Title: Proficiency Testing for Measurement of Total Mass and Elements in Workplace Air Filters. Round 8.

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Summary:

In this proficiency testing programme laboratories from England, Lithuania, Finland, Sweden, Denmark and Norway have participated.

Filters and cassettes were distributed to the laboratories in March 2000. The laboratories were asked to pre-weigh the filters prior to exposure to welding fume, and to return the prepared filter cassettes by 7th of April 2000. Realistic work-room air and synthetically produced reference filters were distributed to the participants in May 2000 with a deadline for replies of 16th of June 2000.

The laboratories were asked to measure a number of occupational important elements listed in the enclosed protocol (Ag, Al, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Ti, Zn*)* and total mass.

Four out of the thirteen laboratories completed the analytical protocol with a performance complying with the assessment criteria.

Stikkord: Interkalibrering, grunnstoffbestemmelse, gravimetri arbeidsatmosfære

Key words: Proficiency testing, elements, total mass, workroom air filters

CONTENTS

SUMMARY

The purpose of this proficiency testing programme is to assess the performance of methods used for routine measurements by commercial, public and industrial laboratories.

Filters and cassettes were distributed to the laboratories in March 2000. The laboratories were asked to pre-weigh the filters prior to exposure to welding fume, and to return the prepared filter cassettes by 7th of April 2000. Welding fume filters (Series V) and synthetically produced reference filters (Series C) were distributed to the participating laboratories in May 2000.

In order to determine the "true" quantities of total mass and elements on the filters, randomly selected parallel filters from each filter series were analysed at the National Institute of Occupational Health in Oslo. The reference values for Series V (welding fume) were based on the results using ICP-AES. The reference values for Series C (reference filters) were calculated and the theoretical values verified by chemical measurements.

In this round of the proficiency testing programme, thirteen laboratories from England, Lithuania, Finland, Sweden and Norway have participated. Each laboratory was asked to determine a total of fourteen elements in two filter matrices (Ag, Al, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Ti, Zn) and total mass on the welding fume filters. Four out of the thirteen laboratories completed the analytical protocol with a performance complying with the assessment criteria.

The inter-laboratory variance for the individual elements after rejection of outliers shows good agreement among the participants.

ABBREVIATIONS

EAAS:	Electrothermal Atomic Absorption Spectrometry
FAAS:	Flame Atomic Absorption Spectrometry
ICP-AES:	Inductively Coupled Plasma Atomic Emission Spectrometry
ICP-OES:	Inductively Coupled Plasma Optical Emission Spectrometry
ICP-QMS:	Inductively Coupled Plasma Quadropole Mass Spectrometry
ICP-MS:	Inductively Coupled Plasma Mass Spectrometry
RSD:	Relative Standard Deviation
SD:	Standard Deviation

1. INTRODUCTION

The National Institute of Occupational Health in Oslo is the national reference laboratory for work environment measurements in Norway, as well as a regional laboratory for the Labour Inspectorates. As a national reference laboratory one of the objectives is to carry out proficiency testing programmes for work environment measurements in commercial, public and industrial laboratories.

There is no official approval scheme for laboratories which offer work environment measurement services in Norway, but the Governmental Labour Inspectorate requests all laboratories to participate in the proficiency testing programmes organised by the National Institute of Occupational Health. Participation is voluntary, and the laboratories are informed in advance that the results will be published with identification of the participants. The purpose of this proficiency testing programme is to assess the laboratory performance using routine procedures. The laboratories were therefore requested to include the samples in their normal analytical routine.

In this round measurements of total mass was included in the testing programme. Filters and cassettes were distributed to the laboratories in March 2000. The laboratories were asked to pre-weigh the filters prior to exposure to welding fume, and to return the prepared filter cassettes by 7th of April 2000. The prepared samples were distributed in May 2000, with a deadline for replies of 16th of June. Each participant received duplicates of work-room air filters (Series V), reference filters spiked with known quantities of selected elements (Series C) and blank filters. The laboratories were asked to measure total mass (Series V) and the elements listed in the enclosed protocol.

2. PARTICIPATING LABORATORIES

Lab.no	Name, address	Name used
1	Analyselaboratoriet, Høgskolen i Agder Serviceboks 422 N-4604 Kristiansand, Norway	Analyselaboratoriet
2	Elkem ASA Bremanger Smelteverk N-6930 Svelgen, Norway	Elkem Bremanger
3	Falconbridge Nikkelverk A/S, Hovedlaboratoriet P.O.Box 457 N-4601 Kristiansand, Norway	Falconbridge
4	Health and Safety Laboratory Broad Lane UK-Sheffield S3 7HQ, United Kingdom	HSL
5	Centre of Occupational Medicine, Institute of Hygiene Etmonu str. 3 LT-2001 Vilnius, Lithuania	Inst. of Hygiene

6	Kuopio Region Institut för Arbetshygien P.O.Box 93 FIN-70701 Kuopio, Finland	Kuopio
7	Miljø-Kemi, Dansk Miljøsenter A/S Smedeskovvej 38 DK-8464 Galten, Denmark	Miljø-Kemi
8	Molab as P.O.Box 5000 N-8601 Mo, Norway	Molab
9	National Institute of Occupational Health Lersø Parkallè 105 DK-2100 København Ø, Denmark	NIOH
10	Sero AS, Avd. Norsk Analyse Center P.O.Box 24 N-1361 Billingstad, Norway	Sero AS
11	SGAB Analytica P.O.Box 511 S-183 25 Täby, Sweden	SGAB Analytica
12	Tinfos Jernverks as, Øye Smelteverk P.O.Box 246 N-4481 Kvinesdal, Norway	Tinfos
13	West Lab AS Oljeveien 2 N-4056 Tananger, Norway	West Lab

3. SAMPLING

The multi-channel sampler unit used for the collection of replicate filter samples of welding fumes was developed at the National Institute of Occupational Health in Oslo.

To ensure constant flowrates through the filters during the sampling period each position is equipped with a critical orifice. The flowrate through each filter was measured at the start and stop of sampling using a high precision rotameter.

The parallel sampler was designed for use with 25 mm plastic filter holders (Costar - Nuclepore art.no. N-800932) with an extended connecting piece. Since these filter holders are no longer available the 25 mm plastic filter holders used in this round (Millipore art.no. M000 025 A0) were mounted to the parallel sampler using external connecting pieces. Particulate matter was collected on 0,8 µm cellulose ester membrane filters (Millipore art.no. AAWP 025 00).

In order to obtain homogeneous deposition on the filters the filter holders are open-faced. This is of particular importance for X-ray fluorescence spectrometry for the direct measurement of the analytes.

Welding fumes were generated in the workshop at the National Institute of Occupational Health in Oslo.

4. REFERENCE FILTERS

Reference filters were prepared by spiking 37 mm cellulose ester membrane filters (Millipore art.no. AAWP 037 00) with an aqueous solution containing elements with concentrations gravimetrically traceable to ultrapure metals or stoichiometrically well defined oxides. The amounts correspond to approximately threshold limit values of contaminations in workroom atmospheres (provided that the simulated filter has been exposed to one cubic meter of air) except for Mo and Zn. The reference values are based on a gravimetric procedure, i.e. weight per volume composition of the primary reference material dissolved in high purity sub-distilled acids. The uncertainties (half width of the 95% confidence intervals) for the individual elements is based on scientific judgement and represents an estimate of the combined effects of any error, attributed to gravimetric and volumetric procedures, purity of the source material and possible contamination throughout the production steps.

5. ANALYTICAL CONDITIONS

The sample preparation and analytical methods used by the participants are presented in the following table:

Laboratory	**Sample Preparation**	**Sample-volume**	**Analytical Method**
Analyselaboratoriet	HNO_3/HCl/HF in teflon autoclave with microwave assisted digestion.	50 ml	FAAS Mettler AT 261
Elkem Bremanger			
Falconbridge	H_2O, HNO_3 and HCl, hot plate digestion.	50 ml	ICP-OES Mettler AT 250
HSL	HNO_3 /HF, teflon autoclave with microwave assisted digestion.		ICP-AES
Inst. of Hygiene	HNO_3, teflon autoclave with microwave assisted digestion.		EAAS Scaltec SBC 21
Kuopio	HNO_3/HCl, teflon autoclave with microwave assisted digestion.		FAAS, EAAS
Miljø-Kemi	HNO_3, teflon autoclave with microwave assisted digestion.		ICP-AES Micro balance
Molab as	HNO_3/HCl, teflon autoclave with microwave assisted digestion.		ICP-AES Mettler AT 261
NIOH	HNO_3/HCl, teflon autoclave with microwave assisted		ICP-AES

	digestion.		
Sero	HNO_3/HCl/HF, teflon autoclave, heated in laboratory oven.	14 ml	ICP-AES
SGAB Analytica	Series C: HNO_3/H_2O_2, Series V: HNO_3/HCl/HF, both series in teflon autoclave with microwave assisted digestion.		ICP-QMS ICP-AES
Tinfos	HNO_3/HCl, teflon autoclave with microwave assisted digestion.	100 ml	FAAS Mettler AE 163
West Lab	NIOSH Method 7300.		ICP-AES

6. REFERENCE VALUES

In order to determine the "true" quantities of elements on the filters, randomly selected parallel filters from each filter series were analysed at the National Institute of Occupational Health in Oslo. Filters from both series were dissolved in 2 ml aqua regia and 0,2 ml hydrofluoric acid in teflon autoclaves with microwave assisted digestion. After cooling to room temperature all samples were diluted with ultra pure water to a volume of 25 ml.

