickel U-Ni	1485	0.05 µmol/l Target level	353	Various occupations in the metal industry: e.g. installers, different workers in electrolyt-ic nickel refining, grinders, welders, maintenance work-ers, gas cutters, plasma cut-ters and flame cutters, ma-chine repairers and operators, transport workers, chrome platers and surface treatment workers, laboratory techni-cians, sorters and packers, metal sheet workers and welders, thermal processors, painters, mechanics, metal sprayers, metal workers, chimney sweeps, radiators recyclers, platers, drillers, cleaners, metal casting work-ers, electricians, foremen, founders and foundry work-ers, water company workers
Pyrene U-Pyr	310	2.6 µg/l	35	Creosote exposure: installa-tion of electricity, rail and shift work, impregnation work
Styrene U-MaPGa	352	1.2 mmol/l	35	Lamination workers, painters, sprayers, machine operators directors, entrepreneurs

Exposure / Analysis	Number of samples	BAL, TL	Exceed-ances / number of persons	Job titles, tasks, occupa-tions
Xylene U-MetHipp	106	5 mmol/l	1	Painter

2 ANALYSIS-SPECIFIC SUMMARIES

Aluminium

Mirja Kiilunen

Urinary aluminium, U-Al

Upper reference limit	0.6 µmol/l
Biomonitoring action limit	6.0 µmol/l*

* The BAL is 3.0 µmol/l since 1.4.2013.

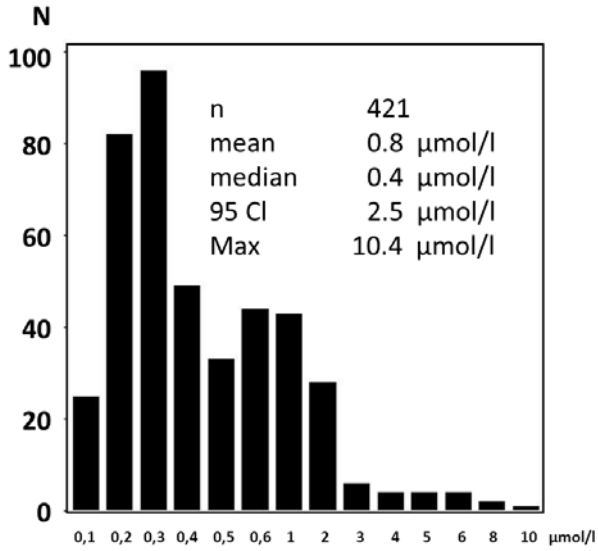
The URL was exceeded in 263 samples: in, for example installation work, electrical installation, welding, grinding work, mechanical installation and repair work, metal sheet work and welding, spraying of aluminium metal, foundry work, boat building. The exposure measurements of various supervisors in the metal industry, and self-employed entrepreneurs also exceeded the URL.

The exposure of three workers exceeded the BAL (6.0 µmol/l) in installation and welding operations. The exposure measurements of 19 workers in assembling and welding, and in foundry work exceeded the new BAL.

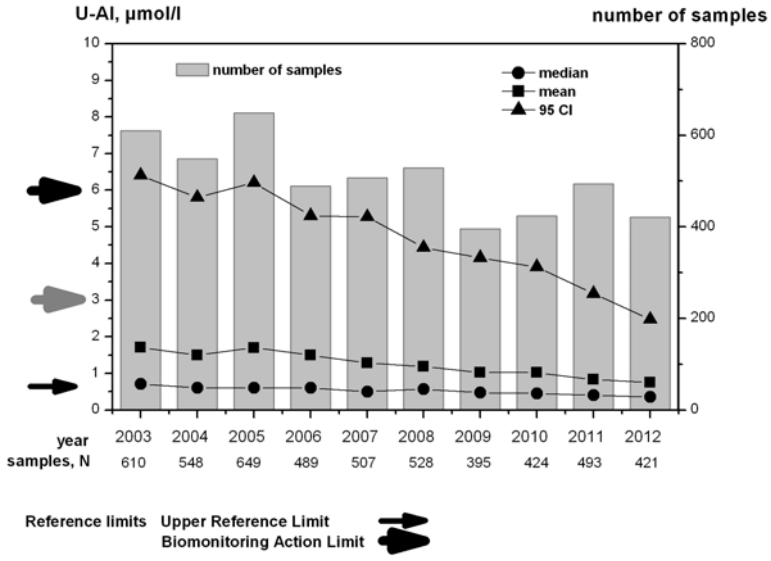
	N
Number of service analyses	421
Number of persons	415
Women	17
Men	398
Number of workplaces	118
Workplace data missing	65

It is estimated that in Finland over 5000 employees are exposed to aluminium, mainly in welding, metal sheet work, grinding and foundry work. The workers most highly exposed to aluminium were welders and sheet metal workers, who also did installation work. In 2012, the exposure of fitters and welders also exceeded the BAL; their aluminium levels were 7.1 - 10.4 µmol/l.

During the past decade there have been no significant changes in the amount of workers exposed to aluminium. The number of high exposures appears to be declining, as the 95 confidence limit for the past seven years has steadily decreased from 6.4 µmol/l in 2003 to 2.5 µmol/l in 2012.



U-Al, concentration distribution in 2012



Urinary aluminium in 2003–2012

Arsenic, inorganic

Mirja Kiilunen

Urinary inorganic Arsenic, U-As-i

Upper reference limit	30 nmol/l
Biomonitoring action limit	70 nmol/l
Pregnant women should not be exposed to arsenic.	

The URL was exceeded in 117 samples: in, for example the production and casting of copper, nickel and other metals; installation; electrical installation; demolition and insulation work; maintenance of machines and industrial boilers; masonry reparation; laboratory and cleaning work, consultation and research work in the production of metals.

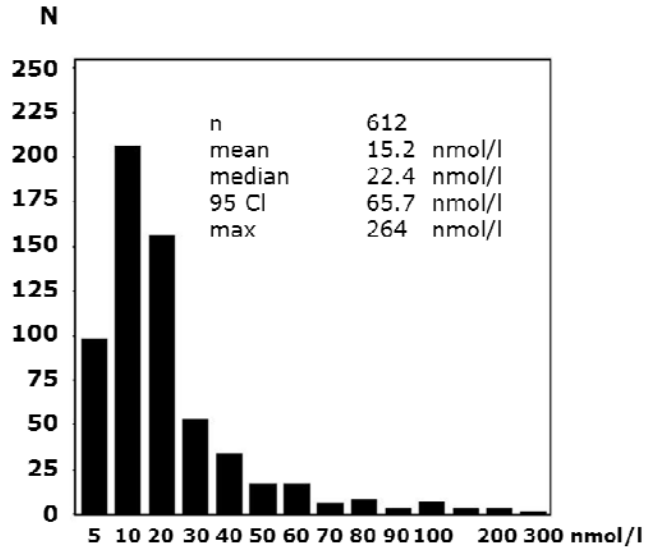
The BAL was exceeded in 27 samples: in installation, maintenance, masonry and process work; cleaning and reparation work in the production of the metals (Cu, Ni) and research-related work. One person's job title was unknown.

	N
Number of service analyses	612
Number of persons	559
Women	60
Men	552
Number of workplaces	55
Workplace data missing	74

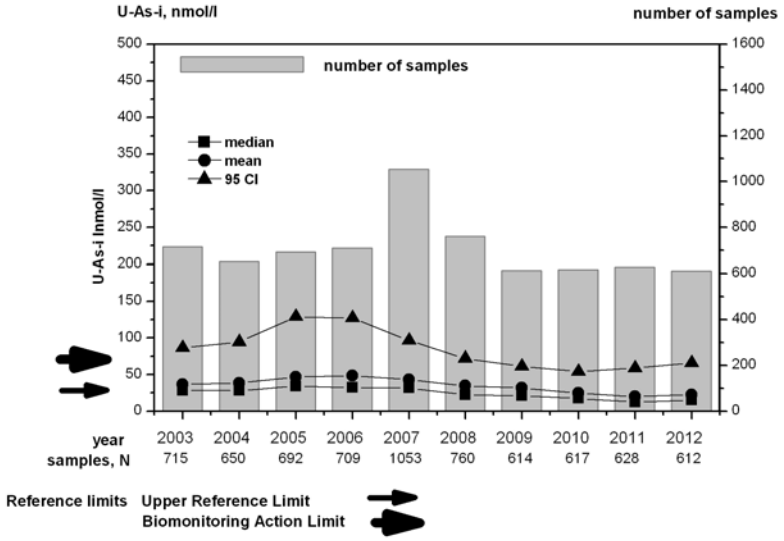
It is estimated that over 1600 employees are exposed to inorganic arsenic in Finland. The number of those indirectly exposed is greater. In addition, new mining projects will increase the number of exposed workers. Outside of work, exposure to inorganic arsenic can occur through the use of well and deep well water, but not to a significant extent from other nutritional sources. Mushrooms and berries growing in contaminated soil can also accumulate elevated levels of arsenic.

Exposure to arsenic has been stable in recent years. Most of the BAL exceedances were observed in people who worked in different tasks in the refining of metals: cleaning and casting.

The BAL of urinary inorganic arsenic at the end of a work shift toward the end of the working week has been set by the Ministry of Social Affairs and Health (Ministry of Social Affairs Regulation 1213/2011).



U-As-i, concentration distribution in 2012



Urinary inorganic arsenic in 2003–2012

Benzene

Jouni Mikkola

Urinary t*rans, trans*-Muconic acid, U-Mukon

Upper reference limit	2 µmol/l
Biomonitoring action limit	14 µmol/l
Pregnant women should not be exposed to benzene.	

The URL was exceeded in 50 samples, which were mainly originated from installers, machine drivers, gas and process workers, handymen, operators, and in the maintenance of fuel gauges and tanks.

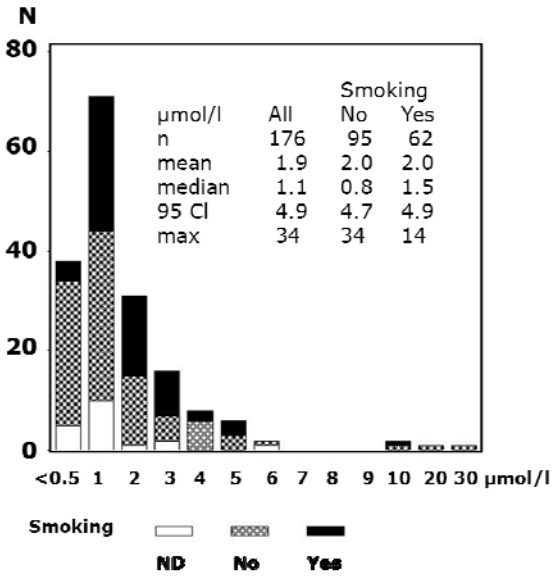
The BAL was exceeded in two samples.

	N
Number of service analyses	176
Number of persons	163
Women	12
Men	151
Smoking	
Smokers	62
Non-smokers	95
Unknown smoking data	19
Number of workplaces	27
Workplace data missing	8

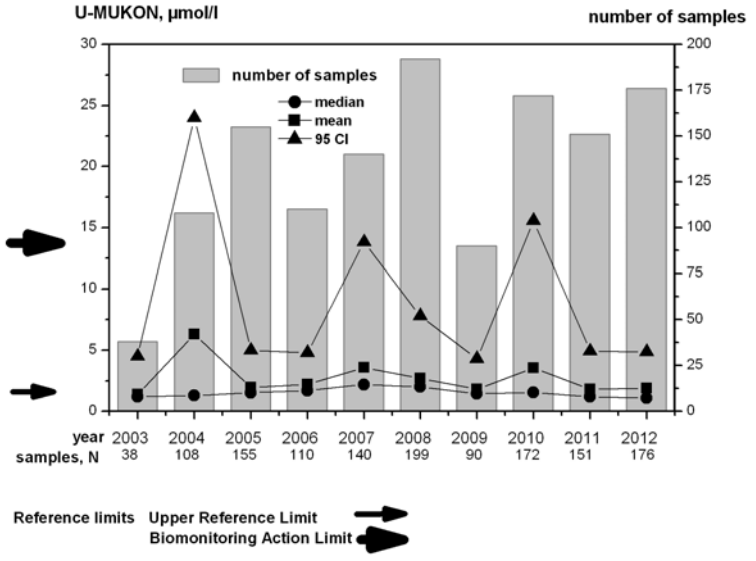
In the supply chain of motor fuels, around 2000–3000 workers are exposed to gasoline vapours. Car maintenance and repair work employs about 8000 people, some of whom may be exposed to benzene. Exposure to motor gasoline benzene is the greatest health risk. Gasoline may only contain up to one per cent benzene (Government Decision 1271/2000).

Exposure to benzene may occur in hazardous waste treatment, fuel tank maintenance and cleaning work, cleaning of contaminated soil, and in the steel industry. Coal tar contains benzene and other aromatic hydrocarbons. About 1600 workers are reported as exposed to benzene each year in the register of workers exposed to carcinogenic substances and processes (ASA register).

Based on the biomonitoring data, the number of benzene exposed workers has remained unchanged in the last 10 years. The number of high exposures and exposure levels vary greatly each year.



U-Mukon, concentration distribution in 2012



Urinary muconic acid in 2003–2012

Cadmium

Mirja Kiilunen

Blood cadmium, B-Cd

Upper reference limit	5 nmol/l non-smokers 18 nmol/l smokers
Biomonitoring action limit	50 nmol/l
Pregnant women should not be exposed to cadmium.	

