

IX. APPENDIX I

METHOD FOR SAMPLING VANADIUM IN AIR

The recommended sampling method for airborne vanadium is adapted from NIOSH Method No. S388 [121].

General Requirements

To evaluate conformance with the standard, collect breathing-zone samples representative of the individual worker's exposure. Record the following on all sampling data sheets:

- (a) The date and time of sample collection.
- (b) Sampling duration.
- (c) Volumetric flowrate of sampling.
- (d) Worker's name and job title and description of work station.
- (e) Temperature and atmospheric pressure.
- (f) Other pertinent information.

Apparatus

The sampling train for the collection of personal air samples has the following components:

- (a) Filter: Mixed cellulose ester membrane filter with a pore size of 0.8 μm , supported by a cellulose backup pad.
- (b) Filter holder: 37-mm, 3-piece cassette filter holder.

(c) Personal sampling pump: Calibrated sampling pump whose flow can be determined to an accuracy of 5% at the recommended flowrate. The pump must be calibrated as described in Calibration of Sampling Trains.

(d) Miscellaneous: Thermometer, barometer, and stopwatch.

Calibration of Sampling Trains

The accurate calibration of a sampling pump is essential for the correct interpretation of the volume indicated. The proper frequency of calibration is dependent on the use, care, and handling to which the pump is subjected. Pumps should be recalibrated if they have been subjected to misuse or if they have just been repaired or received from a manufacturer. If the pump receives hard usage, more frequent calibration may be necessary. Maintenance and calibration should be performed on a regular schedule and records of these kept.

Ordinarily, pumps should be calibrated in the laboratory both before they are used in the field, during field procedures, and after they have been used to collect a large number of field samples. The accuracy of calibration is dependent on the type of instrument used as a reference. The choice of calibration instrument will depend largely on where the calibration is to be performed. For laboratory testing, a soapbubble meter or spirometer is recommended, although other standard calibrating instruments, such as a wet-test meter or dry-gas meter, can be used.

Instructions for calibration with the soapbubble meter follow. If another calibration device is selected, equivalent procedures should be used. Since the flowrate given by a pump is dependent on the pressure drop of the sampling device, in this case a membrane filter, the pump must be

calibrated while operating with a representative filter in line. Calibration of the sampling train should be performed at a pressure of 1 atmosphere.

(a) While the pump is running, check the voltage of the pump battery with a voltmeter to assure adequate voltage for calibration. Charge the battery if necessary.

(b) Place the preweighed membrane filter in the filter cassette.

(c) Assemble the sampling train according to the manufacturer's specifications or as shown in Figure XII-1.

(d) Turn on the pump and moisten the inside of the soapbubble meter by immersing the buret in the soap solution. Draw bubbles up the inside until they are able to travel the entire buret length without bursting.

(e) Adjust the pump rotameter to provide a flowrate of 1.7 liters/minute.

(f) Start a soapbubble up the buret and measure with a stopwatch the time it takes the bubble to pass through a minimum of 1.0 liter.

(g) Repeat the procedure in (f) at least three times, average the results, and calculate the flowrate by dividing the volume of air between the preselected marks by the time required for the soapbubble to traverse the distance.

(h) Record the following calibration data: volume measured, elapsed time, air temperature, atmospheric pressure, serial number of the pump, date, and name of the person performing the calibration.

(i) Corrections to the flowrate may be necessary if the atmospheric pressure or temperature at the time of sample collection

differs significantly from those conditions under which calibration was performed. Where flowrates are read from rotameters or orifice meters only, the following formula may be used:

$$q \text{ (sampling)} = q \text{ (indicated)} \times \sqrt{\frac{P \text{ (calibration)}}{P \text{ (sampling)}} \times \frac{T \text{ (sampling)}}{T \text{ (calibration)}}}$$

where:

q = volumetric flowrate (liters/minute)

P = atmospheric pressure

T = temperature (degrees Kelvin or Rankine)

When wet test meters or bubble meters, etc are used to determine flowrates, the above formula should be used without the radical sign.

Air Sampling

(a) Collect samples as close as practicable to the employee's breathing zone without interfering with the employee's freedom of movement.

