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V. Vitols and S. Larssen*

* Author to whom correspondence should be addressed.

NORWEGIAN INSTITUTE FOR AIR RESEARCH
P.O. BOX 64, N-2001 LILLESTRØM
NORWAY

SUMMARY

The two-filter (2F) method has, in a field sampling program, been compared with the US virtual impactor (dichotomous sampler - DICHO) method, for the measurement of inhalable particle concentration, and separation of sampled particles into fine and coarse fractions. The inhalable particle fraction is defined by required performance characteristics of the sampler air inlet. The 50% cut-off diameter of inhalable particle inlets should be 10 µm EAD*. The DICHO method is considered the reference method. The particle cut-off diameter in the DICHO sampler, separating the fine and coarse fractions, is approximately 2 µm EAD*. The program also included parallel sampling with two identical 2F samplers.

The field sampling program comprised three comparison series at two different locations, conducted during spring and summer periods. The ranges of particle concentrations were 3-48 $\mu g/m^3$ and 2-38 $\mu g/m^3$ for the fine and coarse fractions, respectively, measured with the DICHO sampler.

The 2F samplers were run with two different air inlets, both designed to have a particle cut-off diameter of 10 µm EAD, the same as the inlet for the DICHO sampler. The two inlets were the AERO inlet, supplied by the 2F sampler manufacturer (Aerovironment Inc.), and the S-A (Sierra-Andersen) inlet, of the same design as the DICHO inlet, but modified according to a lower air sampling rate.

The following conclusions can be drawn from this field study:

1 The 2F sampler with S-A inlet gave on the average a 6% larger inhalable particle concentration than the DICHO. Statistically, this difference was not significantly different from zero, at a 95% confidence level (24 samples).

2 The 2F sampler with AERO inlet gave on the average a 25% larger inhalable particle concentration that the DICHO. The AERO inlet most probably has a particle cut-off diameter considerably larger than 10 µm EAD.

* Equivalent aerodynamic diameter.

3 The 2F sampler gave on the average a 14% larger fine fraction than the DICHO sampler. This same result was reached irrespective of which of the two inlets was used. This 14% difference was not significantly different from zero at a 95% confidence level.

Two effects, namely reentrainment of coarse particles through the coarse to the fine particle filter (described by John et al., 1983) and/or a smaller amount of internal particle loss in the 2F sampler, may explain a possible real difference between the samplers, with somewhat larger fine fraction in the 2F sampler.

The reentrainment question may be resolved from such parallel sampling studies, by microscopic examination of the fine filters, counting and size classifying coarse particles. A prerequisite for this is the use of non-fibrous membranes for collection of the fine fraction, which enables counting of particles on the filter surface. In the present study fibrous membranes were used. Thus, such microscopic examinations to resolve the reentrainment question could not be done in this study.

4 The two 2F/S-A samplers run in parallel gave average fine, coarse and inhalable particle concentrations within ± 2% of the mean. For 15 samples, the correlation coefficients were 0.952, 0.856 and 0.955 for the fine, coarse and inhalable particles, respectively.

The main purpose of this study was to determine whether or not the two-filter method can be used as an alternative to the DICHO method.

This and other studies have shown some differences between the methods. The difference in measured aerosol mass concentration, when the same inlet is used on both samplers, is rather small. A larger number of parallel samples may reveal a statistically significant difference of the order of 10-15%.

The advantages of the 2F method are its relative inexpensiveness and easy operation under field conditions. Its reproducibility, as documented in this study, is acceptable.

We feel that the two-filter method, as described here, is an acceptable alternative to the DICHO method for many projects, to provide an inexpensive assessment of exposure to inhalable particles, and separation of those into fine and coarse particle fractions as defined in the DICHO method.

Further investigations, using parallel sampling under field conditions at more sampling locations are necessary, before the two-filter method can be accepted as a routine monitoring method. Especially, the degree of loss of coarse particles from exposed filters during mail transport back from the stations must be assessed. Also, the range of coarse filter particle loads that can be accomodated by the two-filter sampler under field conditions, should be further investigated. The maximum coarse filter particle load encountered in this investigation was approximately 700 µg (35 $\mu g/m^3$, 24 h sampling period). The sampler performance was acceptable also for this load.

CONTENTS

COMPARISON OF VIRTUAL IMPACTOR AND TWO-FILTER PARTICLE SAMPLERS

1 INTRODUCTION

The comparison study of virtual impactor and two-filter particle samplers was proposed to the Norwegian State Pollution Control Authority in 1983, after earlier aerosol sampler comparisons by NILU in 1982 (Larssen and Vitols, 1986) had shown promising results from very preliminary two-filter method sampling.

The comparatively simple features and possibly lower cost of the two-filter sampler makes it an attractive candidate for routine field monitoring of airborne fine and coarse particle concentrations in Norway. The aim of the comparison study was to ascertain the feasibility of using the two-filter sampler as an alternative to the current U.S. reference method for gravimetric determination of coarse and fine aerosol fractions - the dichotomous virtual impactor.

2 THE TWO-FILTER METHOD

Aerodynamic behavior and fate (e.g., dispersion, transport and removal), chemical nature, and health and various other environmental effects of airborne particles are largely aerodynamic size-dependent. To assess these important aerosol properties, it is desirable to separate the particles in at least two size fractions, usually referred to as "coarse" and "fine". The two-filter method has this capability, but has been possible only after the so-called Nuclepore filters (NP) became available (Spurny et al., 1969).

The two-filter method (from here on referred to as 2F) in concept is as simple as its name implies: two filters, arranged in series, each collect a different size range of particles. Consequently, it has been variously referred to in the literature as "two-stage", "sequential", "tandem" and "stacked" filter (SFU) method.

The first filter, a large-pore NP with appropriate filtration characteristics, fractionates the aerosol in the sample airstream and retains the coarse particles. The second collects the penetrating fine particles. Any type of filter may be used for this, provided the filtration efficiency for fine particles is adequate and the medium is compatible with the subsequent analytical procedure.

The application of Nuclepore filters for aerosol particle fractionation was first proposed by Spurny et al. (1969). Since then the filtration characteristics of large-pore NP filters have been thoroughly investigated, both theoretically and empirically (e.g., Parker and Buzzard, 1971; Cahill et al., 1979; Heidam, 1981; John et al., 1983), and numerous applications reported (e.g., Cahill et al., 1977; Flocchini et al., 1981; Armstrong et al., 1981; Heidam, 1981; Heintzenberg, 1981; Feeney et al., 1984).

2.1 TWO-FILTER SAMPLERS

The basic components of a 2F sampler are:

a) the sampling "head",
b) sample air inlet,
c) flowmeter, and
d) vacuum source with means for flow adjustment/regulation.

2.1.1 The sampling head

The sampling head for the 2F sampler is usually a dual, open face filter holder of appropriate diameter. The filter holder must be leak-proof, and of a design that keeps the two filters physically separated.

Figure 1 shows schematically the construction features of two dual filter holders, which has been used for 2F sampling. Feeney et al. (1984) reports using a filter holder which suits a standard 47 mm diameter, large-pore NP filter to retain coarse particles, and a 25 mm diameter filter for fine particles (Figure 1a). This arrangement gives increased face velocity for the fine particle filter, which results in improved filtration efficiency for most filter media. Furthermore, the fine particles are collected on a smaller area (advantageous for some analytical methods), and the lower tare weight of the filter allows a more accurate gravimetric analysis. From the experience of the present study, however, a 25 mm diameter fine particle filter is only practical under light aerosol loadings, and usually the same diameter coarse and fine particle filters have to be used. An example of such a filter holder* is shown in Figure 1b.

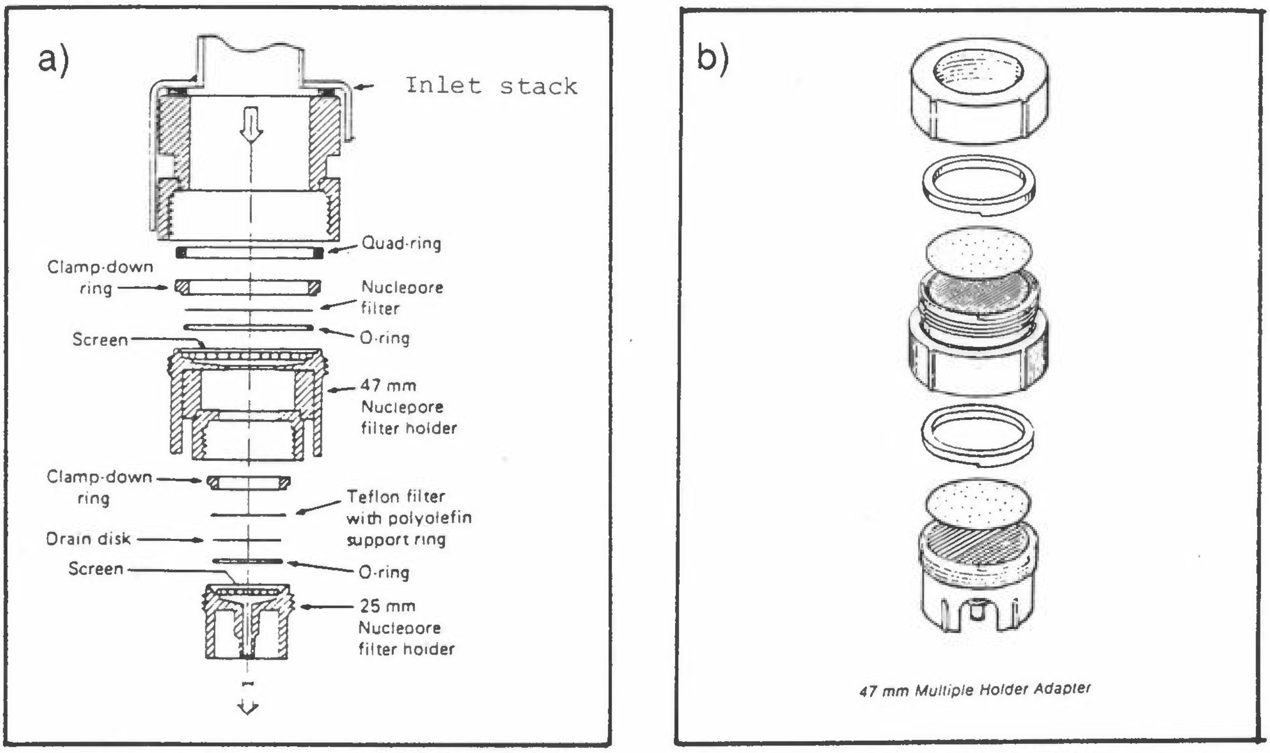

Figure 1: Schematic diagrams of two dual filter sampling head for the two-filter sampler.

2.1.2 Sample air inlet

The realization that sample air inlets of known "intake effectiveness" characteristics are essential in ambient aerosol measurement is relatively recent, and came mainly after the concept of "inhalable particles" had gained momentum (Vitols, 1981; Shaw et al., 1983). The air inlet provides a defined upper particle size cut-point**, such that only particles penetrating the inlet make up the "aerosol

* Nuclepore corporation, Pleasanton, CA.
** Equivalent aerodynamic diameter (EAD) of particles, of which 50% are retained and 50% prenetrate the inlet.

sample", which then may be subsequently fractionated in fine and coarse fractions by, for example, the 2F head. When sampling "inhalable particles" the particle-size cut-point of the inlet is at 10 µm equivalent aerodynamic diameter (EAD).

Now, both theoretical evaluations (Watson et al., 1983; Wedding and Carney, 1983) and findings from major field studies (e.g., Rodes et al., 1985) have shown that measurement results for a given aerosol population may differ, even with only minor differences in sampler inlet effectiveness.

Unfortunately, at the present time commercial air inlets, specifically designed for 2F samplers, are not available. (Two U.S. air sampling equipment manufacturers each marketed for a period a different sampler, but these are now available only on special order.) One reason for this is that, despite its frequent use by some aerosol researchers, the sampler is yet to receive general acceptance as an "equivalent method" to the virtual impactor sampler. As a consequence, the sampling rates reported in the literature have varied widely (from ca. 2 to 50 l min^{-1}) and, in the absence of some standardization, it is not possible to design an inlet which would suit all conditions. Some of the simple, "home-made" versions used in the past have shown undesirable windspeed-dependent characteristics (McFarland, 1979).

At present then the simplest recourse would to be to operate a 2F sampler at a flowrate for which commercial inlets have been designed for other samplers. The design flowrate (16.7 l min^{-1}) of the U.S.type dichotomous sampler is within the range of sampling rates for 2F samplers, and thus the various inlets available for it could be adapted. There is strong evidence, however, that while the particle fractionation cut-point of the large-pore NP filters is relatively insensitive to flowrate changes for liquid particles, solid particles exhibit considerable bounce-off and carry-over to the fine fraction at higher filtration face velocities. John et al. (1983) in their laboratory tests found that, even with grease-coated 8 µm-pore NP filters, face velocities as low as 1.8 cm s^{-1} were required to avoid substantial bounce-off. This means a sampling rate of only ca. 1.5 l min^{-1} with a

47 mm dia. filter, which cannot be expected to give sufficient particle deposits during a 24-h sampling period for accurate weighing. This then also means, that an intermediate compromise sampling rate has to be chosen, and the commercial inlet modified to retain approximately its design inlet effectiveness.

2.1.3 Flow metering and vacuum source

A float-type flowmeter is commonly used for setting and checking the chosen sampling rate of 2F samplers. An additional dry gas meter would provide a direct and more reliable sample volume measurement than the product of the average flowrate for the sampling period and the sampling time.

The maintenance of a constant flowrate through the air inlet and the sampling head is an advantage, particularly under heavy aerosol loading conditions. Several constant volumetric flow regulation systems have been described in the literature (e.g., Caffo et al., 1980; Walters, 1982). The flow regulators normally do not exact excessive additional pump capacity penalties.

Any sort of vacuum pump of appropriate pressure drop-capacity characteristics is an adequate vacuum source for the 2F sampler. Diaphragm-type pumps have a proven field record of reliability.

3 EXPERIMENTAL

3.1 EQUIPMENT AND FILTER MEDIA

At the time of equipment acquisition for the study, 2F samplers were not available as in-stock items. One U.S. manufacturer could offer their discontinued model* on special order. Another manufacturer could supply "left-over" 110 V, 60 Hz models**, with a 15 µm cut inlet

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* Sierra-Andersen Instrument Inc., Carmel Valley, CA. Model 202-2F
** Aerovironment Inc., Monrovia, CA. Model SFS-500.

instead of the currently accepted 10 µm EAD for inhalable particles. Because of their more reasonable delivery time, the latter offer was accepted and two units purchased, on the proviso that the inlet be modified for the 10 µm cut. As of this writing, however, the promised wind tunnel verification of the accuracy of the manufacturers adjusted inlet still remains unavailable. The unit has a volumetric flow regulation system reportedly regulating flow within ± 5% to a pressure drop of 5 cm Hg across the filters, and is monitored by the system´s float-type flowmeter (Flocchini et al., 1981).

