XI. APPENDIX III

DETERMINATION OF PROTEIN IN URINE

Urine protein concentrations can be determined by reaction with sulfosalicylic or trichloracetic acid or by reaction with phosphotungstic acid followed by biuret analysis. Conventional clinical procedures for urine protein detection, such as the boiling test, are not adequate for detection of cadmium-induced proteinuria, because most of the proteins excreted by those intoxicated by cadmium are of low molecular weight. Specific details of analysis of urine protein by the methods mentioned above are described in the following discussion. In addition, some comments on more specific examination of urine proteins by electrophoresis or by β_2-microglobulin analysis are offered.

While 12-hour or, preferably, 24-hour urine samples are superior to spot samples, spot samples will often be all that can be obtained. Early morning samples are preferred if only spot samples can be obtained. If these samples have a low specific gravity (eg, below 1.01), further samples should be taken. For further treatment of data from urine analysis, correction for the dilution of the urine should be made. This is usually performed by correcting to a standard specific gravity, eg, 1.024, or by dividing the amount of urine protein in the sample by the amount of creatinine in the same sample.

Piscator (written communication, May 1976) has compared the methods of protein determination described below, and concluded that neither trichloroacetic acid nor sulfosalicylic acid is so useful for quantitative protein determination as the phosphotungstic acid-biuret method. With sulfosalicylic acid, an acceptable standard curve was obtained, but with trichloroacetic acid he was not able to obtain an acceptable standard curve at low protein concentrations. With sulfosalicylic acid, he found in two cases average urine protein concentrations of about 50-60% of the values obtained on the same urines with phosphotungstic acid-biuret analysis. On this basis, he suggested that while sulfosalicylic acid analysis might be useful for routine checking of urines of workers, more quantitative examinations should be performed at intervals of 1-2 years. He pointed out that even the best quantitative methods for total protein might fail to detect the first changes of tubular proteinuria, citing a case whose protein excretion was at the upper normal level but who had, on electrophoretic examination of urine protein, a pattern typical of tubular proteinuria and a significant increase in excretion of β_2-microglobulin.

Sulfosalicylic or Trichloroacetic Acid Analysis

For analysis of urine protein by precipitation with sulfosalicylic or trichoroacetic acid, the methods described by Henry et al[280] and Meulemans[281] can be used. Measure the specific gravity and the volume of the urine sample, and, after gentle mixing, filter about 75 ml; the sample should be at room temperature. Check for the approximate concentration of protein by some procedure such as use of Albustix® If the estimated concentration is higher than 150 mg/100 ml, dilute the sample with saline solution (0.99%) to a protein concentration of about 100 mg/100 ml.

Pipet 0.5 ml of urine into each of 2 tubes. Add to the first tube 2 ml of saline solution and to the other 2 ml of 3% sulfosalicylic acid or trichloracetic acid. Mix the contents of each tube immediately after the addition and let stand for 5 minutes, followed by a second mixing and reading of the absorbance in a spectrophotometer at 620 nm against a reagent blank. Subtract the reading of the reagent blank and the reading of the urine sample to which saline was added from the reading of the reagent-treated urine sample. Calculate the

total amount of protein (per unit of volume or per unit of time such as 12 or 24 hours) from the standard curve. According to McGarry et al, [282] normal urine protein excretion is about 70 mg/day but may be as high as 90 mg/day; these values are equivalent to 5 and 6.4 mg/100 ml if daily urine excretion is about 1,400 ml. It is likely that better estimates of normal urine excretion of protein can be developed from analyses of urine samples taken at preplacement examinations of workers.

For preparation of a standard curve, use a serum sample with a known protein content and dilute 3:100 with saline solution. Prepare standards by diluting 1, 2, 4, 6, 8, and 10 ml of diluted serum with saline to 10 ml. As with the urine samples, pipet 0.5 ml of each dilution into each of two tubes, add 2 ml of saline to one and 2 ml of sulfosalicylic or trichloroacetic acid solution to the other, mix and let stand for 5 minutes, then mix again and read absorbance at 620 nm, subtracting the absorbance of the reagent blank and that of the serum plus saline from the absorbance of the reagent-treated serum. Plot the resultant absorbances against the protein concentration to get the standard curve. If, for example, the protein concentration of the serum were 7.2 g/100 ml, the diluted standard samples would be 0.22, 0.43, 0.86, 1.30, 1.73, and 2.16 g/liter.