All volumetric equipment which was used for the preparation of samples and standard solutions was volumetrically calibrated. The maximum volumetric uncertainty was 0,1 %.

All standard solutions (traceable to NIST primary certified solutions) used for instrument calibrations were matrix-matched to be as nearly as possible identical to the sample solutions in order to minimise inter-element and matrix effects.

For the measurement of total mass a semi micro balance of type Sartorius MC 210 P was used.

For the simultaneous measurement of all elements a Perkin-Elmer OPTIMA 3000 inductively coupled plasma atomic emission spectrometer (ICP-AES) was used.

The reference values for Series V (welding fumes) are based on the results using ICP-AES (elements) and semi micro balance (total mass). The results are given in Appendix 1, table 1 and 2.

The spiked analyte masses of the reference filters (Series C) are measured by weighing. Exact reference value of individual filters are obtained by using a correction factor for each filter. The theoretical values are verified by chemical measurements.

7. ASSESSMENT CRITERIA

The National Institute of Occupational Health in Oslo has drawn up proposals for assessing analytical performance. Routine measurements of workroom air filters should comply to the following criteria:

Quantity in relation to TLV	**Requirement 1 Good accuracy**	**Requirement 2 Acceptable accuracy**
>100 %	Better than ± 5 %	Better than ± 10 %
10 %	Better than ± 10 %	Better than ± 20 %
1 %	Better than ± 25 %	Better than ± 50 %

Accuracies considered «good» or «acceptable» are dependent on the relationship between the concentration in a sample and the threshold limit value (TLV) for each individual element, expressed by the following formula:

$\log y = 4{,}8*\exp(-2)*\log x^2 - 4{,}5*\exp(-1)*\log x + 1{,}4$

where x is the proportion of element in sample relative to TLV (in %)
y is requirement 1 or 2 (in %)

Analysis performed at the National Institute of Occupational Health in Oslo show that filter-to-filter variation was ≤ 1 % (relative standard deviation) for Series C and ≤ 1,5 % for Series V. In order to take filter homogeneity into account, two times the relative standard deviations is added.

The following limits emerge:

Requirement 1 or 2 + filter homogeneity (2 RSD)

Thus, instances of results falling outside the acceptable limits because of filter quality are rejected after applying Grafs and Hennings method for evaluation of extreme analytical results.

8. DETECTION LIMIT

With regard to samples from workroom atmospheres, detection limits for analytical procedures should reflect the threshold limit value for each element. Provided that the filter has been exposed to one cubic meter of air, the detection limit of the applied method of measurements must be no higher than 1% of the TLV.

Element	Threshold limit value, µg/m^3	Detection limit µg
Ag	100 (metal dust and fume)	1
Al	5000 (welding fume)	50
Be	1	0,01
Cd	20	0,2
Co	50 (fume)	0,5
Cr	500	5
Cu	100 (fume)	1
Fe	3000	30

Mn	1000 (fume)	10
Mo	5000 (soluble compounds)	50
Ni	100	1
Pb	50	0,5
Ti	5000 (titanium dioxide)	50
Zn	4000	4
Total mass	5000 (welding fume)	50

9. RESULTS

The results reported by the participating laboratories are given in Appendix 1, Table 3 (Series C) and Table 4 (Series V).

The individual results are also presented graphically in Appendix 2.
The performances of the participating laboratories are summarised in Table 1 and 2. Results complying to Requirement 1 («good accuracy») are indicated by ●, results complying to Requirement 2 («acceptable accuracy») are indicated by ❍, while results outside these two acceptance limits are indicated «not acceptable», ↙. To comply with either Requirement 1 or Requirement 2 both parallel measurements must fall within the acceptance limits.

Table 1. Summary of results: Series C - Reference filters.

		Be	Cd	Co	Mo	Ni	Pb	Zn
	Reference value, µg	**1,7**	**16,9**	**42,3**	**42,7**	**68,4**	**42,0**	**256**
1	**Analyselaboratoriet**		●	●		●	❍	●
2	**Elkem Bremanger**							
3	**Falconbridge**	↙	●	●	●	●	●	●
4	**HSL**	●	●	●	●	●	●	●
5	**Inst. of hygiene**		●			●	●	●
6	**Kuopio**		●	●		↙	●	●
7	**Miljø-Kemi**	●	●	●	●	❍	❍	●
8	**Molab as**		●	●		●	↙	●
9	**NIOH**		●				↙	●
10	**Sero**	●	●	●	●	●	●	●
11	**SGAB Analytica**	●	●	●	●	●	●	●
12	**Tinfos**	●	●	●		●	●	●
13	**West Lab**		●	●	●	●	●	●

●: «good accuracy» ❍: «acceptable accuracy» ↙: «not accepted»
«blank»: «not measured»

Table 2. Summary of results: Series V - Welding fume filters.

		Total mass	Ag µg	Al µg	Cr µg	Cu µg	Fe µg	Mn µg	Ti µg
	Reference value	**4,7 mg**	**77,7**	**57,3**	**44,8**	**21,4**	**382**	**77,4**	**27,3**
1	**Analyselaboratoriet**	●		↙	●	●	●	●	
2	**Elkem Bremanger**	●							
3	**Falconbridge**	↙	❍	❍	●	●	●	●	●
4	**HSL**	●	↙	●	●	●	●	●	●
5	**Inst. of hygiene**	●	↙	↙	●	↙	↙	●	
6	**Kuopio**			❍	●	●	●	❍	
7	**Miljø-Kemi**	●		●	●	●	●	●	●
8	**Molab as**	●		●	●	●	●	●	
9	**NIOH**				●		●	●	
10	**Sero**	●	●	●	●	●	●	●	●
11	**SGAB Analytica**	●	↙	●	●	●	●	●	●
12	**Tinfos**	●	●	●	●	●	●	●	●
13	**West Lab**	●	●	❍	●	●	●	●	●

●: «good accuracy» ❍: «acceptable accuracy» ↙: «not accepted»
«blank»: «not measured»

10. DISCUSSION

In this round of the proficiency testing programme the participating laboratories were asked to determine a total of 14 elements in two filter matrices in addition to total mass on welding fume filters. Four out of the thirteen laboratories completed the analytical protocol with a performance complying with Requirement 1 or 2.

The inter-laboratory relative standard deviations after rejection of outliers range, depending on the element, varies from 1,1 to 15% (3,4 to 13 % in Round 7). In average for all elements the deviation is 6,1 % (7,3 % in Round 7) which shows good agreement among the participants.

Quality control filters for daily use are available from the National Institute of Occupational Health, Oslo, at moderate cost. The use of these may be beneficial in further improving the quality of the laboratory measurements.

Table 3. Laboratory results for the last nine proficiency testing programmes.

Round	No of laboratories	No of elements	No of measurements	● %	❍ %	↙ %	Extreme values, %
0	9	15	185	65	21	14	**12**
1	14	22	652	56	24	20	**7**
2	12	13	372	70	17	10	**4**
3	18	11	285	68	18	13	**2**
4	20	11	201	36	21	23	**10**
5	15	9	199	79	8	13	**3**
6	16	10	153	78	15	7	**1,5**
7	10	10	115	88	6	7	**4**
8	13	15	152	87	5	8	**4**

APPENDIX

Table 1. ICP-AES measurements of welding fume filters, Series V. Randomly selected filters analysed at the National Institute of Occupational Health, Oslo

Analytical Wave-length in nm	Filter no. V13 µg	Filter no. V33 µg	Filter no. V49 µg	Filter no. V56 µg	Filter no. V57 µg	Filter no. V58 µg	Filter no. V60 µg	Filter no. V61 µg	Filter no. V62 µg	Filter no. V63 µg
Ag 328.068	74,4	76,7	77,8	76,6	77,3	75,8	75,2	74,8	75,6	74,8
Ag 338.289	74,4	76,9	77,8	76,5	77,4	75,8	75,1	74,8	75,7	74,7
Al 308.215	58,9	61,0	62,0	61,1	61,5	60,3	59,9	59,8	60,3	59,5
Al 394.401	60,7	63,0	63,7	62,9	64,0	64,0	63,1	62,7	63,8	63,3
Al 396.152	59,9	62,1	62,5	61,5	61,9	61,3	60,6	60,2	61,0	60,7
Cr 205.552	45,1	46,3	47,2	45,9	46,6	46,3	45,7	45,4	46,2	45,1
Cr 206.149	45,7	46,0	46,9	45,3	46,0	45,9	45,3	44,3	45,1	44,6
Cr 267.716	44,8	45,9	46,9	45,5	46,1	45,6	45,2	44,8	45,6	44,5
Cr 357.869	44,9	46,2	47,1	45,9	46,5	45,2	44,7	45,3	46,0	45,1
Cu 224.700	21,3	22,0	22,4	22,2	22,3	21,9	21,7	21,7	22,0	21,4
Cu 324.754	20,9	21,5	21,9	21,5	21,7	21,1	20,9	20,9	21,1	20,6
Cu 327.396	21,3	22,0	22,4	22,2	22,5	21,8	21,7	21,8	22,0	21,5
Fe 234.349	373	384	392	384	388	387	383	376	382	377
Fe 238.204	369	379	386	377	381	379	375	368	373	368
Fe 259.940	372	383	391	384	387	385	382	376	381	376
Fe 239.562	366	376	383	374	377	376	371	362	367	364
Mn 257.610	77,1	79,4	80,6	78,8	79,7	79,1	78,2	77,0	78,1	77,2
Mn 260.569	77,0	79,2	80,3	78,4	79,3	78,7	77,8	76,5	77,7	76,8
Mn 294.920	77,9	80,3	81,5	79,8	80,9	80,5	79,6	78,5	79,5	78,6
Ti 368.520	28,5	29,5	30,3	30,1	30,3	29,8	29,5	29,4	29,8	29,1
Ti 334.941	28,6	29,5	30,2	29,8	30,0	29,7	29,3	29,0	29,3	29,0
Ti 336.121	28,1	29,0	29,7	29,1	29,2	28,9	28,5	28,1	28,4	28,1

Table 2. Reference values, Series V - welding fume filters.

