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A COMPARISON OF MEASUREMENTS WITH ISO REFERENCE AND NILU ATMOSPHERIC DUSTFALL DEPOSIT GAUGES

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SUMMARY

Measurements of dustfall, collected in two types of atmospheric dustfall deposit gauges, have been compared. One is the reference gauge described by the International Organization for Standardization (ISO/DIS 4222.2). The other is the gauge designed and used by the Norwegian Institute for Air Research (NILU).

Measurements were made at two locations, one with relatively high and one with low dustfall exposure. At both locations three gauges of each type were exposed. 14 successive monthly samples were collected. The comparison was made only for water insoluble dustfall.

On the average the results from the NILU gauges were approximately 3.5% higher than those from the ISO gauges at the high exposure station, and 6.5% higher at the low exposure station. The results from the two gauge types correlated well. The difference between the two types was statistically significant at the low exposure station.

Thus, this study indicates that there is a statistically significant difference between results obtained with the two gauge types. The difference, however, seems to be well within the ISO equivalence requirement of ± 10% systematic difference.

CONTENTS

A COMPARISON BETWEEN ISO REFERENCE AND NILU ATMOSPHERIC DUSTFALL DEPOSIT GAUGES

1 INTRODUCTION

1.1 Background

Gauges for the measurement of atmospheric particulate fallout (dustfall) have been in use in many countries for several decades. The most commonly used method can be termed the "horizontal deposit gauge method". The gauge is basically a flat bottomed cylinder exposed to atmospheric fallout with its axis vertical, and the open horizontal end facing upward. This type of gauge collects the total amount of fallout deposited into it, both wet (as precipitation) and dry (dust particles), during the period of exposure.

There are many such gauges of various shapes and dimensions in use today. In 1972 the International Organization for Standardization (ISO) initiated work to propose a reference method to measure atmospheric particulate fallout (hereafter called dust deposit, a term that is intended to include both wet and dry dust deposit). The reference method was to specify a detailed design of a reference gauge and an analytical procedure for determination of the amount of deposit.

This work within ISO resulted in a Draft International Standard (ISO/DIS 4222.2) for such a method, issued in 1980 (International Organization for Standardization, 1980). The specified gauge (hereafter called the ISO gauge) is essentially a flat-bottomed cylinder with straight walls and a sharp edge at the exposed opening of the gauge (Figure 1).

The proposed standard includes the following definition of equivalence:

"Apparatus with different characteristics than those described in this International Standard may be used if the equivalence to the standard apparatus is proved to be within a range of error of $\pm$ 10% systematic".

1.2 Purpose of this study

The Norwegian Institute for Air Research (NILU) in the period 1970-1972 designed a dust deposit gauge (hereafter called NILU gauge) with overall dimensions close to those of the proposed ISO standard gauge (Figures 2 and 3).

The purpose of this limited study was to ascertain whether there is an equivalence between these two gauge designs within the 10% limits specified in the standard above.

2 SAMPLING PROGRAM AND METHODS

2.1 Sampling program

The study was designed to check the equivalence between the methods, as well as the variance between deposits in gauges of the same design, exposed at sampling points very close (within 2 m) to each other.

The study used two sampling stations; one with a dust deposit level of 1-2 $g/m^2 \cdot 30$ days, the other with a level of 5-10 $g/m^2 \cdot 30$ days. Three gauges of each type were exposed at each station. The measurement program extended over a 14 months period.

The gauges were arranged at each station as shown in figure 4.

2.2 Description of sampling stations

Station I: Strømmen, address Stasjonsveien 18. The station was located in a grassy field, approximately 20 meters away from a street with low traffic volume. The terrain falls off slightly from the street level towards the samplers. Across the street is an iron foundry (Strømmen Verksted) with occasional large particulate emissions. Otherwise the area is mainly residential.

Station II: Fjellhamar, address Marcus Thranes vei.

The station was located in a flat, private garden. The area is residential, with no significant particulate emission sources other than road traffic nearby. The station was located some 30 meters away from the nearest street with very low traffic volume.

2.3 Design features

2.3.1 ISO gauge

The gauge is described in detail in ISO/DIS 4222.2 Section 5.1.1 of that document is reproduced below.

5.1.1 Deposit gauge

The deposit gauge is a cylindrical, flat-bottomed vessel having an internal diameter of 200 mm and a depth of 400 ± 10 mm. In the region of the aperture, the diameter shall not differ by more than ± 5 % from the nominal value, and the top edge of the cylinder shall be externally bevelled at 45°.

The deposit gauge shall be made of a material impervious to light, for example polyethylene, inert to the atmospheric dustfall collected, and sufficiently strong to maintain its shape and to permit transport when filled. In order to assure constant aperture size, it is advisable to press a coated steel ring around the top of the vertical part of the wall, as shown in the figure.

