NBSIR 73-254 A Mercury Vapor Generation and Dilution System

E. P. Scheide, R. Alvarez. B. Greifer, E. E. Hughes, J. K. Taylor

National Bureau of Standards Department of Commerce Washington, D. C. 20234

October 1973

Final Report

Prepared for

National Institute for Occupational Safety and Health Division of Laboratories and Criteria Development Cincinnati, Ohio 45202

NBSIR 73-254

A MERCURY VAPOR GENERATION AND DILUTION SYSTEM

E. P. Scheide, R. Alvarez, B. Greifer, E. E. Hughes, J. K. Taylor

National Bureau of Standards Department of Commerce Washington, D. C. 20234

October 1973

Final Report

Prepared for National Institute for Occupational Safety and Health Division of Laboratories and Criteria Development Cincinnati, Ohio 45202



U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director



A Mercury Vapor Generation and Dilution System

ABSTRACT

This report describes a system capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concentrations between 0.005 and 0.5 μ g/l and an analytical system for the analysis of these gas mixtures. Various parameters that affect the generator and analytical system and their interactions are discussed. This gas delivery system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer.

1. INTRODUCTION

This report describes a system capable of producing welldefined test atmospheres containing concentrations of mercury for the calibration of analytical instruments and evaluation of analytical methodology. The system developed and described was designed to produce concentrations in the industrially important range of 0.005 to 0.5 μ g/l but other concentrations could be achieved by suitable adjustment of the operational parameters.

2. EXPERIMENTAL

2.1 Apparatus

Mercury lends itself readily to the evaporation method for generating test atmospheres. Basically, this entails saturating the gas of interest with mercury and diluting the subsequent test gas to achieve the concentrations desired.

A schematic of the mercury generation system is shown in Figure 1. Two streams of air pass through silica gel/charcoal driers and filters to remove impurities. One stream goes through a differential flow controller (DFC-1), a regulating valve (V-2), and a high flow rotameter (FM-1), to the mixing chamber. This stream is subsequently used as the dilution air. The other stream flows through a differential flow controller (DFC-2), an on-off valve (V-3), a regulating valve (V-4), through a low flow rotameter (FM-2) and into the

saturation unit. The saturation unit is composed of two parts; a heater-vaporizer and a condenser. The air stream, upon passing through the heater-vaporizer unit, becomes saturated with mercury at a relatively high temperature. Ιt then passes into a condenser unit where it cools rapidly and any excess mercury collects on the mercury pool present in the condenser. The temperature of the condenser determines the concentration of the mercury-in-air stream. This stream then passes into the mixing chamber where it is diluted with the other air stream, and then into a manifold where samples The condenser is connected to a constantcan be withdrawn. temperature water-circulating bath, containing anti-freeze effective to -5°C. The bath maintains temperatures between $0^{\circ}C$ and $26^{\circ}C$ to at least $\pm 0.1^{\circ}C$.

2.2 Analysis

The method used for analysis of the mercury concentrations was similar to that described by Long, Scott, and Thompson [1]. Analyses were made by withdrawing samples from the manifold at 200 cc/min and collecting the mercury on silver wool. The mercury was then desorbed by a controlled heating cycle and measured using a flameless atomic absorption spectrometer. The spectrometer was calibrated by injecting a known volume of saturated mercury vapor onto the silver wool, using a "headspace" technique from standards kept at a very constant and well known temperature. A block diagram of the mercury generation and analysis system is shown in Figure 2.

3. PERFORMANCE EVALUATION

3.1 Calibration

As stated previously, the mercury generation system was calibrated by injection of known volumes of saturated air. A comparison of the atomic absorption signals given by these standards and samples taken from the generation system is shown in Figure 3. The non-linearity of the line is due to the non-linearity of the atomic absorption instrument and not to the generation system.

3.2 Sampling

When samples of mercury are absorbed onto the silver wool collector and then heated to desorb the mercury for analysis, recorder traces similar to those shown in Curve A of Figure 4 are obtained. The peak shape, though not symmetrical, is very reproducible so that the peak height can be measured and compared with standards to determine the amount of mercury in the sample. An alternative to collecting the mercury samples on silver wool and then heating to desorb them would be to connect the atomic absorption instrument directly to a sampling port of the generation system and monitor the mercury output continuously. Curve B of Figure 4 shows the type of graph obtained. The sensitivity is not as great as in the first method, but this is not serious, since a mercury concentration of $0.005 \ \mu g/1$ will still give a recorder deflection. However, the analyzer must be previously calibrated for this mode of operation by some other technique.