The Aerovironment 2F sampler has a design flow rate of 10 l/min., and this flow rate was used throughout the present comparison study.

For the operation of the vacuum pump and cooling fan of the units, 220/110 voltage transformers were used, but the built-in clock/timer and elapsed time meter, of course, did not function properly on 50 Hz. The vacuum pump of one of the units received had a faulty motor bearing, and a new 220 V, 50 Hz pump was substituted.

This Model SFS-500 sampler uses the rather unique-design AERO inlet (Tombach, 1982; Shaw et al., 1983), shown in Figure 2. It consists of two concentric cylinders with offset slots. The space between these air "decelerators" is a "stilling volume", from where the sample air is drawn into the inlet cap. The idea of slowing the airstream down for representative sampling of aerosols was first proposed by K.R. May. The space between the inlet cap and the "internal fractionator" ring then defines the particle cut point. The dual filter holder with the 2 filters is clamped tightly against the gasket in the inlet "stack", as also seen in Figure 1. The performance of the 15 µm EAD AERO inlet has been determined in wind tunnel tests (Tombach, 1982). It falls within the "envelope" of recommended sampling effectiveness curves, and is relatively unaffected by windspeed changes.

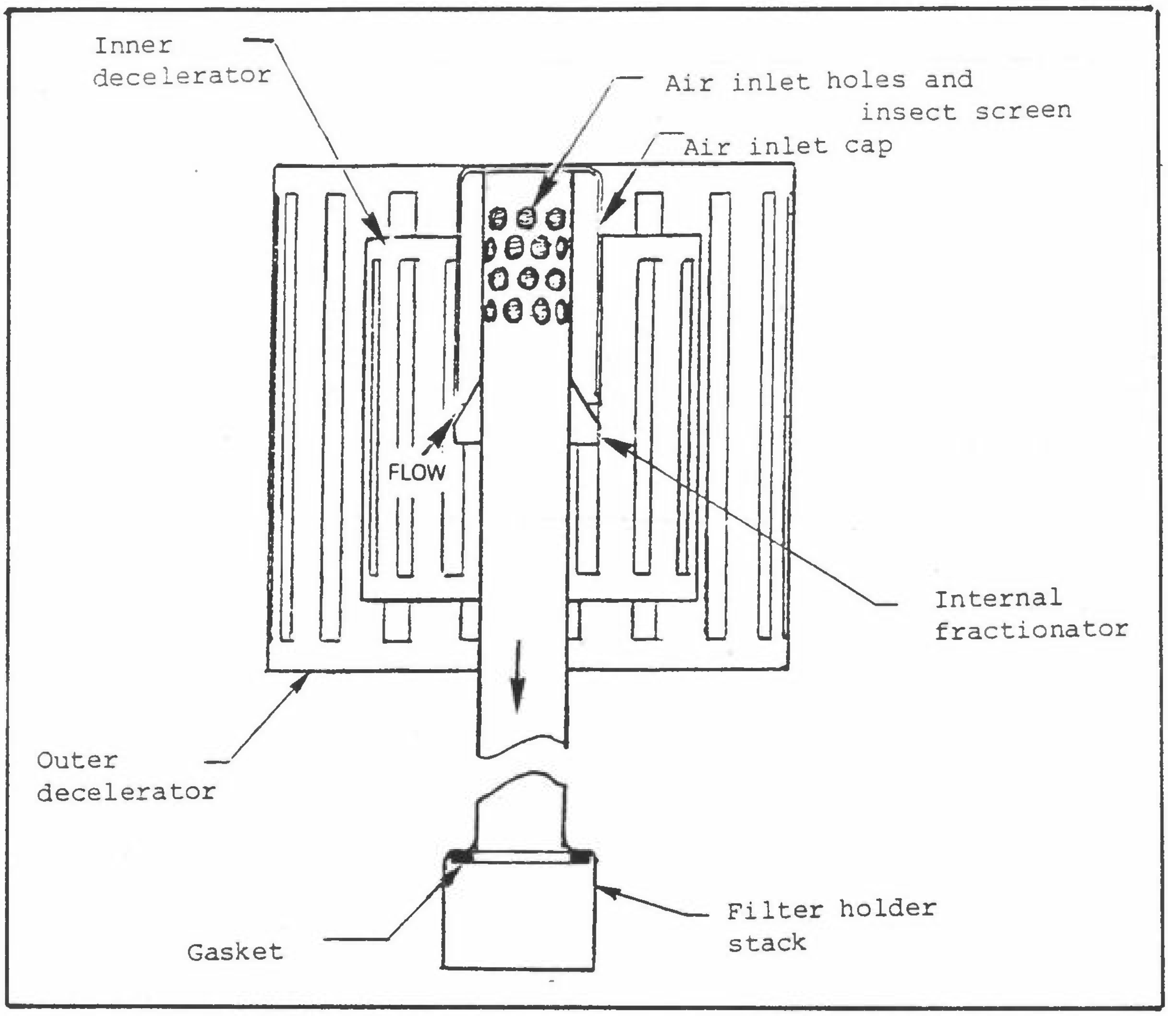

Figure 2: The construction features of Aerovironment Inc. "AERO" inlet for inhalable particle sampling.

The "standard" against which the performance of the 2-filter sampler was to be compared in this study was the U.S. type dichotomous (virtual impactor) sampler (see, e.g., Olin, 1978; Vitols, 1981), hereafter referred to as the "DICHO"*. The "automatic" model 245 DICHO can be programmed to cycle through up to 20 samples in unattended operation. It consists of a sampling and a control module. The coarse and fine filter pairs are housed in the weather-resistant sampling module in a filter cassette carousel. The sampling module also has the sample air inlet and the particle-fractionating, virtual impactor. This automatic DICHO will switch to the next filter pair, if the pressure drop across filters becomes too high for the volumetric flowrate controller to handle. Although there are now several types of inlets

* Sierra Instruments Inc., Carmel Valley, CA. Model 245.

commercially available for the DICHO, NILU uses the S-A inlet* originally designed at the University of Minnesota/Lawrence Berkeley Laboratory (Liu and Piu, 1981). It has undergone two modifications in commercial production, the latest of which is shown in Figure 3. The aerosol is drawn into the inlet through a circumferential side entrance and accelerated downwards through a single impaction nozzle. In the original design, the coarser particles were impacted on the bottom of a cup, which was intended to prevent bouncing particle re-entrainment. The cup has now been replaced by three "vents", (see Figure 3), which convey the fine particle stream further to the sampling head, while the coarse particles impact and are retained on the flat surface beween the vents. The cut-point of the S-A Model 246A inlet is 10µm EAD at the DICHO sampling rate of 16.7 l min^{-1} (1 m^3/h).

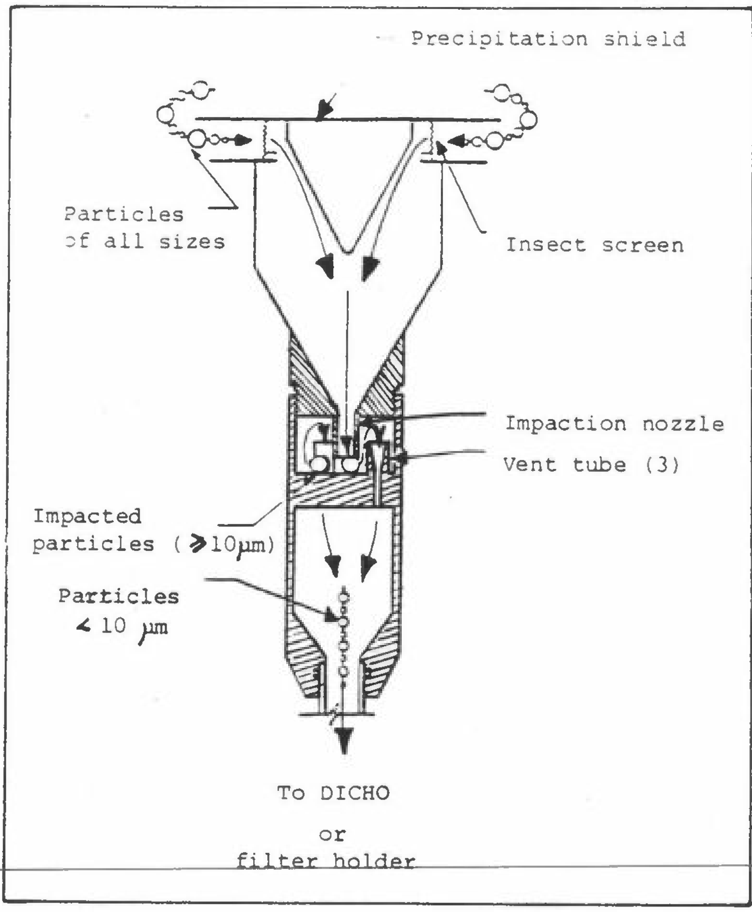

Figure 3: Construction features of the Sierra-Andersen Model 246 A inlet for inhalable particle sampling.

* Sierra-Andersen, Carmel Valley, CA. Model 246A.

During parts of the comparison sampling, the S-A inlet was also used for the 2F samplers. Since the main particle fractionating element of the inlet is the impactor, the diameter of the impaction nozzle (see Figure 3) was reduced (by an insert piece) to obtain the same average impaction velocity at the 10 l min^{-1} sampling rate, as with the original nozzle at 16.7 l min^{-1}. The inlet, modified in this manner, has not been tested to ascertain its actual inlet effectiveness.

As 2F sampling head, commercially available dual filter holders* were used. In the very beginning of the sampling program, a home-made sampling head similar to that in Figure 1 was tried, but the results reported here come from 2F sampling with 47 mm dia. coarse and fine particle filters only.

The DICHO sampler collects both coarse and fine particles on 2 µm pore Teflon membrane filters. A similar filtration medium** was chosen for the 2F fine fraction, to ensure best possible compatibility between the samplers. The choice of the coarse fraction filter was either 12 µm, 8 µm, or 5 µm pore NP***. Apiezon-coated 8 µm pore filters were readily available from European suppliers, and were chosen for the comparison study. The filtration characteristics of these large-pore NP filters have been thoroughly investigated and reported in the literature (e.g., John et al., 1983).

A special inlet adapter piece was made for the 2F sampling head, to fit it directly to the modified S-A inlet.

Two sets of sampling heads were used for the 2F samplers, enabling the exchange of already assembled filter holders at the sampling site. The filters were inserted and removed from the holders in a clean area at NILU.

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* Nuclepore Corporation, Pleasanton, CA. Swin-Lok Aerosol Holder and Multiple Holder Adapter.

** Membrana Inc., Pleasanton, CA; Zeflour, 2 µm pore, Product No. P5PJ047.

*** Nuclepore Corporation, Pleasanton, CA; Polycarbonate 8 µm, Apiezon coated.

The DICHO and 2F samplers were started and stopped manually for all sampling runs. The durations of the sampling runs were for the most part approximately 24 hours. On several occasions, however, they had to be extended to multi-day periods, either due to very light aerosol loadings (Third comparison series), or because weekend access to the samplers was not possible (Second comparison series).

The indicated flowrates of all samplers were recorded at the start and end of each sampling run. The flowrate of the DICHO was additionally checked by attaching a calibrated flowmeter to the virtual impactor intake (sampling head removed). About 10 minutes after a run was started, all flowrates were rechecked and, if necessary, readjusted.

3.2 SAMPLING SITES AND EXPERIMENTAL DESIGN

To ensure a reasonably wide range of aerosol concentrations, two sampling sites were used for the comparison sampling.

The first, on the flat roof of the NILU building, some 15 m above ground level, was expected to represent the normally fairly "clean" air on the outskirts of Lillestrøm. During the March 1985 sampling (First comparison series) the samplers were grouped in a triangular pattern about 10 m east of the roof penthouse, with the sampler inlets about 1.5 m from each other and about 1.5 m above the roof level. The same pattern was repeated during the Aug./Sept., 1985, measurements (Third comparison series), exept the samplers were then within ca. 6 m of the penthouse.

For the second "dirty" air site, a flat second story roof, about 10 m above ground, adjoining the cafeteria "balcony" of the Bergen Bank building in downtown Lillestrøm was made available for the March-May 1985 sampling (Second comparison series). The downtown site is close to a busy street corner and thus was expected to provide higher aerosol concentrations, due to the considerable traffic below during the day and reentrained, blown street dust. Here the samplers were placed about 5 m east of the cafeteria wall about 2 m from the edge of the building, in the triangular pattern. The sampler control units at this site were kept in the open on top of a table on the balcony. The balcony was not in use during this sampling period.

During the First and Second comparison series, both 2F samplers were operated with the AERO inlets for about half of the periods, and then the modified S-A inlet used for one of them for the rest of the period. Both 2F samplers were equipped with the modified S-A inlets in the Third comparison series.

3.3 EVALUATION OF SAMPLES

All gravimetric evaluation of the DICHO and 2F filters before and after sampling were done on a micro-balance* in NILU's filter weighing room. The room is partially climate-controlled, at approximately 21^{0}C and 45% relative humidity. All filters were charge-neutralized before weighing, with a radioactive Polonium source**.

Before the preweighing, the clean NP and Teflon filters were placed on the table surface in the weighing room, and "conditioned" for 24 hours. After preweighing, the filters were placed in clean plastic "cassettes" and kept in the weighing room until mounted. The exposed 2F sample filters were returned to the weighing room immediately after the completion of a sampling run, and kept in partially opened cassettes on the table for varying periods of time (>24 h) before weighing. The DICHO filters remained in the sampling module until the filter carousel had to be reloaded. The DICHO sample filters were then returned to the weighing room, and handled in the same manner as the 2F filters. Filter blanks from the same batches of DICHO and 2F filters were gravimetrically evaluated at the same time as the sample filters.

For the third comparison series, two independent sets of weighing results for all filters were provided by two weighing operators (see Appendix, Figure A1).

* Mettler Instrumente AG, Greifensee, Switzerland; M3 Microbalance.
** Nuclear Products Co., El Monte CA; Model 24500, 500 μC Po210.

DICHO and 2F filter sets and blanks from a few selected sampling runs were also analyzed for aerosol lead (Pb) content by atomic absorption spectroscopy (AAS). The gravimetric (and Pb) blank values were used to adjust the sample weights in aerosol mass (and Pb) concentration calculations. The sample volumes for all three samplers were obtained from average flowrate and sampling time information.

4 RESULTS

The calculated aerosol concentrations for the three comparison series are all shown graphically in Figures 4 through 9. The complete data set, containing sampling time, sample volume, and calculated coarse, fine and inhalable particle concentrations is given in Tables A1, A2 and A3 in the Appendix A.