NOTE — Deposit gauges with different characteristics from those described in this International Standard may be used if comparison of measurements between such deposit gauges and the standard deposit gauge show a level of significance (statistical certainty 95 %) of ± 10 % systematic error.

Figure 1 shows a schematic of the ISO gauge with support and bird ring.

A number of such gauges were manufactured by NILU for the purpose of this study. Since the study included only a comparison of the water insoluble material, the restrictions to choice of gauge material are less severe. Glass fiber reinforced polyester was used.

2.3.2 NILU gauge

Figures 2 and 3 show the details of the NILU gauge.

The gauge is constructed from polyethylene. The wall thickness is approx. 1.5 mm.

The characteristics of the gauge are as follows.

- height: 400 $\pm$ 10 mm
- inside diameter of open end: 200 mm $\pm$ 2 mm
- sharp top edge that falls off vertically inside the gauge, and at a 45^0 angle (downwards) at the outside
- the upper 2 cm of the gauge wall is slanted towards the center of the cylinder at an angle of 45^0 to keep the exposure area within 5% of the nominal value. In addition the top part of the cylinder is equipped with a polyethylene coated stainless steel ring of diameter 5 mm $\pm$ 1 mm that is pressed into a corresponding groove in the cylinder wall.

2.3.3 Major difference in design

The main difference between the two gauges is in the details around the top of cylinders. The exposed area and sharp top edge are the same for both gauges, such that viewed from the top the gauges are nearly identical, although the NILU gauge appears to have a thicker wall.

The difference is apparent when looking at the top details in Figures 1 and 3. The ISO gauge falls off vertically inside from the edge of the exposure area to the bottom. In the NILU gauge, the top of the cylinder forms a lip, so that the inside diameter increases from the top of the gauge and downwards. This lip might cause differences in the turbulence around the top of the NILU gauge, which might affect the collection efficiency of the gauge. Such effects have been studied at Warren Spring Laboratory (Ralph et al., 1984), where the ISO, NILU and a British Standard gauge were compared. A summary of the results is given in section 3.

2.3.4 Sampling and analytical procedures

The procedures specified in ISO/DIS 4222.2 were followed.

At the start of each one-month exposure period, 0.5 l of a 5% (V/V) solution of methoxyethanol was placed in each gauge during. At the end of each sampling period, the exposed gauges were taken directly to the laboratory for analysis.

During this study the methoxyethanol solution did not prevent the liquid content of the gauges to freeze during very cold periods. However, it seemed to keep the surface of the ice moist, facilitating the trapping of particles that deposited on the surface.

3 PREVIOUS COMPARISON OF MEASUREMENTS WITH ISO AND NILU GAUGES

A wind tunnel study was conducted at Warren Spring Laboratory to study the effects of the different edge designs of the ISO, NILU and British Standard gauges (Ralph et al., 1984).

Glass spheres of diameters between 120 µm and 970 µm were used to check the efficiency of particle collection over a wind speed range 0-22 m/s.

It was found that above a limiting wind speed, little or no catch of particles occurred. For 120 µm particles, this limiting wind speed was ca. 14 m/s. The gauges continued to catch the 970 µm particles at wind speeds up to 22 m/s, which was the maximum test speed. No collection difference between the ISO and NILU gauges was noted for the wind speeds tested.

The study showed that blow-out of already deposited particles is insignificant for ISO or NILU gauges with wetted bottoms.

The study concluded that the lip around the edge of the NILU gauge is likely to reduce its catch efficiency below that of the ISO gauge. The difference appears to be due to the shear layer separating at the upwind edge of the gauge. This layer is much less disturbed with the lip than without it. The greater degree of disturbance seems to lead to a higher probability of particles entering the gauge.

4 RESULTS AND DISCUSSION

Tables 1 and 2 show the results of water-insoluble dust deposit measurements at stations I and II, respectively.

They show a mean deposit level of 5-6 $g/m^2 \cdot 30$ days at Station I, and 1.2-1.3 $g/m^2 \cdot 30$ days at Station II.

During January, February and March the gauges were filled to a varying degree with ice and snow. In May, the gauges were completely dry, while during the rest of the months they contained various amounts of liquid water.

4.1 Variations in the average deposit for gauges of the same type

The average deposit for each gauge type at each station is considered to be the grand arithmetic mean of all measurements done with each type at each station. The mean exposure at each individual position varies around this grand mean.

Individual ISO gauges show a somewhat smaller variation from the grand mean than do NILU gauges. The maximum deviation from the grand mean is + 1.8% for an individual ISO gauge and + 3.5% for an individual NILU gauge.

For both gauge types, the variation was largest at Station I, which had the highest dust deposit.

Table 1: Station I (Strømmen).
Measurements of water insoluble dust deposit.