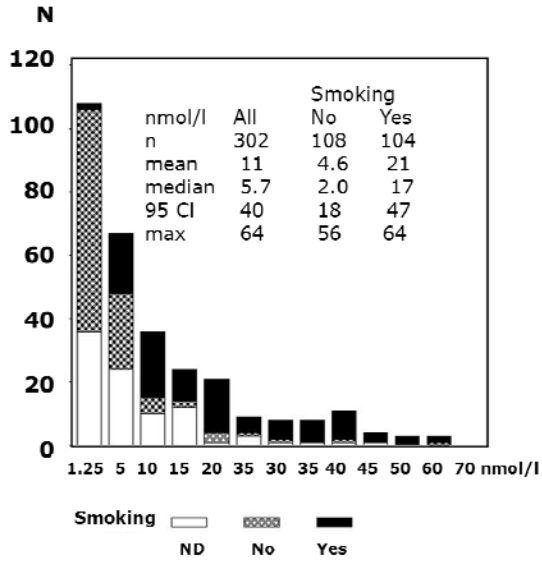
The URL of 5 nmol/l was exceeded in 161 samples, of which 20 were non-smokers and 40 had missing smoking data. The URL for smokers, 18 nmol/l, was exceeded in 64 samples, of which six were from non-smokers and 50 from smokers. Information was missing in eight samples.

The URL was exceeded in, for example, installation work, car repair work, machine transport, maintenance work, operation and maintenance of machines, machining, glass blowing and glass mass production, masonry, hazardous waste management, work at hazardous waste disposal facilities, turning, foundry work (cleaners, melters, founders), and in a variety of supervisory and office tasks.

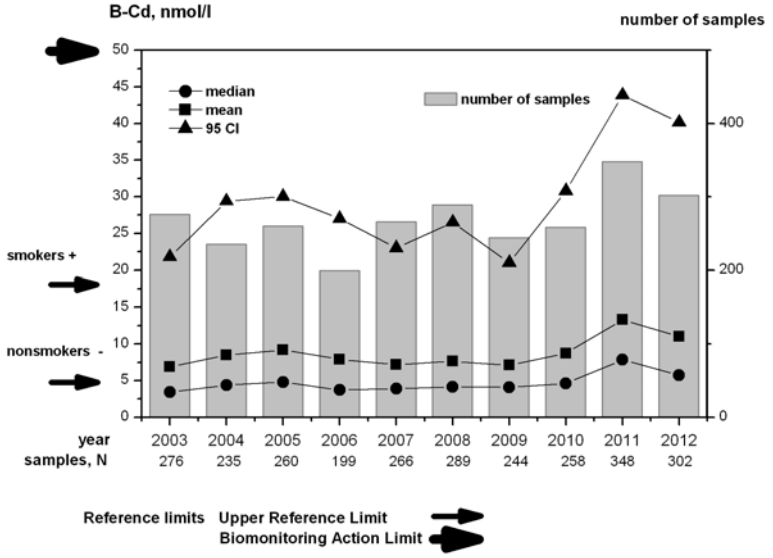
The exposure of three workers exceeded the BAL: they worked with the blending of glass colours and hazardous waste treatment. The glass colour blender did not smoke but the others were smokers.

	N
Number of service analyses	302
Number of persons	276
Women	26
Men	252
Smoking	
Smokers	104
Non-smokers	108
Unknown smoking data	90
Number of workplaces	36
Workplace data missing	43

About 1300 people in Finland are exposed to cadmium.
Exposed smokers clearly had the highest concentrations. Average exposure has started to grow in recent years and high individual exposures have increased. In 2012, exposures levelled off.



B-Cd, concentration distribution in 2012



Blood Cadmium in 2003–2012

Urinary cadmium, U-Cd

Upper reference limit	5 nmol/l non-smokers 10 nmol/l smokers
Biomonitoring action limit	40 nmol/l
Pregnant women should not be exposed to cadmium.	

The URL of 5 nmol/l was exceeded in 54 samples, of which seven cases were non-smokers and 29 were smokers. The URL for smokers, 10 nmol/l, was exceeded in 25 samples, of which 14 were from non-smoking and eight were smokers. Two workers' smoking information was missing.

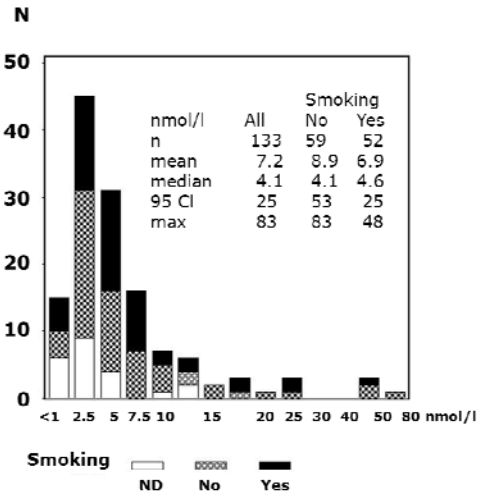
The BAL was exceeded in, for example, grinding, soldering, sandblasting, machining, various occupations in the production of metals and metal products (such as casting), glass mass manufacture and glassblowing, plating, and in office work.

The exposure of four people exceeded the BAL, two of which melted glass mass, one hard soldered and one cleaned up at a hazardous waste disposal facility.

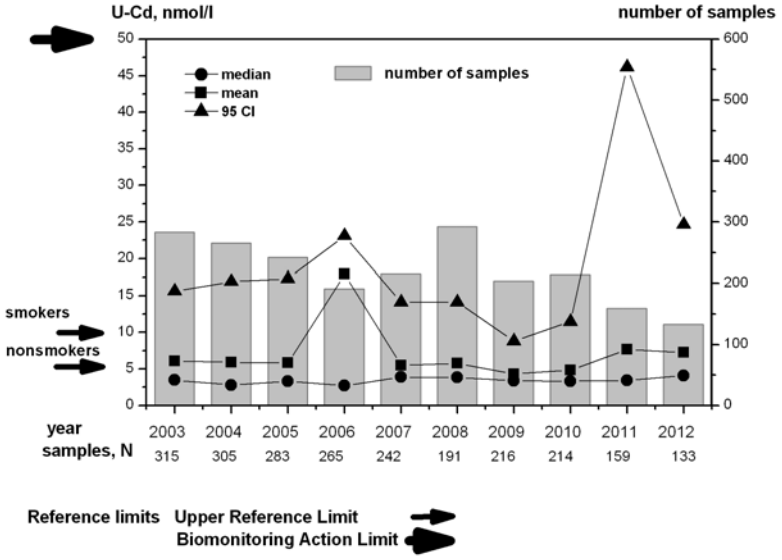
	N
Number of service analyses	133
Number of persons	127
Women	9
Men	118
Smoking	
Smokers	52
Non-smokers	59
Unknown smoking data	22
Number of workplaces	28
Workplace data missing	18

About 1300 people in Finland are exposed to cadmium.

Exposed smokers clearly had the highest concentrations. Average exposure has started to grow in recent years and high individual exposures have increased. In 2012, exposures levelled off.



U-Cd, concentration distribution in 2012



Urinary Cadmium in 2003–2012

Blood cadmium, B-Cd, and urinary cadmium, U-Cd

B-Cd

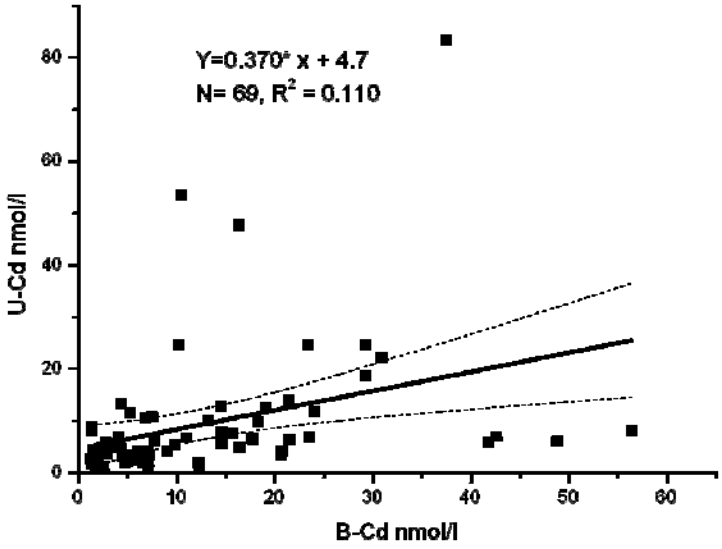
Upper reference limit	5 nmol/l non-smokers 18 nmol/l smokers
Biomonitoring action limit	50 nmol/l
Pregnant women should not be exposed to cadmium.	

U-Cd

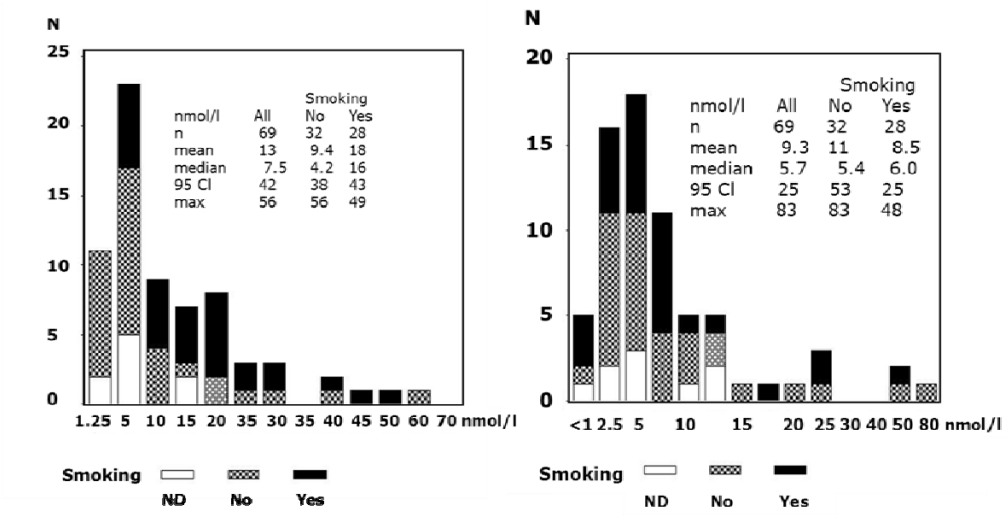
Upper reference limit	5 nmol/l non-smokers 10 nmol/l smokers
Biomonitoring action limit	40 nmol/l
Pregnant women should not be exposed to cadmium.	

The blood and urinary cadmium measurement of 69 workers was carried out simultaneously. The table lists the average concentration of cadmium in their blood and urine. On average, the concentrations of cadmium in this group were slightly higher than those of all exposed to cadmium. In addition, exposure has increased on average over the last year. Blood cadmium concentration cannot be definitely evaluated by urinary cadmium concentration. Blood cadmium describes more recent exposure, and the concentration of urinary cadmium indicates the cadmium load in the kidneys. Blood cadmium concentrations increase more quickly than the urinary cadmium concentration. The detection of exposure is delayed in urine.

	N	Median	Mean	95 Cl	Maximum
B-Cd	69	7.5	12.6	41.8	56
Non-smokers	32	4.2	9.4	37.5	56
Smokers	28	16.0	18.1	42.7	49
U-Cd	69	5.7	9.3	24.7	83
Non-smokers	32	5.4	10.9	53.4	83
Smokers	28	5.9	8.6	24.7	48



Blood and urinary cadmium concentrations in simultaneously taken samples



B-Cd and U-Cd, concentration distribution in 2012

Carbon disulphide

Jouni Mikkola

Urinary 2-Thiothiazolidine-4-carboxylic acid, U-TTCA

Upper reference limit	0.3 mmol/mol creatinine
Biomonitoring action limit	2.0 mmol/mol creatinine
Pregnant women should not be exposed to carbon disulphide.	

The URL was exceeded in 33 samples, which were mainly originated from bath maintenance men, machine operators, handymen and dryers.

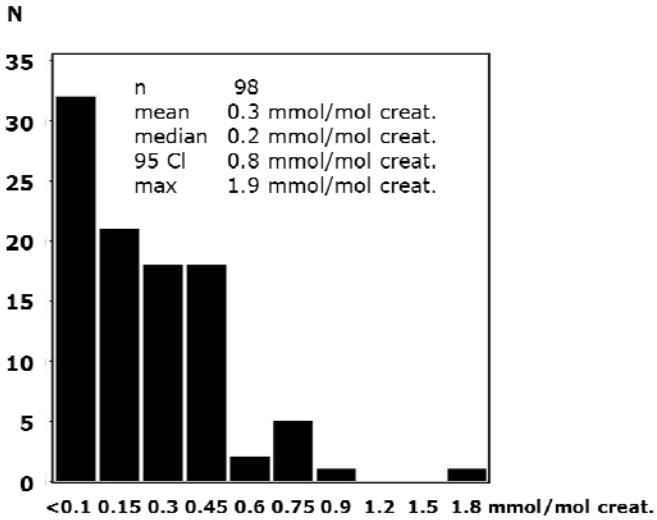
The BAL was not exceeded.