4.1 FIRST COMPARISON SERIES

Aerosol sampling in this first series was started on the NILU roof in February, 1985. The combination of 47 mm dia. coarse (8 µm pore NP) and 25 mm dia. fine filters*, in the sampling head shown in Figure 1a, and the AERO inlet (Figure 2) was used for the two 2F samplers. During February 1985 the Lillestrøm valley experienced persistent atmospheric stagnation, due to very light winds and continual temperature inversions. The very cold weather also meant increased space heating, contributing to relatively high aerosol concentrations. As a consequence, the smaller fine particle filters became completely clogged with the aerosol particles in a 24-h period. Even the automatic DICHO sampler switched to a new filter pair, when the resistance of the collected aerosol to airflow exceeded its pressure drop limit. Sampling was then suspended, and new 2F sampling heads prepared, with 47 mm dia. filter holders (Figure 1b) for both coarse and fine particles.

* Membrane Inc., Pleasanton, CA; Stretched Teflon 3 µm pore, Product No. R2PI025.

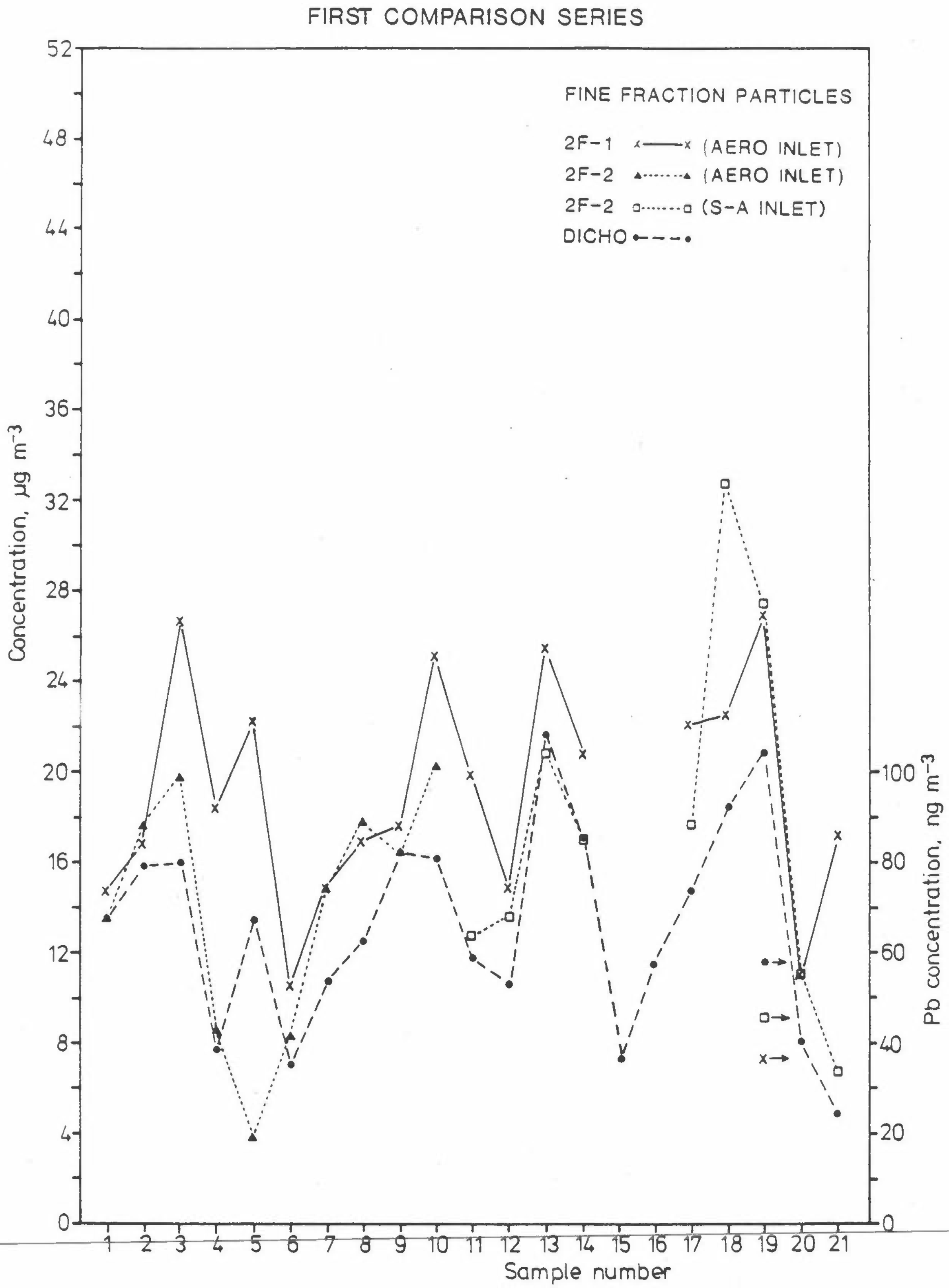

Figure 4: Comparison of fine fraction aerosol concentrations, measured by DICHO and 2F samplers on NILU roof, 9-29 March, 1985. A few Pb concentrations (right hand scale) are shown as well.

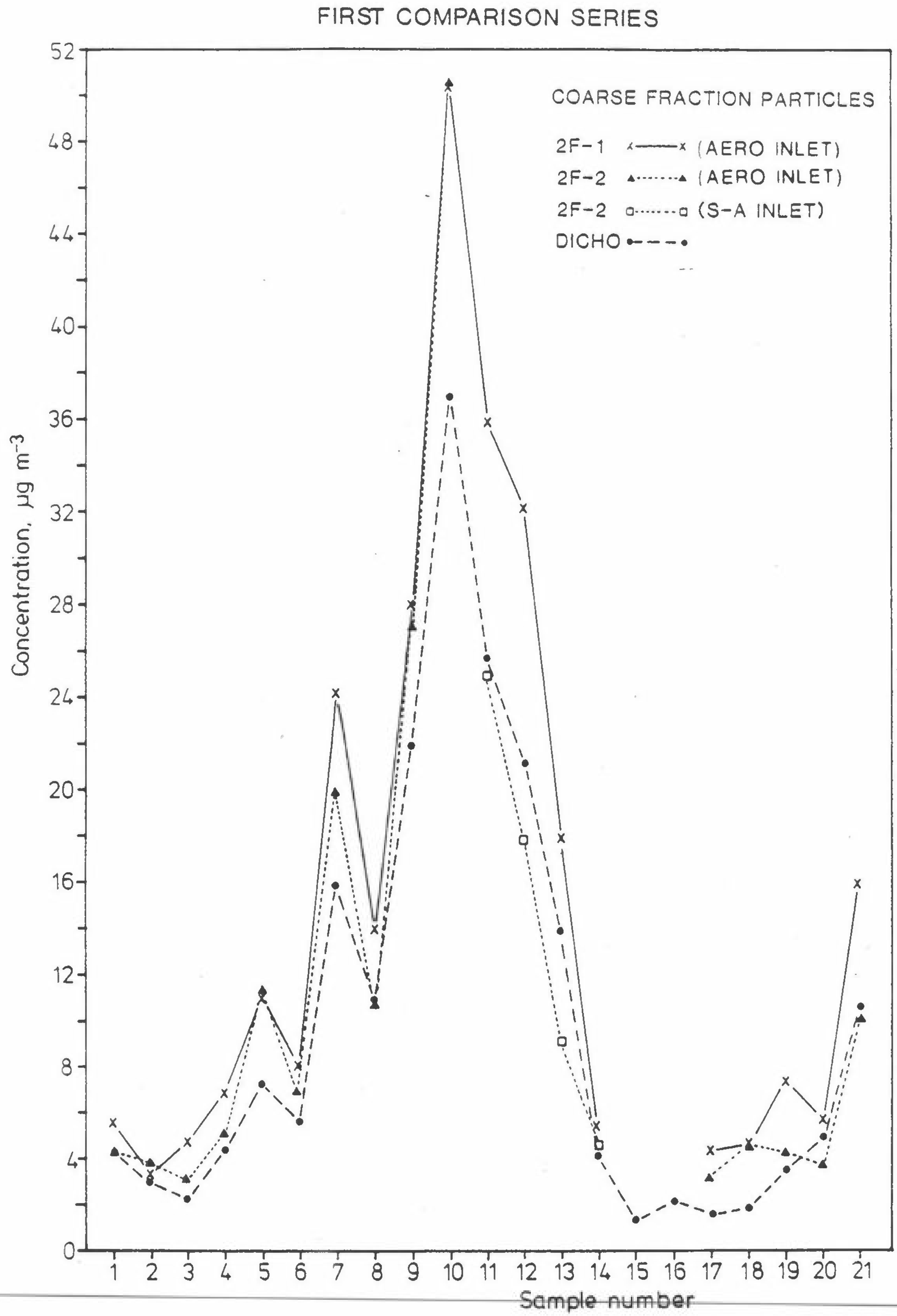

Figure 5: Comparison of coarse fraction aerosol concentrations, measured by DICHO and 2F samplers on NILU roof, 9-29 March, 1985.

Comparison sampling was resumed on 8. March and continued until 29. March, 1985. The calculated 24-h average coarse and fine particle concentrations for the 3 samplers from 21 runs are plotted in Figures 4 and 5, respectively. Some Pb concentration values are also included. During periods with wet and melting snow, some penetration of water into all sampler inlets was noted, which may have affected the coarse particle deposits.

During this period, the fine particle concentration varied within approximately 5-30 $\mu g/m^3$. The period included a coarse particle "episode" on 16-20 March, with very high coarse particle concentrations. The main source of these particles is road dust from the wearing of road surfaces caused by studded tires, being reentrained by vehicle turbulence and wind during dry road conditions.

4.2 SECOND COMPARISON SERIES

During the second series sampling on the roof adjoining the Bergen Bank building in downtown Lillestrøm, there were several problems with the 2F equipment. The vacuum pump of 2F-1, operating with transformed voltage, would tend to overheat so that its thermal protection device shut the sampler down for unknown periods. The elapsed time meters also were malfunctioning when operated on the transformed voltage, so that the sample volumes for several sampling runs were uncertain. Extensive recalibrations of the flowmeters and the complete sampling systems were done after the conclusion of this series.

The calculated aerosol fraction concentrations for 13 runs are shown in Figures 6 and 7, including some Pb determinations. Samples 26 and 28 are from 3-day runs, and sample 32 from a 4-day run.

The fine and coarse particle concentrations varied widely during this spring period. High fine particle concentrations corresponded to episodes of long-range transported aerosol, while high coarse particle concentrations were caused by road dust during dry periods.

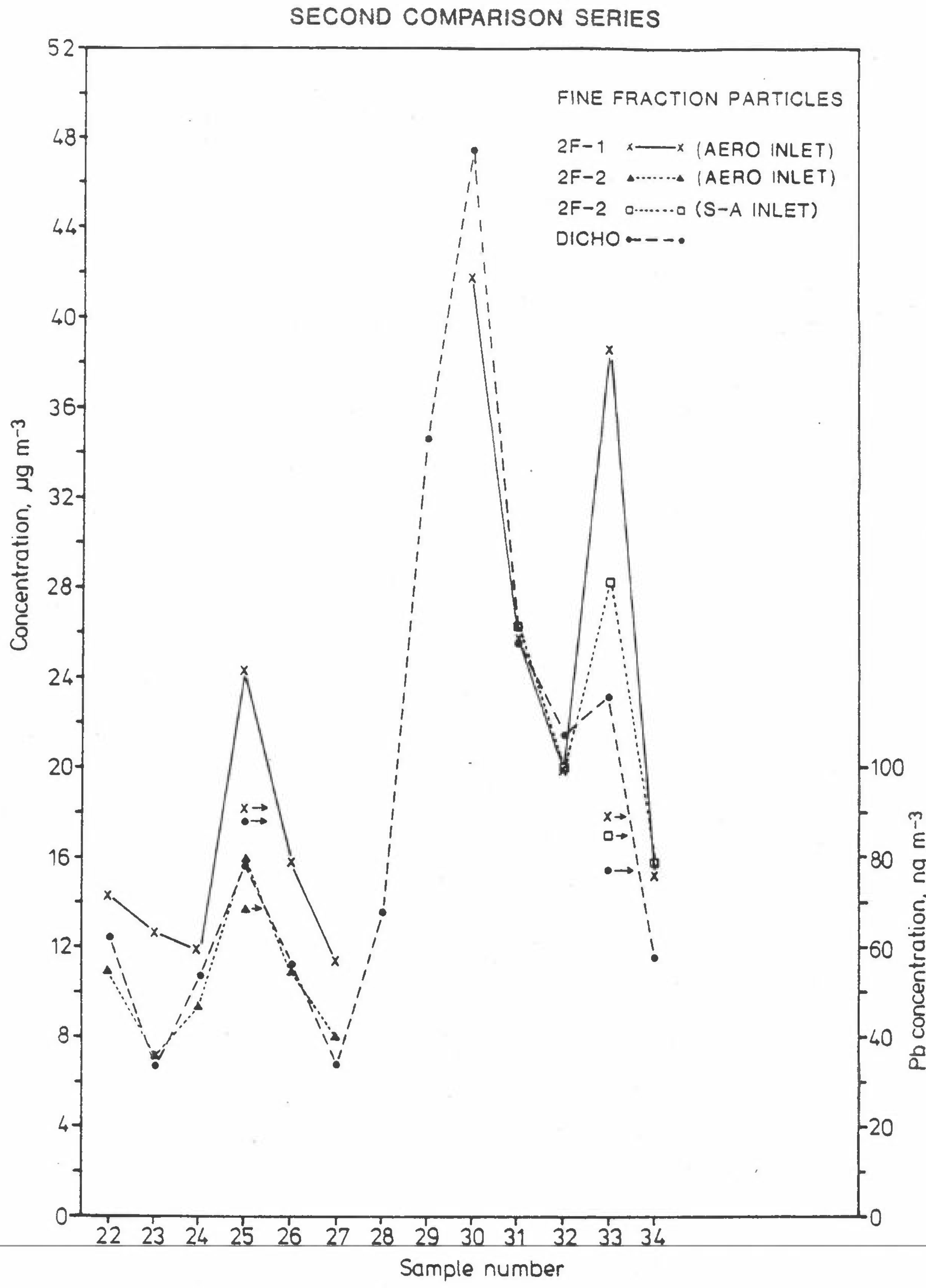

Figure 6: Comparison of fine fraction aerosol concentrations, measured by DICHO and 2F samplers at Bergen Bank building, 23 March-15 May, 1985.