Sampling period	No. of days exposed	ISO gauge mg			NILU gauge mg			ISO $g/m^2 \cdot 30$ d	NILU $g/m^2 \cdot 30$ d
Month		1	2	3	1	2	3	mean	mean
Oct. 1976	30	193	192	194	199	188	187	6.0	5.9
Nov. 1976	39	120	165	170	194	199	181	4.8	6.1
Des. 1976	29	456	404	427	452	430	430	14.1	14.4
Jan. 1977	30	164	153	154	151	148	154	5.0	4.8
Feb. 1977	29	212	210	191	212	210	239	6.7	7.3
March 1977	31	172	173	184	190	191	183	5.4	5.8
April 1977	31	136	131	136	128	134	124	4.1	4.0
Mai 1977	28	225	217	211	173	178	162	7.4	5.8
June 1977	29	159	170	168	170	180	176	5.6	5.7
July 1977	32	218	171	186	198	249	183	5.7	6.3
Aug. 1977	31	68	74	76	76	90	84	2.2	2.5
Sept. 1977	33	134	137	118	141	145	133	3.7	4.0
Oct. 1977	27	32	52	47	48	50	48	1.5	1.7
Nov. 1977	30	88	78	69	88	92	88	2.49	2.85
Mean		170	166	167	166	177	170	5.34	5.52
			167.7			171			
Deviation from mean		+ 1.8%	-1.1%	-0.4%	-2.9%	+3.5%	-0.5%		

Table 2: Station II (Fjellhamar).
Measurements of water insoluble dust deposit.

Sampling period	No. of days exposed	ISO gauge mg			NILU gauge mg			ISO $g/m^2 \cdot 30$ d	NILU $g/m^2 \cdot 30$ d
Month		1	2	3	1	2	3	mean	mean
Oct. 1976	30	32	30	33	26	30	37	1.00	0.95
Nov. 1976	30	34	33	35	36	35	34	1.10	1.10
Dec. 1976	29	31	32	36	26	29	34	1.09	0.98
Jan. 1977	30	19	21	23	24	22	20	0.67	0.70
Feb. 1977	29	24	24	19	26	25	23	0.74	0.81
March 1977	31	49	58	57	44	66	63	1.68	1.78
April 1977	31	70	71	78	75	72	77	2.25	2.30
May 1977	28	53	49	60	63	60	57	1.84	2.05
June 1977	29	50	46	37	49	48	44	1.46	1.55
July 1977	32	29	24	27	29	27	27	0.79	0.83
Aug. 1977	31	32	31	30	37	33	33	0.96	1.06
Oct. 1977	27	24	28	18	35	32	34	0.83	1.19
Nov. 1977	30	38	42	50	50	46	52	1.38	1.57
Mean		37.9	37.9	38.4	40.0	40.9	41.0	1.21	1.29
			38.1			40.6			
Deviation from mean		-0.5%	-0.5%	+0.8%	-1.5%	+0.7%	+0.9%		

At Station I, the samplers closest to the road (ISO 1, NILU 2) gave the highest deposit level, 1,8% and 3.5% higher than the mean, respectively. Thus, it appears that variation in dust exposure accounts for some of the differences found between individual gauge locations.

At station II, no relationship between gauge location relative to dust sources (roads) and deposit level was apparent.

Statistical causes for the variation between individual locations are variations between individual gauges (design tolerance requirements) and variations originating in the analytical procedure.

4.2 Differences between the means from each gauge type

At Station I, the arithmetic mean from NILU gauges (NILU mean) was 3.4% higher that than from ISO gauges (ISO mean). At Station II, the NILU mean was 6.6% higher than the ISO mean.

It thus appears that the NILU gauge collects dust deposits slightly higher than the ISO gauge, and thus seems to be slightly more efficient. This is contradictory to what was indicated in the Warren Spring Laboratory report (2), which indicated a lower efficiency for the NILU gauge.

4.3 Statistical evaluation of results

4.3.1 Sample variability

There is a variability in the results obtained with three gauges of the same type, at each station for each month. This is due in part to real exposure differences because of the distance between sampler positions (some 4 meters) and other factors, such as small differences in sampler dimensions, sampler openings not exactly horizontal, and analytical errors.

The standard deviations were calculated for each gauge type for every month at both stations. The mean standard deviations for the 14 months period, and the minimum and maximum standard deviations are given in Table 3. The mean variability was somewhat less for the NILU gauge than for the ISO gauge. At Station I, the mean variability was 4-5% of the average dust deposit. At Station II, the low-exposure station, the corresponding figure was 7-8%.

Table 3: Results of analysis of standard deviation

	Standard deviation			
	mean		min	max
	$g/m^2 \cdot 30$ d	%	$g/m^2 \cdot 30$d	$g/m^2 \cdot 30$d
<u>Station I</u>				
ISO gauge	0.28	5.2	0.025	0.70
NILU gauge	0.23	4.2	0.03	0.90
<u>Station II</u>				
ISO gauge	0.10	8.3	0.05	0.17
NILU gauge	0.09	7.0	0.03	0.31

4.3.2 Regression analysis

Regression analysis was performed on the average dust deposit values for each gauge type and month for both stations.