Phosphotungstic Acid-Biuret Analysis

At the Department of Environmental Hygiene, Karolinska Institute, a method of analysis of urine protein has been used for many years that involves precipitation of urine protein by Tsuchiya's reagent, followed by biuret analysis. This method appears to be better than analysis by sulfosalicylic acid or trichloracetic acid in that it can detect urine protein more sensitively than is possible by the other methods. The methods involving reaction with sulfosalicylic or trichloracetic acid have the advantage of involving procedures more familiar to many clinical laboratories.

The procedure as described by Piscator[283] involves mixing 1-2 ml of urine with an equal volume of Tsuchiya's reagent. This reagent is made from 15 g of phosphotungstic acid, 60 g of concentrated hydrochloric acid, 770 ml of 95% ethyl alcohol, and 60 ml of distilled water. After 15 minutes, the precipitate formed by reaction of urine protein with Tsuchiya's reagent is centrifuged at 3,500 rpm. It is then washed twice with 95% ethyl alcohol and dissolved in 4 ml of 3% sodium hydroxide, followed by the addition of 0.2 ml of Benedict's reagent. The Benedict's reagent is made by dissolving 173 g of pure sodium citrate and 100 g of dry sodium carbonate in 500-600 ml of distilled water with the aid of gentle heating, but avoiding boiling. While still warm, the solution is filtered. Meanwhile, 17.3 g of copper sulfate pentahydrate is dissolved with heating in about 100 ml of distilled water. The two solutions are then mixed and after cooling made up to 1,000 ml with distilled water. This mixture is kept in dark bottles with rubber stoppers.

With human albumin as the standard, as described by Piscator,[283] and sample cells of 1 cm light path, readings of the biuret color are made in a spectrophotometer at 330 nm, comparing the readings with those from a blank consisting of 4 ml of 3% sodium hydroxide and 0.2 ml of the Benedict's solution.

Piscator[283] found that when trichloroacetic acid was used as the precipitating agent, much lower values were obtained than with Tsuchiya's reagent when the centrifuge rate was 3,500 rpm. But at a centrifuge rate of 10,000 rpm and a final trichloroacetic acid concentration of 4%, values obtained were similar to those obtained with Tsuchiya's reagent.

Examination for Tubular Proteins

There are probably many individual proteins in normal urine as well as in urines of workers with abnormal proteinuria from cadmium intoxication. Electrophoretic patterns of urine proteins presented in a review by Piscator[284] show lower albumin content in cadmium workers than in the normal man, but a higher content of some fractions that correspond with some of those found in serum. The electrophoretic patterns of the urines of the cadmium workers were characterized by peaks corresponding to α_2-, β-, and γ-globulins, with the elevation due to the β-fraction being especially marked. This β-globulin peak is accounted for by a microglobulin named by Berggard and Bearn[69] as β_2-microglobulin, which they isolated from the urines of patients with chronic cadmium poisoning and of patients with Wilson's disease, which is also a disease involving tubular proteinuria.

Enzymes such as muramidase and ribonuclease have also been found in the urines of people occupationally exposed to cadmium[74,284]

Radioimmunoassay and single radial immunodiffusion have been used for β_2-microglobulin assay, and values obtained by these methods correlated well, according to Evrin et al.[275] They found the average concentration of this protein in urines of 10 healthy subjects to be 73 μg/24-hour volume, by radioimmunoassay. In another study by these University of Uppsala investigators, Peterson et al[285] found the average 24-hour excretion of this microglobulin in healthy subjects was 120 μg. Average 24-hour albumin excretion in these subjects was 10 mg and total protein 80 mg. Patients with glomerular disorders had normal or only slightly increased excretion of microglobulin but marked increases in albumin and total protein excretion. Most of the patients with tubular disorders had large amounts of microglobulin in their urines with normal or only slightly increased quantities of albumin and only moderately increased quantities of total protein. These investigators[285] used the single radial immunodiffusion method of Mancini et al[286] for determination of albumin and microglobulin in urine. Sevier and Reisfeld[276] have described a semi-automatic method for double-antibody radioimmunoassay capable of analyzing 24 samples simultaneously in the range of 1-100 ng, using goat anti-β_2-microglobulin and Sepharose-bound rabbit anti-goat-immunoglobulin G. Facilities for microglobulin analysis are not available in many laboratories.