3.3 Response Time

As indicated in Curve B of Figure 4, the response time in producing a steady-state concentration of mercury vapor upon going from one concentration to another is about 5 minutes at concentrations not too different from each other, and about 10 minutes when large concentration changes are made. The response time is about the same in going from high to low and from low to high concentrations. It is recommended that 10 minutes elapse after changing concentrations before taking samples.

3.4 Temperature Effects

Initially, upon comparing the calculated and observed mercury concentrations from the generation system, a difference of about 7 percent was noticed, with the output higher than that calculated. It was determined that the cause of this discrepancy was a temperature difference between the water bath-circulator and the condenser. To correct this problem, the condenser and the water lines were insulated and a copper constantan thermocouple was installed at the condenser in order to accurately measure its temperature. The temperature difference using the modified arrangement is about 0.3°C at 0.0°C, which will cause results that are 3 percent higher without a temperature correction. If the temperature is measured and corrected for, the calculated and observed values are the same. When the condenser is operated at room temperature, its temperature may be considered that of the bath.

The optimum condenser temperature for the concentration range of interest was determined to be 0°C for concentrations between 0.005 and 0.200 μ g/1 and 26°C for concentrations between 0.100 and 0.500 μ g/1.

3

Experiments were also conducted in order to determine the effect of the heater saturator temperature upon the generator output. The optimum temperature difference between saturator and condenser is about 25°C. At higher temperature differences, complete condensation in the condenser does not occur and the output is higher than calculated, whereas, at lower temperature differences, complete saturation is not achieved and the output is lower than calculated. The temperature difference should be controlled at 25°C ±5°C for best results.

It should be noted that a correction to the volume of mercury saturated air must be made when there is a difference between the temperature of the condenser and of room air.

3.5 Condenser Design

Ľ

Figure 5 shows the final condenser design. The condenser is imbedded in styrofoam and placed in an aluminum box which is attached to the chassis. The water inlets and outlets are connected to bulkheads at the rear of the chassis to which the water bath-circulator is connected. The water lines are insulated to minimize temperature changes of the flowing stream. The mercury pool and stainless steel wool that are placed inside the condenser are to facilitate the condensation of mercury vapor.

4. CONCLUSIONS

The system described in this report is capable of producing well-defined test atmospheres of mercury vapor in air and an analytical system is described for the analysis of these test mixtures and/or the industrial atmospheres under investigation directly. Figure 6 shows the relationship between the observed and calculated values for the output of the mercury generation system. As can be seen, the output is theoretical within the accuracy of the analysis of ±2 percent.



FIGURE 1. SCHEMATIC DIAGRAM OF GENERATING SYSTEM FOR MERCURY.



MERCURY GENERATION AND ANALYSIS SYSTEM

SCHEMATIC REPRESENTATION OF GENERATION AND ANALYSIS SYSTEM FOR MERCURY. FIGURE 2.





MERCURY SAMPLING AND ANALYSIS SHOWING BOTH CONTINUOUS SAMPLING AND DISCRETE SAMPLES. FIGURE 4.





OBSERVED CONCENTRATION OF MERCURY VERSUS THE CALCULATED CONCENTRATION GENERATED WITH THE MERCURY SYSTEM. FIGURE 6.