Collect sufficient breathing-zone samples representative of worker exposure in each operation to permit calculation of each worker's TWA exposure. Sampling flowrates should be checked frequently. When filters become clogged so that airflow is too restricted, ie, when the flowrate drops below the design flowrate, change the filters and collect new samples.

(b) Collect samples using a portable sampling pump with a flowrate that can be determined to an accuracy of 5% at 1.7 liters/minute. Connect the pump to the filter unit, which consists of a membrane filter supported

by a cellulose backup pad mounted in a three-piece cassette filter holder.

(c) Operate the sampler at a known flowrate of 1.7 liters/minute, and record the total sampling time. A sample size of at least 25 liters is recommended.

(d) Seal the filter holder with the plugs provided and transport the cassette intact to the lab for analysis (see Appendix II).

(e) With each batch of 10 samples, submit 1 filter from the same lot used for sample collection, subjecting it to exactly the same handling as the samples except that no air is drawn through it. Label this as a blank.

X. APPENDIX II

ANALYTICAL METHOD FOR VANADIUM

Principle of the Method

(a) A known volume of air is drawn through a mixed cellulose ester membrane filter to trap the vanadium particles present.

(b) "Vanadium compounds" as defined in Chapter I are separated from the sample on the basis of their solubilities in a 0.01 N sodium hydroxide solution.

(c) Vanadium not dissolved by treatment with 0.01 N sodium hydroxide is "metallic vanadium" or vanadium carbide and is dissolved by wet ashing.

(d) The solutions of samples and standards are analyzed by flameless atomic absorption spectrophotometry (graphite furnace) with a deuterium background corrector. A hollow cathode lamp for vanadium is used to provide a characteristic vanadium line at 318 nm. The absorbance is proportional to the vanadium concentration of the sample solution.

Range and Sensitivity

(a) Except for that portion of the method dealing with atomic absorption analysis of vanadium pentoxide, this analytical method has not been evaluated by NIOSH or collaboratively tested; however it is recommended as an interim method pending further research.

(b) The detection limit for the determination of metallic vanadium by atomic absorption has been reported as 1 ng/ml for a maximum sample

injection of 100 μ l [103]. This represents an absolute sensitivity of 0.1 ng of vanadium.

Interferences

(a) There are no known spectral line interferences in this atomic absorption assay for vanadium.

(b) Iron and molybdenum do not interfere with the atomic absorption analysis for "vanadium compounds" even when present in the proportion of 1 part of vanadium pentoxide to 10 parts of ferric nitrate or sodium molybdate [121].

(c) Vanadium exhibits self-absorption at 318 nm. To minimize this absorption, it is necessary to operate the vanadium hollow cathode lamp at low currents.

Advantages and Disadvantages

(a) The method proposed for separating vanadium compounds from metallic vanadium is based on the alkaline solubility of the most frequently encountered and most widely used vanadium compounds. It may be that not all base-insoluble vanadium compounds can be included in the definition of "metallic vanadium", and that a few compounds, rarely encountered in industrial situations, may cause positive interference with analysis for metallic vanadium. One such compound, vanadium oxide (VO), is likely to be found with other vanadium compounds primarily in the vicinity of boiler-cleaning operations, areas where metallic forms of vanadium would be absent. In this case, the sum of the results of both alkali and acid treatments should best estimate total vanadium content of vanadium compounds in boiler soot.

The proposed procedure, while not completely tested, appears to be the best method that can be recommended at this time for separation of the toxicologic classes of vanadium, ie (1) vanadium compounds and (2) metallic vanadium and vanadium carbide.

(b) The calibration curve is nonlinear above an absorbance of 0.9 units, and in certain cases, depending on the graphite tube characteristics, it may be necessary to alternate samples with standards of similar response to obtain reliable results.

(c) It is possible that the precision and sensitivity of the method may be improved through the use of pyrolytic graphite tubes.

Apparatus

(a) Atomic absorption spectrophotometer having a monochromator with a reciprocal linear dispersion of about 6.5 Angstroms/mm in the ultraviolet region. The instrument must have a graphite furnace and a deuterium arc background corrector.

(1) Vanadium hollow cathode lamp.

(2) Deuterium arc lamp.

(3) Purge gases: argon (graphite furnace), nitrogen (deuterium arc).