	N
Number of service analyses	98
Number of persons	76
Women	9
Men	67
Number of workplaces	1
Workplace data missing	11

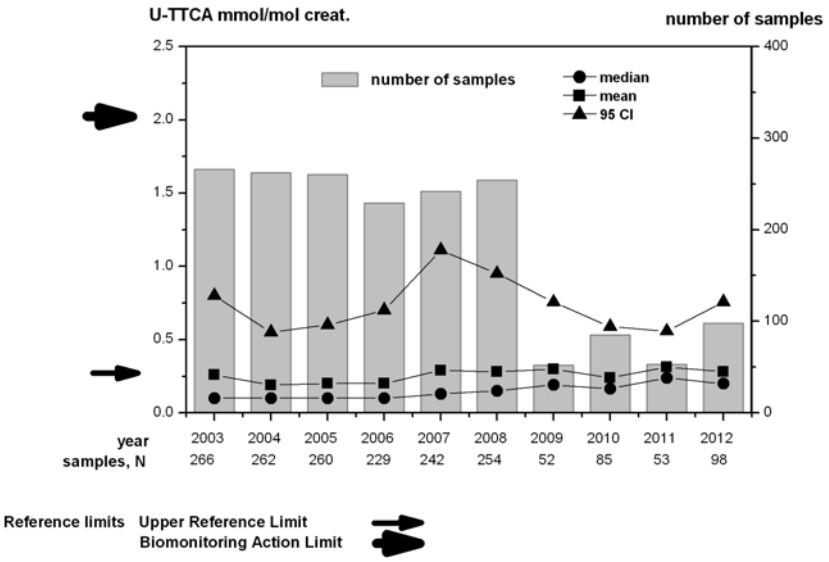
The number of workers exposed to carbon disulphide has decreased since 2008.

The URL was exceeded on average in one-third of the samples between 2011 and 2012. Measurements continue to reveal individual high concentrations.

The BAL of urinary 2-thiothiazolidine-4-carboxylic acid, U-TTCA in a post shift sample, is set by the Ministry of Health and Social Affairs (Ministry of Social Affairs Regulation 1213/2011).



U-TTCA, concentration distribution in 2012



Urinary 2-thiothiazolidine-4-carboxylic acid in 2003–2012

Carbon monoxide, dichloromethane, methylene chloride

Jouni Mikkola

Carboxyhaemoglobin, B-Hb-CO

Upper reference limit	0.015 (=1.5 %)
Biomonitoring action limit	0.050 (=5.0 %)
Biomonitoring action limit during pregnancy	0.020 in carbon monoxide exposure 0.015 in dichloromethane exposure

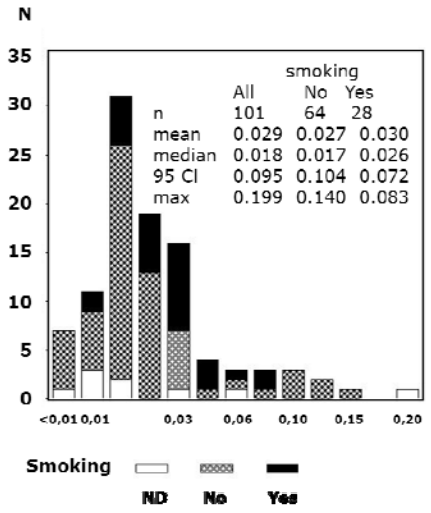
The URL was exceeded in 63 samples. No exposure to dichloromethane was observed.

The URL was exceeded in cars' technical inspections, maintenance work, container work and foundry work (mould maker, potter).

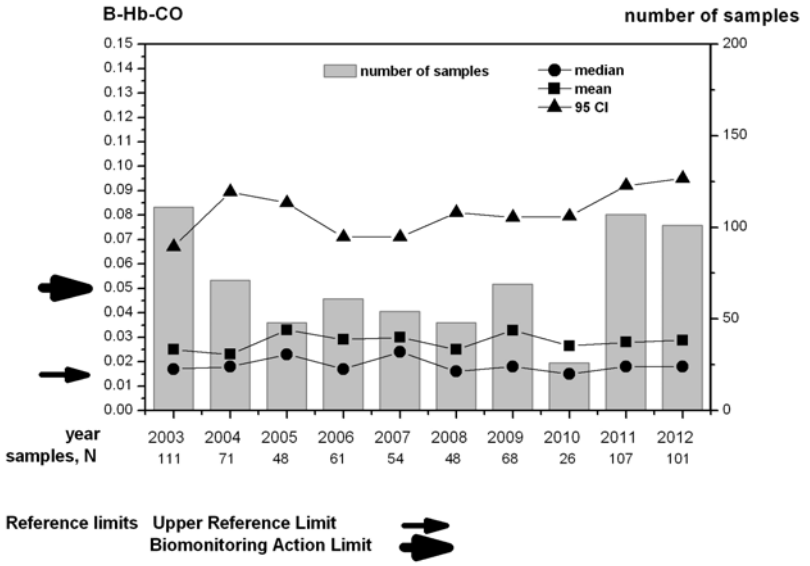
The BAL was exceeded in the exposures of 13 workers in fire renovation work and foundries (mould maker, core sand maker, potter).

	N
Number of service analyses	101
Number of persons	91
Women	8
Men	83
Smoking	
Smokers	28
Non-smokers	64
Unknown smoking data	9
Number of workplaces	14
Workplace data missing	9

Exposure to carbon monoxide continues to be significant year after year.
The BAL is exceeded yearly. The share of samples exceeding the BAL was 28% in 2009, 23% in 2010, 15% in 2011, and 13% in 2012. High individual exposures have increased in recent years.



B-Hb-CO, concentration distribution in 2012



Carboxyhaemoglobin in 2003–2012

Chromium

Mirja Kiilunen

Urinary chromium, U-Cr

Upper reference limit	0.01 µmol/l
Target limit	0.01 µmol/l
Pregnant women should not be exposed to chromium.	

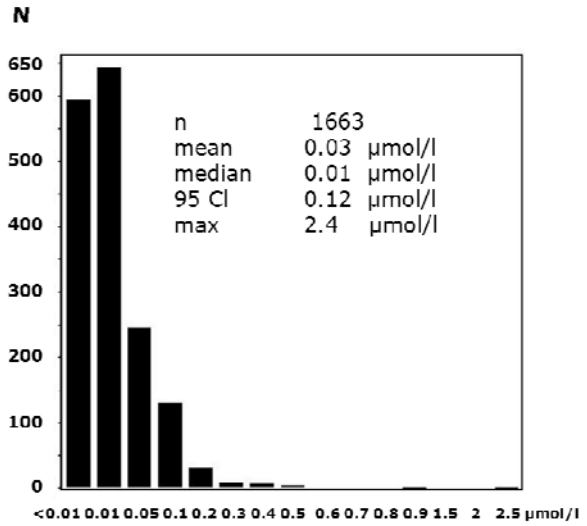
URL and TL were exceeded in 920 samples, which is 55% of all measurements.

The TL was exceeded in many occupations in the metal industry, for example, among various installers, grinders, welders, founders, maintenance and repair workers, gas cutters, plasma cutters and flame cutters, polishers, machinists, chrome platers, surface treatment workers and hangers, laboratory technicians, laser cutters, sheet metal workers and welders, platers, plumbers, painters and spray painters, various metal workers, metal sprayers, cleaners, construction workers, and labour leaders.

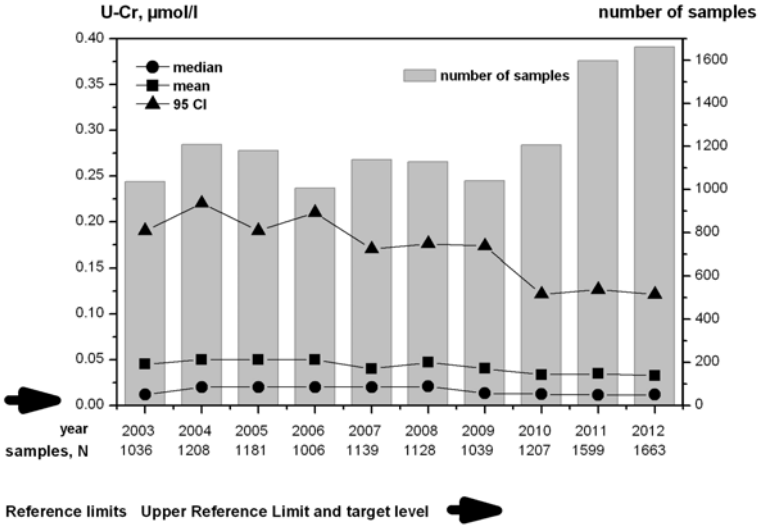
The highest concentrations measured were among welders, 0.51 µmol/l, 0.50 µmol/l and 0.47 µmol/l. The exposure of 19 surface handlers was over 0.10 µmol/l and the concentration in two workers exceeded 0.4 µmol/l.

	N
Number of service analyses	1663
Number of persons	1588
Women	73
Men	1515
Number of workplaces	344
Workplace data missing	196

About 27 000 people are occupationally exposed to chromium in Finland. The average concentrations have remained invariable in recent years, and a previously reported decline in concentrations has levelled off. Although occasional high concentrations occur, 0.30 µmol/l was exceeded in only 13 samples. Setting the target level has also resulted in more accurate exposure monitoring.



U-Cr, concentration distribution in 2012



Urinary chromium in 2003–2012

Cobalt

Mirja Kiilunen

Urinary cobalt, U-Co

Upper reference limit	25 nmol/l*
Biomonitoring action limit	130 nmol/l*
Pregnant women should not be exposed to cobalt.	

* The URL is 25 nmol/l and the BAL is 130 nmol/l since 1.4.2012.

The URL was exceeded in 189 samples, of which 83 cases were non-smokers and 51 were smokers.

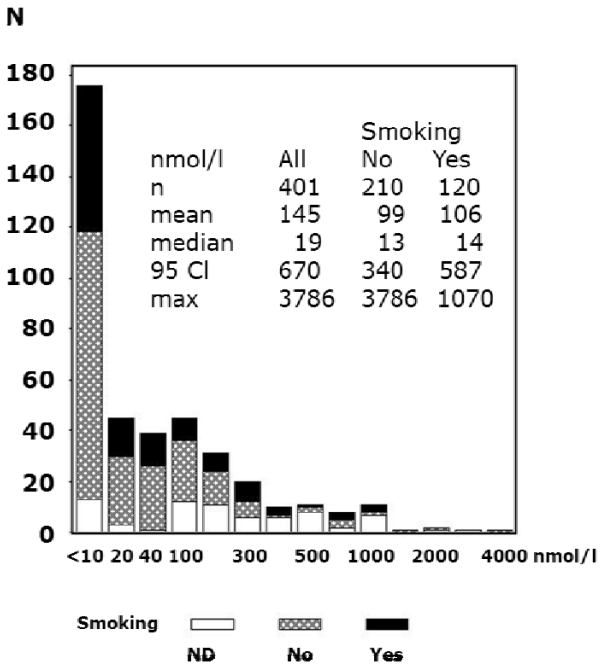
The URL was exceeded in the exposure measurements of, for example, technicians, grinders, welders, solderers, plant and maintenance workers, machinists, hard metal workers (e.g. grinding blades), metal sprayers, various workers in cobalt refining and the manufacture of cobalt salts, platers, pressing workers, plumbers, cleaners, and foremen.

The BAL exceeded in 106 samples in 98 persons (3 women, 95 men); in, for example, assembly and welding work, hard metal work, repair and maintenance work, plating and metal spraying and in various tasks in cobalt refining and cobalt salt production. Similarly, foremen's exposure exceeded a concentration of 130 nmol/l.

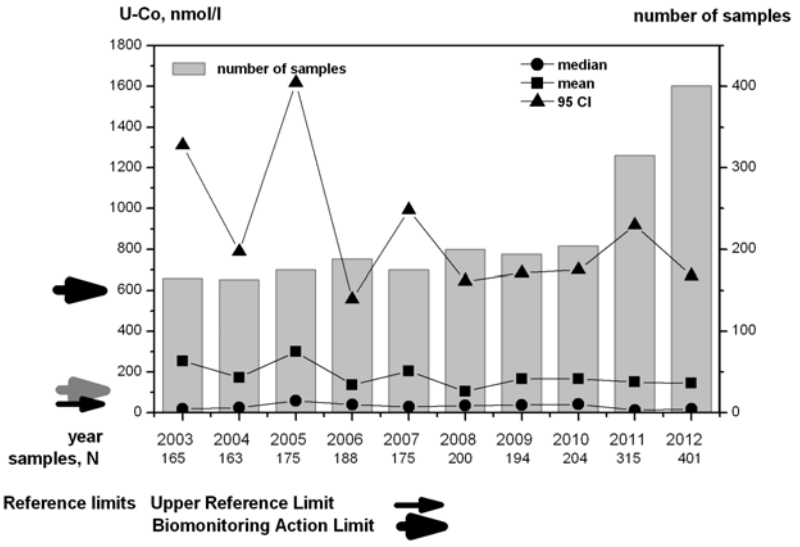
	N
Number of service analyses	401
Number of persons	369
Women	32
Men	337
Smoking	
Smokers	120
Non-smokers	210
Unknown smoking data	71
Number of workplaces	64
Workplace data missing	12

About 1500 people are occupationally exposed to cobalt in Finland.

Large cobalt exposures are still likely to occur in various tasks related to cobalt and its salt manufacturing. Blade grinders and hard metal workers are also clearly exposed. The highest measured concentration was 3786 nmol/l in one process operator. Cobalt is present in tobacco smoke, but cobalt levels of smoking workers as a group were not detected to be higher than those of non-smokers. The amount of cobalt released from artificial joints is determined primarily from blood cobalt, but elevated cobalt values can be also detected in urine samples.



U-Co, concentration distribution in 2012



Urinary cobalt in 2003–2012

Formic acid, Methanol

Jouni Mikkola

Urinary formic acid, U-Formia

Upper reference limit	70 mmol/mol creatinine
Biomonitoring action limit	200 mmol/mol creatinine

The URL was exceeded in six samples, which were mainly originated from preliminary typesetters, impregnators, and pressing and warehouse workers.