Овзекуер

10. Contract of COMM IPERILATION OF REPORT NO. 2. Beerginat's Accession 3. Beerginat's Accession No. SHELT A METCY NEET 3. Deerginat's Accession 3. Beerginat's Accession No. A Mercury Vapor Generation and Dilution System 5. Publication Code 0ctober 1973 A Mercury Vapor Generation and Dilution System 5. Publication Code 7. AUTHORSE.P. Scheide, R. Alvarez, B. Groifer, E. Hughes, and J.K. Taylor 8. Performing Organization Code 7. AUTHORSE.P. Scheide, R. Alvarez, B. Groifer, E. Hughes, and J.K. Taylor 8. Performing Organization Code 8. Partonal Querkaitor Standard 10. Project/Task/Wak Unit No. National Institute for Occupational Safety and Health 10. Project/Task/Wak Unit No. 11. Contract/Grant No. 9. Supervise Accession 12. Sponsoring Agreet Code 11. Contract/Grant No. 13. Needed of the Station Spheres Soft mercury in air or other diluont gas at concentrations between 0.005 and 0.500 gg/l and an analytical system for the analytical system for the analytical system for the distribution of the various analytical systems for mercury now in use. The analytical unit of the systems can also be used for the determination of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of the various analytical systems for mercury now in use. The analytical unit of the system JACOMIC absorption; gas generation system; mercury; occupational safety.		•					
4. FITLE AND SUPITITE 5. Publication Due October 1973 A Mercury Vapor Generation and Dilution System 5. Publication Code 7. ACTHORSDE.P. SCheide, R. Alvarez, B. Greifer, B. Hughes, and J.K. Taylor 6. Performing Organization Code 7. ACTHORSDE.P. Scheide, R. Alvarez, B. Greifer, B. Fulleation Code 6. Performing Organization Code 7. PERFORMING ORGANIZATION NAME AND ADDRESS WATCHARL OF COMMERCE WASHINGTON, D.C. 2023 10. Project Task Wark Unit No. 12. Spensoring Organization None and Complete Address (Street, Cip. Store, 200) 13. Type of Report & Period Prinal 13. SUPPLEMENTARY NOTES 14. Spensoring Agency Code 14. ANSTRACT 14 200 mode or how farmed anomal significant information. If document includes a significant bibliography or information None and Complete Address (Street, Cip. Store, 200) 13. Type of Report & Period Prinal 15. SUPPLEMENTARY NOTES 14. Spensoring Agency Code 14. Spensoring Agency Code 15. SUPPLEMENTARY NOTES 14. Spensoring Agency Code 14. Spensoring Agency Code 16. Marchard Address a System capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concen- trations between 0.05 and 0.540 gg/1 and an analytical system for the ganalytical system for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. <td>BIBLIOGRAPHIC DATA</td> <td>1. PUBLICATION OR REPORT NO. NBSIR 73-254</td> <td>2. Gov't Accession No.</td> <td>3. Recipient</td> <td>'s Accession No.</td>	BIBLIOGRAPHIC DATA	1. PUBLICATION OR REPORT NO. NBSIR 73-254	2. Gov't Accession No.	3. Recipient	's Accession No.		
A Mercury Vapor Generation and Dilution System October 1973 A Mercury Vapor Generation and Dilution System 6. Performing Organization Code 7. ALTHOM(S)E.P. Scheide, R. Alvarez, B. Greifer, E.P. Hughes, and J.K. Taylor 8. Performing Organ Equent No. Marchael Stream Code 7. PURFORMING OKAMALADIN NAME AND NAMES 10. Proport/Fask/Weik Unit No. National Institute for Occupational Safety and Health 11. Centract/Grant No. Cincinnati, Ohio 14. Sponsoring Ageney Code 15. SUPPLEMENTARY NOTES 14. Sponsoring Ageney Code 16. ANNTRACT (A 200 word or loss factual summary of most significant infomation. If document includes a significant Methodraphy or lifestative survey, method there.) 16. ANNTRACT (A 200 word or loss factual summary of most significant infomation. If document includes a significant Methodraphy or lifestative survey, method 15. Strength 29. and an analytical system for the analysis of these gas mixtures. Various parameters that affect the generatable and analytical system and their interactions are discussed. This/system provides a means of calibration of the Various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flumeless atomic absorption spectrometer. 17. REV WORDS for to heave entres, alphabetical order, capitalize only the first here word unless a proper name; sequencies by collecting the mercury on a silver wool collector, and then desorpting; gas generation system; mercury; oc	4. TITLE AND SUBTITLE		l	5. Publicatio	on Date		