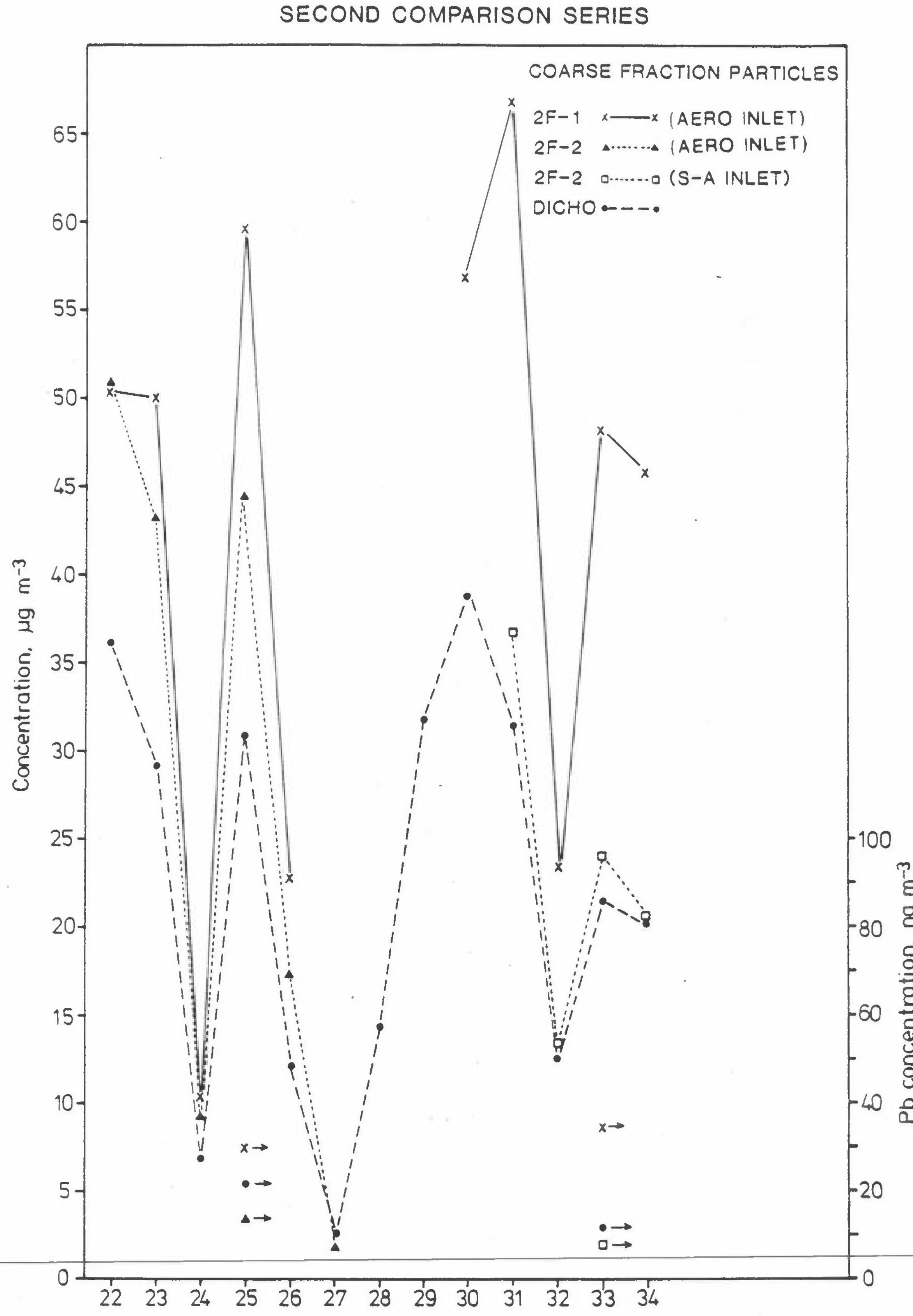

Figure 7: Comparison of coarse fraction aerosol concentrations, measured by DICHO and 2F samplers at Bergen Bank building, 23 March-15 May, 1985.

4.3 THIRD COMPARISON SERIES

For this last comparison series, starting 7 August, the samplers were returned to the NILU roof. The 110 V vacuum pump of 2F-1 had been replaced with a 220 V "twin" and no further vacuum pump problems were experienced. The period was, however, characterized by rainy weather and sometimes heavy dew formation during the night. Some water penetration into the sampling heads was again noted.

The sampling series was terminated when very high and gusty winds on the morning of 6 September 1985, overturned and damaged some of the samplers.

The calculated aerosol fraction concentrations from 15 runs are shown in Figures 8 and 9. Samples 38, 44, 45, 48 and 49 come from 2-day runs, samples 40, 41, 46 and 47 from 3-day runs, and sample 43 from a 4-day run.

During this summer period, particle concentrations were low.

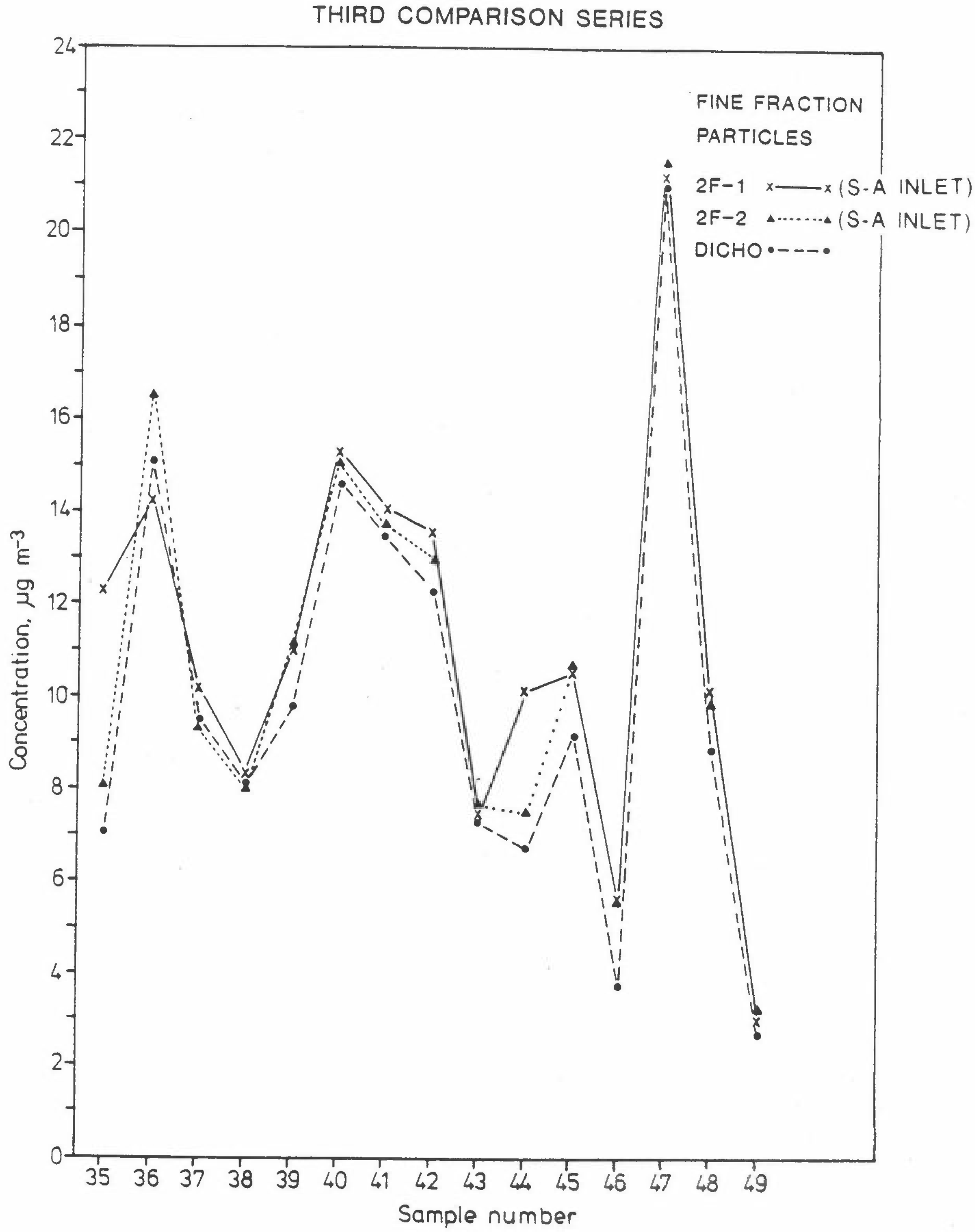

Figure 8: Comparison of fine fraction aerosol concentrations, measured by DICHO and 2F samplers on NILU roof, 7 August-4 September, 1985.

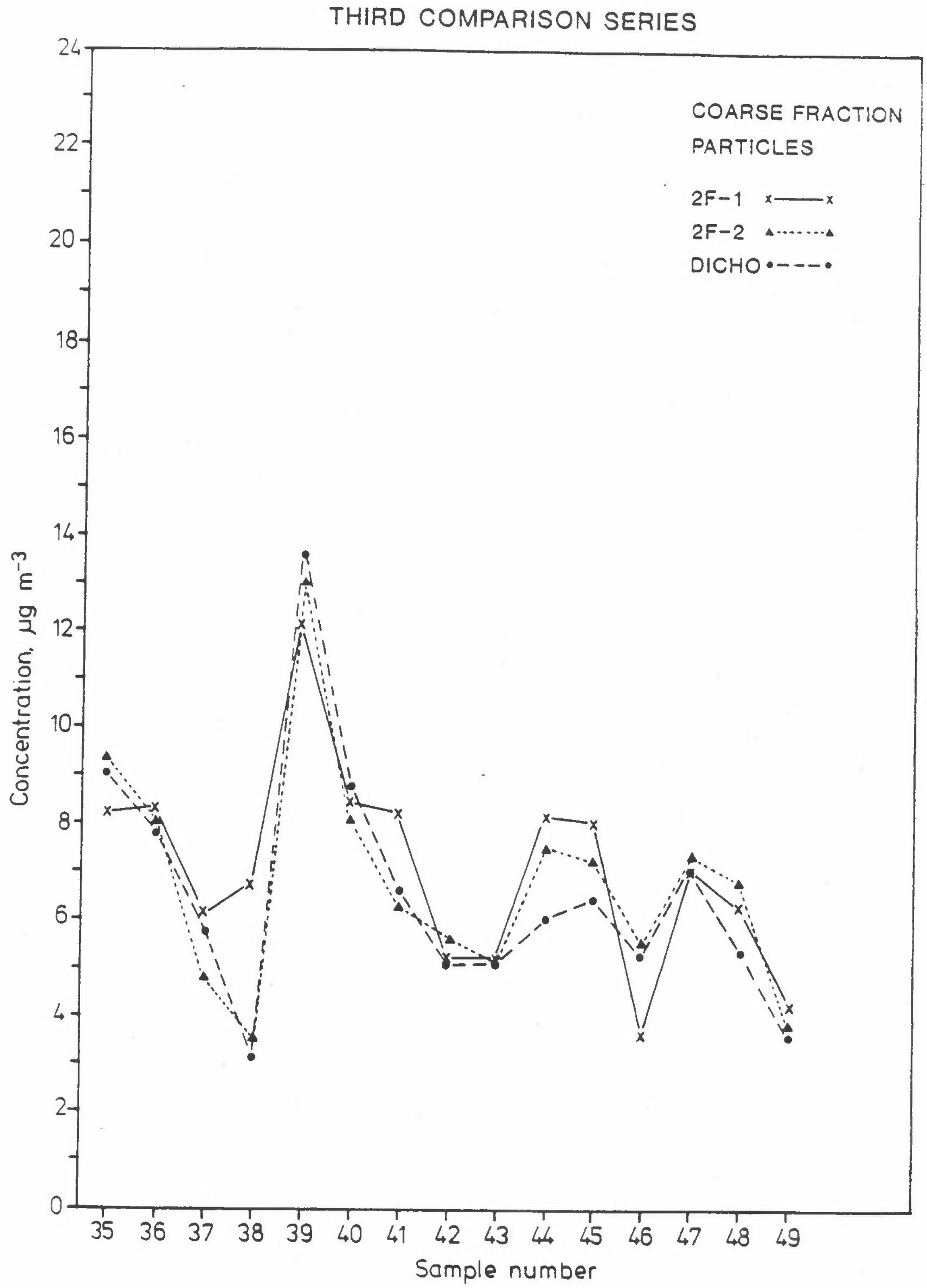

Figure 9: Comparison of coarse fraction aerosol concentrations, measured by DICHO and 2F samplers on NILU roof, 7 August- 4 September, 1985.

5 DISCUSSION OF RESULTS

The time series in Figures 4-9 show some deviations from a perfect day-to-day covariation.

In the first and second series, the 2F-1 sampling pump malfunctioned, resulting in uncertain, and too low, sample volume measurements, thus giving too high aerosol concentration values for some of the samples 1-34 of the 2F-1 sampler.

In general, the results from the 2F sampler with the modified S-A inlet (same as the inlet used for the DICHO) agree better with the DICHO sampler than does the 2F sampler with the AERO inlet. In the third series (Figures 8 and 9), where both 2F sampler have S-A inlets, the curves follow each other fairly well.

Results of regression analysis between samplers are shown in Table 1 and Figures 10-17.

<u>DICHO - 2F/AERO</u>

Figures 10 and 11 show the results of the regression between the DICHO and the 2F/AERO (Aerovironment inlet) samplers. In the fine fraction, one outlier (sampler no. 5) has been excluded from the regression. The regression and correlations coefficient are shown in Table 1.

Table 1 also includes the confidence interval of the regression coefficient, a, on a 95% confidence level, based on a t-statistics test (National Bureau of Standard, 1966). If the confidence interval includes the number 1.0, it can be said that the regression coefficient is not significantly different from 1.0, and thus the data do not indicate that the results from the two methods differ.

Table 1: Results of pairwise linear regression analysis (y=aX+b) between particle concentration measurements from various sampler/inlet combinations.

SAMPLER x	y	n	$\bar{x}$	σ_x	$\bar{y}$	σ_y	R	a	$\pm a_1$ *	b
FINE FRACTION										
DICHO	2F2/AERO	15	12.0	3.7	13.3	4.7	0.876	1.14	0.38	-0.35
DICHO	2F2/S-A	25	12.4	8.0	14.5	8.0	0.924	1.14	0.21	0.27
2F1/S-A	2F2/S-A	15	11.2	4.4	10.7	4.7	0.952	1.02	0.20	-0.63
COARSE FRACTION										
DICHO	2F2/AERO	16	14.4	12.5	19.4	17.9	0.995	1.43	0.08	-1.14
DICHO	2F2/S-A	24	8.8	7.8	9.3	7.8	0.990	1.06	0.07	0.04
2F1/S-A	2F2/S-A	15	7.1	2.2	6.9	2.4	0.856	0.94	0.34	0.20
FINE + COARSE FRACTIONS										
DICHO	2F2/S-A	24	21.6	11.8	23.8	13.3	0.943	1.06		0.98
2F1/S-A	2F2/S-A	15	18.2	5.7	17.6	5.9	0.955	0.99		-0.46

* Confidence interval for the regression coefficient a, on a 95% confidence level (see Appendix B).