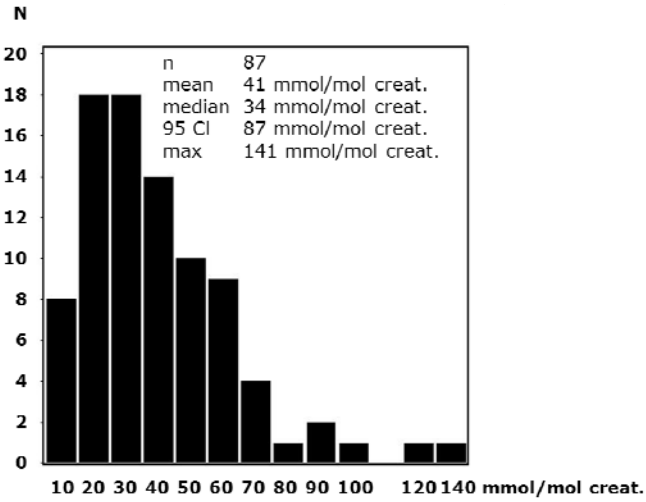
The BAL was not exceeded.

	N
Number of service analyses	87
Number of persons	65
Women	18
Men	47
Number of workplaces	10
Workplace data missing	-

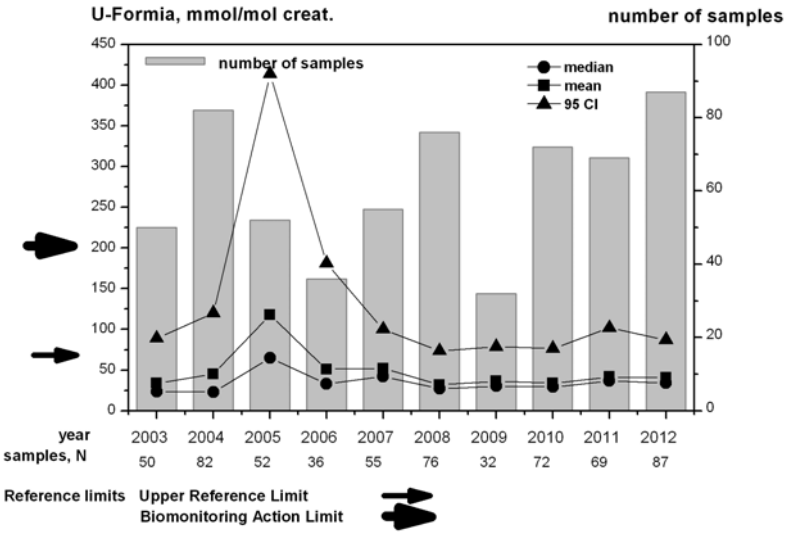
The number of workers exposed to methanol and formic acid has remained low in recent years. In 2008–2012, 5-10 per cent of the samples annually exceeded the URL (with the exception of 2011, 13%). The BAL was not exceeded after 2008.

Methanol is absorbed easily through the skin. Special attention should be paid to skin protection. The suitability of protective gloves for methanol work should be checked before starting such work.

A new biomonitoring test for determining occupational exposure to methanol was introduced at the beginning of 2013 (urinary methanol, U-MeOH). This method provides a better assessment of exposure to methanol, especially at low exposure levels. Urinary formic acid analysis (U-Formia) is still used for assessing the exposure of formic acid.



U-Formia, concentration distribution in 2012



Urinary formic acid in 2003–2012

Lead

Mirja Kiilunen

Blood lead, B-Pb

Upper reference limit	0.09	µmol/l
Biomonitoring action limit	1.4	µmol/l
Biomonitoring action limit during pregnancy	0.09	µmol/l

The URL was exceeded in 360 samples: in, for example, shooting (e.g. police officers), gunsmith work, installation and mechanical work, electronic work, grinding and welding, reparation and maintenance, soldering, the handling and transfer of waste and contaminated soil, assembly work, machining, machine transportation, laboratory work, glass blowing, lead work, construction work, mould casting, masonry, hazardous waste handling, printing, sheet metal work, plating and surface treatment, thermal cutting, flame cutting, pipe laying, construction and demolition work, metal concentrate handling, cutting, cleaning, galvanizing, ash removal, foundry work (turners, melters, casters, other workers), and foremen's work.

The BAL was exceeded in 15 samples, which were originated from 11 employees in welding, machining and foundry work. Two workers' tasks were unknown.

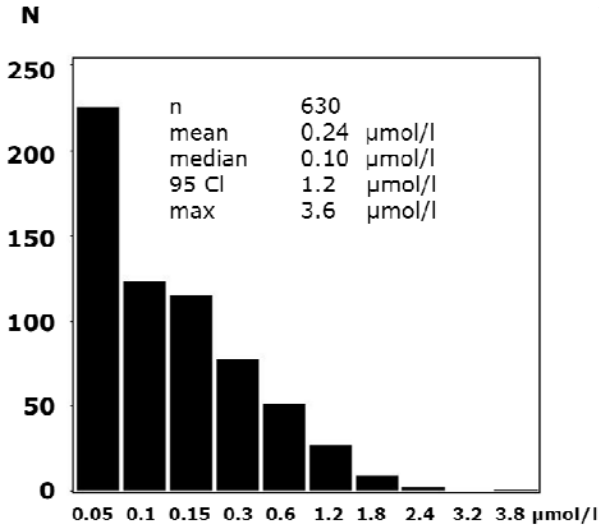
	N
Number of service analyses	630
Number of persons	574
Women	76
Men	498
Number of workplaces	93
Workplace data missing	149

According to Government decision (1154/1993) on lead work, an employee whose blood lead level exceeds 2.4 µmol/l, may not perform work that exposes to lead. In a workplace in which an employee's blood lead levels exceeds 1.9 µmol/l, the employer must pay special attention to the use of lead that might cause adverse health effects.

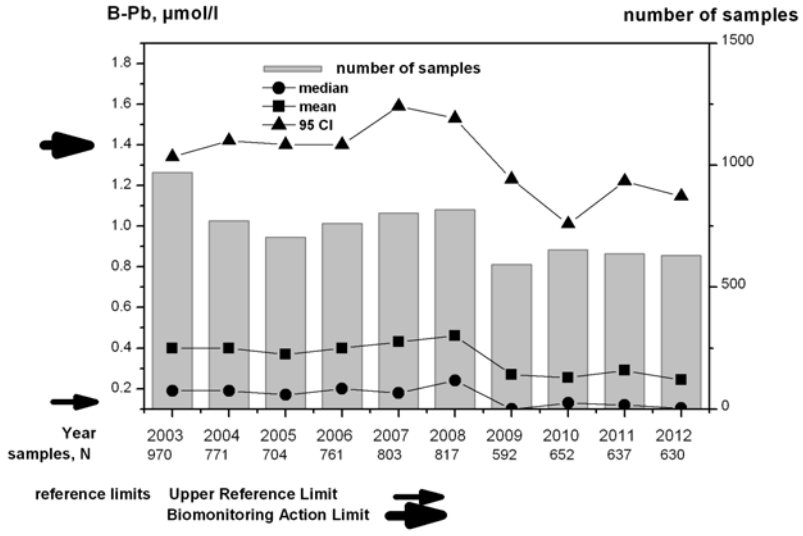
The BAL of 1.4 µmol/l is based on the decree of the Ministry Social Affairs and Health on lead and its inorganic compounds of biological samples (Ministry of Social Affairs and Health Regulation 1213/2011).

According to Government Decree 1335/2004 on lead and its derivatives, lead may be evaluated as posing a threat to maternal or foetal health. Pregnant women should thus not be exposed to lead; their blood lead concentration should not exceed the URL of 0.09 µmol/l.

About 4500 employees are occupationally exposed to lead in Finland. This number has declined significantly over the past ten years.
Smelter and foundry workers are the most highly exposed to lead.



B-Pb, concentration distribution in 2012



Blood lead in 2003–2012

Urinary lead, U-Pb

Upper reference limit	0.008 µmol/l *
Biomonitoring action limit	0.1 µmol/l
Biomonitoring action limit during pregnancy	0.008 µmol/l *

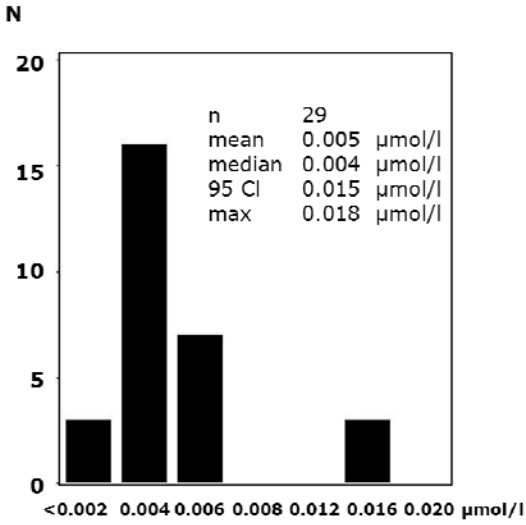
*The URL is 0.008 µmol/l since 1.4.2012.

The URL of 0.008 µmol/l was exceeded in three samples, which were mainly originated from car painters and environmental cleaning process workers. One worker's task was unknown.

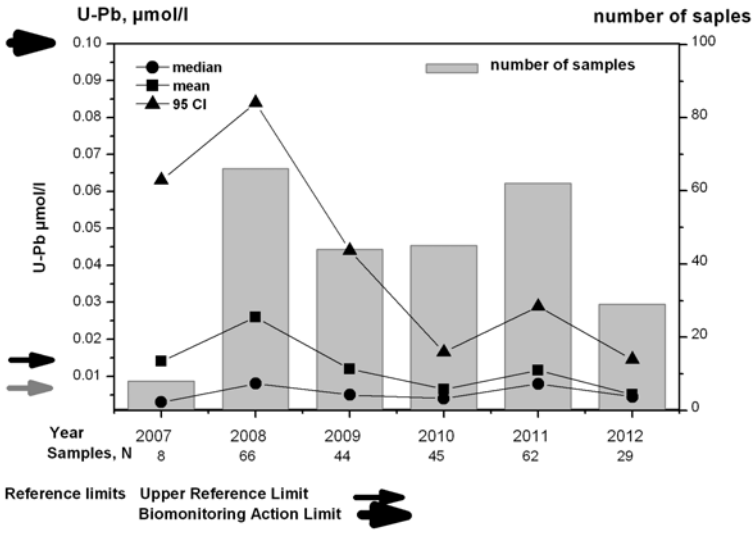
	N
Number of service analyses	29
Number of persons	27
Women	1
Men	26
Number of workplaces	6
Workplace data missing	13

About 4500 employees are occupationally exposed to lead in Finland.

Urinary lead measurements are primarily for the assessment of exposure to organic alkyl lead compounds. Organic alkyl compounds mostly occur in renovations of old petrol tanks and in contaminated soil. Organic lead compounds may also be used in the electronics industry. Blood lead level measurements are used for other lead exposure monitoring.



U-Pb, concentration distribution in 2012



Urinary lead in 2003–2012

Manganese

Mirja Kiilunen

Urinary manganese, U-Mn

Upper reference limit	10 nmol/l *
Biomonitoring action limit	Not established. In workers who weld manganese steels and produce alkaline batteries the average urinary manganese concentrations have been less than 50 nmol/l.

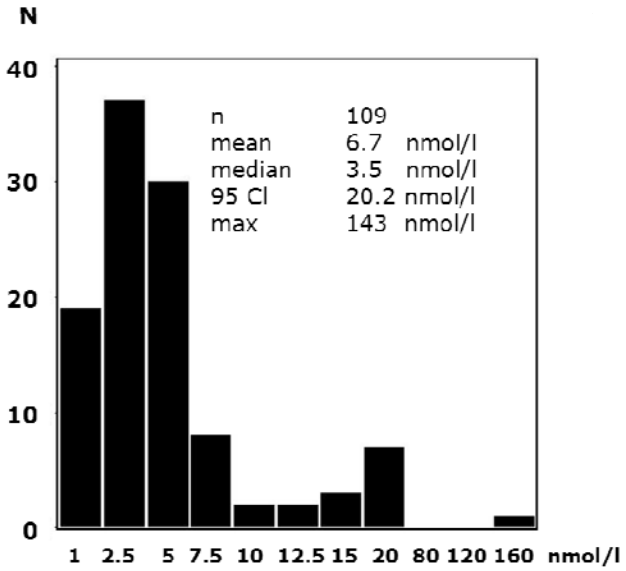
* The URL is 10 nmol/l since 1.4.2012.

The samples of 14 welders exceeded the URL of 10 nmol/l: an implementer, an ore processor, a crane operator, a refiner, a turner and a foreman. The tasks of three people were unknown.

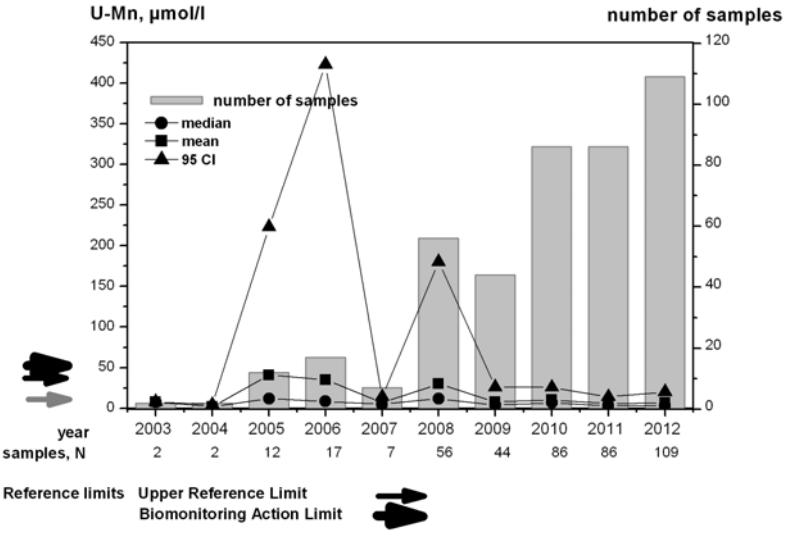
The turner's exposure exceeded the BAL (143 nmol/l).