A Nercury Vapor Generation and Dilution System Occode 1975 A Nercury Vapor Generation and Dilution System - Performing Organization Code A. ALTHORGEL, P. Scheide, R. Alvarez, B. Greifer, E.E. Hughes, and J.K. Taylor - Performing Organization Code B. Prince Construction Name and J.K. Taylor - Performing Organization Code National Endstitute for Name and Complete Address (Street, Cire, State, 2019) - Performing Organization Code National Institute for Occupational Safety and Health Cincinnati, Ohio - Performing Organization Name and Complete Address (Street, Cire, State, 2019) National Endstitute for Occupational Safety and Health Cincinnati, Ohio - Performing Organization Code National Endstitute for Occupational Safety and Health Conversed - Performing Organization Code National Endstitute for Occupational Safety and Health Conversed - Performing Organization Code This report describes a system capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concen- trations between 0.005 and 0.540 µg/1 and an analytical system for the generatore and analytical system and their interactions are discussed. This/System provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 18. AVAILABILITY (Y. Unlinked				Octobe	~ 1072		
1 ACTHOR(S) F. P. Scheide, R. Alvarez, B. Greifer, E.E. Hughes, and J.K. Taylor 6. Performing Organization Code 7. ACTHOR(S)E.P. Scheide, R. Alvarez, B. Greifer, E.E. Hughes, and J.K. Taylor 8. Performing Organization Code 8. PURPORTING ORGANIZATION NAME AND ADDRESS DEPARTMENT OF CONNECT 10. Project/Task/Wack Link No. 12. Specuring Organization Code 11. Contract/Grant No. National Institute for Occupational Safety and Health Clincinnati, Ohio 11. Contract/Grant No. 13. Supplementation of the Code of th	A Mercury Vapor Generation and Dilution System			OCLOBE			
7. AUTHOR(S)E.P. Scheide, R. Alvarez, E. Greifer, 8. Pergenan Orea, Egrent No. 7. PERFORMING ORGANIZATION NAME AND ADDRESS 10. Project/Task/Kack Unit No. NATIONAL BUREAU OF STANDARDS 10. Project/Task/Kack Unit No. DEPARTMENT OF COMMERCE 11. Courset/Grant No. WASHINGTON, D.C. 20234 11. Courset/Grant No. National Institute for Occupational Safety and Health 11. Courset/Grant No. Cincinnati, Ohio 13. Type of Report & Period Cocced 15. SUPPLEMENTARY NOTES 13. Type of Report & Period Cocced 16. ADSTRACT (4 200 word or less factual summary of most significant information. If document includes a significant Biolography or literature survey, maximum (1 mer.) 13. Type of Report & Period Cocced 17. SUPPLEMENTARY NOTES 14. Sponsoring Agency Code 14. Sponsoring Agency Code 18. SUPPLEMENTARY NOTES 14. Sponsoring Agency Code 15. Supplementary of most significant information. If document includes a significant Biolography or literature survey, maximum (1 mer.) 17. NEW MODS (Str. to Assess the factual summary of most significant information of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 19. SecURITY CLASS (THIS REPORT) 21. No. OF PAGES (THIS				6. Performin	g Organization Code		
7: PERFORMING ONGANIZATION NAME AND ADDRESS NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234 10. Penyect/TasL/Work Univ No. 12: Spunsoring Cramization Name and Complete Address (Street, City, State, ZiP) National Institute for Occupational Safety and Health Cincinnati, Ohio 13. Type of Report & Period Coerced Final 14: Spunsoring Agency Code 14. Spunsoring Agency Code 15: SUPPLEMENTARY NOTES 16. ABSTRACT (A 200 word or less factual summary of most significant information. If document includes a significant bibliography or Interstitute survey, monitor it there.) 16. ABSTRACT (A 200 word or less factual summary of most significant information. If document includes a significant bibliography or Interstitute survey, monitor it there.) 17. NUMERCE Concentrations between 0.005 and 0.500 µg/1 and an analytical system for the generators and analytical system for the ciri interactions are discussed. This/System provides a means of calibration of the Various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WOUDS ferix to twelve entries, alphabetical order, capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [V. Unlinited [1. NO. OF PACES (THIS REPORT) [2. No. OF PACES (THIS REPORT) 14. <td< td=""><td colspan="3">7. AUTHOR(S)E.P. Scheide, R. Alvarez, B. Greifer, E.E. Hughes, and J.K. Tavlor</td><td colspan="2">8. Performing Organ. Report No. NBSIR 73-254</td></td<>	7. AUTHOR(S)E.P. Scheide, R. Alvarez, B. Greifer, E.E. Hughes, and J.K. Tavlor			8. Performing Organ. Report No. NBSIR 73-254			