Figures 5 and 6 show results of linear regression analyses between ISO (x) and NILU (y) gauges.

At both stations, the correlation coefficient (r) was high: 0.978 at Station I and 0.972 at Station II. At station I, the regression line indicates an intercept of 0.33 $g/m^2 \cdot 30$ days in favor of the NILU gauge. At both stations, the regression coefficient was within 3% from unity.

A student's t-test was used to determine whether the difference in average water insoluble dust deposition, as measured by the two gauge types, is statistically significant. The test was performed on the monthly average values of each gauge type (the two columns to the far right in Tables 1 and 2).

The null hypothesis was that there is no difference in the water insoluble dust deposit values from the two gauges.

At the 5% significance level, and based on measurements from Station I, the high exposure station, the t-test accepts the results from the two gauge types as being equal. However, at Station II, the low exposure station, the null hypothesis is rejected.

5 CONCLUSIONS

The comparison study of ISO reference and NILU dust deposit gauges gave the following results for water insoluble deposit:

- The variability in parallel determinations was somewhat less for the NILU gauge than for the ISO gauge.

- Results from the ISO and NILU gauge correlated well. Based on the 14 monthly deposit values, averaged over three parallel measurements with each gauge, the correlation coefficient was 0.978 at the high exposure station (Station I) and 0.972 at the low exposure station (Station II).

- The regression coefficients were 0.971 and 1.029 at Station I and II, respectively, indicating a certain difference in results from the two gauge types.

- A student's t-test indicate that at Station I the measured difference is within the statistical variation that can be expected (at a 5% significance level) from measurement errors, while at Station II the measured difference slightly exceeds the expected statistical variation.
- These results indicate there is a statistically significant difference between the two gauge types. On the average the NILU gauges gave results 3.4% higher than the ISO gauges at Station I, and 6.6% higher at Station II. The difference seems to be well within the equivalence requirement of $\pm$ 10% systematic difference.

6 REFERENCES

International Organization for Standardization (1980) Air quality-Measurements of atmospheric dustfall - Horizontal deposit gauge method. Draft, Geneve. (Draft International Standard ISO/DIS 4222.2).

Ralph, M.O., Barrett, C.F. (1984) A wind tunnel study of the efficiency of three deposit gauges. Stevenage, Warren Spring Laboratory. (LR 499 (AP) M).