Filter no.	Ag µg	Al µg	Cr µg	Cu µg	Fe µg	Mn µg	Ti µg
V13	74,4	59,9	45,1	21,1	370	77,4	28,4
V33	76,8	62,0	46,1	21,8	381	79,6	29,3
V49	77,8	62,7	47,0	22,2	388	80,8	30,1
V56	76,6	61,8	45,6	22,0	380	79,0	29,7
V57	77,4	62,4	46,3	22,2	383	80,0	29,8
V58	75,8	61,9	45,8	21,6	382	79,4	29,5
V60	75,1	61,2	45,2	21,4	378	78,5	29,1
V61	74,8	60,9	45,0	21,5	371	77,3	28,8
V62	75,7	61,7	45,7	21,7	376	78,4	29,2
V63	74,7	61,2	44,8	21,2	371	77,5	28,7
Reference value	**75,9**	**61,6**	**45,7**	**21,7**	**378**	**78,8**	**29,3**
SD	**1,2**	**0,8**	**0,7**	**0,4**	**5,9**	**1,2**	**0,5**
RSD, %	**1,5**	**1,3**	**1,5**	**1,8**	**1,6**	**1,5**	**1,8**

Table 3. Results reported by the participating laboratories, Series C - Reference Filters

			Reported results							Corrected results						
Laboratory	**Filter no.**	**Correction factor**	**Be**	**Cd**	**Co**	**Mo**	**Ni**	**Pb**	**Zn**	**Be**	**Cd**	**Co**	**Mo**	**Ni**	**Pb**	**Zn**
		µg	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**	**µg**
Analyselaboratoriet	C 7	0,997		15,7	42,8		72,0	46,2	264,4		15,7	42,9		72,2	46,3	265,2
	C 27	0,999		15,8	42,8		71,5	45,5	266,5		15,8	42,8		71,6	45,5	266,8
Falconbridge	C 16	0,999	2,65	16,7	42,2	49,1	68,5	41,0	256	2,65 *	16,7	42,2	49,1	68,6	41,0	256
	C 40	1,001	2,65	16,7	42,1	49,0	69,0	41,0	256	2,65 *	16,7	42,1	49,0	68,9	41,0	256
HSL	C 18	0,999	1,68	17,2	43,3	39,7	68,7	43,7	255	1,68	17,2	43,3	39,7	68,8	43,7	255
	C 46	1,000	1,68	17,7	44,5	40,7	70,7	44,4	260	1,68	17,7	44,5	40,7	70,7	44,4	260
Inst. of Hygiene	C 12	0,997		16,00			67,00	43,10			16,05			67,20	43,23	
	C 36	0,998		16,10			67,50	43,30			16,13			67,64	43,39	
Kuopio	C 1	1,001		17	40		78	42	245		17	40		78	42	245
	C 22	0,999		17	40		80	42	246		17	40		80	42	246
Miljø-Kemi	C 9	1,001	1,67	18,0	43,2	45,3	73,9	46,9	279	1,67	18,0	43,2	45,3	73,8	46,9	279
	C 30	0,999	1,70	16,0	42,7	44,4	72,4	44,6	256	1,70	16,0	42,7	44,4	72,5	44,6	256
Molab as	C 5	0,995		15,9	41,5		64,7	49,1	233		16,0	41,7		65,0	49,3	234
	C 44	1,002		15,9	41,5		65,0	44,1	231		15,9	41,4		64,9	44,0	231
NIOH, Denmark	C 14	1,005		16,57				36,85	265,33		16,49				36,67	264,01
	C 43	0,999		16,59				40,25	264,15		16,61				40,29	264,41
Sero AS	C 20	0,998	1,72	16,7	43,8	44,1	70,4	43,1	256	1,72	16,7	43,9	44,2	70,5	43,2	257
	C 47	0,999	1,71	16,8	43,5	43,5	69,5	44,3	255	1,71	16,8	43,5	43,5	69,6	44,3	255
SGAB Analytica	C 13	0,998	1,69	16,8	43,5	42,0	68,4	41,7	262	1,69	16,8	43,6	42,1	68,5	41,8	263
	C 42	0,998	1,72	17,0	44,4	42,7	69,7	44,0	268	1,72	17,0	44,5	42,8	69,8	44,1	269
Tinfos	C 10	0,999	1,7	17,5	44,0		73,0	44,0	265	1,7	17,5	44,0		73,1	44,0	265
	C 41	0,999	1,7	17,5	43,0		73,0	42,5	265	1,7	17,5	43,0		73,1	42,5	265
West Lab	C 26	0,999		17	42	42	67	42	260		17	42	42	67	42	260
	C 38	0,996		17	43	43	68	41	260		17	43	43	68	41	261
Reference value										**1,7**	**16,9**	**42,3**	**42,7**	**68,4**	**42,0**	**256**
Uncertainty, µg										**0,01**	**0,1**	**0,1**	**0,1**	**0,1**	**0,1**	**2**
Average										**1,7**	**16,7**	**42,7**	**43,8**	**70,4**	**43,2**	**258**
SD, µg										**0,02**	**0,62**	**1,27**	**2,88**	**3,72**	**2,51**	**11,0**
RSD, %										**1,1**	**3,7**	**3,0**	**6,6**	**5,3**	**5,8**	**4,3**

*: Outlier, result rejected after applying Grafs and Hennings method for evaluation of extreme analytical results. A significance level of 95 % was used.

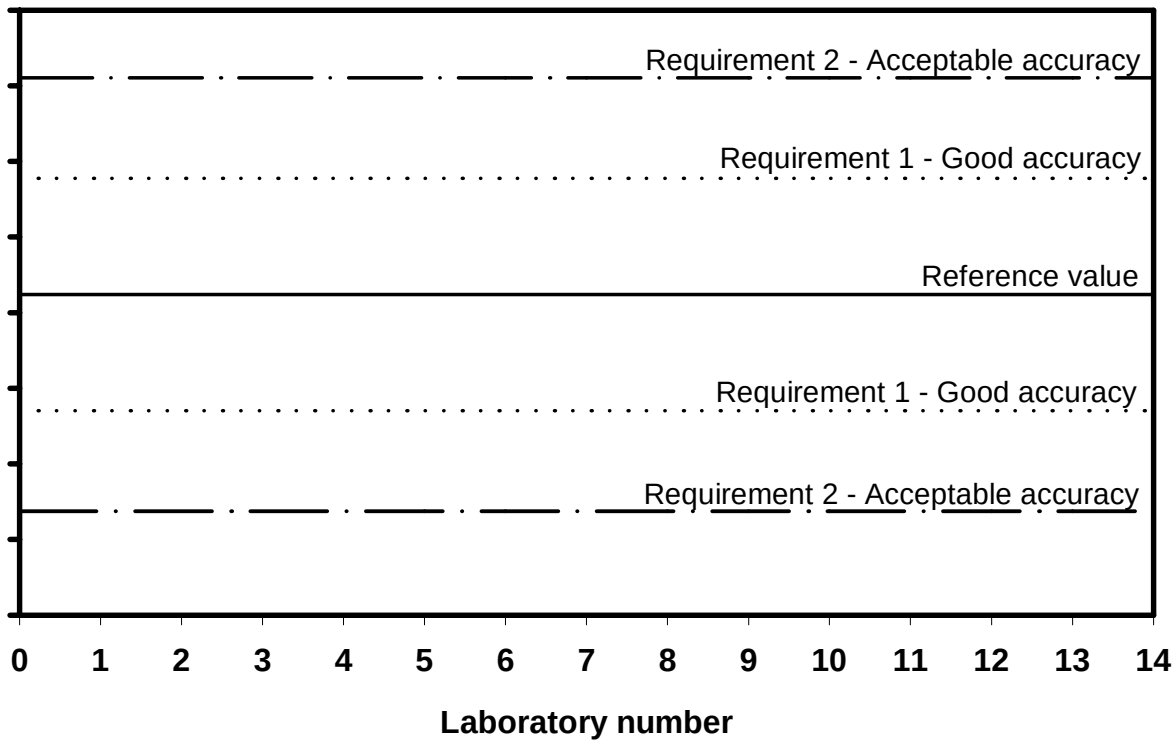
Table 4. Results reported by the participating laboratories, Series V - Welding fume filters