NATIONAL BUREAD OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 2023 II. Contract/Grant No. 12. Spensoring Organization Name and Complete Address (Street, Ciry, State, 21P) National Institute for Occupational Safety and Health Cincinnati, Ohio II. Contract/Grant No. 15. SUPPLEMENTARY NOTES II. Spensoring Agency Code 16. ABSTRACT (A 200-Word or less factual summary of most significant information. If document includes a significant bibliography or lifetature survey, mention if here.) II. Contract/Grant No. 16. ABSTRACT (A 200-Word or less factual summary of most significant information. If document includes a significant bibliography or lifetature survey, mention if here.) II. document includes a significant bibliography or lifetature survey, mention if here.) 17. Is report describes a system capable of producing well-defined various analytical systems for mercury now in use. The analytical with of the system can also be used for the determination of the various analytical systems for mercury on win use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. NEY WORDS (six to inverve entries; alphabetical order; capitalize only the first letter of the first here word unless a proper name; separated by semicolonic Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABULITY Y. Unlimited 19. SECURITY CLASS (THE REPORT) 21. No. OF PACES (THE REPORT) 14. Onder From	9. PERFORMING ORGANIZATION NAME AND ADDRESS			10. Project/Task/Work Unit No.			
12. Spunsting Organization Name and Complete Address (Street, City, State, 21P) 12. Type of Report & Period Covered National Institute for Occupational Safety and Health 12. Type of Report & Period Cincinnati, Ohio 14. Spunstering Agency Code 15. SUPPLEMENTARY NOTES 16. ABSTRACT (A 200 word or loss focual summary of most significant information. If document includes a significant abblingarphy or Hoseburg survey, mention it here.) 17. Spunstering Agency Code 18. SUPPLEMENTARY NOTES 19. ADSTRACT (A 200 word or loss focual summary of most significant information. If document includes a significant abblingarphy or Hoseburg survey, mention it here.) 19. This report describes a system capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concentrations between 0.005 and 0.500 µg/l and an analytical system for the analytical system and their interactions are discussed. This/System provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 19. KEY WORDS (six to twelve entries, alphabetical order, capitalize only the first letter of the first key word unless a proper name, separated by semicolon() Atomic absorption; gas generation system; mercury; occupational safety. 19. KEY WORDS (six to twelve entries, alphabetical order, capitalize only the first letter of the first key word unless a proper name; sepa	NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234			11. Contract/Grant No.			
National Institute for Occupational Safety and Health Cincinnati, Ohio Corceed Final 15. SUPPLEMENTARY NOTES 16. ARSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) It document includes a significant bibliography or literature survey, mention it here.) 16. ARSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) 16. ARSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) 16. ARSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) 17. his report describes a system capable of producing well-defined test atmospheres of mercury in and an analytical system for the generatabody and analytical systems for mercury now in use. The analytical wations analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to two the entime, alphabetical order, capitalize only the first letter of the first key word unless a proper name: separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABULITY X unlinited P. SECURITY CLASS (THIS REPORT) <	12. Sponsoring Organization Na	ume and Complete Address (Street, City, St	ate, ZIP)	13. Type of H	Report & Period		
Health Cincinnati, Ohio Hinal 14. Sponsoring Agency Code 15. SUPPLEMENTARY NOTES 16. ANSTRACT (A 200 word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) 16. ANSTRACT (A 200 word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) 17. Ist report describes a system provides a means of calibration of the various analytical system provides a means of calibration of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entities, stphebetical order, capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY IX. Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES (THIS REPORT) 18. AVAILABILITY IX. Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES (THIS PAGE) 18. AVAILABILITY IX. Unlimited 19. SECURITY CLASS (THIS PAGE) 21. NO. OF PAGES (THIS PAGE)	National Institu	te for Occupational Safe	ety and	Covered			