	N
Number of service analyses	109
Number of persons	101
Women	7
Men	94
Number of workplaces	11
Workplace data missing	28

Manganese is used as a mixture compound of various alloys. Urinary manganese is a group level indicator, and can distinguish exposed and non-exposed groups of individuals from each other. The highest measured concentration (143 nmol/l) in 2012 was double the highest value of the previous year.



U-Mn, concentration distribution in 2012



Urinary manganese in 2003–2012

Mercury

Mirja Kiilunen

Blood inorganic mercury, B-Hg-i

Upper reference limit	10 nmol/l
Biomonitoring action limit	50 nmol/l
Biomonitoring action limit during pregnancy	10 nmol/l

One worker's sample exceeded the URL of 10 nmol/l. This person's task and industry sector were unknown.

The BAL of 50 nmol/l was not exceeded.

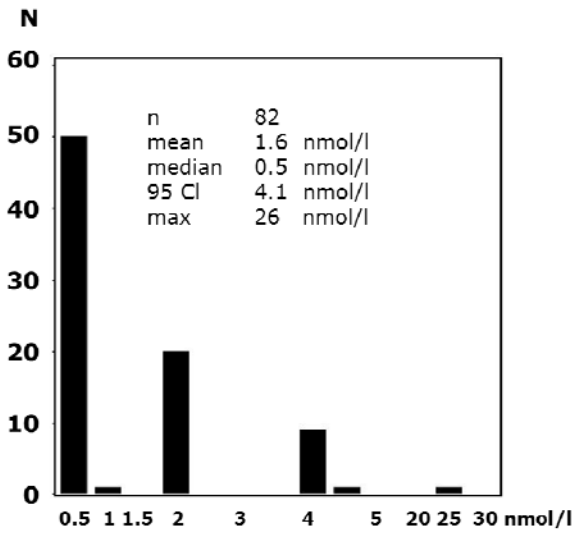
	N
Number of service analyses	82
Number of persons	80
Women	15
Men	65
Number of workplaces	18
Workplace data missing	28

Work-related mercury exposure is measured by blood inorganic mercury. Dietary intake of organic mercury, for example, is determined separately. Environmentally derived methyl mercury exposure can be measured from human hair.

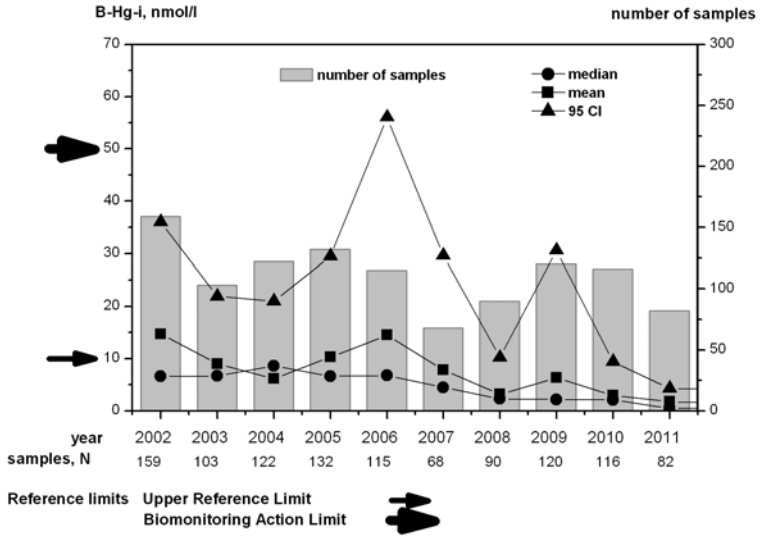
About 200 employees may continuously be exposed to mercury, mostly in the chlor-alkali industry. Exposure to mercury-containing lamps, and exposure through the scrapping of equipment and the recovery of mercury is more intermittent. Workers can also be exposed to mercury in industrial demolition work, as well as in the manufacture and maintenance of instruments. All other work exposure is low, but equipment breakdowns and damage may cause occasional exposure.

In the last ten years, the number of workers exposed to mercury has decreased considerably, in the chlor-alkali industry in particular. Exposure levels have also decreased, with the exception of isolated high exposures. The assembly and disposal of energy-saving lamps during recycling increases mercury exposure.

The BAL of 50 nmol/l is based on the decree of the Ministry Social Affairs and Health on the inorganic mercury of blood samples (Ministry of Social Affairs and Health Regulation 1213/2011).



B-Hg-i, concentration distribution in 2012



Blood inorganic mercury in 2003–2012

Urinary mercury, U-Hg

Upper reference limit	20 nmol/l
Biomonitoring action limit	140 nmol/l
Biomonitoring action limit during pregnancy	20 nmol/l

The URL of 20 nmol/l was exceeded in 78 samples: in for example, installation, maintenance and repair work; in a variety of tasks in chlor-alkali processes; and in cleaning and casting in mines. In addition, one dental nurse had a mercury concentration over the URL.

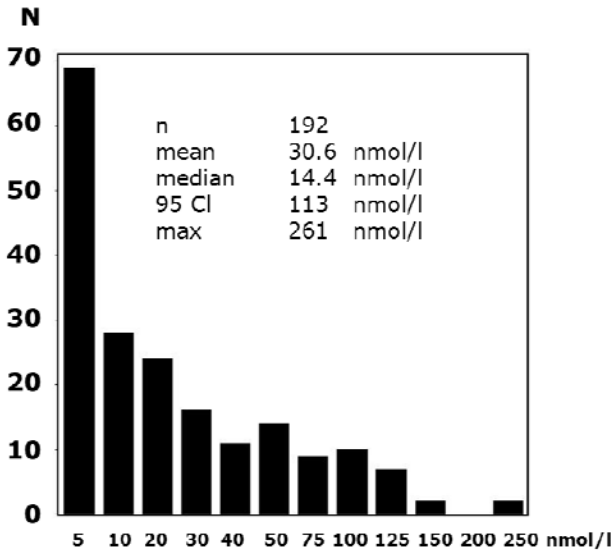
The BAL of 140 nmol/l was exceeded in the exposure measurements of three workers who did repair work in the chlor-alkali industry. One of these had two exceedances.

	N
Number of service analyses	192
Number of persons	136
Women	31
Men	105
Number of workplaces	17
Workplace data missing	24

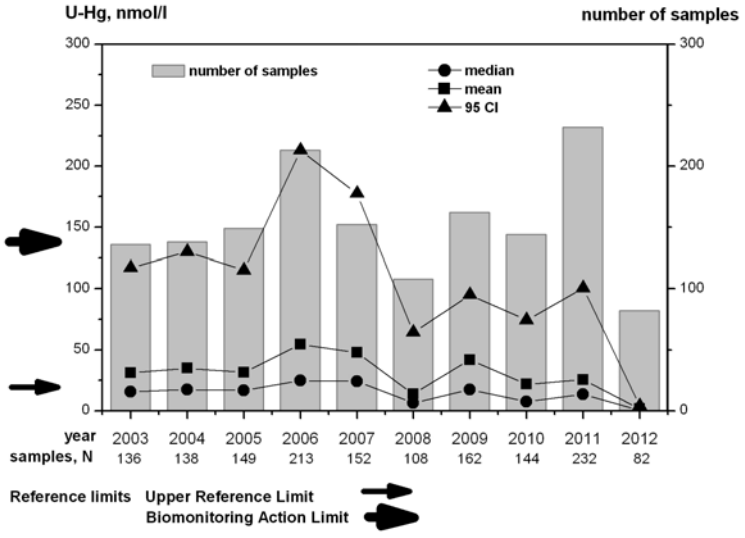
About 200 employees may continuously be exposed to mercury, mostly in the chlor-alkali industry. Exposure to mercury-containing lamps, and exposure through the scrapping of equipment and the recovery of mercury may be more intermittent. Workers may also be exposed to mercury in industrial demolition work, as well as in the manufacture and maintenance of instruments. All other work exposure is low, but equipment breakdowns and damage may cause occasional exposure.

On average, the change in urinary mercury concentration levels is in the same direction as that of blood mercury concentration levels. In the last four years, 95% of the concentrations measured have remained below the URL. Urinary mercury indicates long-term total mercury exposure.

The BAL of 140 nmol/l in morning specimen is based on the decree of the Ministry of Social Affairs and Health on the mercury of urine samples (Ministry of Social Affairs and Health Regulation 1213/2011).



U-Hg, concentration distribution in 2012



Urinary mercury in 2003–2012

Naphthalene and mixtures of polycyclic aromatic hydrocarbons (PAH)

Sinikka Vainiotalo

Urinary 2-Naphthol, U-2-Naftol

Upper reference limit	7 µg/l non-smokers * 30 µg/l smokers*
Biomonitoring action limit	Not established
Pregnant women should not be exposed to PAH compounds.	

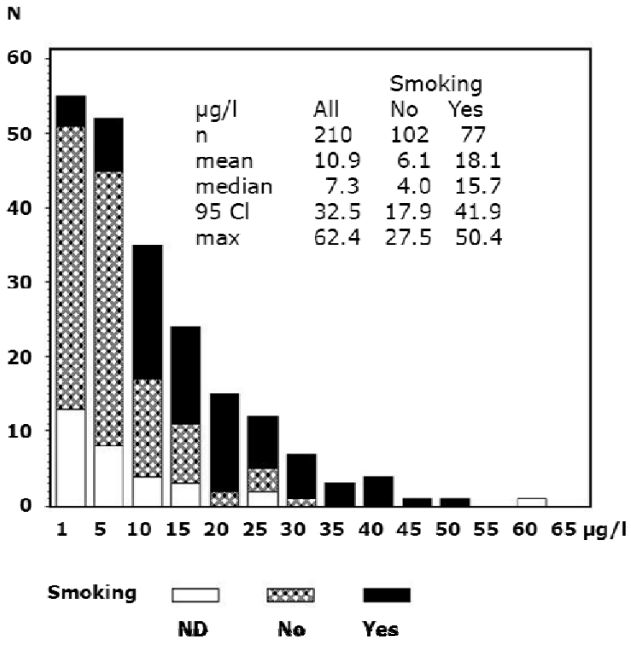
* Determination of urinary 2-naphthol was introduced in 2012. At the same time the unit was changed to µg/l.

The URL was exceeded in 48 samples, which were mainly originated from impregnators, aircraft maintenance workers, hazardous waste handlers, electricity pole installers, bitumen insulators and heating plant workers. The highest single concentrations were measured in electricity pylon installers and aircraft maintenance technicians.

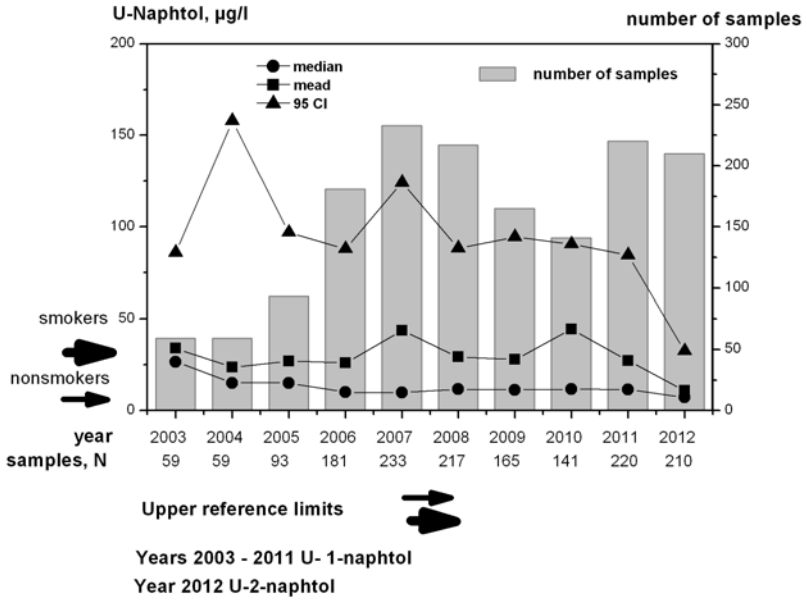
	N
Number of service analyses	210
Number of persons	163
Women	12
Men	151
Smoking	
Smokers	77 [a]
Non-smokers	102 [b]
Unknown smoking data	31 [c]
Number of workplaces	33
Workplace data missing	74

[a] of which 11 were over the URL of 30 µg/l
[b] of which 26 were over the URL of 7 µg/l
[c] of which 11 were over 7 µg/l

Naphthalene is an important ingredient in volatile PAH mixtures, e.g. in coal tar, creosote oil and in bituminous material.



U-Naphthol, concentration distribution in 2012



Urinary naphthol in 2003–2012

Nickel

Mirja Kiilunen

Urinary nickel, U-Ni

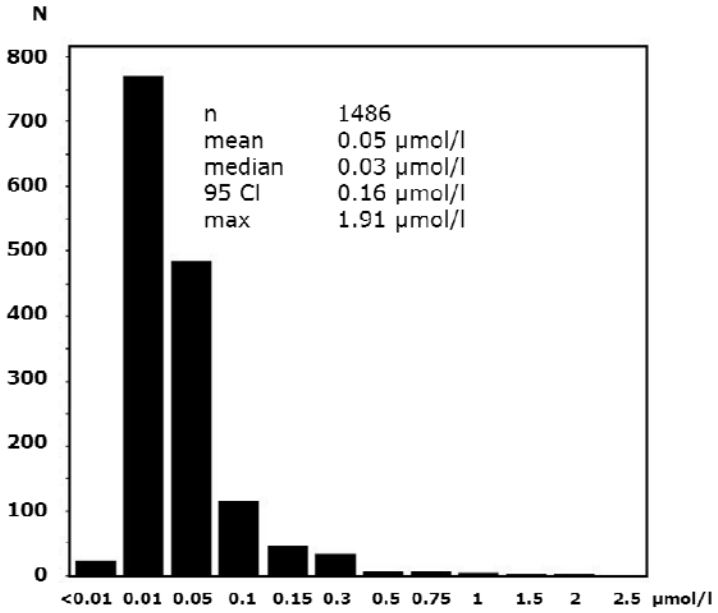
Upper reference limit	0.05 µmol/l
Target limit	0.05 µmol/l
Pregnant women should not be exposed to nickel.	