(4) Pressure regulators, two-stage, for each compressed gas tank used.

(b) Glassware, borosilicate.

(1) Beakers, 50-ml, with covers.

(2) Pipettes, delivery, 1, 5, and 10 ml and other convenient sizes for making standards.

- (3) Volumetric flasks, 10-ml, 25 ml, 1000 ml.
- (4) Automatic microliter pipette.
- (5) Polyethylene dropper.
- (c) Water bath maintained at 50 C.
- (d) Laboratory hotplate.

Reagents

All reagents used must be ACS Reagent Grade or better.

- (a) Water, distilled or deionized.
- (b) Sodium hydroxide, 0.01 N.
- (c) Sulfuric acid, concentrated.
- (d) Nitric acid, concentrated.
- (e) Nitric acid, 1%(v/v)
- (f) "Vanadium compounds" aqueous standard stock solutions containing 100 $\mu\text{g V/ml}$ prepared by dissolving 0.179 g of vanadium pentoxide in 0.01 N sodium hydroxide and diluting to 1.0 liter with 0.01 N sodium hydroxide.
- (g) "Vanadium compounds" working standard solutions 0.1 to 1.0 $\mu\text{g V/ml}$ prepared by appropriate dilution of above solution with 0.01 N sodium hydroxide.
- (h) "Metallic vanadium" standard stock solutions containing 100 $\mu\text{g/ml}$, prepared by dissolving 0.100 g vanadium metal in a minimum volume of concentrated nitric acid, and diluting to 1.0 liter with 1% (v/v) nitric acid.
- (i) "Metallic vanadium" working standard solutions 0.1 to 1.0 $\mu\text{gV/ml}$, prepared by appropriate dilution of the above solution with 1% (v/v) nitric acid.

Analytical Procedure

Before use, all glassware should be initially soaked in a mild detergent solution to remove any residual grease or chemicals. After initial cleaning, the glassware should be thoroughly rinsed with distilled water, soaked in dilute (1:10) nitric acid for at least 30 minutes, then rinsed with tap water followed by distilled water, and allowed to air dry.

(a) Open the filter container and carefully remove the membrane filter.

(b) Transfer the filter to a 50-ml beaker with the aid of filter tweezers.

(c) To ensure complete dissolution of the "vanadium compounds" from the filter, add 3 ml of 0.01 N sodium hydroxide to the beaker and heat in a water bath at 50 C for 30 minutes.

(d) Filter the sample solution through a 0.45- μ m membrane filter into a 10-ml volumetric flask, rinsing the beaker twice with 1-2 ml portions of 0.01 N sodium hydroxide. After filtration, transfer the 0.45 μ m membrane filter to the beaker containing the original sample filter and reserve both filters for analysis of "metallic vanadium."

(e) Dilute the filtrate to 10 ml with 0.01 N sodium hydroxide and proceed to step (k), the analysis for "vanadium compounds." Steps (f) through (j) are for the analysis of "metallic vanadium".

(f) To the beaker containing the membrane filters add 12 ml of concentrated nitric acid (in 3-4 ml portions) and 1 ml concentrated sulfuric acid. Cover the beaker with a watch glass and heat on a 120 C hotplate until solution is complete. If insoluble material persists, stronger acid mixtures may be necessary [122].

- (g) Evaporate to a volume of about 2 ml.
- (h) Cool, and slowly add 5 ml 1% (v/v) nitric acid.
- (i) Heat at 85-100 C until salts are dissolved.
- (j) Quantitatively transfer the clear solution to a 25 ml volumetric flask, and take up to volume with 1% (v/v) nitric acid. Proceed to step (1).

(k) Analysis of "vanadium compounds": Inject 25 μ l of the resultant solution into the graphite furnace. Furnace parameters may vary among laboratories. Suggested parameters are: dry at 100 C for 20 seconds; char at 1100 C for 10 seconds; and atomize at 2,600 C for 15 seconds. Use the deuterium arc lamp to correct for matrix effects. Record the absorbance at 318 nm. The absorbance is proportional to the sample concentration and can be determined from the calibration curve for "vanadium compounds" if the graphite tube in use gives reproducible results.