Laboratory	Filter no.	Total mass mg	Ag µg	Al µg	Cr µg	Cu µg	Fe µg	Mn µg	Ti µg
Analyselaboratoriet	V10	4,80		535 *	46,3	21,2	412,0	76,8	
	V14	4,79		523 *	47,8	21,9	415,5	76,3	
Elkem Bremanger	V 8	4,9							
	V 39	4,6							
Falconbridge	V 11	5,4	67,5	46,4	40,0	21,1	362	75,5	27,0
	V 28	5,4	74,0	46,1	41,4	22,4	377	78,5	28,1
HSL	V 19	4,84	17,2 *	59,2	49,1	21,5	408	83,7	31,5
	V 25	4,80	16,4 *	57,9	47,6	20,8	395	81,2	30,7
Inst. of Hygiene	V 21	4,82	12,8 *	78,25	46,00	54,6 *	300,00	83,50	
	V 38	4,60	12,5 *	74,25	47,00	53,4 *	287,00	82,00	
Kuopio	V 2			69	40	21	369	66	
	V 45			69	40	21	356	64	
Miljø-Kemi	V 22	4,65		53,4	48,7	22,2	394	83,3	26,7
	V 30	4,89		54,0	51,0	23,7	398	85,8	28,3
Molab as	V 20	4,65		58,5	46,8	21,6	370	74,6	
	V 37	4,69		60,5	44,1	21,7	385	74,0	
NIOH, Denmark	V 17				45,61		389,38	76,52	
	V 36				45,29		387,76	76,54	
Sero AS	V 1	4,75	78,9	62,6	45,8	21,8	376	77,6	29,9
	V 23	4,75	76,6	61,4	46,0	22,0	377	78,0	30,2
SGAB Analytica	V 12	4,75	2,24 *	59,0	46,2	19,3	396	77,4	30,3
	V 42	4,69	1,52 *	57,3	44,4	19,3	387	75,4	29,2
Tinfos	V 14	4,79	80,5	60,0	45,5	22,5	394	81,5	25,0
	V 47	4,90	83,0	63,0	46,5	23,0	398	84,0	25,0
West Lab	V 29	4,60	76	45	43	21	360	75	25
	V 44	4,50	71	50	40	22	350	72	24
Reference value		**4,72**	**77,7**	**57,3**	**44,8**	**21,4**	**382**	**77,4**	**27,3**
Average		**4,80**	**75,9**	**59,2**	**45,2**	**21,6**	**377**	**77,5**	**27,9**
SD, µg		**0,2**	**5,1**	**8,9**	**3,1**	**1,1**	**31,0**	**5,3**	**2,5**
RSD, %		**4,6**	**6,7**	**15,0**	**6,8**	**4,9**	**8,2**	**6,9**	**8,9**

*: Outlier, result rejected after applying Grafs and Hennings method for evaluation of extreme analytical results. A significance level of 95 % was used.

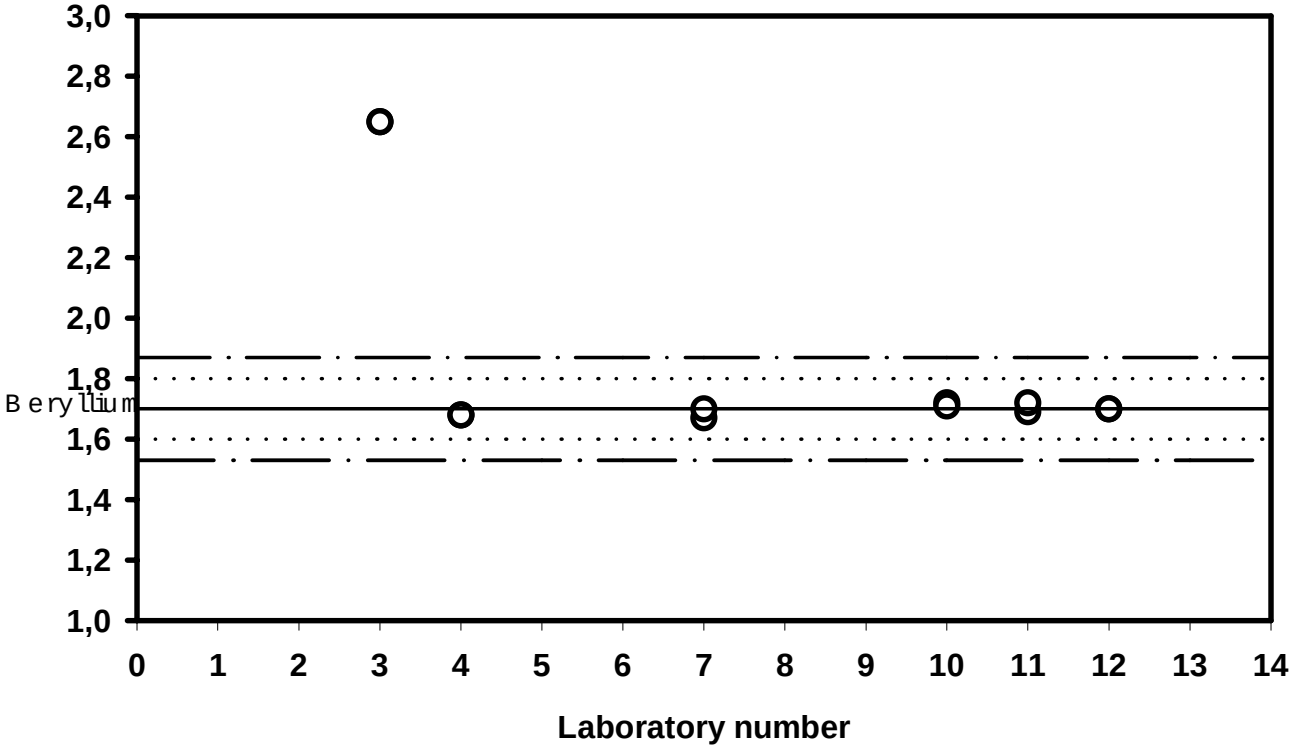
APPENDIX 2

The following figure is used to illustrate the reported values from each laboratory. The solid line represents the reference value, while the dotted lines indicate the requirements for «good» and «acceptable» results.