The URL and TL were exceeded in 354 samples; in various occupations in the metal industry, for example, installers, different workers in electrolytic nickel refining, grinders, welders, maintenance workers, gas cutters, plasma cutters and flame cutters, machine repairers and operators, transport workers, chrome platers and surface treatment workers, laboratory technicians, sorters and packers, metal sheet workers and welders, thermal processors, painters, mechanics, metal sprayers, metal workers, chimney sweepers, radiator recyclers, platers, drillers, cleaners, metal casting workers, electricians, foremen, founders and foundry workers, and water company workers.

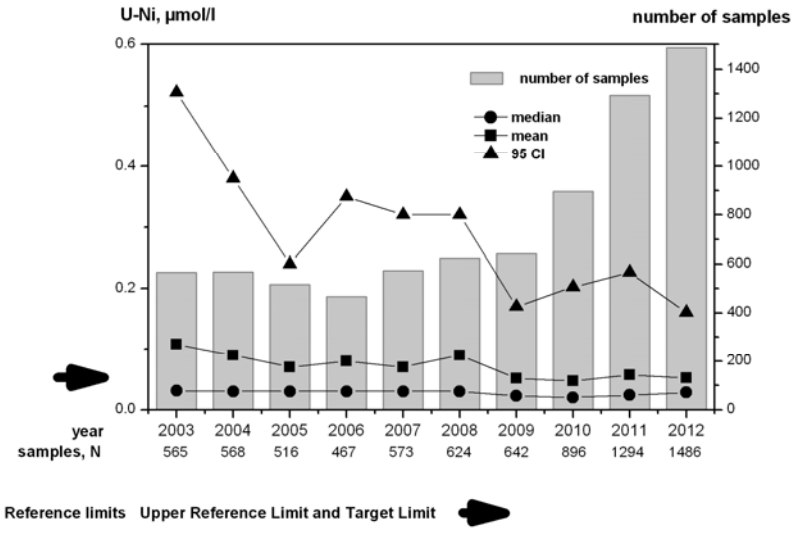
	N
Number of service analyses	1486
Number of persons	1410
Women	84
Men	1326
Number of workplaces	235
Workplace data missing	132

Over 30 000 people are exposed to nickel in Finland. The largest exposures occur in nickel ore extraction and separation, refining nickel, welding, and a variety of purification and cleaning work.

High urinary nickel concentrations have grown even further due to increased control. However, the amount of high urinary nickel concentrations in nickel refining has declined considerably in recent years.



U-Ni, concentration distribution in 2012



Urinary nickel in 2003–2012

Polychlorinated biphenyls (PCB)

Simo Porras

Polychlorinated biphenyls in fasting serum, fS-PCB

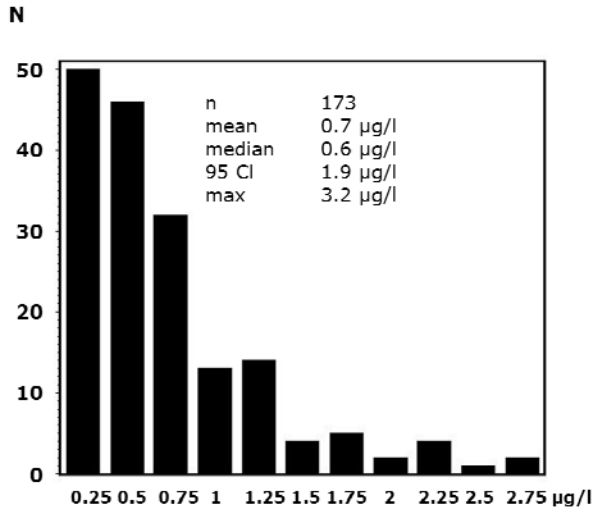
Upper reference limit	Sum of 24 chlorobiphenyl isomers, 2 µg/l*
Biomonitoring action limit	Not established.
Pregnant women should not be exposed to PCB.	

*The URL was 3 µg/l until 31.3.2012.

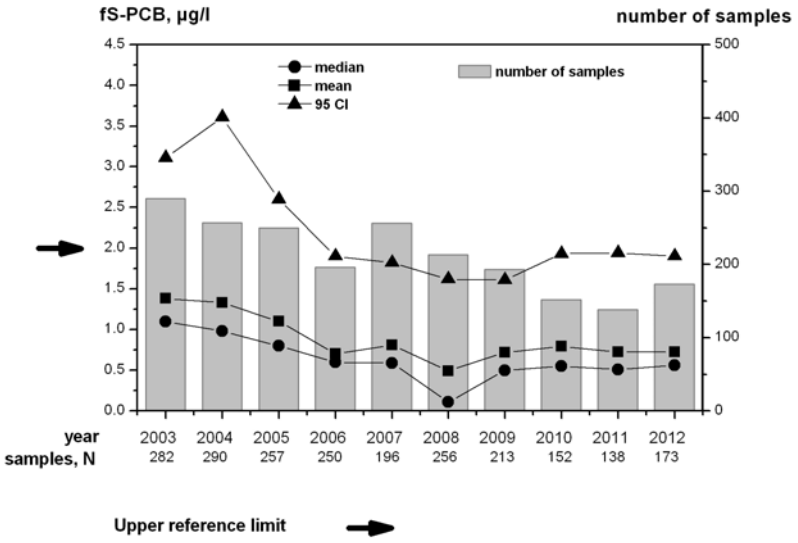
The URL of 2 µg/l was exceeded in two samples; in, for example, the exposure of a machine installer.

	N
Number of service analyses	173
Number of persons	169
Women	9
Men	160
Number of workplaces	10
Workplace data missing	40

PCBs are chemically stable; they accumulate in the body during long-term exposure and are eliminated slowly. Their use has been banned in Finland since 1990. Exposure to PCBs may still occur in hazardous waste treatment, renovation of buildings and contaminated soil treatment.



fS-PCB, concentration distribution in 2012



Polychlorinated biphenyls in fasting serum in 2003–2012

Pyrene and mixtures of polycyclic aromatic hydrocarbons (PAH)

Sinikka Vainiotalo

Urinary 1-Pyrenol, U-Pyr

Upper reference limit	0.8 µg/l
Biomonitoring action limit	2.6 µg/l*
Pregnant women should not be exposed to PAH compounds.	

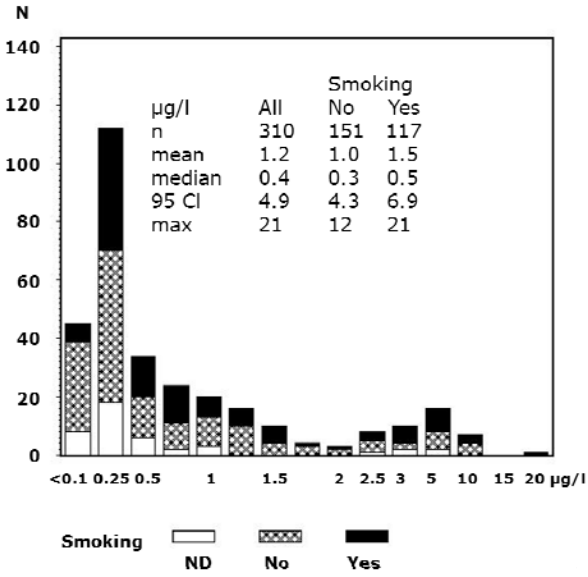
* The BAL was set in 2011 and in 2012 the unit was changed to µg/l.

The URL was exceeded in 102 samples; in, for example, cable installation to creosote impregnated poles, creosote impregnation, refurbishment of track and gear work, foundry and coke oven work, chimney sweeping work, welding and in hazardous waste treatment.

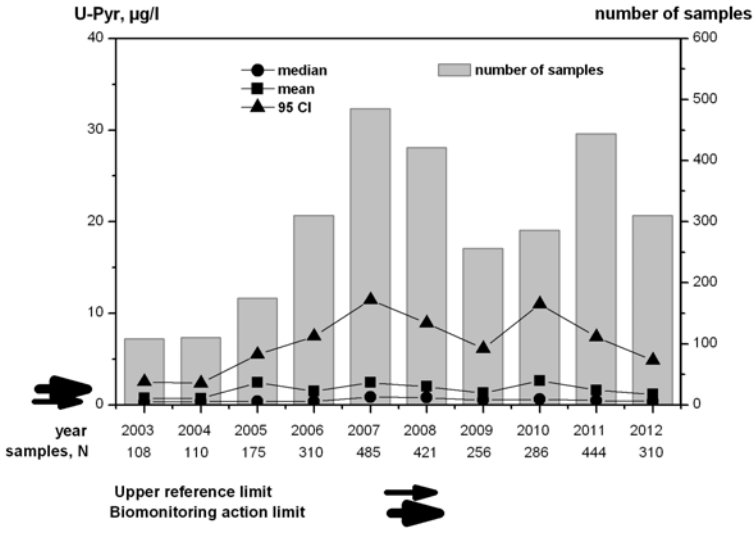
The BAL 2.6 µg/l was exceeded in 35 samples, which were mainly originated from network installers, creosote impregnators, track and gear workers, coke oven workers, and chimney sweeps.

	N
Number of service analyses	310
Number of persons	260
Women	14
Men	246
Smoking	
Smokers	117
Non-smokers	151
Unknown smoking data	42
Number of workplaces	40
Workplace data missing	67

Smoking increases urinary 1-pyrenol concentration by about 0.2 µg/l. PAH compounds are readily absorbed by the body and significantly so via the skin. The highest exposures in 2012 were caused by exposure to creosote in track and gear refurbishment work and in coke oven and chimney sweeping work.



U-Pyr, concentration distribution in 2012



Urinary pyrenol in 2003–2012

Phenol

Jouni Mikkola

Urinary phenol, U-Fenol

Upper reference limit	0.15 mmol/l
Biomonitoring action limit	1.3 mmol/l
Biomonitoring action limit during pregnancy	0.15 mmol/l

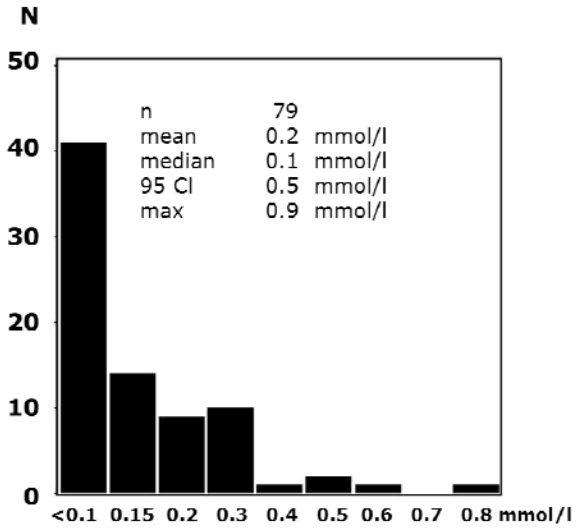
The URL was exceeded in 31 samples, which were mainly originated from resin sprayers, preliminary typesetters, typesetters, impregnators, machine operators, typesetting machine users and press workers.

The BAL was not exceeded.

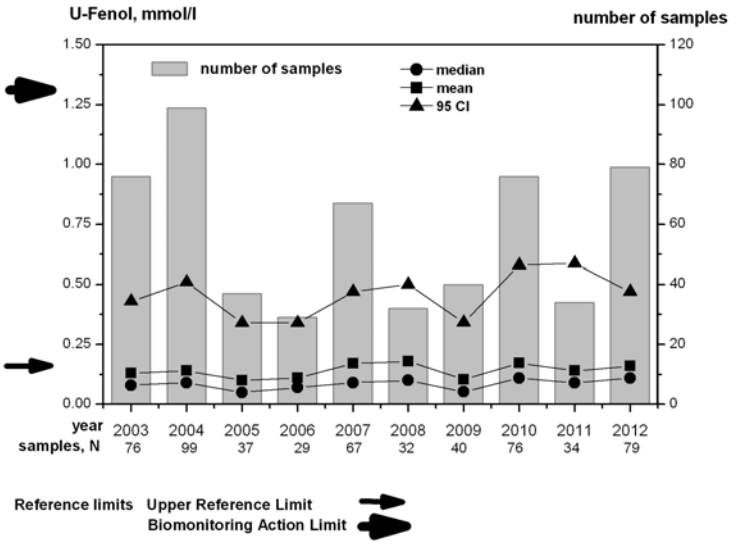
	N
Number of service analyses	79
Number of persons	53
Women	15
Men	38
Number of workplaces	9
Workplace data missing	4

The highest phenol concentrations are usually measured in dermal exposure. Average exposure has remained near the URL in recent years. High urinary concentrations of phenol have been observed through exposure to phenol liquid splashes in particular. BAL exceedances are rarely observed. The number of samples has varied significantly over recent years.

The BAL of urinary phenol at the end of a work shift has been set by the Ministry of Social Affairs and Health (Ministry of Social Affairs Regulation 1213/2011).