(l) Analysis for "metallic vanadium": Follow the procedure described in step (k) using the following furnace parameters: dry at 100 C for 20 seconds; char at 1100 C for 20 seconds, and atomize at 2,600 C for 8 seconds. From the measured absorbance, determine the sample concentration using the calibration curve for "metallic vanadium".

Note: The characteristics of the graphite tubes can influence the results significantly. Careful attention must be paid to the response of the standard, ie, if the graphite tube gives erratic results and a nonreproducible absorbance peak, it must be rejected and replaced because results obtained thereby are not reliable. Also, follow instrument manufacturer's recommendations for specific operating parameters.

If a calibration curve cannot be used because of the changing characteristics of the graphite tube, it is recommended that samples be frequently alternated with standards which give responses close to that of the sample. The experimental protocol recommended is as follows: (1) inject a standard solution in duplicate, (2) inject a sample in triplicate, and (3) reinject standard in duplicate, etc.

Appropriate filter blanks must be analyzed by the same procedure used for the samples.

Sample Recovery

To eliminate any bias in the analytical method, it is necessary to determine the recovery of the compound. The sample recovery should be determined in duplicate and should cover the concentration ranges of interest. If the recovery is less than 95%, the appropriate correction factor should be used to calculate the "true" value. Sample recovery must be studied for both "vanadium compounds" and "metallic vanadium."

(a) Add a portion of a standard solution containing a known amount of vanadium, preferably equivalent to the sample concentration expected, to a representative membrane filter and air dry. Recover the vanadium from the filter and analyze as described above. Duplicate determinations should agree within $\pm 5\%$.

(b) The sample recovery equals the average weight of vanadium in μg recovered from the filter divided by the weight of vanadium in μg added to the filter, or:

$$\text{recovery} = \frac{\text{average weight } (\mu\text{g}) \text{ recovered}}{\text{weight } (\mu\text{g}) \text{ added}}$$

Calibration and Standards

Analysis of "vanadium compounds": From the standard "vanadium compounds" working stock solution, prepare at least six calibration standards to cover the vanadium concentration range from 0.1 to 1.0 $\mu\text{g/ml}$. Prepare these calibration standards fresh daily and make all dilutions with 0.01 N sodium hydroxide. Proceed as in Analytical Procedure.

Analysis of "metallic vanadium": From the "metallic vanadium" standard working stock solution, prepare at least six calibration standards to cover the vanadium concentration range from 0.1 to 1.0 $\mu\text{g/ml}$. Prepare these calibration standards fresh daily, and make all dilutions with 1% (v/v) nitric acid. Proceed as in Analytical Procedure.

Prepare a calibration curve by plotting on linear graph paper the absorbance versus the vanadium concentration of each standard in $\mu\text{g/ml}$. It is advisable to run a set of standards both before and after the analysis of a series of samples to ensure that conditions have not changed.

In cases where a calibration curve could not be used reliably, determine the appropriate response factor. To determine the response factor, the appropriate calibration standards are alternately analyzed with the samples. This practice will minimize the effect of observed fluctuations or variations in absorbance and peak height readings during any given day.

Calculations

(a) Read the vanadium concentration in $\mu\text{g/ml}$ corresponding to the total absorbance from the standard curve. Or, alternatively, determine the vanadium concentration in $\mu\text{g/ml}$ corresponding to the absorbance area of the

sample by using the appropriate response factor determined from the response of the calibration standard.

Make corrections for the blank by subtracting the amounts of vanadium found in the blank from the amounts found in the sample:

$$\text{corrected } \mu\text{g/ml} = \mu\text{g/ml sample} - \mu\text{g/ml blank}$$

(b) Multiply the corrected $\mu\text{g/ml}$ by the sample volume of the liquid sample (10 ml or 25 ml) to obtain the total weight of vanadium in the sample.

(c) Divide the total weight by the recovery to obtain the corrected $\mu\text{g/sample}$:

$$\text{corrected } \mu\text{g/sample} = \frac{\text{total weight}}{\text{recovery}}$$

(d) The concentration of vanadium in the air sampled can be expressed in mg/cu m ($\mu\text{g/liter} = \text{mg/cu m}$).

$$\text{mg/cu m} = \frac{\text{corrected } \mu\text{g}}{\text{volume of air sampled (liters)}}$$

XI. APPENDIX III

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, eg, "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 or the American National Standards Institute Inc. Flashpoint, shock sensitivity

or similar descriptive data may be used to indicate flammability, reactivity, or similar hazardous properties of the material.