Cincinnati, Ohio 4. Spossoring Agency Code 13. SUPPLEMENTARY NOTES 14. ABSTRACT (A 200 word or less factual summary of most significant information. If document includes a significant bibliography of literature survey, mention if here.) 15. ABSTRACT (A 200 word or less factual summary of most significant information. If document includes a significant bibliography of literature survey, mention if here.) This report describes a system capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concentrations between 0.005 and 0.500 µg/1 and an analytical system for the analytical system and their interactions are discussed. This/system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twolve entries; stphobetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILADILITY [X Unlimited 19. SECURITY CLASS (This REPORT) 21. NO. OF PAGES (THIS REPORT) 19. Not first part of for Official Distribution. Do Nor Release to NTIS 14. 19. Not CLASSIFIED 14. 20. Security CLASS (THIS PAGE) 22. Price	Health	I		Final			
15. SUPPLEMENTARY NOTES 16. ABSTRACT (A 200 word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention if here.) This report describes a system capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concentrations between 0.005 and 0.500 µg/l and an analytical system for the analysis of these gas mixtures. Various parameters that affect the generate/off and analytical system and their interactions are discussed. This/system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetice] order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Ualimited 19. SECURITY CLASS (THIS PAGE) 21. NO. OF PAGES (THIS PAGE) 14. 20. Security CLASS 21. NO. OF PAGES (THIS PAGE) 14	Cincinnati, Ohio			14. Sponsorin	ig Agency Code		
10. AUSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant biblioproperty or literature survey, manifor it here.) 11. This report describes a system capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concentrations between 0.005 and 0.5400 µg/l and an analytical system for the analysis of these gas mixtures. Various parameters that affect the generators and analytical system provides a means of calibration of the various analytical system for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 12. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 13. AVAILABILITY IX Unlimited 14. 21. NO. OF PAGES (THIS REPORT) 14. Order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 2002; <u>50 Car, No. C13</u> 14. 20. SECURITY CLASS (THIS PAGE) 15. UNCLASSIFIED	IS SUFFICIAL NUTES						
This report describes a system capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concentrations between 0.005 and 0.540 µg/l and an analytical system for the analysis of these gas mixtures. Various parameters that affect the generators and analytical system and their interactions are discussed. This/system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES (THIS REPORT) 14. Order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 20402; <u>50 Car. No. C13</u> 19. SECURITY CLASS (THIS PAGE) 22. Price 15. Order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 20402; <u>50 Car. No. C13</u> 14. 20. SECURITY CLASS (THIS PAGE) 22. Price	16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)						
test atmospheres of mercury in air or other diluent gas at concentrations between 0.005 and 0.500 µg/l and an analytical system for the analysis of these gas mixtures. Various parameters that affect the generatare and analytical system and their interactions are discussed. This/system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order, capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY IX Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES (THIS REPORT) 14. Order From Sup. of Dac, U.S. Government Printing Office Washington, D.C. 20402; SD Car, No. C13 14. 20. SECURITY CLASS (THIS PAGE) 22. Price 19. SECURITY CLASS (THIS PAGE) 22. Price	This report describes a system capable of producing well-defined						
trations between 0.005 and 0.500 µg/1 and an analytical system for the analysis of these gas mixtures. Various parameters that affect the generate/dwfa and analytical system and their interactions are discussed. This/system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. V. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY IX Unlimited Portor From Sup. of Duc., U.S. Government Printing Office 14 20. SECURITY CLASS 21. NO. OF PAGES Order From Sup. of Duc., U.S. Government Printing Office 20. SECURITY CLASS Order From Sup. of Duc., U.S. Government Printing Office 14 20. SECURITY CLASS 22. Price UNCLASSIFIED 14	test atmospheres of mercury in air or other diluent gas at concen-						
the analysis of these gas mixtures. Various parameters that affect the generators and analytical system and their interactions are discussed. This/system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order, capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABULITY IX Unlimited 19. SECURITY CLASS 21. NO. OF PAGES 14. Order From Sup. of Dec. U.S. Government Printing Office 19. Order From Sup. of Dec. U.S. Government Printing Office 14 10. Order From Sup. of Dec. U.S. Government Printing Office 20. SECURITY CLASS 14. 21. Price	trations between 0.005 and 0.500 µg/1 and an analytical system for						