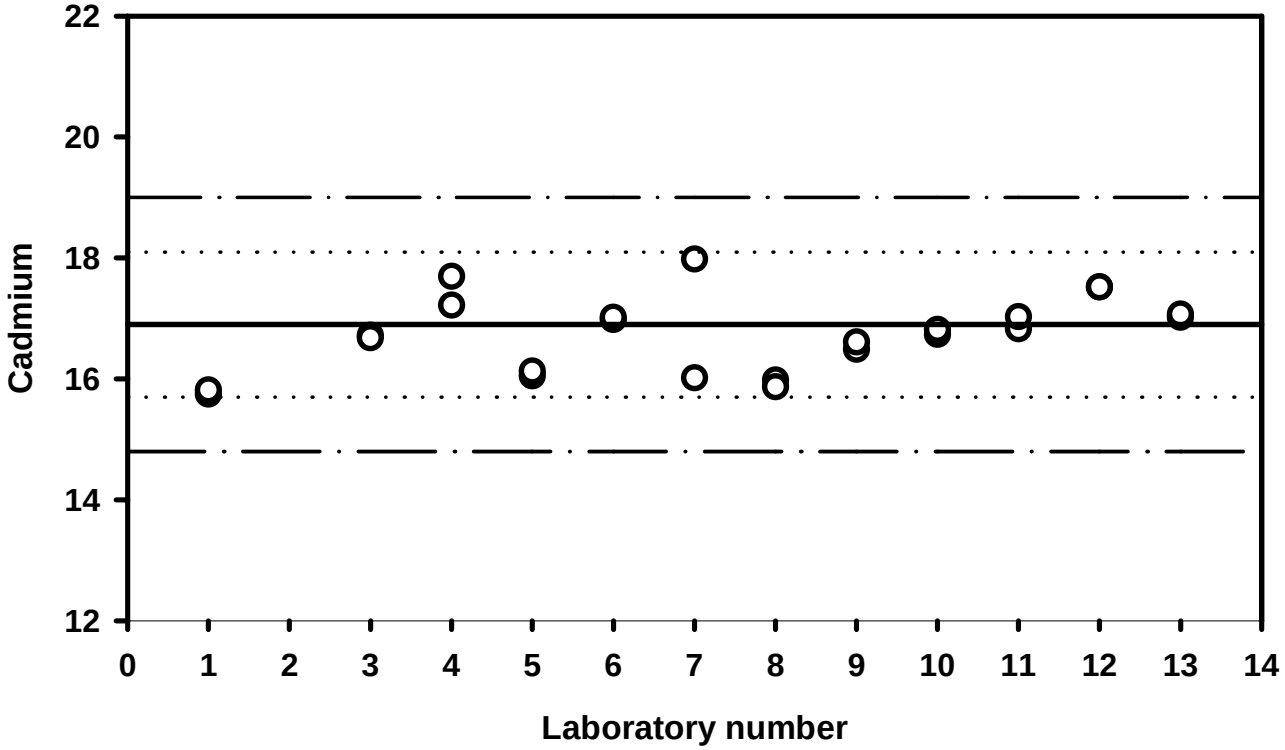
Beryllium - Series C

Reference value: 1,7 µg
Laboratory average: 1,7 µg



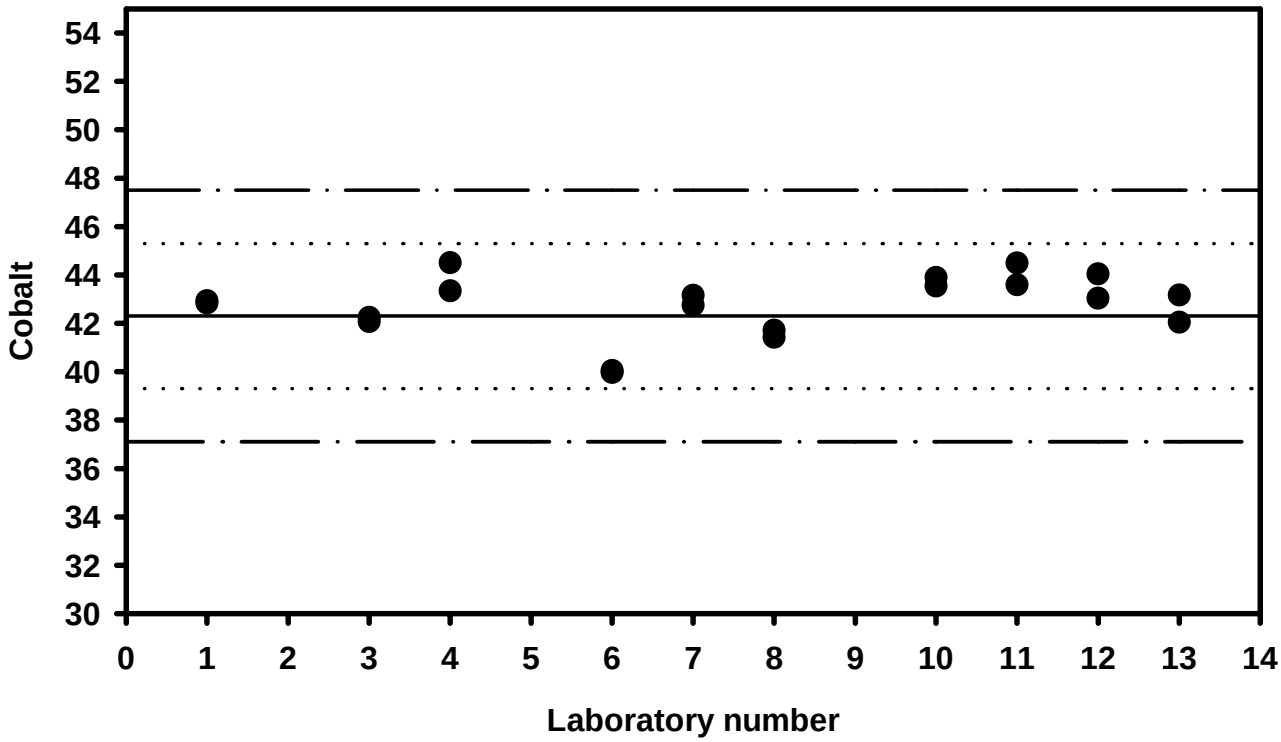
Cadmium - Series C

Reference value: 16,9 µg
Laboratory average: 16,9 µg



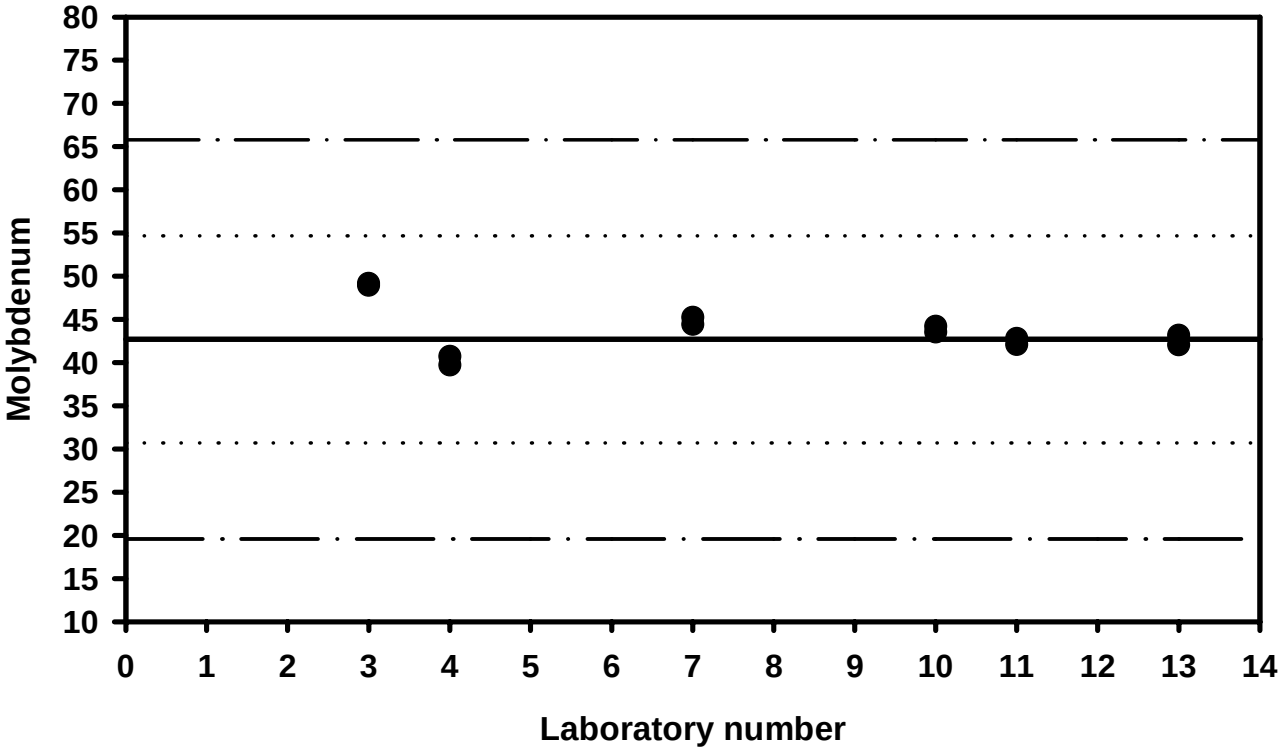
Co - Series C

Reference value: 42,3 µg
Laboratory average: 42,7 µg



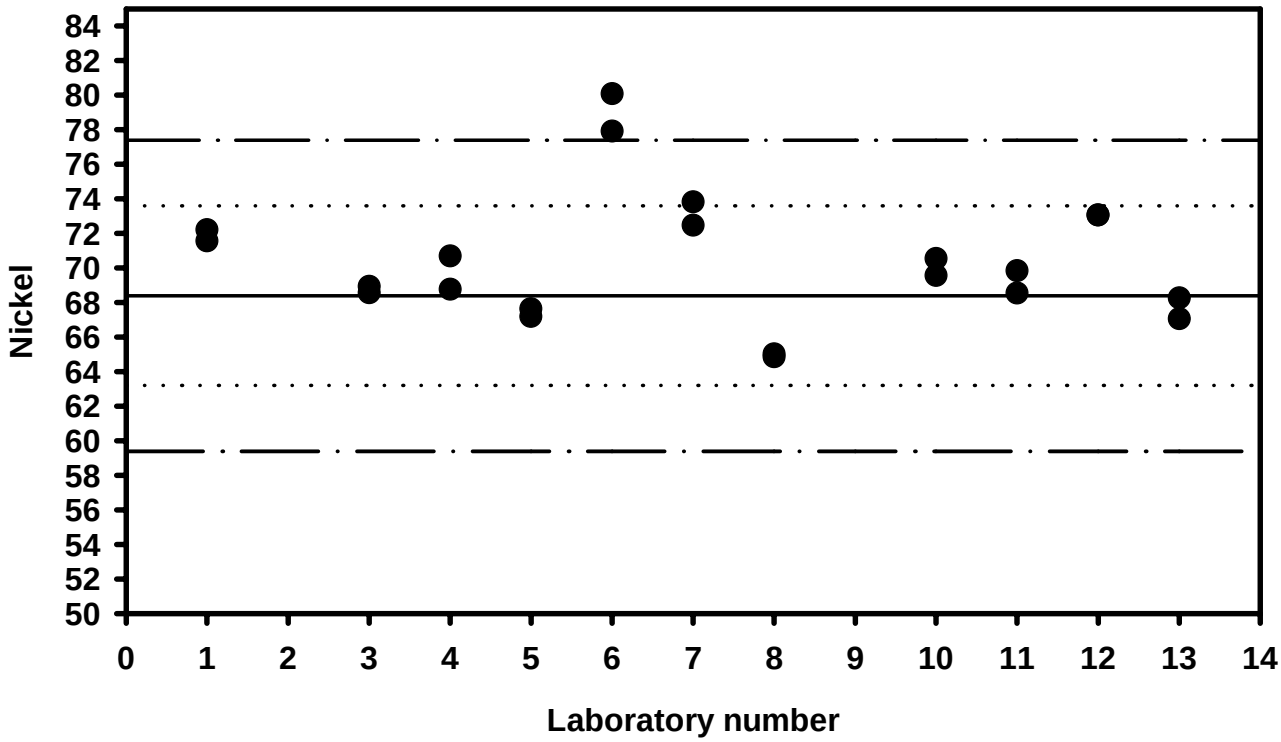
Molybdenum - Series C