(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 conventional millimeters of mercury (mmHg); 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 degrees Fahrenheit (21.1 degrees 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 flashpoint 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 TWA concentration, as a permissible exposure, 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. Typical comments might be:

Skin Contact--single short contact, no adverse effects likely; prolonged or repeated contact, possibly mild irritation.

Eye Contact--some pain and mild transient irritation; no corneal scarring.

"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 employees.

(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 employees 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. Specific procedures 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," 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 employees exposed to the hazardous substance. 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 ₂ O=1)		VAPOR PRESSURE
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H ₂ O, % 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 _____

TABLE XII-1

PHYSICAL AND CHEMICAL PROPERTIES OF VANADIUM AND ITS COMPOUNDS

COMPOUND	Molecular Formula	Molecular Weight	Oxidation State (valence)	Density or Specific Gravity	Melting Point (C)	Boiling Point (C)	Solubility in g/100 cc		
							Cold H ₂ O	Hot H ₂ O	Other Solvents
Vanadium	V	50.942	0	5.96	1,890±10	3,380	Insol	Insol	Sol in aqua regia, HNO ₃ , H ₂ SO ₄ , HF; insol in HCl, alkaline
Vanadium carbide	VC	62.95	4	5.77	2,810	3,900	"	---	Sol in HNO ₃ , fused KNO ₃ ; insol in HCl, H ₂ SO ₄
Vanadium tetrachloride	VC ₄	192.75	4	1.816 ³⁰	-28±2	148.5 ⁷⁵⁵	Sol, decomposes	---	Sol in absolute alcohol, ether, chloroform, acetic acid
Vanadium trichloride	VC ₃	157.30	3	3.00	decomposes	---	"	Sol, decomposes	Sol in absolute alcohol, ether
Vanadyl sulfate	VO ₂ SO ₄	163.00	4	---	---	---	Very sol	---	
Iron metavanadate	Fe(VO ₃) ₃	352.67	5	---	---	---	Insol	---	Sol in acid; insol in alcohol
Ammonium metavanadate	NH ₄ (VO ₃)	116.98	5	2.326	decomposes 200	---	0.52 ¹⁵	6.95, ⁹⁶ decomposes	
Sodium metavanadate	NaVO ₃	121.93	5	---	630	---	21.1 ²⁵	38.8 ⁷⁵	
Vanadium oxide	VO(or V ₂ O ₂)	66.94	2	5.758 ¹⁴	ignites	---	Insol	Insol	Sol in acid
Vanadium dioxide (or tetroxide)	VO ₂ (or V ₂ O ₄)	82.94	4	4.339	1,967	---	"	"	Sol in acid, alkali
Vanadium pentoxide	V ₂ O ₅	181.88	5	3.357 ¹⁸	690	decomposes 1,750	0.6 ²⁰	---	Sol in acid, alkali; insol in absolute alcohol
Vanadium sesquioxide (or trioxide)	V ₂ O ₃	149.88	3	4.87 ¹⁸ ₄	1,970	---	Slightly sol	Sol	Sol in HNO ₃ , HF, alkali
Vanadium oxydichloride	VOCl ₂	137.85	4	2.88 ¹³	---	---	Decomposes	---	Sol in dilute HNO ₃
Vanadium oxytrichloride	VOCl ₃	173.30	5	1.829	-77±2	126.7	Sol, decomposes	---	Sol in alcohol, ether, acetic acid

Adapted from reference 1

TABLE XII-2

OCCUPATIONS WITH POTENTIAL EXPOSURE TO VANADIUM

Alloy makers	Petroleum refinery workers
Boiler cleaners	Photographic chemical workers
Ceramic makers	Textile dye workers
Dyemakers	Uranium millers
Ferrovandium workers	Vanadium alloy makers
Glassmakers	Vanadium millers
Inkmakers	Vanadium miners
Organic chemical synthesizers	Vanadium workers

Adapted from Gafafer [3]