The 2F/AERO sampler gave on the average a 24% larger inhalable (fine + coarse) concentration than the DICHO. The coarse fraction was on the average 43% larger than in the DICHO, while the average fine fraction was 14% larger. The coarse fraction correlation was very good (R=0.995), the fine fraction correlation somewhat less so (R=0.876).

The confidence intervals ($\pm a_1$ in Table 1) indicate that the coarse fraction regression coefficient (a=1.43) is significantly different from zero, while the fine fraction coefficient (a=1.14) is not.

The results suggest the following conclusions:

1 ~~The AERO inlet supplied by Aerovironment has an effective particle~~ cut-off larger than that of the DICHO inlet (approximately 10µm EAD).

2 The fine fraction of the 2F sampler was on the average 14% larger than that of the DICHO. Statistically this is not significantly different from zero. However, if a real difference exist between the samplers, the larger fine fraction in the 2F sampler may be due to:

- some reentrainment of particles from the coarse to the fine fraction, similar to the effect described by John et al. (1983).

- lower internal particle loss in the 2F sampler head than in the DICHO sampler, due to a smaller internal surface area in the 2F head.

Neither of these were assessed in this study.

DICHO - 2F/S-A

The results of the regression between the DICHO and the 2F/S-A (Sierra-Anderson inlet) samplers are shown in Figures 12-14 and in Table 1.

The correlation coefficients were high for both the fine fraction (R=0.924), the coarse fraction (R=0.990) and for the sum (R=0.943).

The 2F/S-A sampler gave on the average a 2.2 $\mu g/m^3$ higher inhalable particle concentration, and most of this difference shows up in the fine fraction. About 1/3 of the difference is caused by one sample (no. 18).

The 2F/S-A sampler gave on the average a 6% larger inhalable particle concentration, a 6% larger coarse fraction and a 14% larger fine fraction. The confidence intervals of the regression coefficients (± a_1 in Table 1) indicate that these differences are not significantly different from zero.

Still, the 14% average fine fraction difference, larger in the 2F/S-A sampler, is the same result as for the DICHO-2F/AERO comparison, indicating that there may indeed be some difference between the samplers, for reasons as those indicated above.

2F reproducibility

In the third comparison series, two 2F/S-A samplers were run in parallel. The regression analysis results are shown in Table 1 and Figures 15-17.

The correlation coefficients for the inhalable and fine fractions were quite high, R=0.955 and 0.952, respectively. For the coarse fraction, R=0.856.

On the average, the two samplers gave the same fine, coarse and inhalable particle concentrations within ± 2% of the mean, a difference not significantly different from zero.

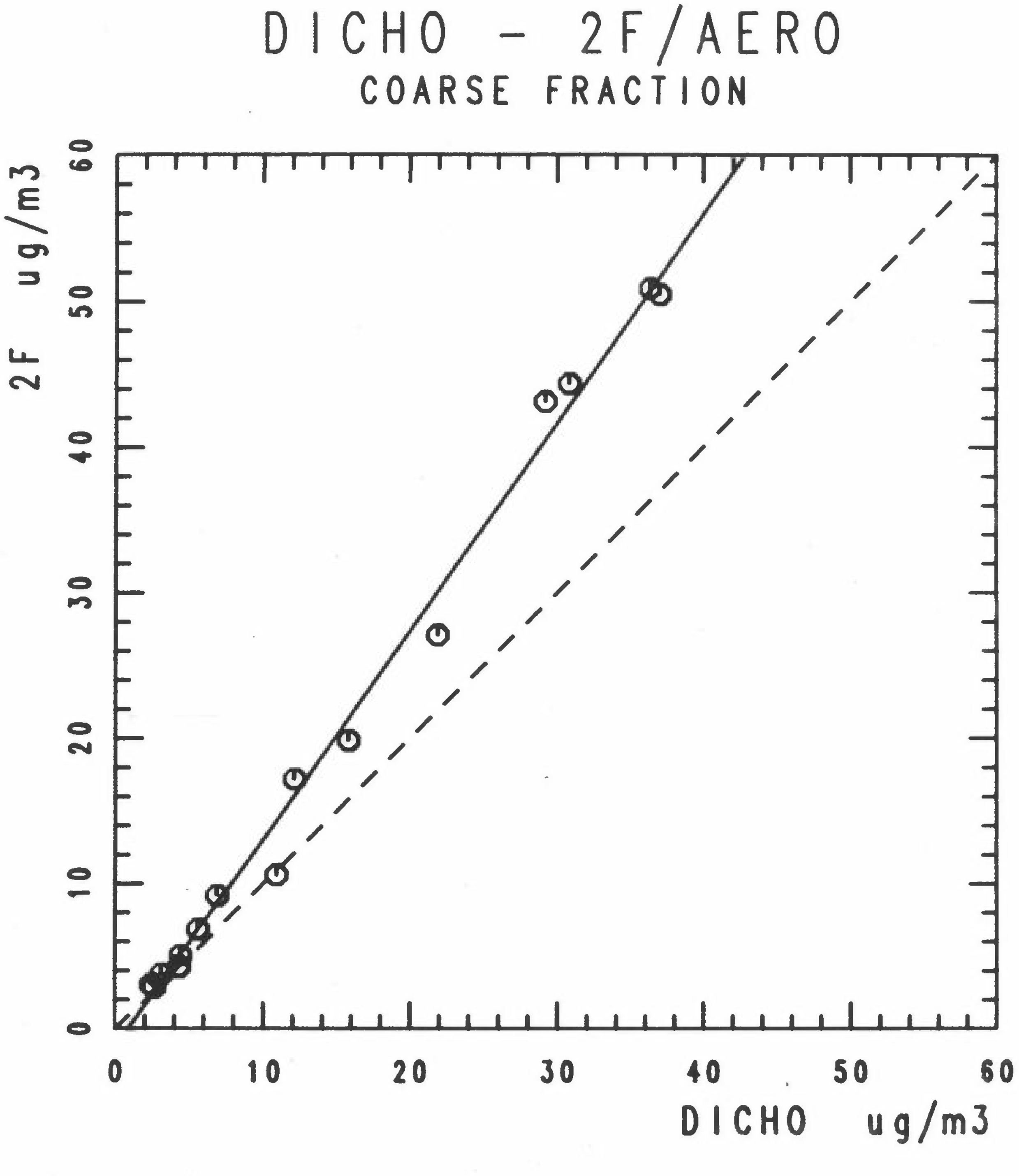

Figure 10: Regression between DICHO and 2F/AERO samplers, COARSE fraction.

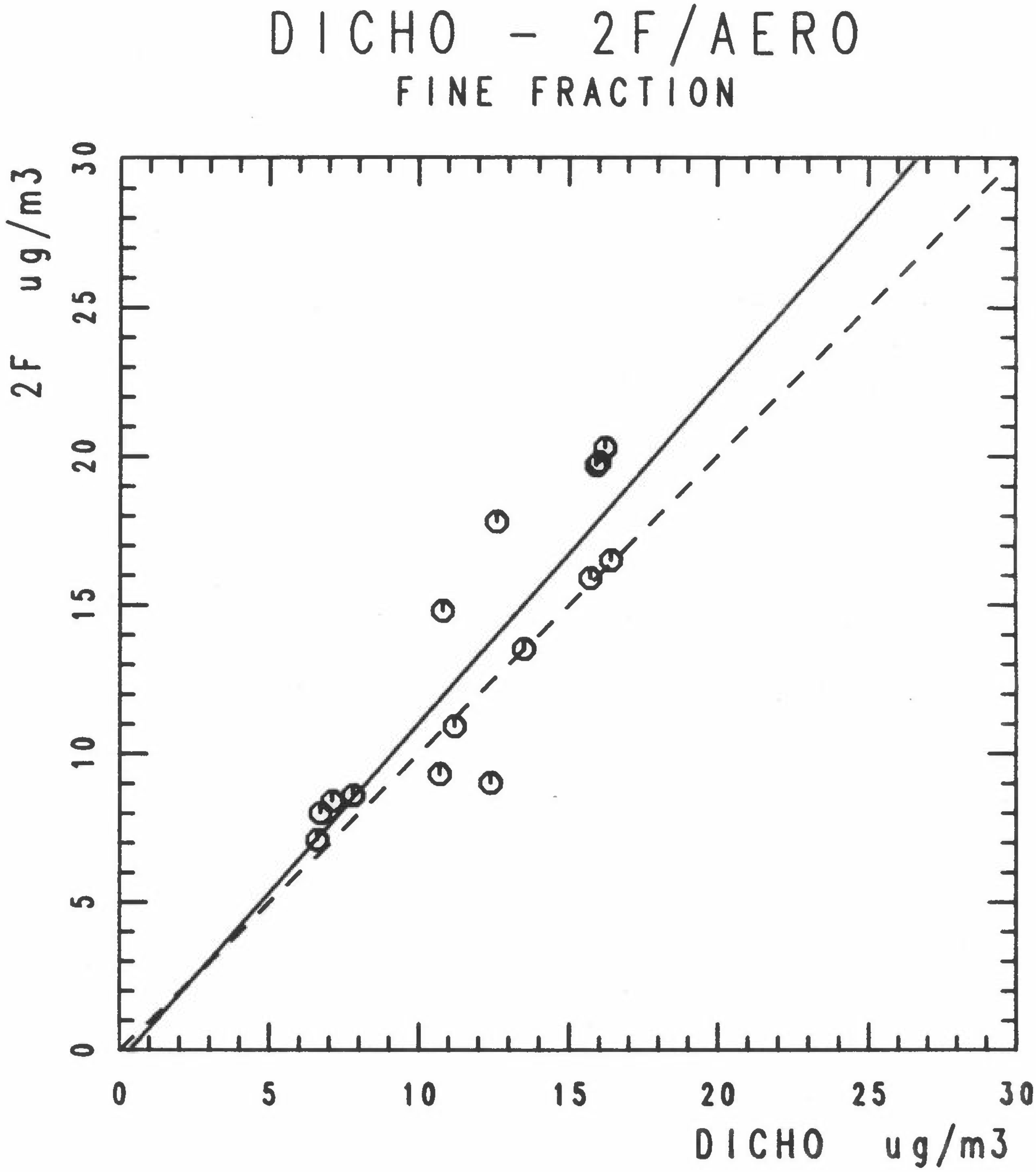

Figure 11: Regression between DICHO and 2F/AERO samplers, FINE fraction.

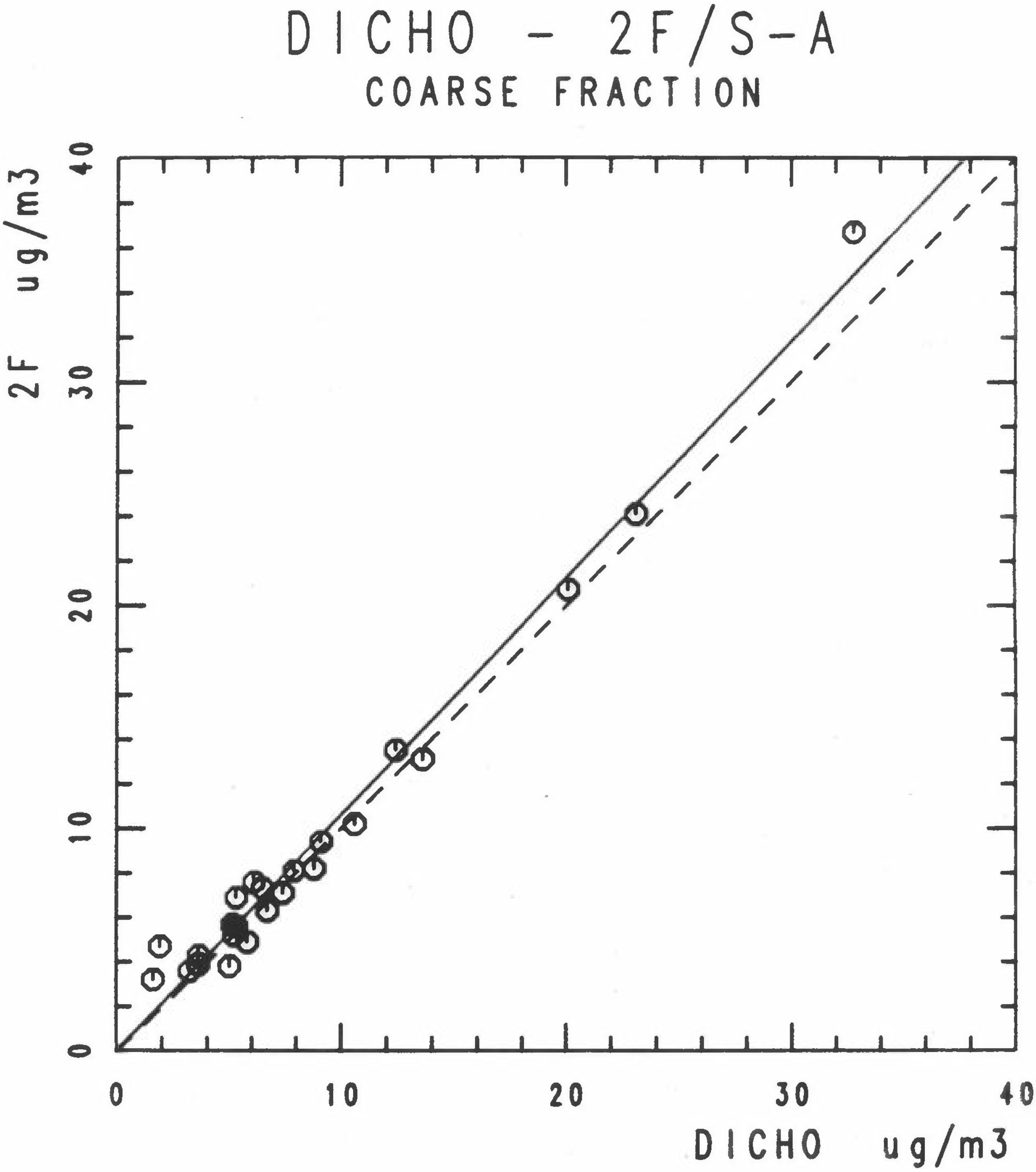

Figure 12: Regression between DICHO and 2F/S-A samplers, COARSE fraction.