Reference value: 42,7 µg
Laboratory average: 43,8 µg



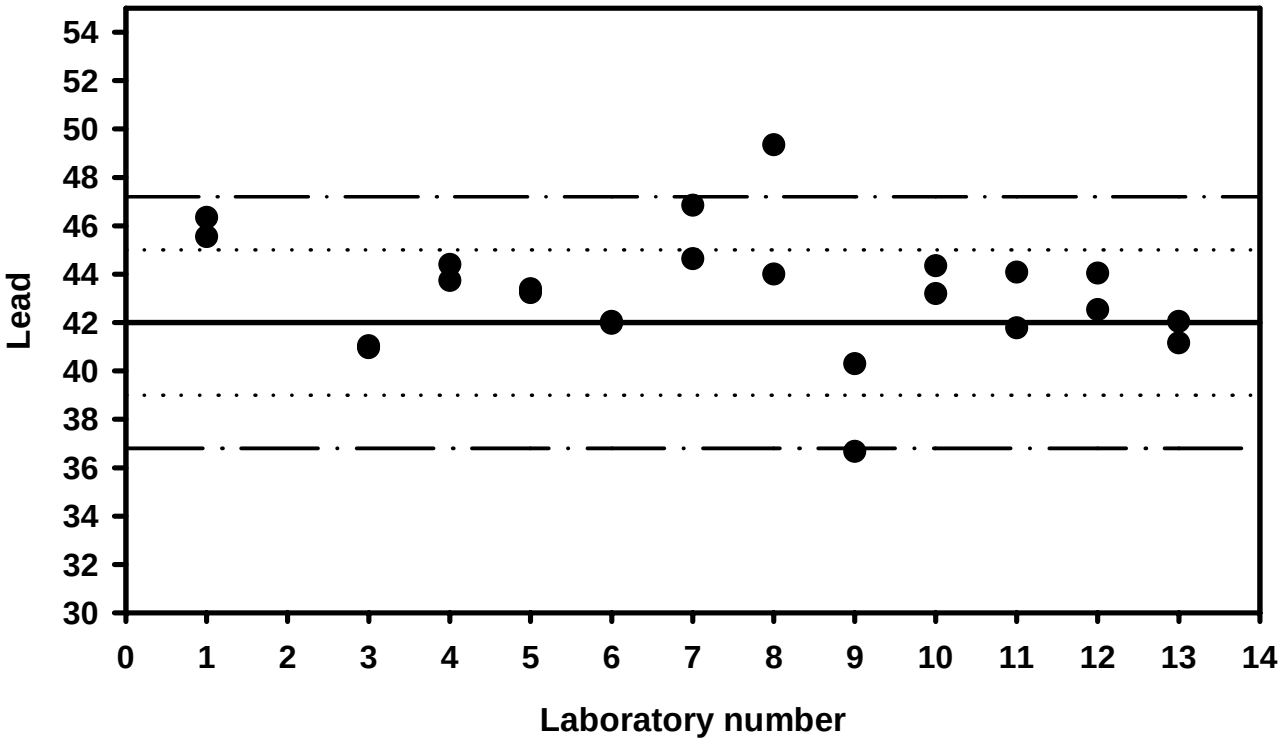
Nickel - Series C

Reference value: 68,4 µg
Laboratory average: 70,4 µg



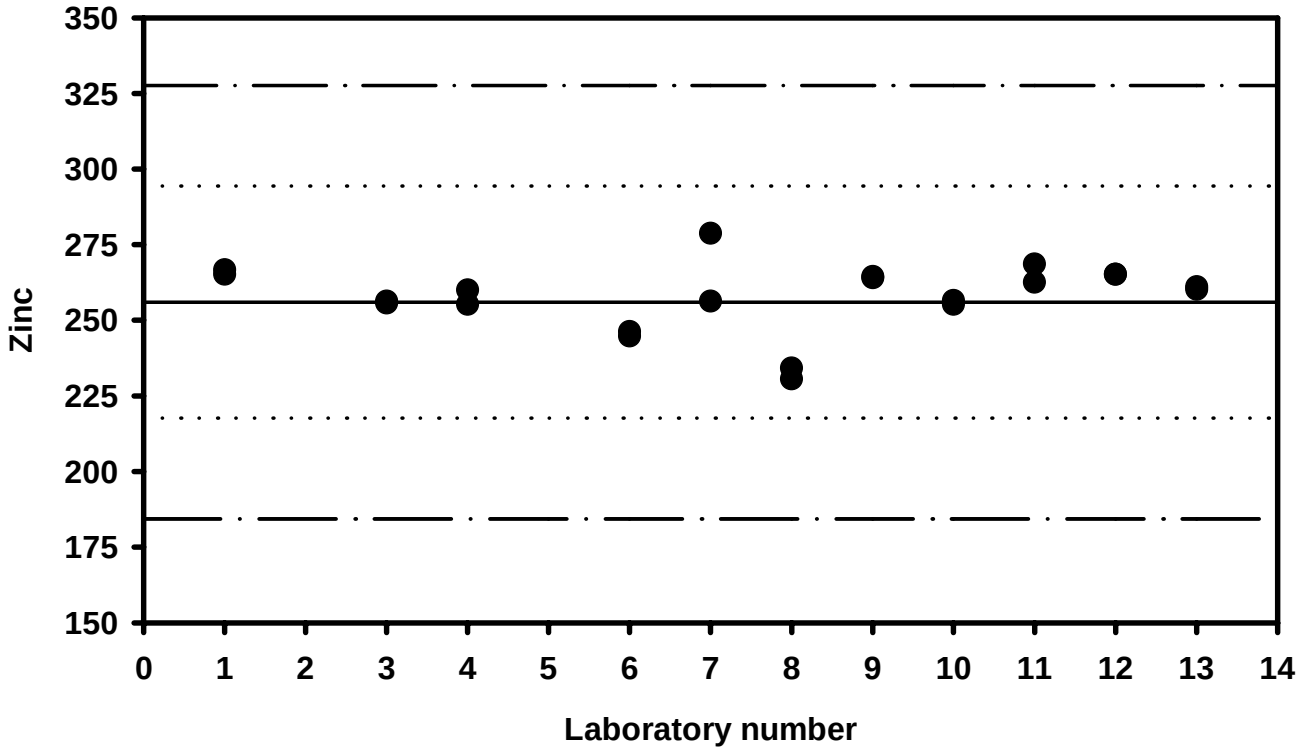
Lead - Series C

Reference value: 42,0 µg
Laboratory average: 43,2 µg



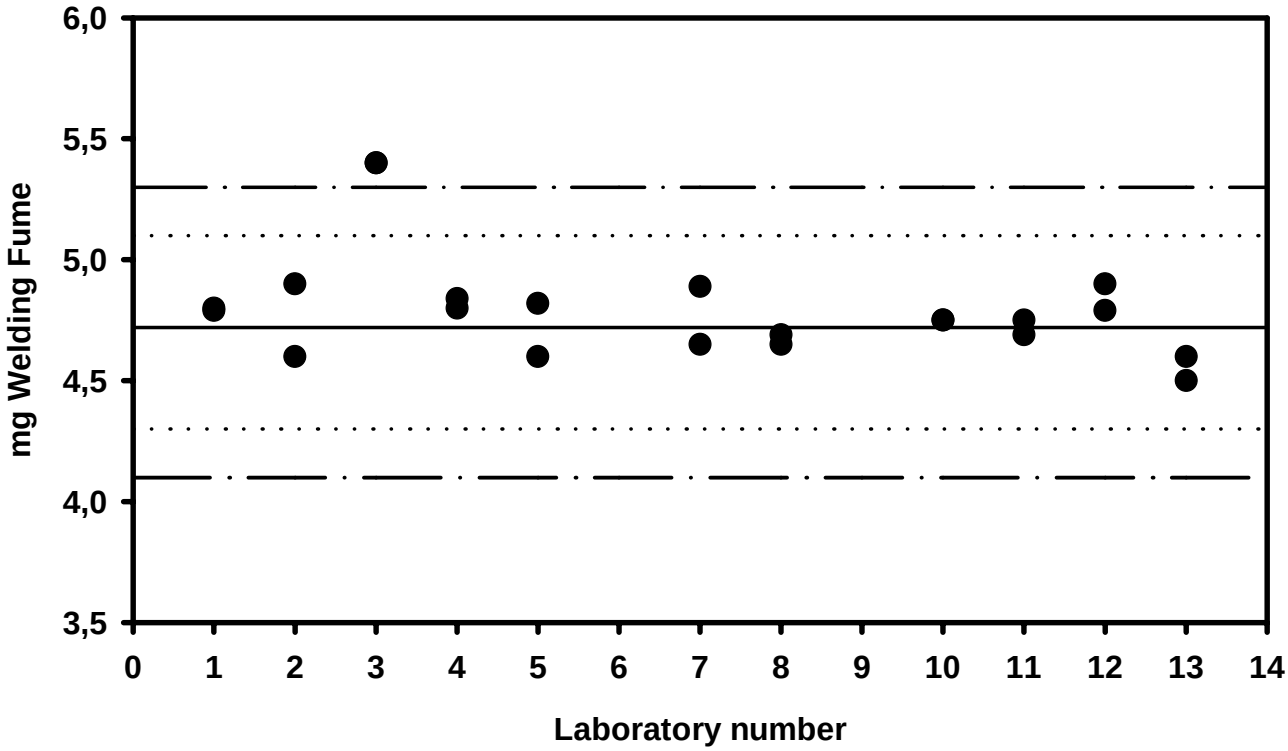
Zinc - Series C

Reference value: 256 µg
Laboratory average: 258 µg



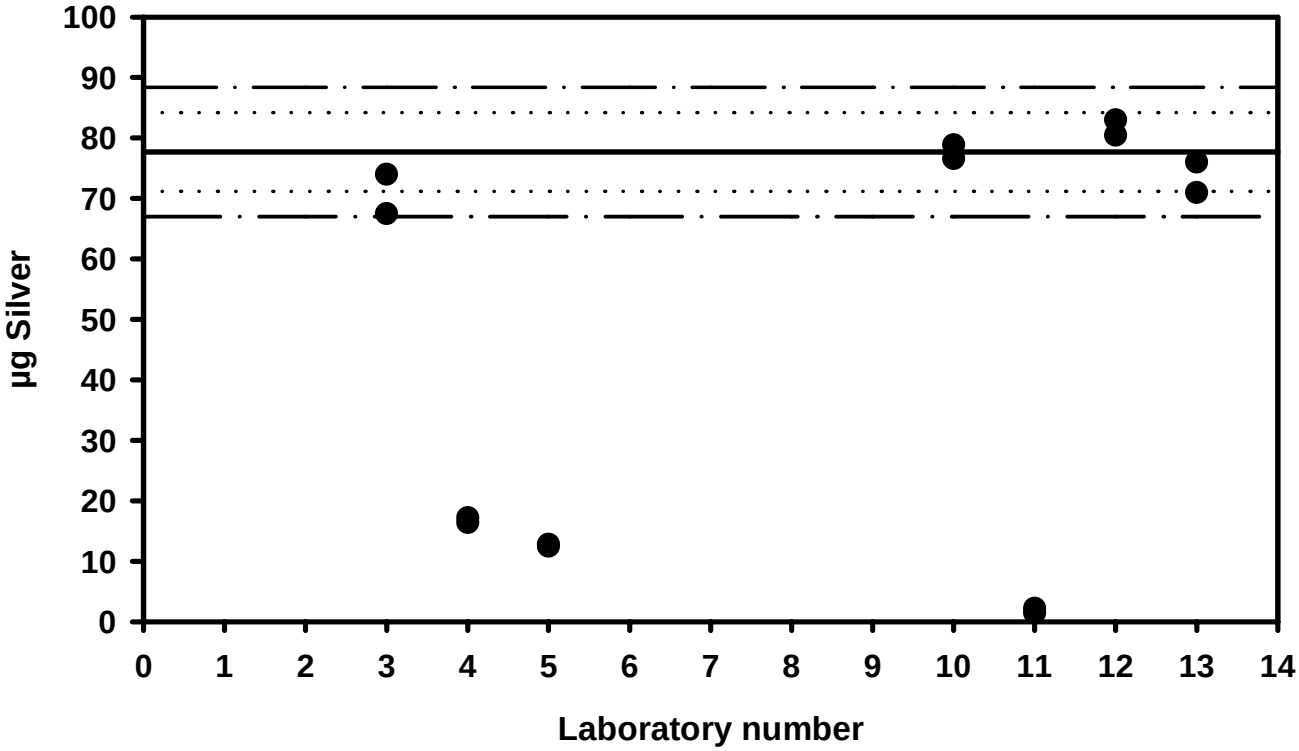