Evrin and Wibell[287] reported that β_2-microglobulin can decompose during storage of urine samples with pH of less than 5.6. This can be prevented by adding buffer to urine samples. However, Kjellstrom et al[132] suggested that this decomposition might also occur in the urinary bladder if the urine pH were below 5.6. They found an average of 450 μg/liter in 15 urine samples of pH less than 5.6 and an average of 2 mg/liter in other samples of higher pH.

XII. APPENDIX IV

MATERIAL SAFETY DATA SHEET

The following items of information which are applicable to a specific product or material shall be provided in the appropriate block of the Material Safety Data Sheet (MSDS).

The product designation is inserted in the block in the upper left corner of the first page to facilitate filing and retrieval. Print in upper case letters as large as possible. It should be printed to read upright with the sheet turned sideways. The product designation is that name or code designation which appears on the label, or by which the product is sold or known by employees. The relative numerical hazard ratings and key statements are those determined by the rules in Chapter V, Part B, of the NIOSH publication, *An Identification System for Occupationally Hazardous Materials.* The company identification may be printed in the upper right corner if desired.

(a) Section I. Product Identification

The manufacturer's name, address, and regular and emergency telephone numbers (including area code) are inserted in the appropriate blocks of Section I. The company listed should be a source of detailed backup information on the hazards of the material(s) covered by the MSDS. The listing of suppliers or wholesale distributors is discouraged. The trade name should be the product designation or common name associated with the material. The synonyms are those commonly used for the product, especially formal chemical nomenclature. Every known chemical designation or competitor's trade name need not be listed.

(b) Section II. Hazardous Ingredients

The "materials" listed in Section II shall be those substances which are part of the hazardous product covered by the MSDS and individually meet any of the criteria defining a hazardous material. Thus, one component of a multicomponent product might be listed because of its toxicity, another component because of its flammability, while a third component could be included both for its toxicity and its reactivity. Note that a MSDS for a single component product must have the name of the material repeated in this section to avoid giving the impression that there are no hazardous ingredients.

Chemical substances should be listed according to their complete name derived from a recognized system of nomenclature. Where possible, avoid using common names and general class names such as "aromatic amine," "safety solvent," or "aliphatic hydrocarbon" when the specific name is known.

The "%" may be the approximate percentage by weight or volume (indicate basis) which each hazardous ingredient of the mixture bears to the whole mixture. This may be indicated as a range or maximum amount, ie, "10-40% vol" or "10% max wt" to avoid disclosure of trade secrets.

Toxic hazard data shall be stated in terms of concentration, mode of exposure or test, and animal used, ie, "100 ppm LC50-rat," "25 mg/kg LD50-skin-rabbit," "75 ppm LC man," or "permissible exposure from 29 CFR 1910.1000," or if not available, from other sources of publications, such as the American Conference of Governmental Industrial Hygienists of the American National Standards Institute Inc. Flammability or reactivity data could be flash point, shock sensitivity, or other brief data indicating nature of the hazard.

(c) Section III. Physical Data

The data in Section III should be for the total mixture and should include the boiling point and melting point in degrees Fahrenheit (Celsius in parentheses); vapor pressure, in millimeters of mercury (mm Hg); vapor density of gas or vapor (air + 1); solubility in water, in parts/hundred

parts of water by weight; specific gravity (water + 1); percent volatiles (indicated if by weight or volume) at 70 Fahrenheit (21.1 Celsius); evaporation rate for liquids or sublimable solids, relative to butyl acetate; and appearance and odor. These data are useful for the control of toxic substances. Boiling point, vapor density, percent volatiles, vapor pressure, and evaporation are useful for designing proper ventilation equipment. This information is also useful for design and deployment of adequate fire and spill containment equipment. The appearance and odor may facilitate identification of substances stored in improperly marked containers, or when spilled.

(d) Section IV. Fire and Explosion Data

Section IV should contain complete fire and explosion data for the product, including flash point and autoignition temperature in degrees Fahrenheit (Celsius in parentheses); flammable limits, in percent by volume in air; suitable extinguishing media or materials; special firefighting procedures; and unusual fire and explosion hazard information. If the product presents no fire hazard, insert "NO FIRE HAZARD" on the line labeled "Extinguishing Media."

(e) Section V. Health Hazard Information

The "Health Hazard Data" should be a combined estimate of the hazard of the total product. This can be expressed as a permissible exposure limit or by some other indication of an acceptable standard. Other data are acceptable, such as lowest LD50 if multiple components are involved.