17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY IX Unlimited 19. SECURITY CLASS CTHES REPORT) 14. Order From National Technical Information Service (NTIS) 19. SECURITY CLASS 19. Order From National Technical Information Service (NTIS) 19. SECURITY CLASS 10. AVAILABILITY IX Unlimited 19. SECURITY CLASS 21. NO. OF PAGES 14. UNCLASSIFIED 14.	the analysis of	the analysis of these gas mixtures. Various parameters that affect					
discussed. This/system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order, capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES (THIS REPORT) 14. Order From Sup. of Due, U.S. Government Printing Office Washington, D.C. 20402; SD Car. No. CL3 14. 20. SECURITY CLASS (THIS PAGE) 22. Price 14. UNCLASSIFIED 14.	the generations and analytical system and their interactions are						
Various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order, capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY IX Unlimited 19. SECURITY CLASS (THIS REPORT) 14 10. Order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 20402; SD Cat. No. CI3 19. SECURITY CLASS (THIS PAGE) 19. Order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 20402; SD Cat. No. CI3 12. Price 10. Order From National Technical Information Service (NTIS) 21. Price 10. Order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 20402; SD Cat. No. CI3 22. Price	discussed. This/system provides a means of calibration of the						
 unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited 19. SECURITY CLASS (THIS REPORT) 14 20. SECURITY CLASS (THIS PAGE) 21. NO. OF PAGES (THIS PAGE) 22. Price 23. SECURITY CLASS (THIS PAGE) 24. Detention of the first page of the page	various analytical systems for mercury now in use. The analytical						
 in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 14. Order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13 Order From Nutional Technical Information Service (NTIS) Order From Nutional Technical Information Service (NTIS) UNCLASSIFIED 21. NO. OF PAGES UNCLASSIFIED 22. Price 	unit of the system can also be used for the determination of mercury						
collector, and then desorbing it by heat into a flameless atomic absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY X Unlimited Pro Official Distribution. Do Not Release to NTIS 19. SECURITY CLASS (THIS REPORT) Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, <u>SD Cat. No. C13</u> 19. SECURITY CLASS (THIS PAGE) Order From Nutional Technical Information Service (NTIS) 14 Order From Nutional Technical Information Service (NTIS) 20. SECURITY CLASS (THIS PAGE)	in industrial atmospheres by collecting the mercury on a silver wool						
absorption spectrometer. 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 14 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 14 10. Order From Sup. of Doc., U.S. Government Printing Office 10. SECURITY CLASS (THIS PAGE) 19. SECURITY CLASS (THIS PAGE) 14 20. SECURITY CLASS (THIS PAGE) 22. Price	collector, and then desorbing it by heat into a flameless atomic						
17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY X Unlimited 19. AVAILABILITY X Unlimited 19. AVAILABILITY X Unlimited 19. SECURITY CLASS 21. NO. OF PAGES 19. Order From Sup. of Doc., U.S. Government Printing Office UNCLASSIFIED 11. Order From National Technical Information Service (NTIS) UNCLASSIFIED 11. Order From National Technical Information Service (NTIS) UNCLASSIFIED	absorption spectrometer.						
17. KEY WORDS (six to twelve entries; elphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 14 UNCLASSIFIED 14 19. order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 20402, SD Car. No. C13 20. SECURITY CLASS (THIS PAGE) 19. order From National Technical Information Service (NTIS) UNCLASSIFIED 22. Price							
17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 14 19. order From Sup, of Doc., U.S. Government Printing Office 20. SECURITY CLASS (THIS PAGE) 22. Price 19. order From National Technical Information Service (NTIS) UNCLASSIFIED 22. Price							
17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES 18. AVAILABILITY [X] Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES 19. Order From Sup. of Doc., U.S. Government Printing Office UNCLASSIFIED 14 19. Order From National Technical Information Service (NTIS) UNCLASSIFIED 22. Price 19. Order From National Technical Information Service (NTIS) UNCLASSIFIED 22. Price							