Total Mass - Series V

Reference value: 4,7 mg
Laboratory average: 4,8 mg



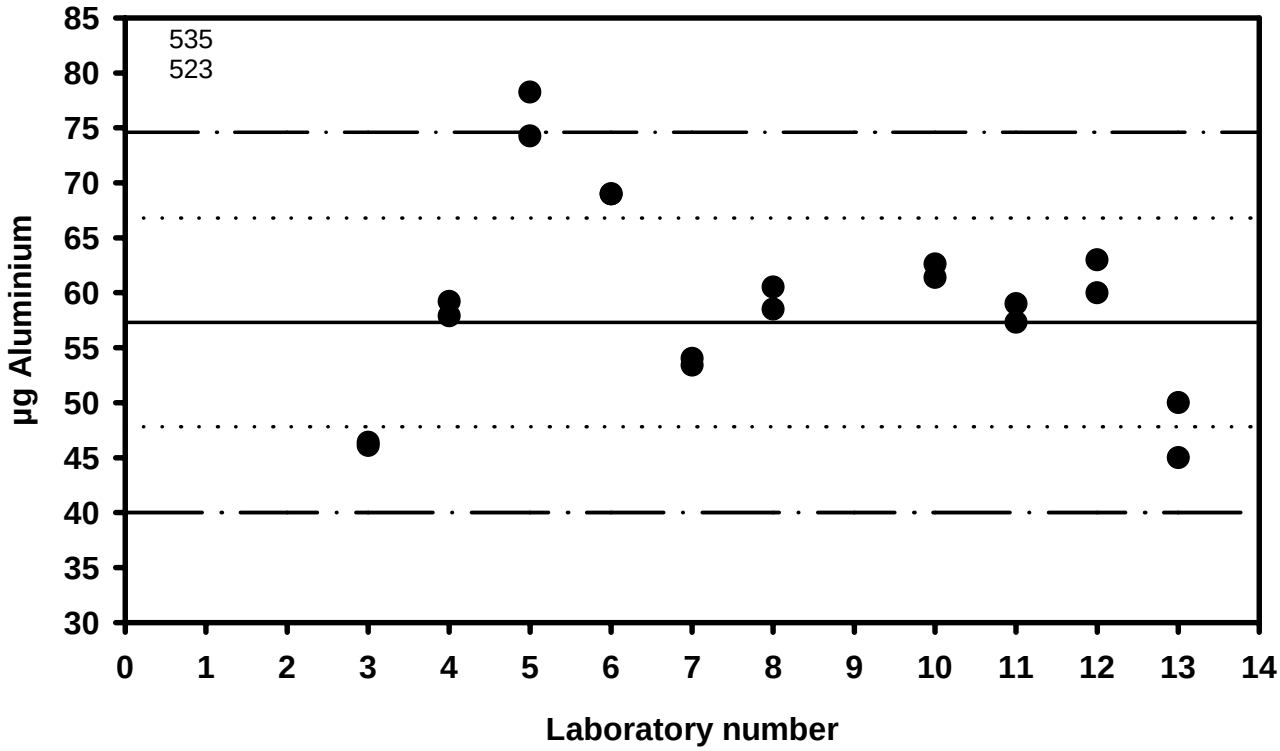
Silver - Series V

Reference value: 77,7 µg
Laboratory average: 75,9 µg



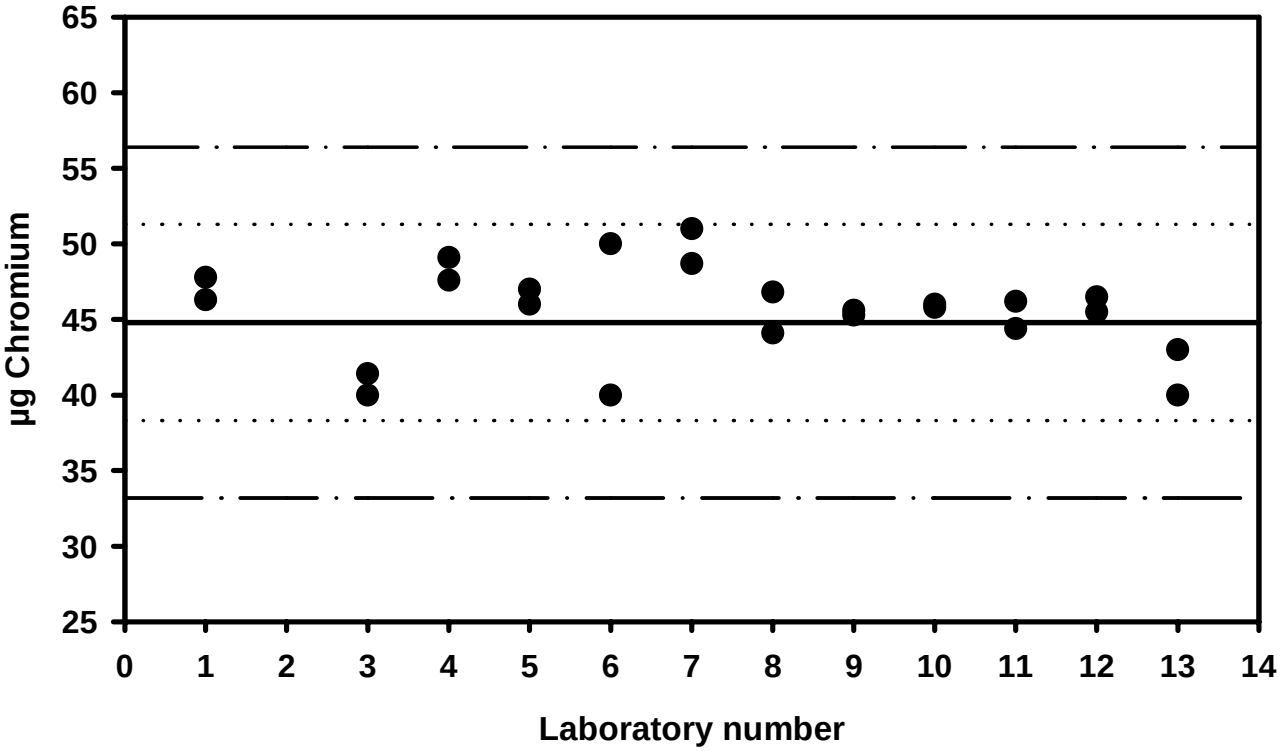
Aluminium - Series V

Reference value: 57,3 µg
Laboratory average: 59,2 µg



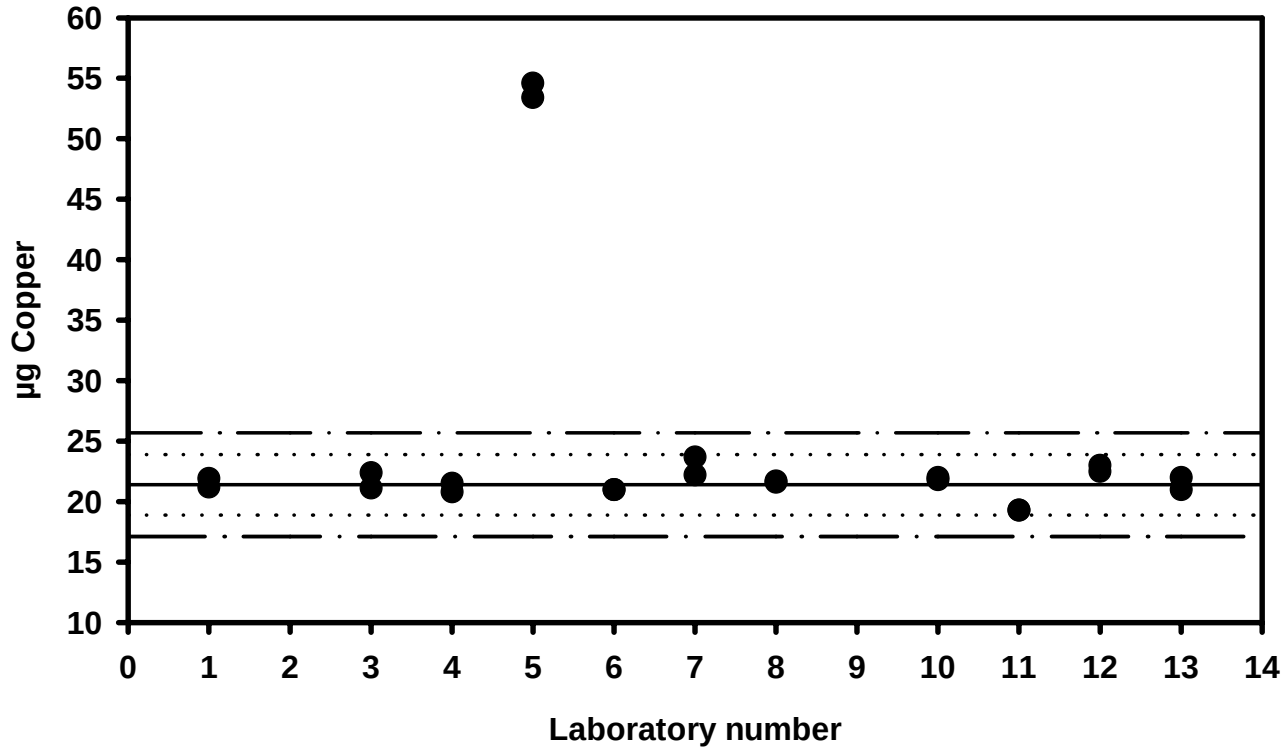
Chromium - Series V

Reference value: 44,8 µg