Under "Routes of Exposure," comments in each category should reflect the potential hazard from absorption by the route in question. Comments should indicate the severity of the effect and the basis for the statement if possible. The basis might be animal studies, analogy with similar products, or human experiences. Comments such as "yes" or "possible" are not helpful.

"Emergency and First Aid Procedures" should be written in lay language and should primarily represent first aid treatment that could be provided by paramedical personnel or individuals trained in first aid.

Information in the "Notes to Physician" section should include any special medical information which would be of assistance to an attending physician including required or recommended preplacement and periodic medical examinations, diagnostic procedures, and medical management of overexposed workers.

(f) Section VI. Reactivity Data

The comments in Section VI relate to safe storage and handling of hazardous, unstable substances. It is particularly important to highlight instability or incompatibility to common substances or circumstances such as water, direct sunlight, steel or copper piping, acids, alkalies, etc. "Hazardous Decomposition Products" shall include those products released under fire conditions. It must also include dangerous products produced by aging, such as peroxides in the case of some ethers. Where applicable, shelf life should also be indicated.

(g) Section VII. Spill or Leak Procedures

Detailed procedures for cleanup and disposal should be listed with emphasis on precautions to be taken to protect workers assigned to cleanup detail. Specific neutralizing chemicals or procedures should be described in detail. Disposal methods should be explicit including proper labeling of containers holding residues and ultimate disposal methods such as "sanitary landfill," or "incineration." Warnings such as "comply with local, state, and federal antipollution ordinances" are proper but not sufficient. Pertinent specific local requirements shall be identified.

(h) Section VIII. Special Protection Information

Section VIII requires specific information. Statements such as "Yes," "No," or "If necessary" are not informative. Ventilation requirements should be specific as to type and preferred methods. Respirators shall be specified as to type and NIOSH or US Bureau of Mines approval class, ie, "Supplied air," "Organic vapor canister," "Suitable for dusts not more toxic than lead," etc. Protective equipment must be specified as to type and materials of construction.

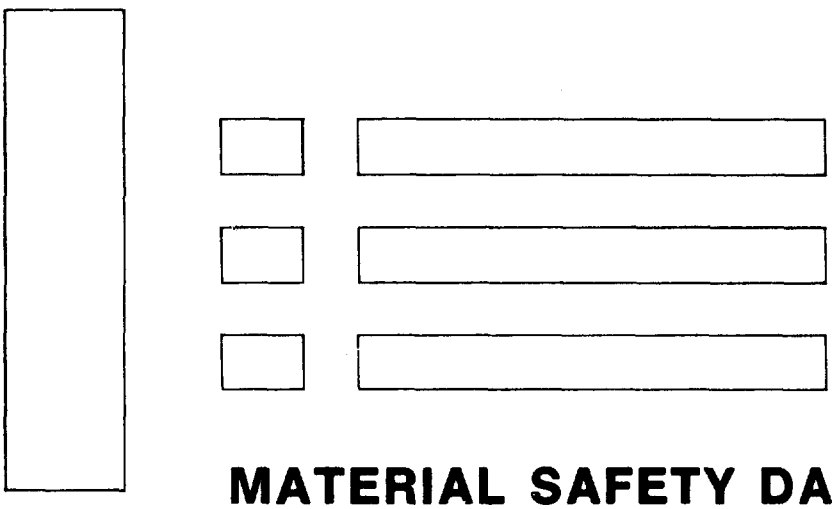
(i) Section IX. Special Precautions

"Precautionary Statements" shall consist of the label statements selected for use on the container or placard. Additional information on any aspect of safety or health not covered in other sections should be inserted in Section IX. The lower block can contain references to published guides or in-house procedures for handling and storage. Department of Transportation markings and classifications and other freight, handling, or storage requirements and environmental controls can be noted.

(j) Signature and Filing

Finally, the name and address of the responsible person who completed the MSDS and the date of completion are entered. This will facilitate correction of errors and identify a source of additional information.

The MSDS shall be filed in a location readily accessible to workers potentially exposed to the hazardous material. The MSDS can be used as a training aid and basis for discussion during safety meetings and training of new employees. It should assist management by directing attention to the need for specific control engineering, work practices, and protective measures to ensure safe handling and use of the material. It will aid the safety and health staff in planning a safe and healthful work environment and in suggesting appropriate emergency procedures and sources of help in the event of harmful exposure of employees.



MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION	
MANUFACTURER'S NAME	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.
ADDRESS	
TRADE NAME	
SYNONYMS	

II HAZARDOUS INGREDIENTS		
MATERIAL OR COMPONENT	%	HAZARD DATA

III PHYSICAL DATA			
BOILING POINT, 760 MM HG		MELTING POINT	
SPECIFIC GRAVITY (H_2O=1)		VAPOR PRESSURE	
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H_2O, % BY WT	
% VOLATILES BY VOL.		EVAPORATION RATE (BUTYL ACETATE=1)	
APPEARANCE AND ODOR			

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)		AUTOIGNITION TEMPERATURE	
FLAMMABLE LIMITS IN AIR, % BY VOL.	LOWER		UPPER
EXTINGUISHING MEDIA			
SPECIAL FIRE FIGHTING PROCEDURES			
UNUSUAL FIRE AND EXPLOSION HAZARD			

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES

SKIN:

INHALATION:

INGESTION:

NOTES TO PHYSICIAN

VI REACTIVITY DATA
CONDITIONS CONTRIBUTING TO INSTABILITY
INCOMPATIBILITY
HAZARDOUS DECOMPOSITION PRODUCTS
CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION
VII SPILL OR LEAK PROCEDURES
STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED NEUTRALIZING CHEMICALS
WASTE DISPOSAL METHOD
VIII SPECIAL PROTECTION INFORMATION
VENTILATION REQUIREMENTS
SPECIFIC PERSONAL PROTECTIVE EQUIPMENT RESPIRATORY (SPECIFY IN DETAIL)
EYE
GLOVES
OTHER CLOTHING AND EQUIPMENT

IX SPECIAL PRECAUTIONS

PRECAUTIONARY
STATEMENTS

OTHER HANDLING AND
STORAGE REQUIREMENTS

PREPARED BY _____

ADDRESS _____

DATE _____

XIII. APPENDIX V

RESEARCH NEEDS

Various effects of cadmium have been studied in animals, but their relevance to humans at workroom concentrations is not clear, and appropriate information should be developed. One of the more important of these gaps pertains to gonadal effects. The study of such effects in cadmium workers poses problems, because of the difficulty in studying gonadal function and the impracticability of obtaining biopsies. Post-mortem examinations may be useful but will often be complicated by senile or terminal changes. The possible role of vascular changes or of alterations in zinc utilization in the gonadal effects should be investigated.

Another important area is in vascular effects of cadmium exposure, since there is conflicting information on the role of cadmium in hypertension and because of suggestions that vascular effects mediate such other effects as those on renal function.

More evidence on the role of cadmium in development of fetal abnormalities in man is needed. Additional assurance is needed that, if cadmium absorption is maintained at sufficiently low levels so that zinc availability to the fetus will not be altered, offspring of cadmium workers will not be harmed by their parents' exposure. In this connection, there is a need for a national surveillance system that can gather information on fetal deaths or anomalies and errors in development of children and relate these data to occupational exposures (or other environmental stresses) of the parents.

The present inadequacies and conflicts in information, from both human and lower animal investigations, on whether cadmium can cause mutations or cancer should be corrected. Further epidemiologic investigations in populations not exposed to other possible causes of these effects should be pursued. At the same time, life-time studies in experimental animals at appropriate doses should be performed. These doses should be high enough to cause significant toxic effects from cadmium but not so high as to cause a significant decrease in longevity, for data to be properly interpretable. Further evidence bearing on the suggestion that cadmium is involved in the causation of prostate cancer should be obtained, preferably from worker populations not also exposed to other possible carcinogens. In this connection, a mortality study now underway at the Karolinska Institute may shed further light on this question. This study of worker populations exposed to cadmium involves two cohorts, one of about 200 and the other smaller. Evaluation of the data developed may be completed within the year (L Friberg, verbal communication, June 1976).

Evidence on adverse effects of cadmium on the nervous system, on the pancreas, on the adrenals, and on thyroids and parathyroids should be confirmed by additional investigations. In particular, conflicting information on whether cadmium causes liver changes at workplace exposure concentrations should be resolved.

Further investigation is also needed on the suggestion, developed in some recent epidemiologic studies, that cadmium workers who smoke may have a greater risk of development of altered renal function.

There are indications that many of the toxic effects of cadmium, possibly all the toxic effects other than some of those on the respiratory tract, result from cadmium's antagonism of the effects of zinc. Further clarification of this and of its impact on deriving safe levels of cadmium should be pursued.