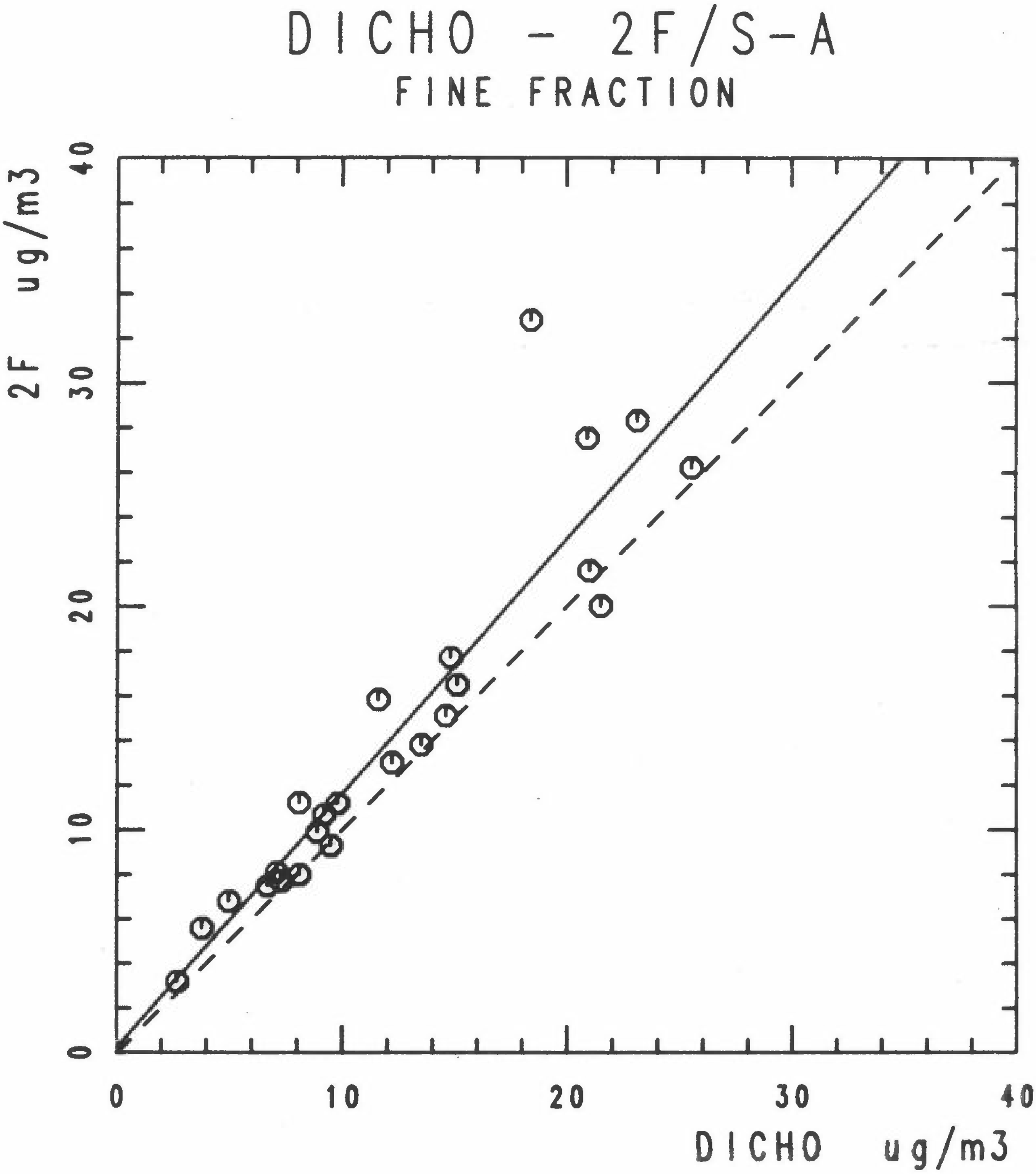

Figure 13: Regression between DICHO and 2F/S-A samplers, FINE fraction.

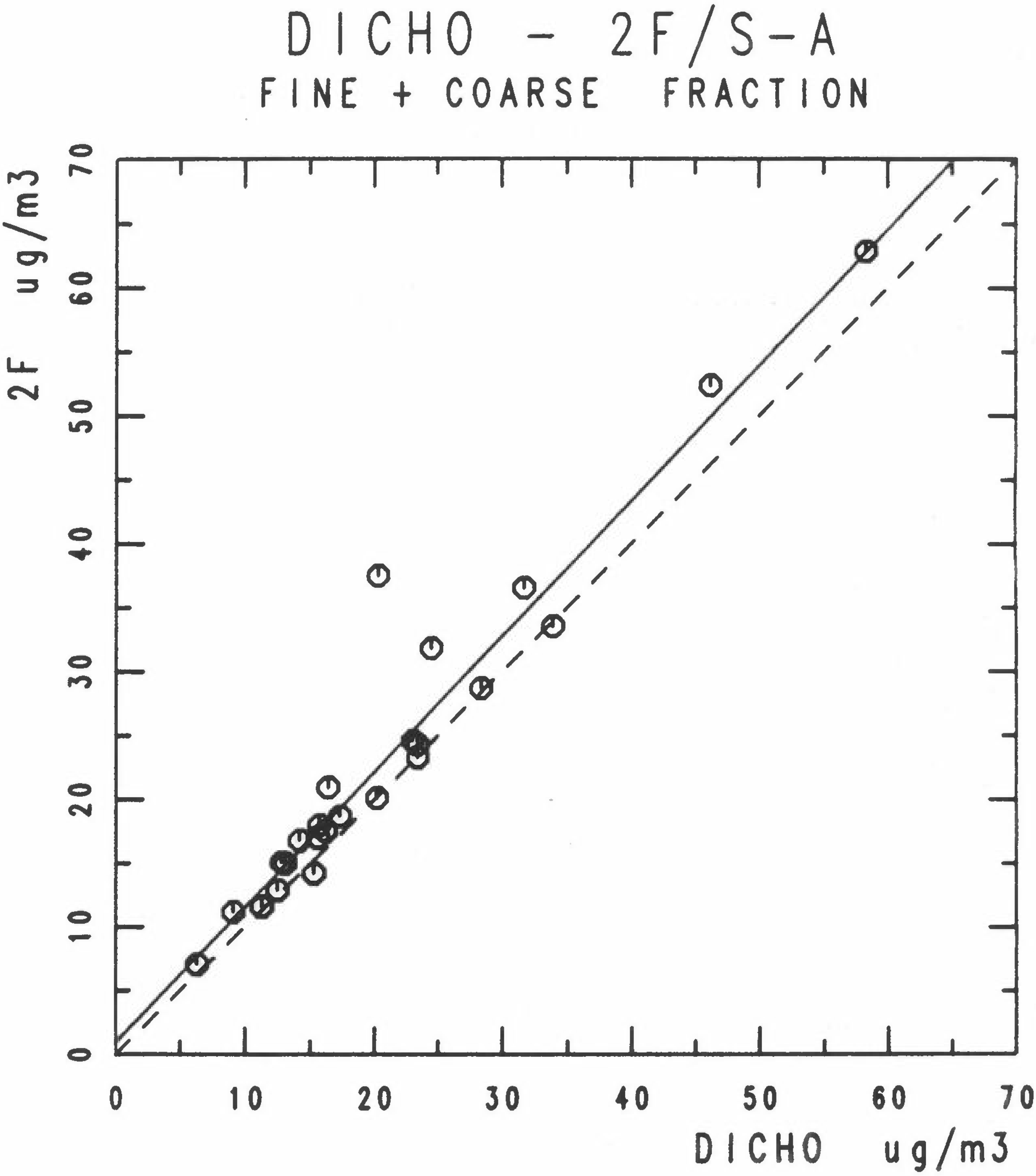

Figure 14: Regression between DICHO and 2F/S-A samplers. FINE+COARSE fraction.

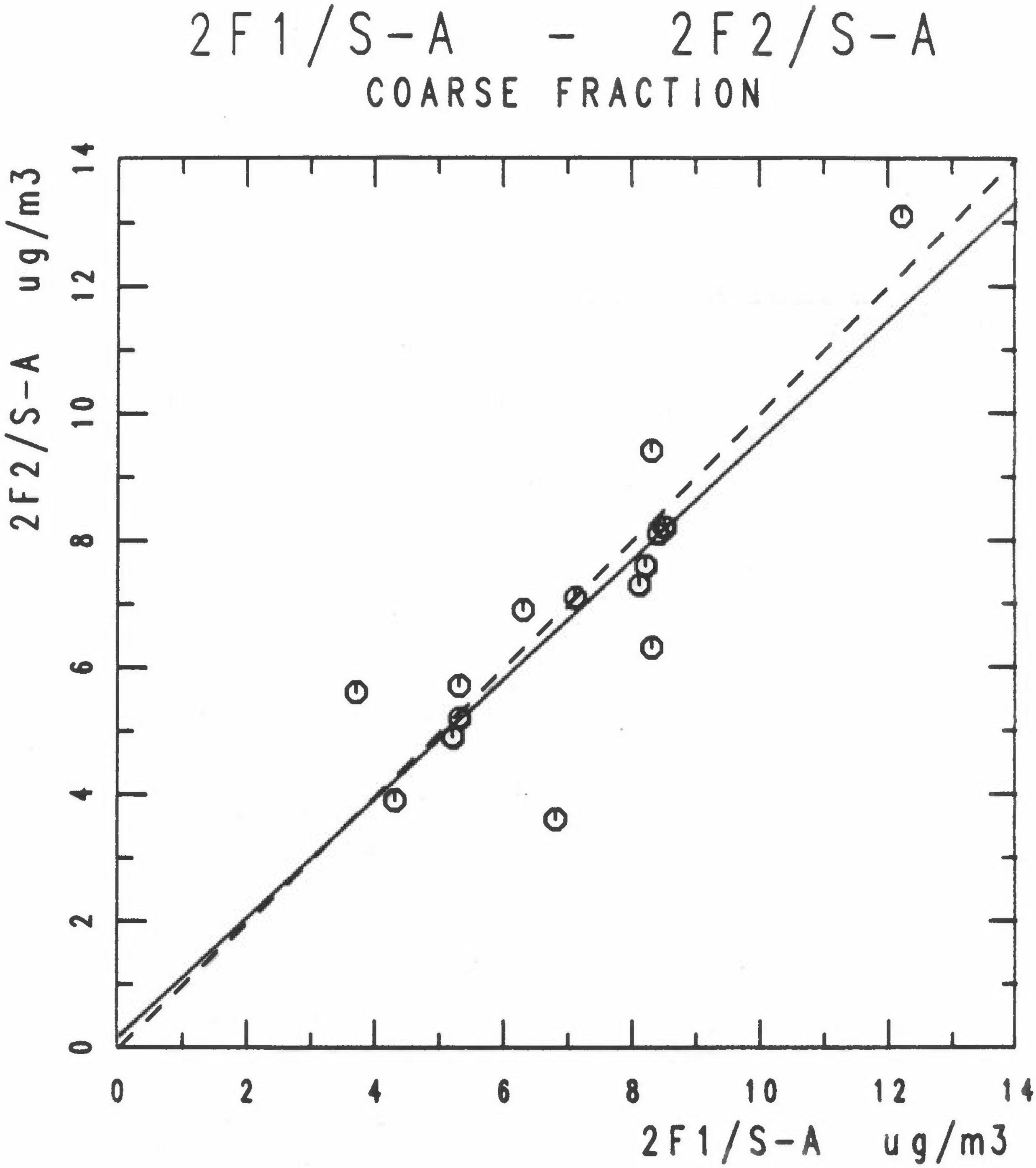

Figure 15: Regression between two 2F/S-A samplers, COARSE fraction.

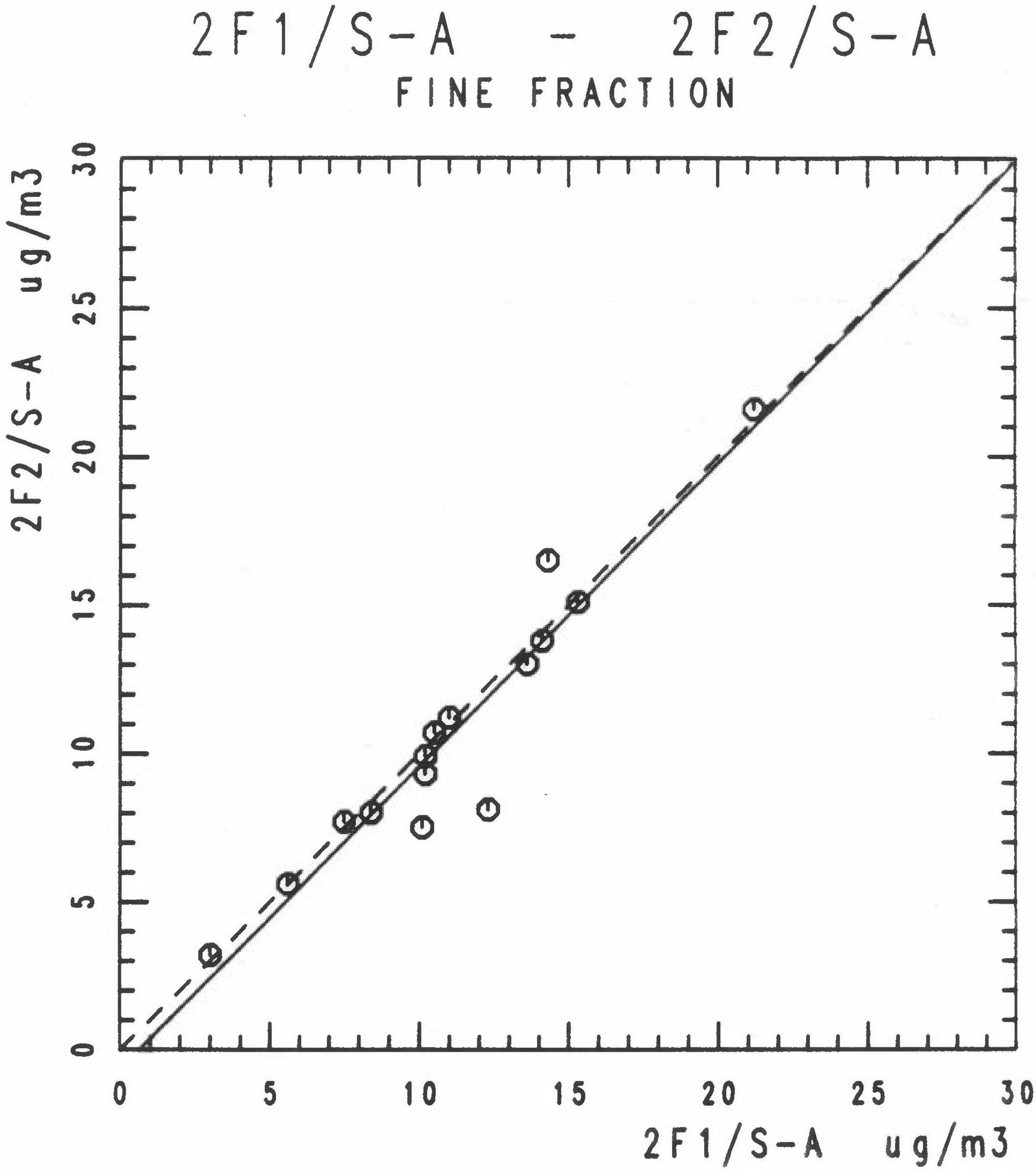

Figure 16: Regression between two 2F/S-A samplers, FINE fraction.