Laboratory average: 45,2 µg



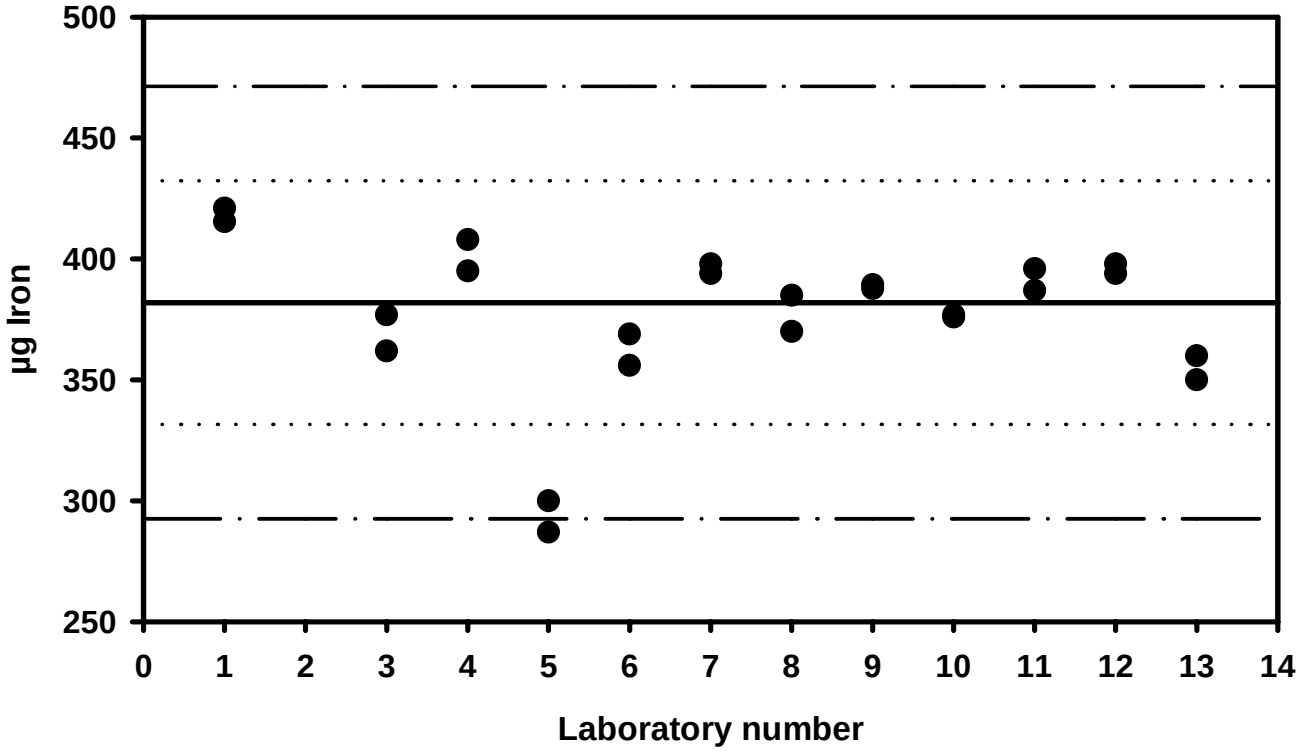
Copper - Series V

Reference value: 21,4 µg
Laboratory average: 21,6 µg



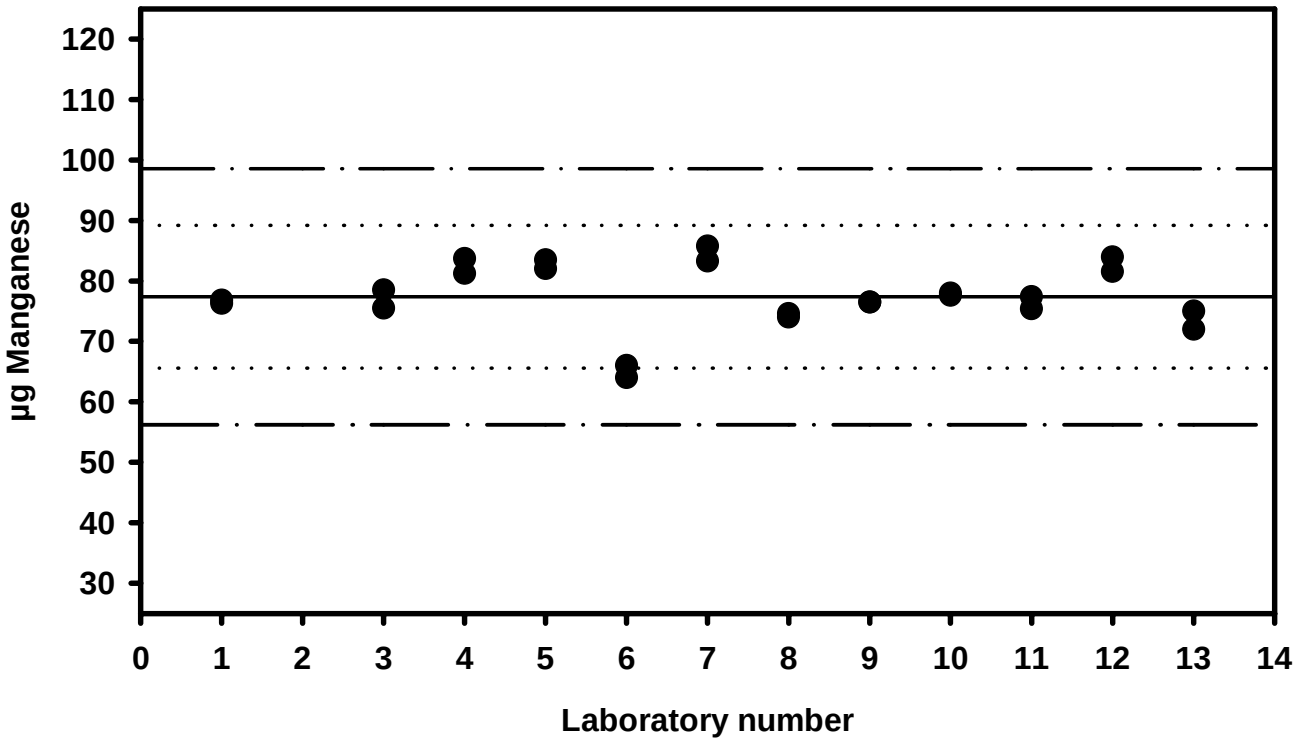
Iron - Series V

Reference value: 382 µg
Laboratory average: 377 µg



Manganese - Series V

Reference value: 77,4 µg
Laboratory average: 77,5 µg



Titanium - Series V

Reference value: 27,3 µg
Laboratory average: 27,9 µg