Most elements of this recommended standard were based on empirical information such as epidemiologic investigations of worker populations. A more fundamental approach, such as the

approach involving the mathematical model briefly discussed in Chapter III, *Correlation of Exposure and Effect*, may become more useful when the relevant factors are better quantitated. This model approach will probably be even more useful in a more accurate development of the human organism's ability to handle cadmium from all sources, and should be especially important to those populations exposed to large amounts of cadmium from such sources as food and water. Thus, better information is needed on the absorption of cadmium in various forms by various routes, its retention (half-life) in the body and in critical organs and tissues, its distribution within the body, and, in particular, the threshold concentrations in critical organs in acute (lungs) and chronic (renal cortex) intoxications. From such studies, a better understanding of the significance of blood and urine cadmium concentrations to estimations of amounts absorbed and of the state of health of the individual is likely to be achieved.

TABLE XIV-1

PHYSICAL PROPERTIES OF CADMIUM

Atomic number	48
Atomic weight	112.40
Outer electron configuration	4d(10) 5s(2)
Melting point	320.9 C, 609.7 F
Boiling point	765 C, 1409 F
Density	8.642 g/cc

Solubility of cadmium compounds in water (0-25 C):

Soluble at more than 100 g/100 cc
Cadmium chlorate, chloride, nitrate

Soluble at 50-90 g/100 cc
Cadmium bromide, iodide, sulfate

Soluble at 1-10 g/100 cc
Cadmium benzoate, cyanide, fluoride, lactate

Insoluble
Cadmium carbonate, hydroxide, oxide, selenide, sulfide

From the Handbook of Chemistry and Physics[10].

TABLE XIV-2

SUMMARY OF EFFECTS OF CADMIUM EXPOSURE*

Species	Route	Dose or Concentration	Exposure	Investigators' Observations	Reference Number
Humans	Inhalation	2500-2900 mg-min/cu m	Once	Fatal pulmonary edema	44, 51, 52
"	"	0.1-25 mg/cu m	Years	Rickets and dental problems in offspring of workers	95
"	"	0.1-24 mg/cu m	"	General complaints, chronaxy changes	116
"	"	0.04-19 mg/cu m	"	Slight anemia, yellow fringe on teeth	62
"	"	3-15 mg/cu m	"	Anosmia, fatigue, renal dysfunction, hepatic dysfunction, emphysema, yellow fringe on teeth	55
"	"	0.1-4 mg/cu m	"	Emphysema, proteinuria	71
"	"	0.6-2.8 mg/cu m	"	Anosmia, proteinuria	65
"	"	0.028-2.8 mg/cu m	"	"	78
"	"	0.33-1.9 mg/cu m	"	Proteinuria, aminoaciduria	75, 129
"	"	20-700 μg/cu m	Years, 1 hr/day	Proteinuria	61
"	"	60-680 μg/cu m	Years	Gastrointestinal and respiratory symptoms, carious teeth	81
"	"	80-450 μg/cu m	"	Emphysema, proteinuria	59
"	"	74-210 μg/cu m	"	Reduced pulmonary function, proteinuria	135
"	"	134 μg/cu m	1-20 years	Proteinuria	133
"	"	125 μg/cu m	Years	Anemia, proteinuria	63
"	"	Below 100 μg/cu m	"	Questionable effects	131
"	"	Below 90 μg/cu m	"	Reduced pulmonary function, proteinuria	134
"	"	66 μg/cu m	21-40 years	"	133
"	"	31 μg/cu m	1-12 years	No effects	133
"	"	16-29 μg/cu m	Years	Improvement in conditions of workers exposed at 125 μg/cu m, no effects in new workers	130
Rats	po, water	50 ppm	3 months	Anemia	138
"	po, diet	45-135 ppm	6 months	Anemia, bleaching of incisor teeth	139
Rabbits	sc	650 μg/kg	10 weeks	Anemia, proteinuria	143
Rats, mice	po, water	5 ppm		Hypertension after 1 year	90
Rats	"	0.2-200 ppm	6-12 weeks	Vascular changes in kidneys	153
"	ip	1 mg/kg	45 days	Increased adrenal activity	154
"	sc	850 μg/kg	Once	Testicular necrosis	147
"	po, water	5 ppm	Up to 4 years	No significant increase in tumors	192
Mice	sc	630 μg/kg	Once	Fetal abnormalities	174
Hamsters	iv	880 μg/kg	Once	"	176
Rats	ip	1.8 mg/kg	Once	"	172
"	Inhalation	2.8 mg/cu m	7 months	Altered estrus, decreased weights of offspring	95

*Some investigators noted deaths of cadmium workers from various causes, including cancer, without necessarily attributing them to exposure. See Table III-2 for a summary of two studies that compared observed and expected deaths from cancer.