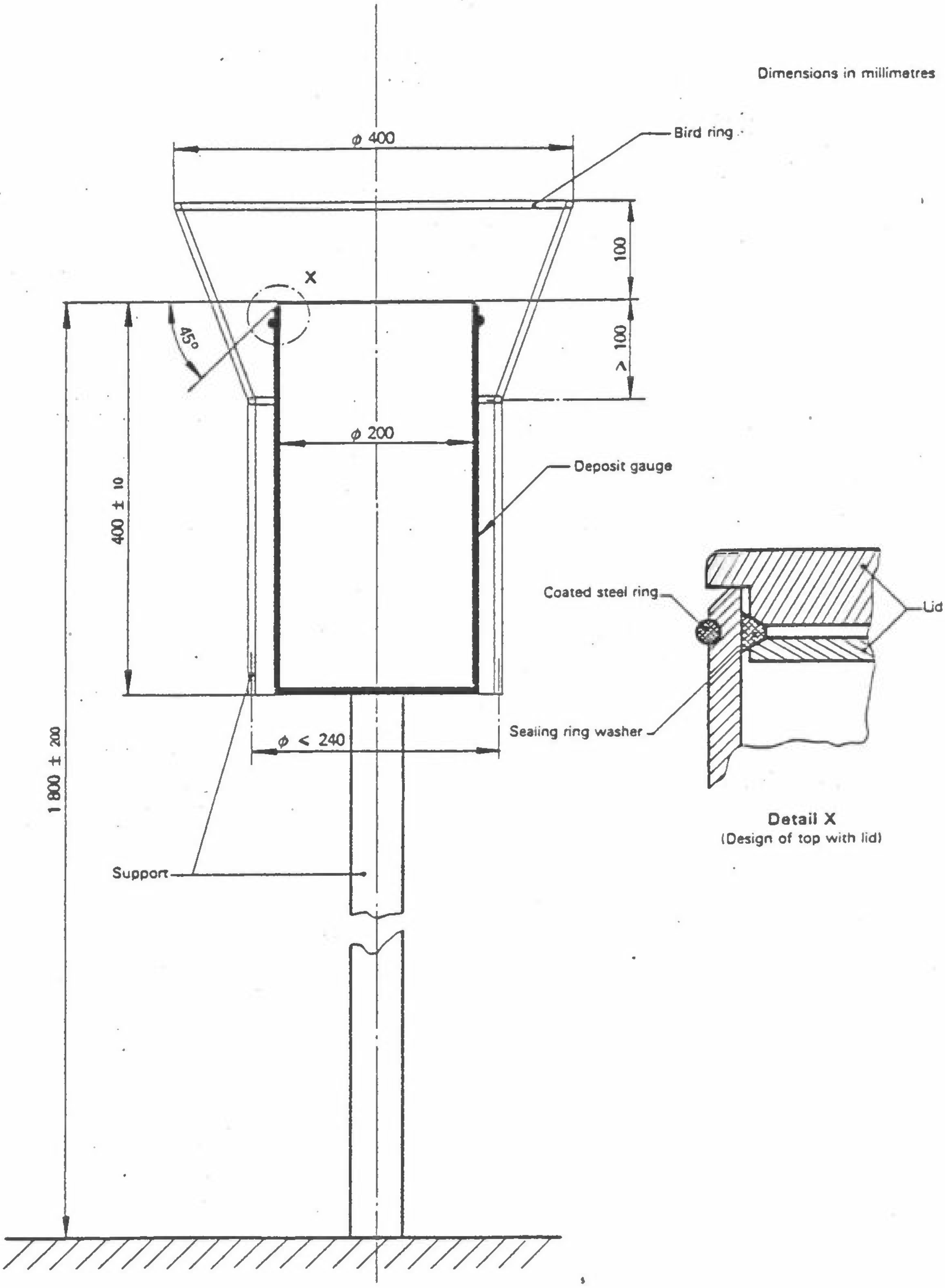

Figure 1: ISO reference "Atmospheric dustfall deposit gauge"