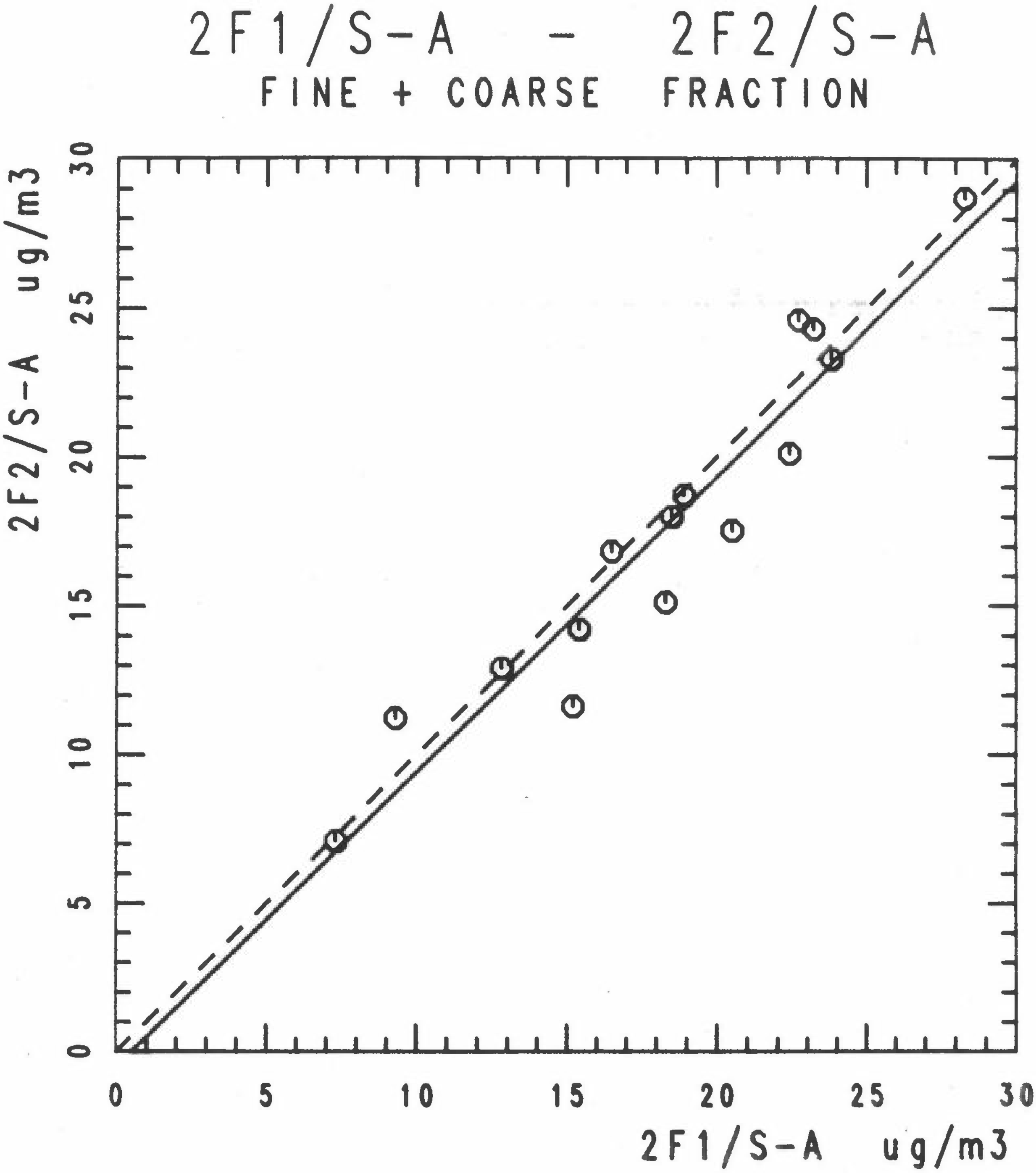

Figure 17: Regression between two 2F/S-A samplers, FINE+COARSE fraction.

6 ON THE EQUIVALENCE BETWEEN THE TWO-FILTER METHOD AND THE DICHO METHOD

Our results indicate that for the aerosol and sampling conditions encountered in this investigation, the two-filter method give fine and coarse particle concentrations that on the average do not differ from those from the DICHO method, and the two methods correlate well. This result is restricted to the following conditions:

- The sample air intake should have cut-off characteristics similar to that of the DICHO sampler.

- The maximum particle load measured on the coarse filter was approximately 700 µg, corresponding to a coarse fraction concentration of about 35 $\mu g/m^3$.
  At higher particle loads the coarse filter will sooner or later become overloaded, resulting in a large increase in pressure drop and altered separation characteristics of the filter.

- The fine particle concentration was never large enough to cause clogging on the fine filter. For a large enough fine particle loading, the filter will clog up, causing a large pressure drop that the flow control unit cannot handle, thus resulting in flow reduction and altered separation characteristics of the coarse filter (see Section 4.1).

- The exposed filter holders are sealed and transported carefully to the laboratory in an upright position, limiting the loss of particles from the coarse filter.

The preliminary investigation (Larssen and Vitols, 1986), representing summer aerosol during dry weather conditions in downtown Oslo, supports these findings.

Cahill et al. (1979) reported results from parallel measurements of elemental concentrations in the aerosol, performed with the two-filter sampler and other sampling methods. For soil elements and sulphur and lead the two-filter method agreed fairly well with the results from other dichotomous samplers, including the virtual impactor. In these early studies, however, the samplers did not have identical sample air inlets. This may affect the comparability of the samplers.

John et al. (1983) investigated the collection efficiency of large-pore Nuclepore filters under laboratory conditions, using generated liquid and solid monodisperse particles with diameter larger than about 1 µm. They concluded that the two-filter method "should not be regarded as a routine monitoring tool", and recommended grease-coated filters, and a very low flow rate, for best results.

For uncoated filters, they found penetration characteristics for liquid particles which agreed well with theoretical predictions, indicating that the large-pore Nuclepore filters are well suited for separating an aerosol sampled into two size fractions with a fairly well defined, but not sharp cut-off. Using solid particles, however, the penetration curve indicated a large degree of penetration of large particles through the filter. Nuclepore filters coated with a very thin grease layer (Apiezon) gave a much better separation for solid particles also. The separation characteristics and pressure drop was shown to be dependent upon the particle loading of the filter.

The non-ideal characteristics of large-pore Nuclepore filters as a medium for separating an aerosol sample into two size fractions, as identified by John et al., limits the applicability of the two- filter sampler. The results of our investigation and those reported by Cahill et al. (1979) indicate, however, that in field sampling of some rural and urban aerosols, the two-filter method agrees well with the DICHO method, and it has a good reproducibility.

We feel the two-filter method, as described here, is an acceptable alternative to the DICHO method for special projects, to provide an inexpensive assessment of exposure to inhalable particles, and separations of those into fine and coarse particle fractions as defined by the DICHO method.

Further investigations, using parallel sampling under field conditions at more sampling locations is necessary, before the two-filter technique can be accepted as a routine monitoring method. Especially, the degree of loss of coarse particles from exposed filters during mail transport back from the stations must be assessed. Also, the range of coarse filter particle load that can be accomodated by the two-filter sampler under field conditions, should be further investigated.

7 CONCLUSIONS

The following conclusions may be drawn from this field study:

1 The 2F sampler with AERO inlet gave on the average a 24% larger inhalable particle concentration than the DICHO. The AERO inlet used most probably had a particle cut-off diameter considerably larger than 10 µm EAD.

2 The 2F sampler with S-A inlet gave on the average a 6% larger inhalable particle concentration than the DICHO. Statistically, this difference is not significantly different from zero, at a 95% confidence level.

3 The 2F sampler gave on the average a 14% larger fine fraction than the DICHO sampler. This same result was reached when the 2F sampler was equipped with either of the Aerovironment or Sierra-Anderson air inlets. This 14% difference is not significantly different from zero at a 95% confidence level.

Two effects, namely reentrainment of coarse particles through the coarse to the fine particle filter (John et al., 1983) and/or a smaller internal loss of particles in the 2F sampler, may explain a possible real difference between the samplers, with somewhat larger fine fraction in the 2F sampler. The importance of these effects was not assessed in this study.

4 The two 2F/S-A samplers run in parallel gave average fine, coarse and inhalable particle concentrations within ± 2% of the mean. For

15 samples, the correlation coefficients were 0.952, 0.856 and 0.955 for the fine, coarse and inhalable particles, respectively.

5 The two-filter sampler, as described in this report, is an acceptable alternative to the DICHO method to provide an inexpensive assessment of exposure to inhalable particles, and a separation into fine and coarse particle fractions, as defined by the DICHO sampler. Certain sampling and operating conditions must be met (see Chapter 6).

Futher investigations under routine field conditions is necessary, before the method can be accepted as a routine monitoring method.

8 ACKNOWLEDGEMENTS

Permission by Bergen Bank in Lillestrøm to locate the aerosol samplers on its property is gratefuly acknowledged. The authors thank Mr. Brynhildsen and other Bergen Bank personell for their cooperation and help during the Second comparison series.

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APPENDIX A

Tabulated sampling information
and concentration data

Table A1: Sampling information and aerosol concentrations: First comparison series: 8-29 March, 1985, roof of NILU building, Lillestrøm. Dichotomous sampler (DICHO) and two 2-filter samplers (2F-1 and 2F-2).

Sample No.	Sampling period	Sampler	Sampling time, min	Sample volume, l	Mass concentration, μg m^{-3} Fine fraction	Coarse fraction	Inhalable
1	8- 9 Mar. 1985	DICHO	1435	20.4*/2.3 **	13.5	4.3	17.8
1	" " "	2F-1	"	15.1	14.8	5.7	20.5
1	" " "	2F-2	"	14.9	13.5	4.3	17.8
2	9-10 Mar. 1985	DICHO	1379	19.6/2.2	15.9	3.1	19.0
2	" " "	2F-1	"	14.6	16.9	3.4	20.3
2	" " "	2F-2	"	14.3	19.7	3.8	23.5
3	10-11 Mar. 1985	DICHO	1305	18.6/2.1	16.0	2.4	18.4
3	" " "	2F-1	"	13.8	26.8	4.8	31.6
3	" " "	2F-2	"	13.8	19.0	3.1	22.1
4	11-12 Mar. 1985	DICHO	1280	18.2/2.0	7.8	4.4	12.2
4	" " "	2F-1	"	13.6	18.2	6.9	25.1
4	" " "	2F-2	"	13.3	8.6	5.1	13.7
5	12-13 Mar. 1985	DICHO	1350	19.2/2.1	13.5	7.2	20.7
5	" " "	2F-1	"	14.3	22.2	11.0	33.2
5	" " "	2F-2	"	14.1	3.9	11.3	15.2
6	13-14 Mar. 1985	DICHO	1385	19.7/2.2	7.1	5.6	12.7
6	" " "	2F-1	"	14.6	10.6	8.0	18.6
6	" " "	2F-2	"	14.4	8.4	6.9	15.3
7	14-15 Mar. 1985	DICHO	1368	19.5/2.2	10.8	15.8	26.6
7	" " "	2F-1	"	14.5	15.0	24.2	39.2
7	" " "	2F-2	"	14.2	14.8	19.9	34.7
8	15-16 Mar. 1985	DICHO	1405	19.8/2.2	12.6	10.9	23.5
8	" " "	2F-1	"	14.9	17.0	13.9	30.9
8	" " "	2F-2	"	14.6	17.8	10.6	28.4
9	16-17 Mar. 1985	DICHO	1380	19.5/2.2	16.4	21.9	38.3
9	" " "	2F-1	"	14.6	17.7	28.0	45.7
9	" " "	2F-2	"	14.4	16.5	27.1	43.6
10	17-18 Mar. 1985	DICHO	1390	19.7/2.2	16.2	37.0	53.2
10	" " "	2F-1	"	14.7	25.2	50.4	75.6
10	" " "	2F-2	"	14.5	20.3	50.5	70.8
11	18-19 Mar. 1985	DICHO	1350	19.1/2.1	11.8	25.6	37.4
11	" " "	2F-1	"	14.3	20.0	35.8	55.8
11	" " "	2F-2***	"	14.1	12.8	24.9	37.7
12	19-20 Mar. 1985	DICHO	1395	19.7/2.2	11.7	21.1	32.8
12	" " "	2F-1	"	14.8	14.9	32.1	47.0
12	" " "	2F-2	"	14.7	13.7	17.8	31.5
13	20-21 Mar. 1985	DICHO	1430	20.2/2.3	21.6	13.9	35.5
13	" " "	2F-1	"	15.2	25.6	17.8	43.4
13	" " "	2F-2	"	15.0	21.0	9.1	30.1
14	21-22 Mar. 1985	DICHO	1440	20.4/2.3	17.1	4.1	21.2
14	" " "	2F-1	"	15.3	20.8	5.4	26.2
14	" " "	2F-2	"	15.1	17.0	4.7	21.7

Table A1: Cont.

Sample No.	Sampling period	Sampler	Sampling time, min	Sample volume, l	Mass concentration, $\mu g\ m^{-3}$		
					Fine fraction	Coarse fraction	Inhalable
15	22-23 Mar. 1985	DICHO	1450	20.5/2.3	7.4	1.4	8.8
15	" " "	2F-1	"	14.8	+	+	-
15	" " "	2F-2	"	15.2	+	+	-
16	23-24 Mar. 1985	DICHO	1420	20.1/2.2	11.6	2.2	13.8
16	" " "	2F-1	"	15.1	+	+	-
16	" " "	2F-2	"	14.9	+	+	-
17	24-25 Mar. 1985	DICHO	1400	20.2/2.2	14.8	1.6	16.4
17	" " "	2F-1	"	14.3	22.1	4.5	26.6
17	" " "	2F-2	"	14.7	17.7	3.2	20.9
18	25-26 Mar. 1985	DICHO	1450	20.6/2.3	18.4	1.9	20.3
18	" " "	2F-1	"	15.4	22.6	4.6	27.2
18	" " "	2F-2	"	15.2	32.8	4.7	37.5
19	26-27 Mar. 1985	DICHO	1425	20.3/2.3	20.9	3.6	24.5
19	" " "	2F-1	"	15.1	27.0	7.4	34.4
19	" " "	2F-2	"	15.0	27.5	4.3	31.8
20	27-28 Mar. 1985	DICHO	1428	20.2/2.2	8.1	5.0	13.1
20	" " "	2F-1	"	15.1	11.1	5.7	16.8
20	" " "	2F-2	"	15.0	11.2	3.8	15.0
21	28-29 Mar. 1985	DICHO	1605	23.1/2.6	5.0	10.6	15.6
21	" " "	2F-1	"	17.0	17.2	15.9	33.1
21	" " "	2F-2	"	16.9	6.8	10.2	17.0

* DICHO fine fraction
** DICHO coarse fraction
*** AERO inlet on 2F-2 exchanged with a modified Sierra-Andersen (S-A) inlet, the rest of the First comparison series.
\+ Missing gravimetric data

Table A2: Sampling information and aerosol concentrations: Second comparison series: 23 Mar - 15 May 1985; roof of Bergen Bank building, Lillestrøm. Dichotomous sampler (DICHO) and two 2-filter samplers (2F-1 and 2F-2).