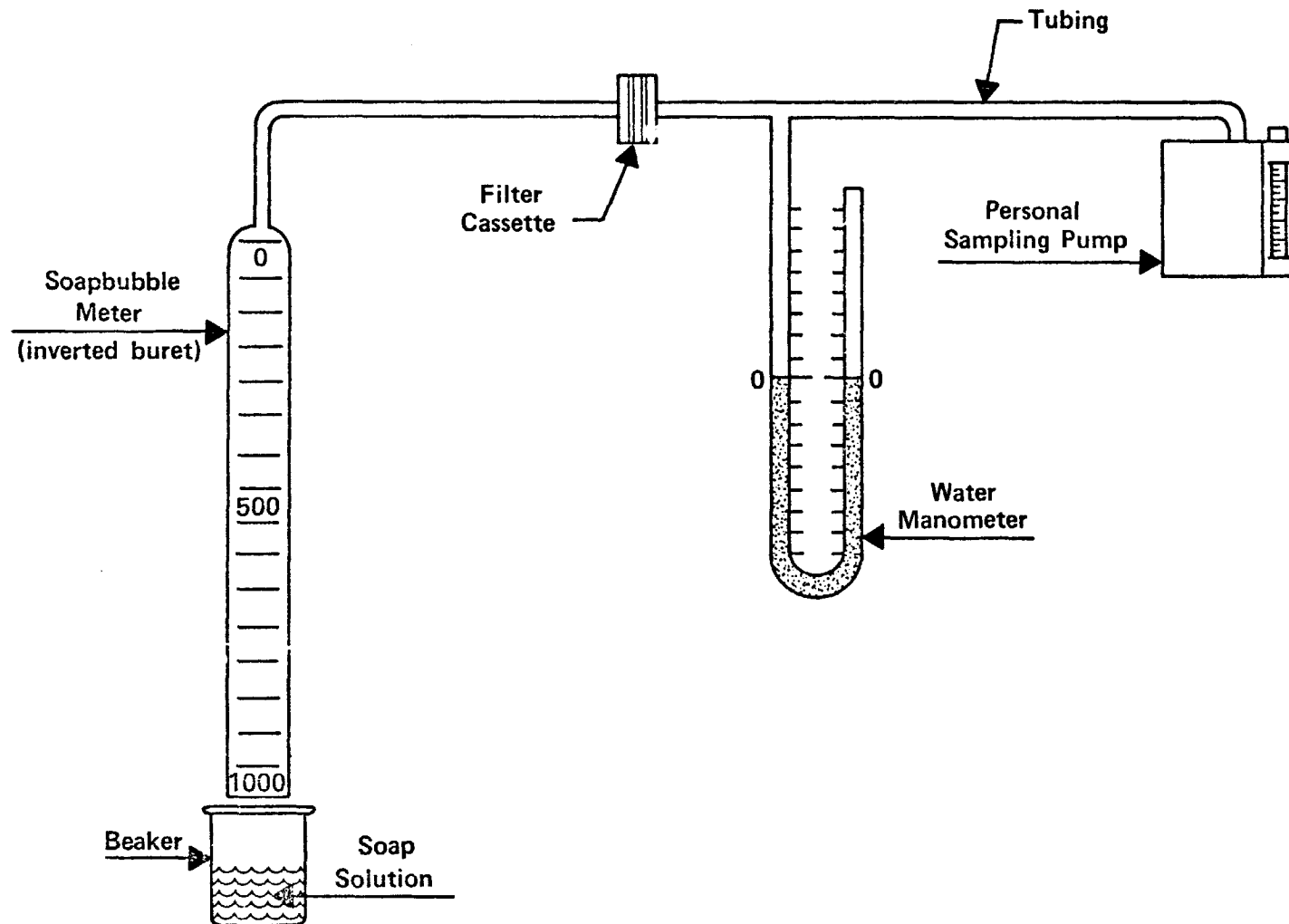


FIGURE XII-1
 CALIBRATION SETUP FOR PERSONAL SAMPLING WITH FILTER CASSETTE

**DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE**

PUBLIC HEALTH SERVICE

CENTER FOR DISEASE CONTROL

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

ROBERT A TAFT LABORATORIES

4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE. \$300



POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.
HEW 399