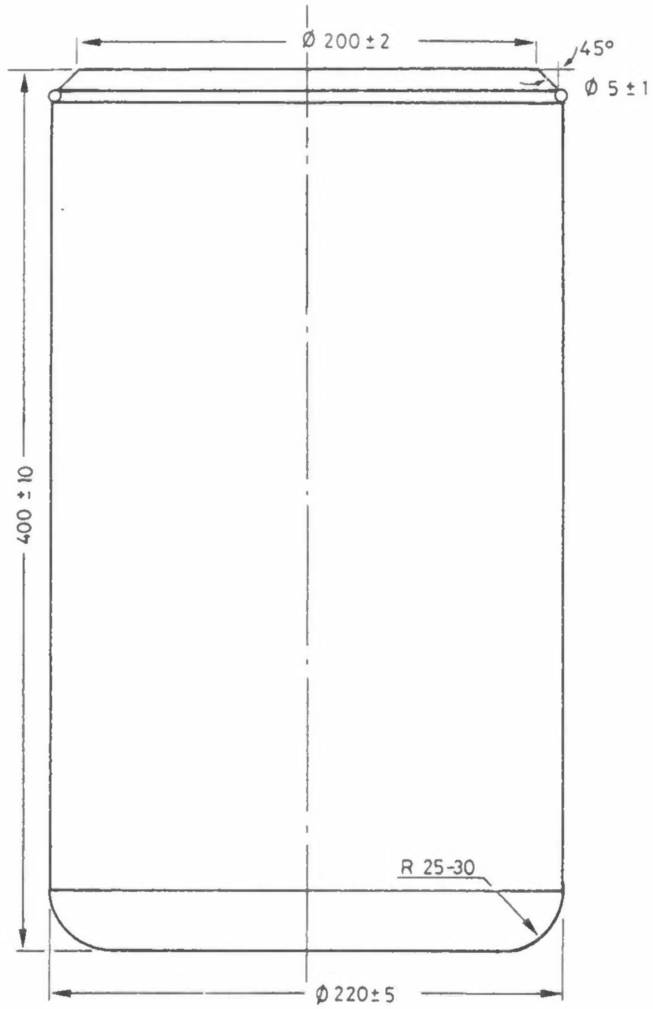

Figure 2: NILU dustfall deposit gauge
Dimensions in millimeters

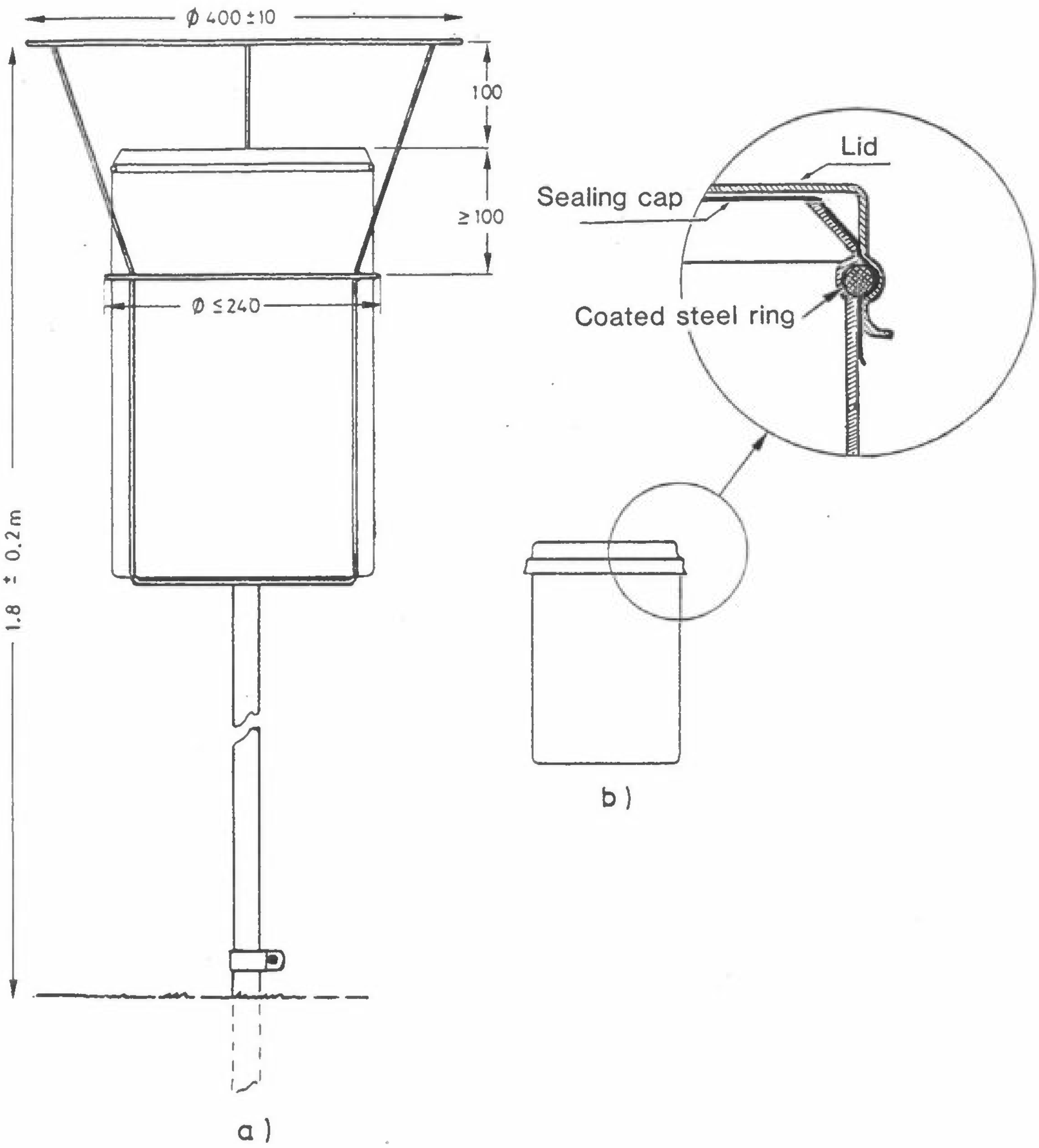

Figure 3: NILU dustfall deposit gauge

a) mounted on stand with bird ring

b) with gasket and lid, mounted for transport