Sample No.	Sampling period	Sampler	Sampling time, min	Sample volume, l	Mass concentration, $\mu g\ m^{-3}$		
					Fine fraction	Coarse fraction	Inhalable
22	23-24 Apr. 1985	DICHO	1440	20.2*/2.3**	12.4	36.3	48.7
22	" " "	2F-1	"	15.3	14.3	50.4	64.7
22	" " "	2F-2	"	15.1	9.0	50.9	59.9
23	24-25 Apr. 1985	DICHO	1425	20.3/2.3	6.6	29.2	35.8
23	" " "	2F-1	"	15.1	12.7	49.9	62.6
23	" " "	2F-2	"	15.0	7.1	43.1	50.2
24	26-29 Apr. 1985	DICHO	4117	56.7/6.3	10.7	6.9	17.5
24	" " "	2F-1	"	43.6	11.9	10.4	22.3
24	" " "	2F-2	"	42.8	9.3	9.2	18.5
25	29-30 Apr. 1985	DICHO	1453	21.1/2.3	15.7	30.8	46.5
25	" " "	2F-1	"	15.4	24.4	59.7	84.1
25	" " "	2F-2	"	15.3	15.9	44.4	60.3
26	30 Apr-2 May,1985	DICHO	2855	40.6/4.5	11.2	12.1	23.3
26	" " " " "	2F-1	"	30.3	15.8	22.7	38.5
26	" " " " "	2F-2	"	29.7	10.9	17.2	28.1
27	2-3 May, 1985	DICHO	1645	23.4/2.6	6.7	2.6	9.3
27	" " "	2F-1	"	17.4	11.3	1.6	12.9
27	" " "	2F-2	"	16.8	8.0	2.9	10.9
28	3-6 May, 1985	DICHO	4065	57.8/6.4	13.5	14.3	27.8
28	" " "	2F-1	"	43.1	+	+	-
28	" " "	2F-2	"	43.5	+	+	-
29	6-7 May, 1985	DICHO	1397	19.9/2.2	34.6	31.7	66.3
29	" " "	2F-1	"	14.8	+	+	-
29	" " "	2F-2	"	14.5	+	+	-
30	7-8 May, 1985	DICHO	1435	20.4/2.3	47.3	38.7	86.0
30	" " "	2F-1	"	15.2	41.8	56.8	98.6
30	" " "	2F-2 ***	++	-	-	-	-
31	9-10 May,1985	DICHO	1622	24.2/2.7	25.5	32.8	58.3
31	" " "	2F-1	"	17.6	25.7	66.6	92.3
31	" " "	2F-2	"	17.3	26.2	36.7	62.9
32	10-13 May,1985	DICHO	4110	58.8/6.5	21.5	12.4	33.9
32	" " "	2F-1	"	43.6	20.0	23.3	43.3
32	" " "	2F-2	"	42.7	20.0	13.5	33.5
33	13-14 May,1985	DICHO	1835	19.8/2.2	23.1	23.1	46.2
33	" " "	2F-1	"	14.7	38.6	48.2	86.8
33	" " "	2F-2	"	14.4	28.3	24.1	52.4
34	14-15 May,1985	DICHO	1405	20.5/2.3	11.6	20.1	31.7
34	" " "	2F-1	"	14.9	15.1	45.7	60.8
34	" " "	2F-2	"	14.6	15.8	20.7	36.5

* DICHO fine fraction.
** DICHO coarse fraction.
*** AERO inlet on 2F-2 exchanged with a modified Sierra-Andersen (S-A) inlet for the rest of the Second comparison series.
\+ Missing gravimetric data.
\++ Sampler malfunction.

Table A3: Sampling information and aerosol concentrations: Third comparison series: 7 August-4 September, 1985; roof of NILU building, Lillestrøm. Dichotomous samplers (DICHO) and two 2-filter samplers (2F-1 and 2F-2).

Sample No.	Sampling period	Sampler	Sampling time, min	Sample volume, l	Mass concentration, µg m^{-3}		
					Fine fraction	Coarse fraction	Inhalable
35	7- 8 Aug. 1985	DICHO	1425	21.1*/2.4**	7.1	9.1	16.2
35	" " "	2F-1	"	15.0	12.3	8.3	20.5
35	" " "	2F-2	"	14.8	8.1	9.4	17.5
36	8- 9 Aug. 1985	DICHO	1440	21.4/2.4	15.1	7.9	23.0
36	" " "	2F-1	"	15.0	14.3	8.4	22.7
36	" " "	2F-2	"	15.1	16.5	8.1	24.6
37	9-10 Aug. 1985	DICHO	1445	21.4/2.4	9.5	5.8	15.3
37	" " "	2F-1	"	15.2	10.2	5.2	15.4
37	" " "	2F-2	"	15.2	9.3	4.9	14.2
38	10-12 Aug. 1985	DICHO	3095	45.9/5.1	8.1	3.2	11.3
38	" " "	2F-1	"	32.5	8.4	6.8	15.2
38	" " "	2F-2	"	32.5	8.0	3.6	11.6
39	12-13 Aug. 1985	DICHO	1425	21.1/2.4	9.8	13.6	23.4
39	" " "	2F-1	"	15.0	11.0	12.2	23.2
39	" " "	2F-2	"	14.8	11.2	13.1	24.3
40	13-16 Aug. 1985	DICHO	4290	62.8/7.2	14.6	8.8	23.4
40	" " "	2F-1	"	44.6	15.3	8.5	23.8
40	" " "	2F-2	"	45.1	15.1	8.2	23.3
41	16-19 Aug. 1985	DICHO	4250	63.0/7.1	13.5	6.7	20.2
41	" " "	2F-1	"	44.6	14.1	8.3	22.4
41	" " "	2F-2	"	44.6	13.8	6.3	20.1
42	19-21 Aug. 1985	DICHO	2940	43.6/4.9	12.2	5.1	17.3
42	" " "	2F-1	"	30.9	13.6	5.3	18.9
42	" " "	2F-2	"	30.9	13.0	5.7	18.7
43	21-25 Aug. 1985	DICHO	5835	87.5/9.7	7.3	5.2	12.5
43	" " "	2F-1	"	61.3	7.5	5.3	12.8
43	" " "	2F-2	"	61.3	7.7	5.2	12.9
44	25-27 Aug. 1985	DICHO	2715	40.7/4.5	6.7	6.1	12.8
44	" " "	2F-1	"	28.5	10.1	8.2	18.3
44	" " "	2F-2	"	28.5	7.5	7.6	15.1
45	27-29 Aug. 1985	DICHO	2865	42.5/4.8	9.2	6.5	15.7
45	" " "	2F-1	"	30.1	10.5	8.1	18.5
45	" " "	2F-2	"	30.1	10.7	7.3	18.0
46	29-31 Aug. 1985	DICHO	3045	45.7/5.1	3.8	5.3	9.1
46	" " "	2F-1	"	32.0	5.6	3.7	9.3
46	" " "	2F-2	"	32.0	5.6	5.6	11.2
47	31 Aug-2 Sep.1985	DICHO	2730	40.5/4.6	21.0	7.4	28.4
47	" " " " "	2F-1	"	28.7	21.2	7.1	28.3
47	" " " " "	2F-2	"	28.7	21.6	7.1	28.7
48	2- 4 Sep. 1985	DICHO	2850	42.3/4.8	8.9	5.3	14.2
48	" " "	2F-1	"	29.9	10.2	6.3	16.5
48	" " "	2F-2	"	29.9	9.9	6.9	16.8
49	4- 6 Sep. 1985	DICHO	2805	48.0/4.7	2.7	3.6	6.3
49	" " "	2F-1	"	29.5	3.0	4.3	7.3
49	" " "	2F-2	"	29.5	3.2	3.9	7.1

* DICHO fine fraction
** DICHO coarse fraction
NB: modified Sierra-Andersen (S-A) inlet was used for both 2-filter samplers.

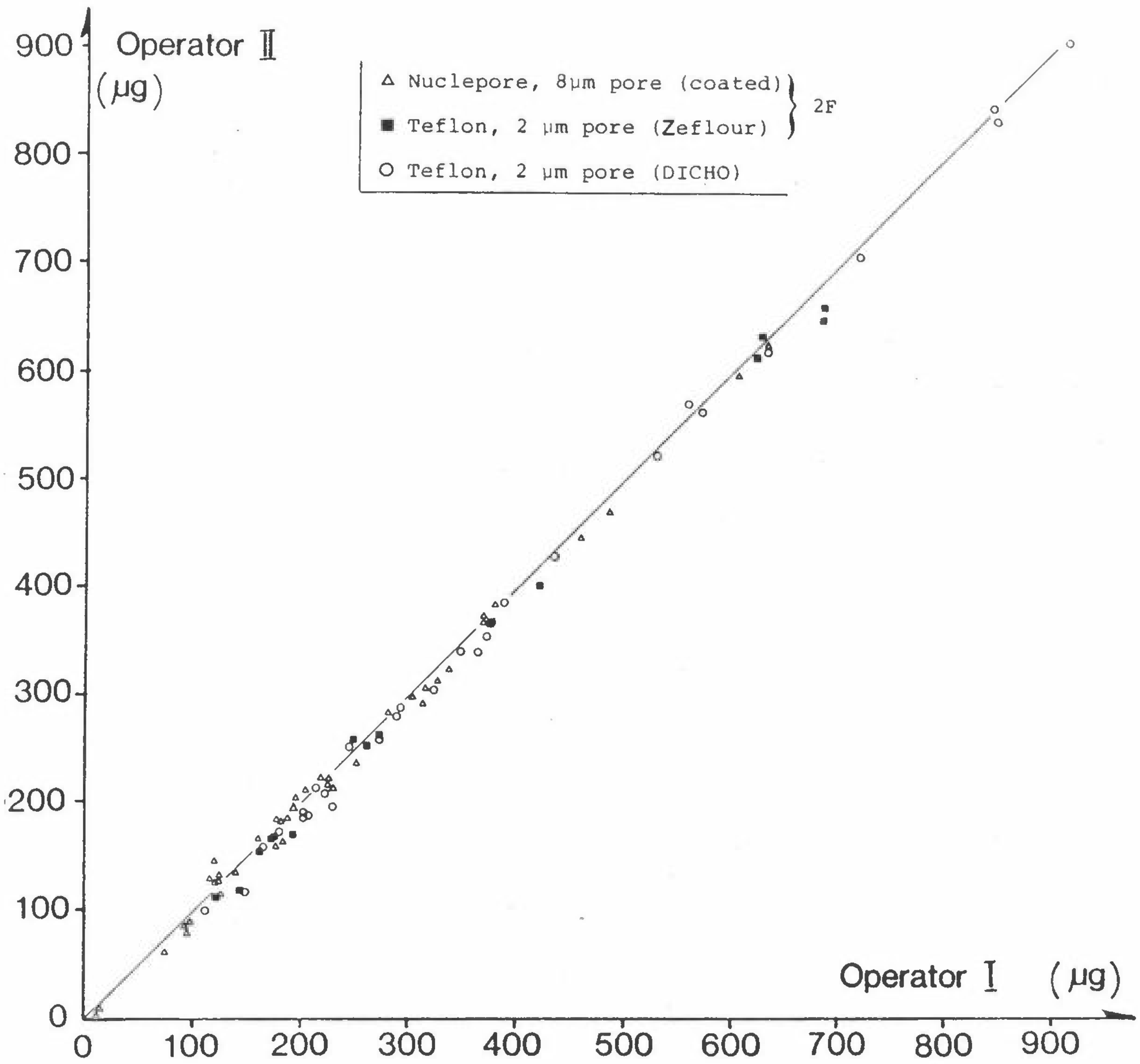

Figure A1: Results of independent filter weighting by two weighting operators.

APPENDIX B

Calculated confidence intervals of the slope of the regression lines between pairs of samplers.

The confidence intervals of the slope a in the regression line Y = aX + b is calculated according to procedures described by National Bureau of Standards (1966), section 5-5.2.3.

SAMPLER Y	X	FRACTION	n	a	S_a *	$1-\alpha$	$t_{1-\alpha/2}$	Conf. interval
2F2/AERO	DICHO	Fine	15	1.14	0.176	0.95	2.160	1.14 ± 0.38
2F2/AERO	DICHO	Coarse	15	1.43	0.036	0.95	2.160	1.43 ± 0.08
						0.99	3.012	1.43 ± 0.11
2F2/S-A	DICHO	Fine	24	1.14	0.101	0.95	2.074	1.14 ± 0.21
2F2/S-A	DICHO	Coarse	24	1.06	0.031	0.95	2.074	1.06 ± 0.07
2F2	2F1	Fine	15	1.02	0.909	0.95	2.160	1.02 ± 0.20
2F2	2F1	Coarse	15	0.94	0.158	0.95	2.160	0.94 ± 0.34

* Standard error of the slope, a.

NORSK INSTITUTT FOR LUFTFORSKNING (NILU)
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Svevestøv	Prøvetakere	Sammenligning

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To-filter-metoden for prøvetaking av inhalerbart svevestøv er sammenlignet med virtuell impaktor-metode ("Dichotomous virtual impactor method"), som betraktes som referanse-metode. To-filter-metoden korrelerte godt med virtuell impaktor-metode, og viste god reproduserbarhet. Avviket mellom de to metodene, begrenset til ca. 14% i gjennomsnitt, når samme luftinntak ble brukt på begge, var ikke signifikant forskjellig fra null, basert på 24 prøver.

TITLE

Comparison of virtual impactor and two-filter particle samplers

ABSTRACT (max. 300 characters, 7 lines)

The two-filter method for samplng of inhalable particles in air has been compared with the virtual impactor method (Dichotomous virtual impactor), which is considered a reference method. The two-filter method correlated well with the virtual impactor method, and showed a good reproducibility. The discrepancy between the methods, limited to about 14% on the average, when the same air intake was used on both samplers, was not significantly different from zero, based on 24 samples.

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