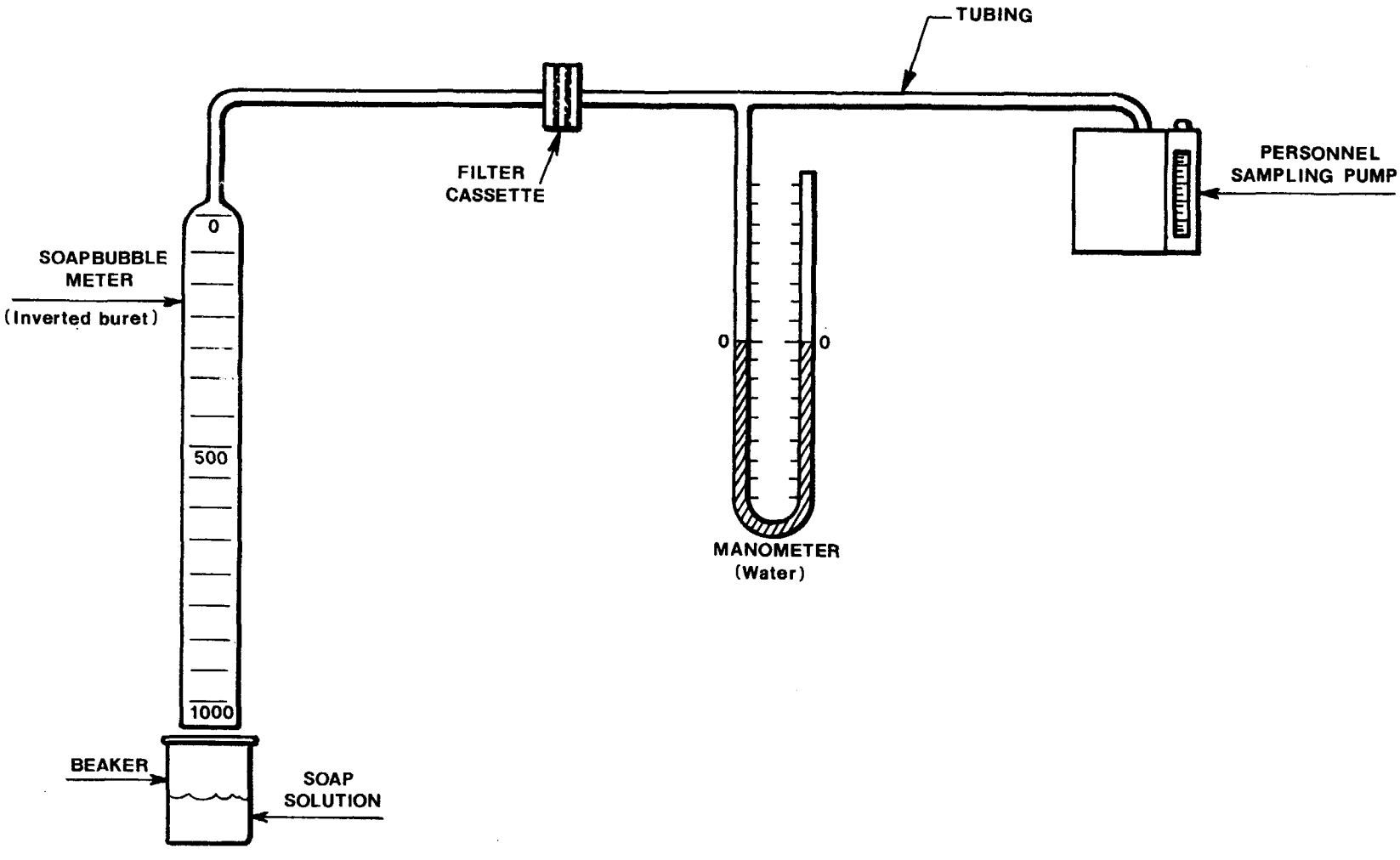


FIGURE XIV-1. CALIBRATION SETUP FOR PERSONAL SAMPLING WITH FILTER CASSETTE

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