U-Phenol, concentration distribution in 2012



Urinary phenol in 2003–2012

Selenium

Mirja Kiilunen

Urinary selenium, U-Se

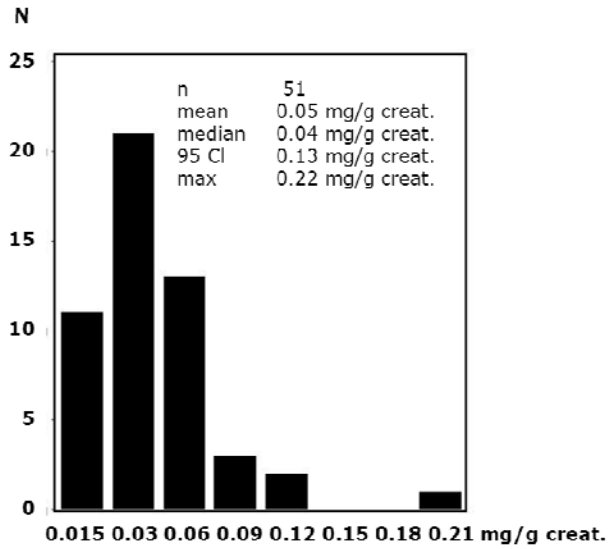
Upper reference limit	0.07 mg/g creatinine*
Biomonitoring action limit	Not established.
Pregnant women should not be exposed to chromium.	

* The URL is 0.07 mg/g creatinine since 1.4.2012. This is equivalent to ~ 1.16 µmol Se/l.

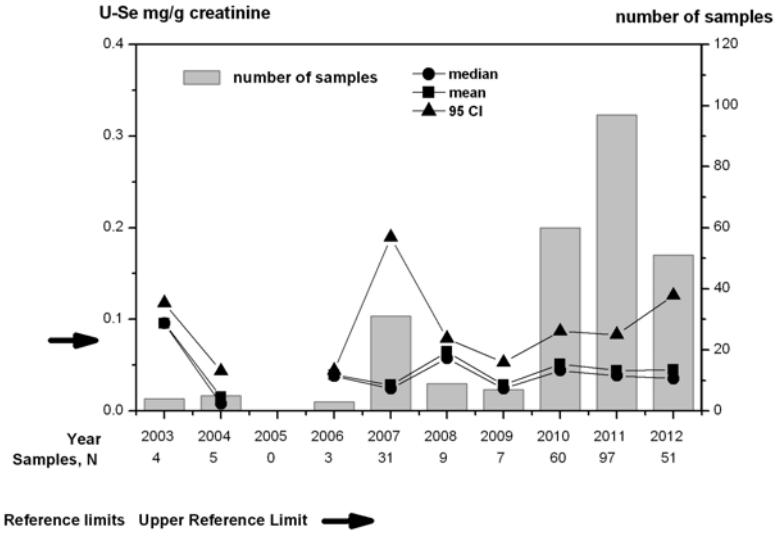
The URL of 0.07 mg/g creatinine was exceeded in seven samples; in, for example, packaging and loading fertilizer and in various tasks in glass manufacture. One worker's task was unknown.

	N
Number of service analyses	51
Number of persons	48
Women	4
Men	44
Number of workplaces	3
Workplace data missing	16

Workers are exposed to selenium in the electronics industry, especially in the manufacture of optical fibres. Exposure also occurs when selenium is used as a colouring agent for glass manufacture and in the fertilizer industry. Selenium is relative of sulphur, and occurs in nature in various pyrite and copper sulphide ores.



U-Se, concentration distribution in 2012



Urinary selenium 2003–2012

Styrene

Jouni Mikkola

Urinary mandelic and phenylglyoxylic acids, U-MaPGa

Upper reference limit	0.2 mmol/l
Biomonitoring action limit	1.2 mmol/l
Biomonitoring action limit during pregnancy	0.2 mmol/l

The URL was exceeded in 222 samples, which were mainly originated from lamination workers, reinforced plastic workers and finishers.

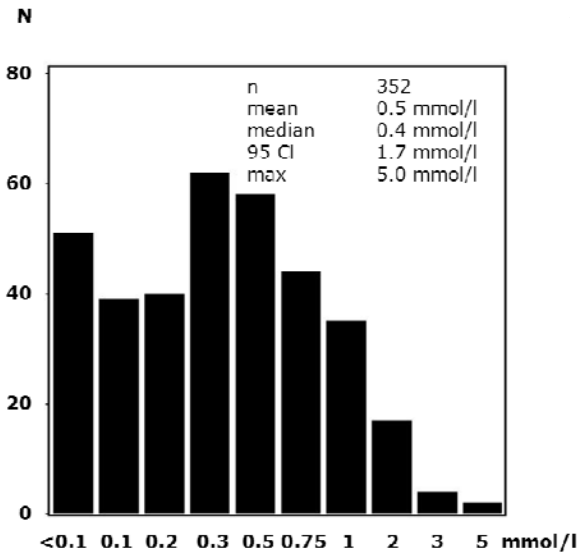
The BAL was exceeded in the exposure measurements of 35 lamination workers, painters, sprayers, machine operators, directors, and entrepreneurs.

	N
Number of service analyses	352
Number of persons	331
Women	24
Men	307
Number of workplaces	46
Workplace data missing	15

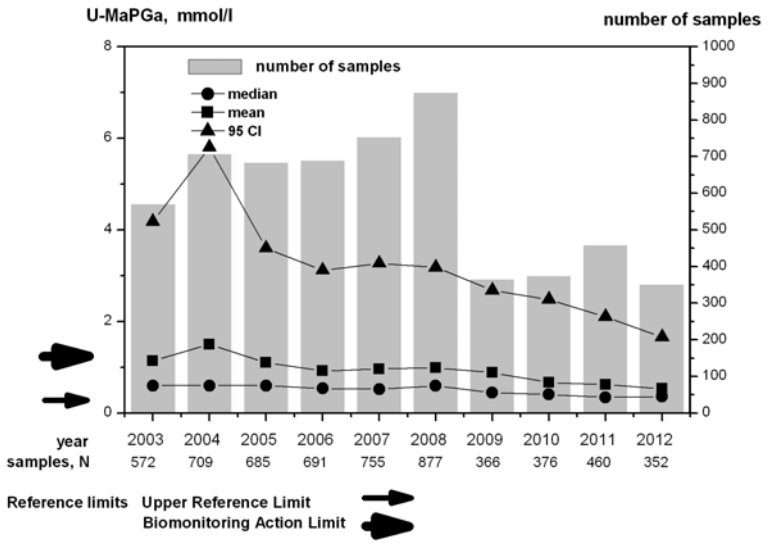
It is estimated that over 3000 employees are exposed to styrene in Finland. Biomonitoring is most common in reinforced plastic work. About 20–30 % of all service measurements were over the BAL in the early 2000s. The trend is downward, as BAL exceedences in 2009–2011 remained at less than 20% of the analysed service samples. In 2012, the BAL exceedences were only 10% of the total samples. At the same time the highest levels have decreased considerably: (2004: 95 CI was 5.5 mmol/l and maximum 20 mmol/l; 2012: 95 CI was 1.7 mmol/l, max 5.0 mmol/l). The number of service samples has also decreased greatly since 2008.

In the lamination of polyester resins, about 10% of styrene evaporates into the air. In hand and spray lamination, average styrene exposure often exceeds the occupational exposure limit (OEL). When the polystyrene is machined into thermoplastic raw material the evaporation of styrene is very low.

The BAL for urinary mandelic and phenylglyoxylic acids the morning after a working day has been set by the Ministry of Social Affairs and Health (Ministry of Social Affairs Regulation 1213/2011).



U-MaPGa, concentration distribution in 2012



Urinary mandelic and phenylglyoxylic acids 2003–2012

Toluene

Simo Porras

Blood toluene, B-Tolu

Upper reference limit	50 nmol/l
Biomonitoring action limit	500 nmol/l
Biomonitoring action limit during pregnancy	50 nmol/l

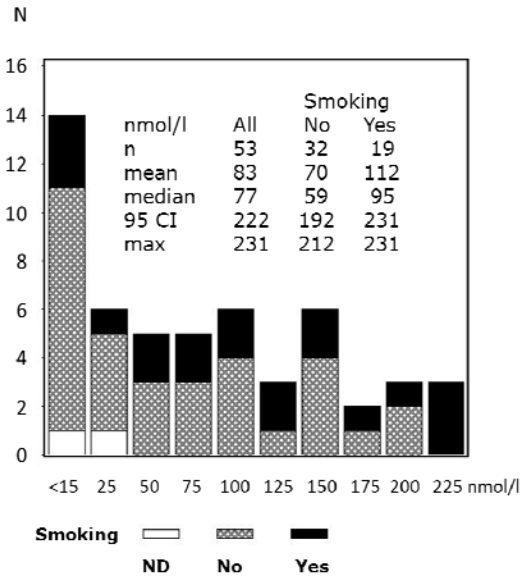
The URL was exceeded in 31 samples: in, for example, printing-related tasks.

The BAL was not exceeded.

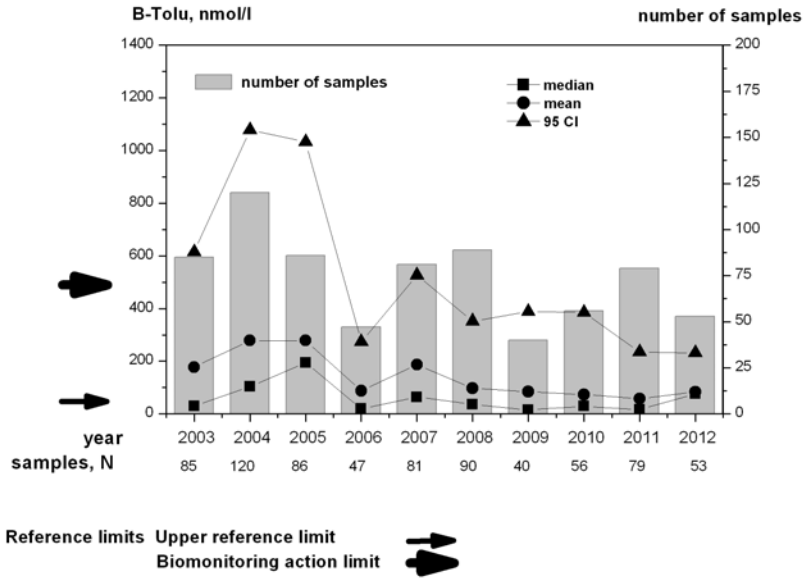
	N
Number of service analyses	53
Number of persons	52
Women	5
Men	47
Smoking	
Smokers	18
Non-smokers	32
Unknown smoking data	2
Number of workplaces	12
Workplace data missing	19

Toluene is widely used as an organic solvent. It occurs in printing inks, paints, varnishes, adhesives, cleaners and motor fuels. Toluene is also used in the manufacturing of drugs and explosives as well as in the manufacture of metal products and vehicles.

The BAL for blood toluene the morning after a working day has been set by the Ministry of Social Affairs and Health (Ministry of Social Affairs Regulation 1213/2011).



B-Tolu, concentration distribution in 2012



Blood toluene in 2003–2012

Xylenes

Jouni Mikkola

Urinary methylhippuric acids, U-Methipp

Upper reference limit	0.2 mmol/l
Biomonitoring action limit	5 mmol/l
Biomonitoring action limit during pregnancy	0.7 mmol/l

The URL was exceeded in 37 samples: in, for example, painting, powder and spray painting, varnishing, sandblasting, and surface treatment.

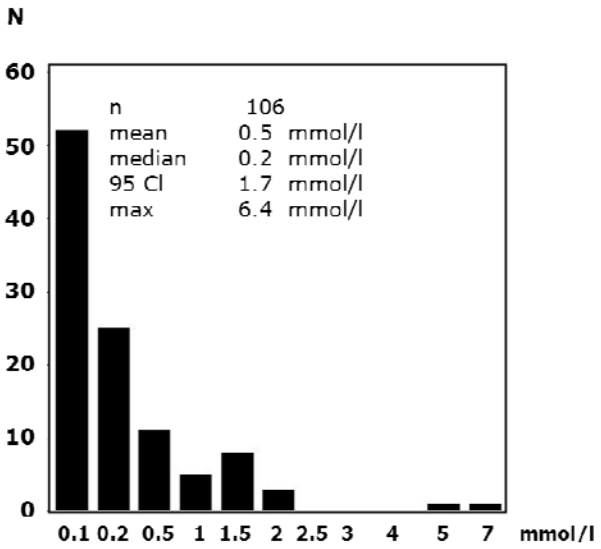
The BAL was exceeded in the exposure measurement of one painter.

	N
Number of service analyses	106
Number of persons	105
Women	13
Men	92
Number of workplaces	44
Workplace data missing	15

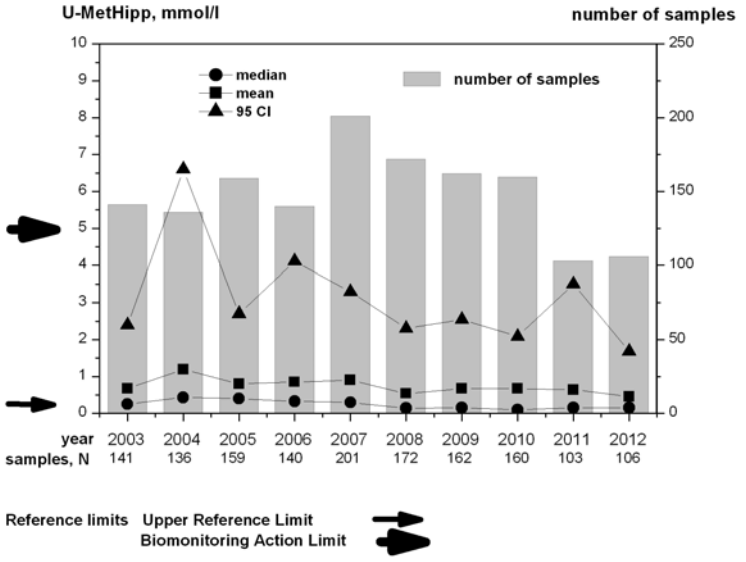
Based on the number of service samples, the number of xylene exposed workers has been declining in recent years. The proportion of samples over the URL has varied from 28–44% of all samples between 2008 and 2012 with no trend. In 2006, URL exceedances were over 63% of all samples and in 2007 over 56%. Occasional high exposures are measured each year, but the trend is downwards.