Dimensions in millimeters, except where noted

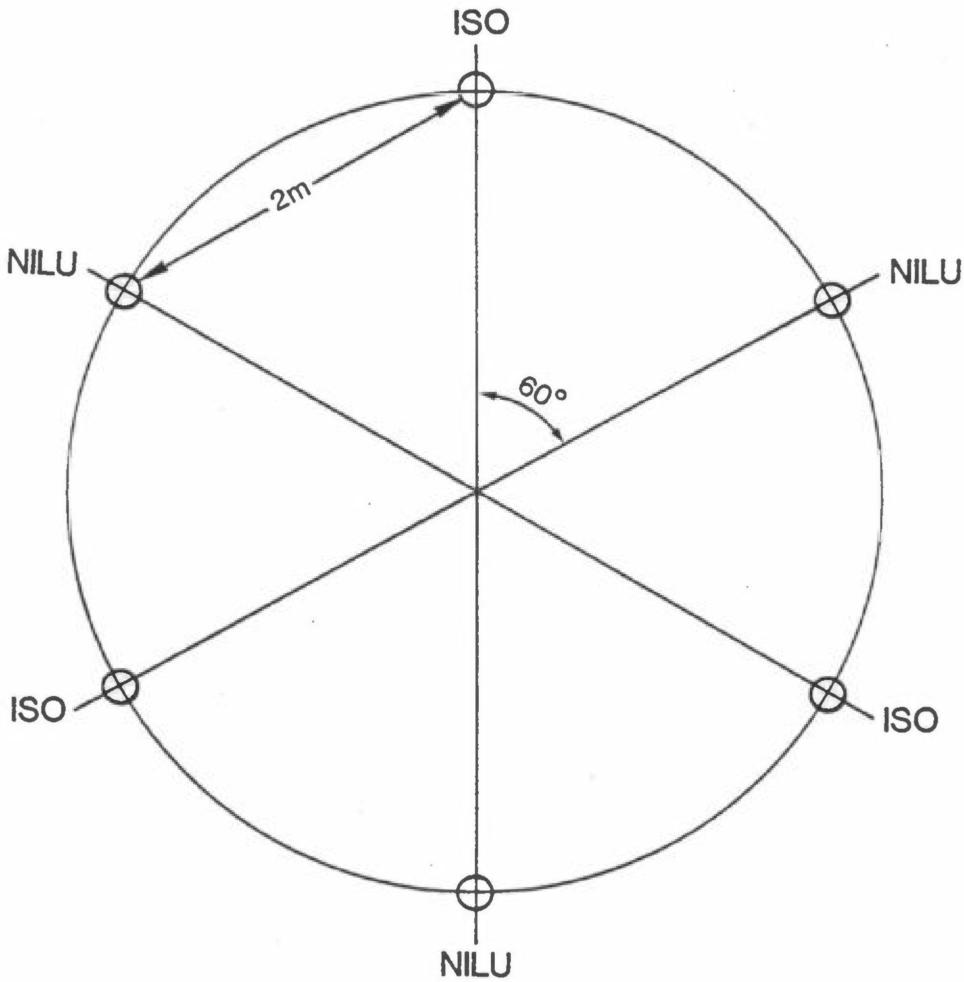

Figure 4: Arrangement of deposit gauges at sampling stations

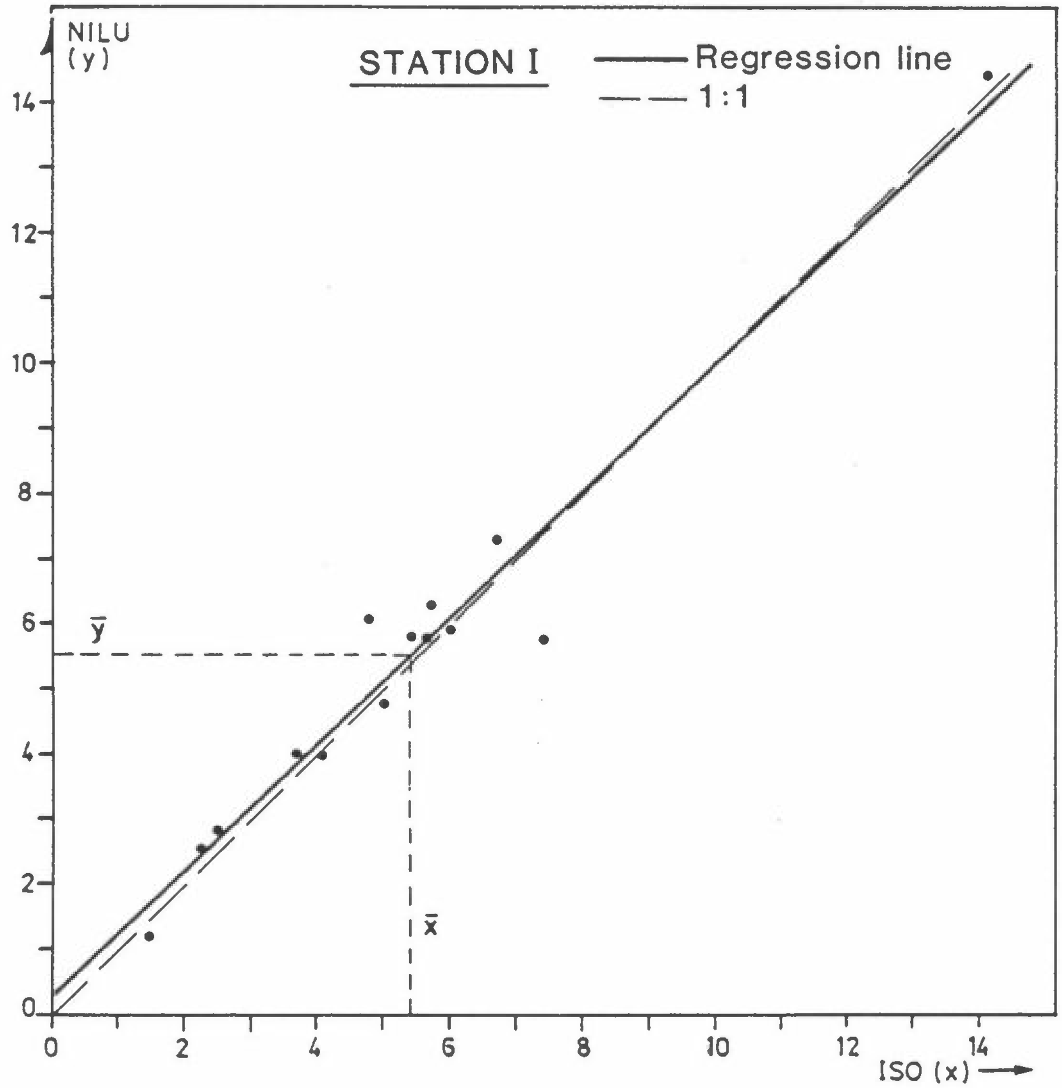

Figure 5: ISO/NILU gauges, Station I.
Water insoluble dust deposit regression line.