 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited [19. SECURITY CLASS (THIS REPORT)] 14 18. AVAILABILITY [X] Unlimited [19. SECURITY CLASS (THIS REPORT)] 14 19. Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Car. No. C13 [THIS PAGE]] UNCLASSIFIED] UNCLASSIFIED 							
 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited 19. SECURITY CLASS (THIS REPORT) 14 14. UNCL ASSIFIED 14. Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Car. No. C13 (THIS PAGE) Order From National Technical Information Service (NTIS) UNCL ASSIFIED UNCL ASSIFIED UNCL ASSIFIED 							
 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited [9. SECURITY CLASS (THIS REPORT)] For Official Distribution. Do Not Release to NTIS UNCLASSIFIED [14] Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, <u>5D Cat. No. C13</u> (THIS PAGE) Order From National Technical Information Service (NTIS) UNCLASSIFIED [22. Price] 							
 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 14 18. AVAILABILITY X Unlimited 19. SECURITY CLASS (THIS REPORT) 14 19. SECURITY CLASS (THIS REPORT) 14 19. Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13 (THIS PAGE) UNCLASSIFIED 20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED UNCLASSIFIED 							
 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited 19. SECURITY CLASS (THIS REPORT) 14. UNCLASSIFIED 14. Order From Sup. of Duc., U.S. Government Printing Office Washington, D.C. 20402, SD Car. No. C13 Order From National Technical Information Service (NTIS) Order From National Technical Information Service (NTIS) UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED 							
 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY [X] Unlimited 19. SECURITY CLASS (THIS REPORT) 14 14 14 19. Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13 Order From National Technical Information Service (NTIS) Order From National Technical Information Service (NTIS) 11. No. OF PAGES 12. No. OF PAGES 14. UNCLASSIFIED 15. UNCLASSIFIED 16. UNCLASSIFIED 17. No. OF PAGES 18. AVAILABILITY 19. SECURITY CLASS 19. SECURITY CLASS 10. Security CLASS 11. UNCLASSIFIED 12. Price 							
name; separated by semicolons) Atomic absorption; gas generation system; mercury; occupational safety. 18. AVAILABILITY X Unlimited Y order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13 19. SECURITY CLASS (THIS REPORT) Order From National Technical Information Service (NTIS) 20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED 22. Price	17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper						
occupational safety. 18. AVAILABILITY X Unlimited Y order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13 19. SECURITY CLASS (THIS REPORT) Order From National Technical Information Service (NTIS) Springfield, Virginia 22151 21. NO. OF PAGES	name; separated by semicolons) Atomic absorption: gas generation system: mergurary						
18. AVAILABILITY IX Unlimited 19. SECURITY CLASS (THIS REPORT) 21. NO. OF PAGES Image: For Official Distribution. Do Not Release to NTIS UNCLASSIFIED 14 Image: Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13 20. SECURITY CLASS (THIS PAGE) 22. Price Image: Order From National Technical Information Service (NTIS) UNCLASSIFIED 20. SECURITY CLASS 22. Price	occupational safety.						
18. AVAILABILITY Image: Construct of Distribution. Image: Consered of Dist							
18. AVAILABILITY Image: Construction of Distribution of Distribution. Image: Construction of Distribution of Distribution. Image: Construction of Distribution of Distribution. Image: Construction of Distribution of Distribution of Distribution of Distribution of Distribution. Image: Construction of Distribution of Distributio of Distribution of Distributio of Distributi							
For Official Distribution. Do Not Release to NTISUNCLASSIFIED14Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C1320. SECURITY CLASS (THIS PAGE)22. PriceOrder From National Technical Information Service (NTIS) Springfield, Virginia 22151UNCLASSIFIED24	18. AVAILABILITY	[X] Unlimited	19. SECURIT (THIS RE	Y CLASS PORT)	21. NO. OF PAGES		
Order From Sup. of Doc., U.S. Government Printing Office 20. SECURITY CLASS (THIS PAGE) Washington, D.C. 20402, SD Cat. No. C13 (THIS PAGE) Order From National Technical Information Service (NTIS) UNCLASSIFIED	For Official Distributio	n. Do Not Release to NTIS	UNCL ASS	SIFIED	14		
Order From National Technical Information Service (NTIS) UNCLASSIFIED	Order From Sup. of Doc Washington, D.C. 2040	., U.S. Government Printing Office 2, SD Cat. No. C13	20. SECURIT	Y CLASS	22. Price		
Springfield, Virginia 22151 UNCLASSIFIED			(IIIISF7	106/			
	Springfield, Virginia 22	echnical Information Service (NTIS) 151	UNCLASS	IFIED			

1 . ser a ched. at it