Xylene is a volatile solvent, so exposure occurs mainly by inhalation. Nevertheless, in some cases, such as in painting and surface treatment, dermal exposure may be significant.

The BAL of urinary methylhippuric acids at the end of a work shift has been set by the Ministry of Social Affairs and Health (Ministry of Social Affairs Regulation 1213/2011).



U-MetHipp, concentration distribution in 2012



Urinary methylhippuric acids in 2003–2012

Exposure to chromium and nickel in metal work, surface treatment and stainless steel welding

Mirja Kiilunen

Urinary chromium and nickel, U-METSUP, U-PINTSU, U-RSTSUP

Urinary chromium, U-Cr

Upper reference limit	0.01 µmol/l
Target limit	0.01 µmol/l
Pregnant women should not be exposed to chromium.	

Urinary nickel, U-Ni

Upper reference limit	0.05 µmol/l
Target limit	0.05 µmol/l
Pregnant women should not be exposed to nickel.	

Exposure in metal work, U-METSUP

Urinary chromium and nickel were measured simultaneously in 295 samples of a variety of metal work excluding welding. Six persons were monitored twice in 2012.

Of the workers, 281 were men and 7 women. The samples came from 71 different workplaces. Employer information was missing in thirty-three samples.

The average urinary chromium and nickel concentrations were 0.03 µmol/l and 0.04 µmol/l, respectively, and the medians 0.01 µmol/l and 0.02 µmol/l, respectively. The 95 confidence interval (CI) of urinary chromium was 0.11 µmol/l and of urinary nickel 0.13 µmol/l. The largest concentrations of urinary chromium were 0.50 µmol/l and of urinary nickel 0.88 µmol/l. The results indicate that exposure to chromium and nickel is significant for metal workers, and measures should be taken to reduce this. Average concentration levels were almost the same as the previous year, but the number of high concentrations had increased proportionately, while the maximum concentration of nickel had fallen from 1.7 µmol/l to 0.88 µmol/l. With chromium, the trend was the opposite: the highest exposure had increased from 0.35 µmol/l to 0.50 µmol/l. Although chromium and nickel concentrations in the range had a significant correlation, this was due to the large number of small concentrations and to the uniform deviation of the higher concentration.

Exposure in surface treatment, U-PINTSU

In electrolytic surface treatment, 61 platers were monitored for chromium and nickel exposure.

Five workers were monitored twice and two workers three times in 2012. The samples were originated from 14 workplaces. Employer information was missing in two samples. Of the workers, 41 were men and 15 women.

The average urinary chromium and nickel concentrations were 0.04 µmol/l and 0.15 µmol/l, respectively, and the medians were 0.02 µmol/l and 0.05 µmol/l, respectively. For urinary chromium the 95 CI was 0.15 µmol/l and for nickel 0.80 µmol/l. The largest concentrations of urinary chromium and nickel were 0.37 µmol/l and 1.40 µmol/l, respectively. The results show that exposure to chromium and nickel is particularly significant in electrolytic plating. Nickel concentrations were clearly higher in 2012 than in the previous three years. No dependence was observed between urinary chromium and nickel concentrations.

Exposure in stainless steel welding, U-RSTSUP

Stainless steel welders' exposure to chromium and nickel was monitored 422 times. Twelve workers' exposure was monitored several times in 2012. The samples came from 113 different workplaces. Employer information was missing in 32 samples. Of the workers, 11 were women and 398 men.

The average urinary concentrations of chromium and nickel were 0.03 µmol/l and 0.04 µmol/l, respectively, and the median values were 0.01 µmol/l and 0.03 µmol/l, respectively. The 95 CI was 0.10 µmol/l for both urinary chromium and urinary nickel results. The highest concentration of urinary chromium was 0.50 µmol/l and of urinary nickel 0.90 µmol/l. The average of chromium and nickel concentrations remained at the same level as that of the previous year. Higher concentrations of urinary nickel were found than in the previous year, while chromium concentrations had decreased to some extent. Welders' exposure is significant, and measures should be taken to reduce this. In 2012, no correlation was found between urinary chromium and nickel concentrations in the studied group.

Table 4. Number of biomonitoring service analyses below 50 in 2012

Exposure / Analyte	Analysis	Unit	N*	Mean	Median	95 CI	Maximum
Aluminium	**S-Al**	**µmol/l**	4	0.2	0.16	0.3	0.4
Anilin	**U-Anilin**	**µmol/l**	3	0.14	0.15	0.16	0.17
Antimony	**U-Sb**	**nmol/l**	40	19	8	75	83
Beryllium	**U-Be**	**nmol/l**	22	1.6	1.7	3.3	3.4
Copper*	**U-Cu**	**µmol/l**	7	0.24	0.20	0.46	0.46
Cyanide	**U-Tiosyan**	**µmol/l**	22	115	83	279	336
Etylenebezene	**U-Mandel**	**mmol/l**	14	0.05	0.03	0.13	0.2
Fluoride	**U-F**	**µmol/l**	14	84	54	267	267
Hexamethylene-di-isocyanate	**U-HDIHDA**	**µmol/mol creat.**	1				
n-Hexane	**U-HD**	**mmol/mol creat.**	8	0.3	0.3	0.4	0.5
Methylenediphenyl-di-isocyanate	**U-MDIMDA**	**µmol/mol creat.**	26	0.2	<0.2	0.4	1.6
Methylethylketone	**U-MEK**	**µmol/l**	2[1]	-	-	-	-
Methyl-tert-butylether (MTBE)	**U-TBA**	**µmol/l**	8	0.6	0.5	1.0	1.2
2-(2-Metoxyetoxy) ethanol	**U-MEAA**	**mmol/mol creat.**	6	0.25	0.25	0.25	0.25
Molybdenum*	**U-Mo**	**nmol/l**	5	609	591	702	702
Nitrous oxide	**U-N_2O**	**nmol/l**	3	114	43	167	290
Platinum	**U-Pt**	**nmol/l**	1[1]	-	-	-	-
Pyretroids	**U-PBA**	**µmol/mol creat.**	24	0.9	0.3	3.8	5.9
Retinol binding protein	**U-RBP**	**µg/g creat.**	3	114	134	152	152
Sevofluran	**U-Sevo**	**nmol/l**	4	2.1	2.1	2.4	2.4
Tetrachlorethene	**U-PerklEt**	**µmol/l**	44	0.1	0.1	0.4	0.6
Trichloroethene (trichloroethylene)	**U-TCA**	**µmol/l**	7	18	15	29	32
Uranium	**U-U**	**nmol/l**	23	0.003	<0.001	0.019	0.022
Zinc	**U-Zn**	**µmol/l**	6	3.6	3.6	4.8	4.8

B = blood; d = 24 hours; f = fasting; P = plasma; S = serum; U = urine

[1] due to lack of samples results are not reported.

* only occupational exposure.

Table 5. Reference and action limits for analyses below 50 for monitoring occupational exposure in 2012

Analysis	Upper reference limit	Biomonitoring action limit
Serum / plasma		
S-Al	Not established.	Not established.
S-Cu	14 – 23 µmol/l [1] 13 – 21 µmol/l men [2] 12 – 28 µmol/l women [2]	Not established.
Blood		
B-AChE/ B-PChE	10% decrease from baseline	30% decrease from baseline
B-Co	0.8 µg/l[1]	7 µg/l Recommendation of the Medicines and Healthcare Products Regulatory Agency [2]
B-Cr	0.8 µg/l[1]	7 µg/l Recommendation of the Medicines and Healthcare Products Regulatory Agency [2]
B-Mn	295 nmol/l[1]	Not established.
B-Mo	1.4 µg/l[1]	Not established.
B-Ti	24 µg/l[1]	Not established.
Urine		
U-Be	15 nmol/l	Not established.
U-Cu	0.08 – 0.50 µmol/l [1] 0.14 – 1.0 µmol/l [2]	Not established.
dU-Cu	0.24 – 0.47 µmol/24 hours [1] 0.2 – 1.4 µmol/24 hours [2]	Not established.
U-F	100 µmol/l	200 µmol/l (ms) 350 µmol/l (as)

B = blood; d = 24-hours urine; f = fasting; P = plasma; S = serum; U = urine
(ms) = morning sample, (as) = after shift sample
[1] Reference value in force since 2012.
[2] Reference value introduced in 2013.

Analysis	Upper reference limit	Biomonitoring action limit
Urine		
U-HD	0.5 mmol/mol creat.	2 mmol/mol creat.
U-Mandel	0.2 mmol/l	4.0 mmol/l
U-MDIMDA and U-TDITDA	0.2 µmol/mol creat.	Not established.
U-MEAA	0.5 mmol/mol creat.	50 mmol/mol creat.
U-MEK	1.5 µmol/l	20 µmol/l
U-Mo	1340 nmol/l	Not established.
U-N_2O	20 nmol/l	700 nmol/l
U-PBa	1 µmol/mol creat.	Not established.
U-Pt	3.5 nmol/l	Not established.
U-Sb	9 nmol/l	Not established.
U-Se	0.07 mg/g creat. [2]	Not established.
U-Sevo	1.5 nmol/l	30 nmol/l
U-TBA	1 µmol/l	30 µmol/l
U-TCA	50 µmol/l	120 µmol/l
U-Ti	680 nmol/l	Not established.
U-U	0.03 µg/g creat. [2]	Not established.
U-Zn	8 – 12 µmol/l [1] 1 – 12 µmol/l [2]	Not established.

B = blood; d = 24-hours urine; f = fasting; P = plasma; S = serum; U = urine (ms) = morning sample, (as) = after shift sample
[1] Reference value in force since 2012.
[2] Reference value introduced in 2013.

Table 6. Changed reference values in 2013

Analysis	Old upper reference limit		New upper reference limit (2013)	
fS-PCB	3	µg/l	2	µg/l
S-In	<0.1	µg/l	0.02	µg/l
S-Cu	14 – 23	µmol/l	13 – 21	µmol/l men
			12 – 28	µmol/l women
S-Tiosyan	100	µmol/l (non-smokers)	110	µmol/l
U-Co	40	nmol/l	25	nmol/l
U-Cu	0.08 – 0.50	µmol/l	0.14 – 1.0	µmol/l
dU-Cu	0.24 – 0.47	µmol/24 hours	0.2 – 1.4	µmol/24 hours
U-Mn	40	nmol/l	10	nmol/l
U-Naftol	30	nmol/l (non-smokers)	7	µg/l (non-smokers)
	300	nmol/l (smokers)	30	µg/l (smokers)
U-Phenol*	0.15	mmol/l	0.2	mmol/l
U-Pb	0.015	µmol/l	0.008	µmol/l
U-Pyr	3	nmol/l	0.8	µg/l
U-Se	0.30	µmol/l	0.07	mg/g creat.
U-TCA*	50	µmol/l	30	µmol/l
U-Tiosyan	85	µmol/l (non-smokers)	140	µmol/l (non-smokers)
U-U	0.08	µg/g creat.	0.03	µg/g creat.
U-V	50	nmol/l	7	nmol/l
fP-Zn	10 – 20	µmol/l	7 – 14	µmol/l
U-Zn	8 – 12	µmol/l	1 – 12	µmol/l

Analysis	Old biological action limit		New biological action limit (2013)	
B-Hb-CO*	0.050 (= 5 %)		0.040 (= 4 %)	
U-Al	6.0	µmol/l	3.0	µmol/l
U-Co	600	nmol/l	130	nmol/l
U-Cr*	<0.01	µmol/l	0.20	µmol/l
U-Mandel*	5.2	mmol/l	4.0	mmol/l
U-MDA*	50	µmol/mol creat.	5	µmol/mol creat.
U-Ni*	<0.05	µmol/l	0.20 µmol/l water soluble compounds	
			0.10 µmol/l slightly soluble compounds	
U-Pyr	12	nmol/l	2.6	µg/l
U-TTCA*	2.0	mmol/mol creat.	1.0	mmol/mol creat.

*Introduced in 1.11.2013.

ACKNOWLEDGMENTS

This book is based on the biomonitoring service activities of the Finnish Institute of Occupational Health. Many people have participated in these activities. My warmest thanks to them all for their work. Alice Lehtinen revised the language of the book.

Chemical exposure can be evaluated through industrial hygiene measurements or biomonitoring. Biomonitoring workers' exposure usually involves a blood or urine sample, from which the exposing substance, its metabolites or a physiological response are measured. Biological monitoring takes into account individual differences in exposure; absorption through all three routes: the skin, inhalation, and the gastrointestinal tract; and accumulation through both long-term and repeated exposure.

In 2012, almost 25 000 samples were analysed. The separate chapters on the quantitatively most important chemicals include the distribution of measured concentrations, the most heavily exposed jobs, the main statistical values, and the follow-up of exposure in the last ten years.

This book of statistics facilitates the comparability of chemical exposure in different workplaces and jobs, and helps reduce workers' further exposure to chemicals that are hazardous to health. These results prove that the need for biomonitoring remains indisputable.

Finnish Institute of Occupational Health
Chemical Safety
Topeliuksenkatu 41 a A, 00250 Helsinki

www.ttl.fi

ISBN 978-952-261-357-8 (PDF)

Finnish Institute of Occupational Health