Regression analysis: $\bar{x} = 5.34$ g/m^2 · 30 d

$\bar{y} = 5.52$ " "

$y = a_1 x + a_0$

$a_0 = 0.33$

$a_1 = 0.971$

$r = 0.978$ (corr. coeff.)

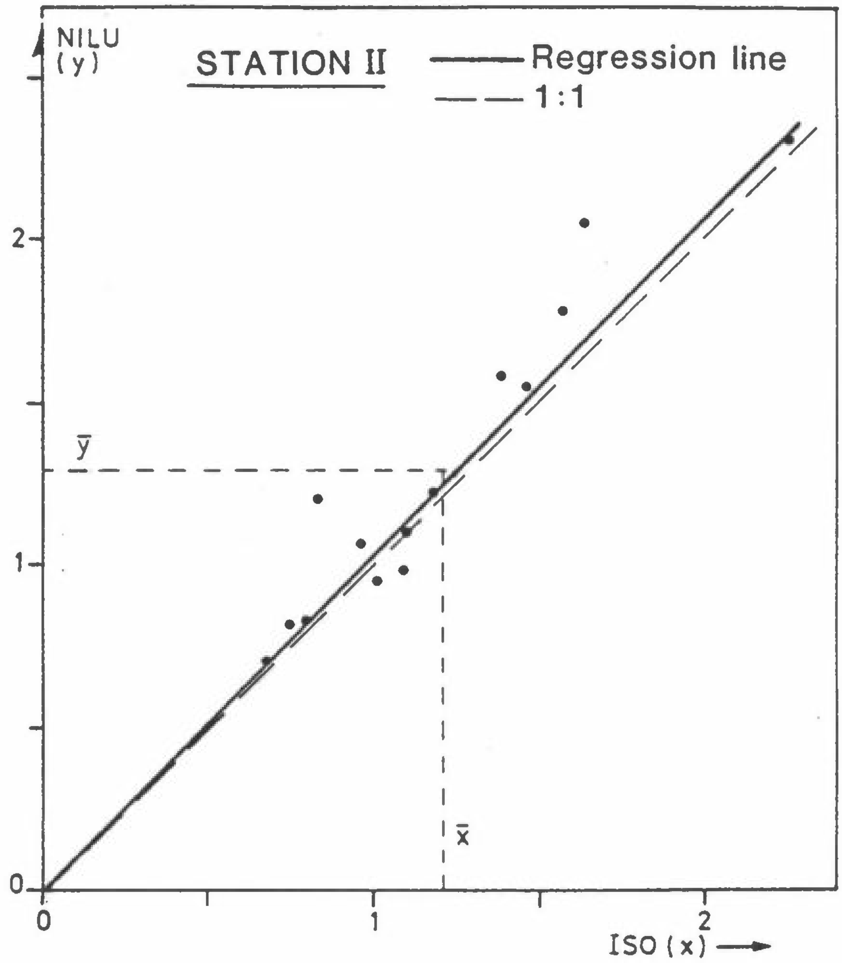

Figure 6: ISO/NILU gauges, Station II.
Water insoluble dust deposit regression line.

Regression analysis: $\bar{x} = 1.21\ g/m^2 \cdot 30\ d$

$\bar{y} = 1.29$ " "

$y = a_1 x + a_0$

$a_0 = 0.044$

$a_1 = 1.029$

$r = 0.972$ (corr. coeff.)

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NILU støvfallsmåler og ISO referanse-metode for støvfallsmåling, er sammenlignet. Sammenligningen gjaldt vannuløselig støvnedfall. NILU-måleren ga noe høyere verdier enn ISO-måleren, men forskjellen i resultater fra de to målerne var mindre enn 10%, regnet som gjennomsnitt over 13-14 etterfølgende månedsverdier.

TITLE A comparison of measurements with ISO reference and NILU atmospheric dustfall deposit gauges

ABSTRACT (max. 300 characters, 7 lines)

Atmospheric dustfall deposit measured with the ISO reference gauge and the NILU gauge have been compared. Only water insoluble deposit was considered. The NILU gauge gave somewhat higher deposit values than the ISO gauge, but the difference was well within 10%, calculated from the average of 13-14 successive monthly values.

* Kategorier:	Åpen - kan bestilles fra NILU	A
	Må bestilles gjennom oppdragsgiver	B
	Kan ikke utleveres	C