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Applications of Aerospace Technology in Air Pollution Control

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March 1970 - September 1970

RESEARCH TRIANGLE INSTITUTE

RESEARCH TRIANGLE PARK, NORTH CAROLINA

Engineering and Environmental Sciences Division
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APPLICATIONS OF AEROSPACE TECHNOLOGY IN AIR POLLUTION CONTROL

Contract No. NASW-1950
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15 March 1970 to 30 September 1970

Prepared for

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Technology Utilization Division
Washington, D. C. 20546

ABSTRACT

This report covers the activities of the National Aeronautics and Space Administration (NASA) Technology Application Team (TATeam) located at the Research Triangle Institute (RTI) for the period from 15 March 1970 to 30 September 1970. Activities covered by this report are those directed towards the accomplishment of Tasks g.1. (a) and g.1. (b), Article II, Statement of Work of the Schedule of NASA Contract No. NASW-1950 and related to the transfer of aerospace science and technology to applications in air pollution control. The work reported here was performed by an interdisciplinary team in the Engineering and Environmental Sciences Division (EESD) of RTI. This project is under the general direction of Dr. J.N. Brown, Jr., Manager, Systems Engineering Department, EESD. Mr. C. E. Decker is the Project Leader and author of this report. At the present time the RTI Technology Application Team is staffed by : Dr. J. N. Brown, Jr., Electrical Engineer; Mr. C. E. Decker, Air Pollution Chemist; Mr. F. Smith, Engineer; and Mr. B. W. Crissman, Research Assistant. Additionally, the team draws upon the capability of other members of the RTI staff as needed. All phases of this project were coordinated with the Technology Utilization Division of NASA and with the National Air Pollution Control Administration in Washington, D. C., Durham, North Carolina, Cincinnati, Ohio, and Ann Arbor, Michigan.

During the reporting period, the Research Triangle Institute Technology Application Team has identified 11 new problems for investigation, closed 20 old problems, and on 30 September 1970 had a total of 26 problems under active investigation.

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1.0 INTRODUCTION

1.1 Introductory Comments

Significant benefits are to be gained by applying the scientific and technological results of federally funded research and development (R and D) programs to problem areas other than those for which they were created. The size of the national investment in R and D programs and the very significant technological achievements which have been realized in the past decade demand that an effort be made to apply the results of these programs to the social, economic, environmental, and health-related sectors of our society.

The National Aeronautics and Space Administration (NASA) has been a leader and innovator in the establishment, study, and assessment of technology transfer programs since that agency was established by the Space Act of 1958. Through its Tech Brief, Special Publication, Technology Survey, and Regional Dissemination Center programs, NASA has been successful in transferring the results of aerospace R and D to nonaerospace applications.

In 1966, NASA established a program which uses an active, directed technology transfer methodology. In this program, NASA established three Biomedical Application Teams at not-for-profit research institutes. The methodology used is active in that the teams initiate the identification and definition of problems which may be amenable to solution by the application of aerospace technology; it is directed in that the teams' efforts are directed toward solving problems in biology and medicine in order to enhance progress in medical research and in establishing more effective medical care in the United States.

More recently, NASA has extended the scope of its team approach to technology transfer and has established four Technology Application Teams (TATeam) at research institutes. The efforts of these TATeams are directed toward transferring aerospace technology to applications in a number of public sector areas. These public sector areas include air pollution control, water pollution control, marine sciences, mine safety, and others. The four Technology Application Teams established by NASA are located at the following institutions:

Research Triangle Institute
Box 12194
Research Triangle Park,
North Carolina 27709

Illinois Institute of Technology
Research Institute
10 West 35th Street
Chicago, Illinois 60616

Stanford Research Institute
333 Ravenswood Avenue
Menlo Park,
California 94025

Abt Associates, Incorporated
55 Wheeler Street
Cambridge, Massachusetts 02138

This report covers the activities of the Research Triangle Institute (RTI) Technology Application Team in the public sector area of air pollution control for the period 15 March 1970 to 30 September 1970. In the remainder of Section 1.0 are presented discussions of Technology Application Team objectives and methodology.

1.2 Technology Application Team Program

The specific objectives of NASA's Technology Application Team program are as follows:

(1) Transfer a maximum number of specific items of aerospace technology to applications in air pollution control in order to solve or partially solve problems in the area of air pollution control;

(2) Analyze, refine, and document the manner in which the transfer of aerospace technology to air pollution control is accomplished in order to enhance the understanding of active processes of technology transfer; and,

(3) Motivate potential adopters of aerospace technology in air pollution control organizations involved in generating advanced technology, and individuals who can influence technology transfer programs to become actively involved in more comprehensive technology utilization programs.

A description of the Technology Application Team program can be facilitated by reference to Fig. 1. Basically, the team represents an interface and information channel between scientists and engineers in the National Air Pollution Control Administration (NAPCA) and the body of scientific and technical information that has resulted from the nation's aerospace R and D effort. The team attempts to couple the technological problems and requirements being encountered in NAPCA with relevant aerospace technology and, in particular, NASA-generated technology. The team actively engages in identifying these problems through direct contact with the NAPCA staff, the "problem originators". The identification and specification of problems is followed by a search for technology which may be relevant to solutions to these problems.

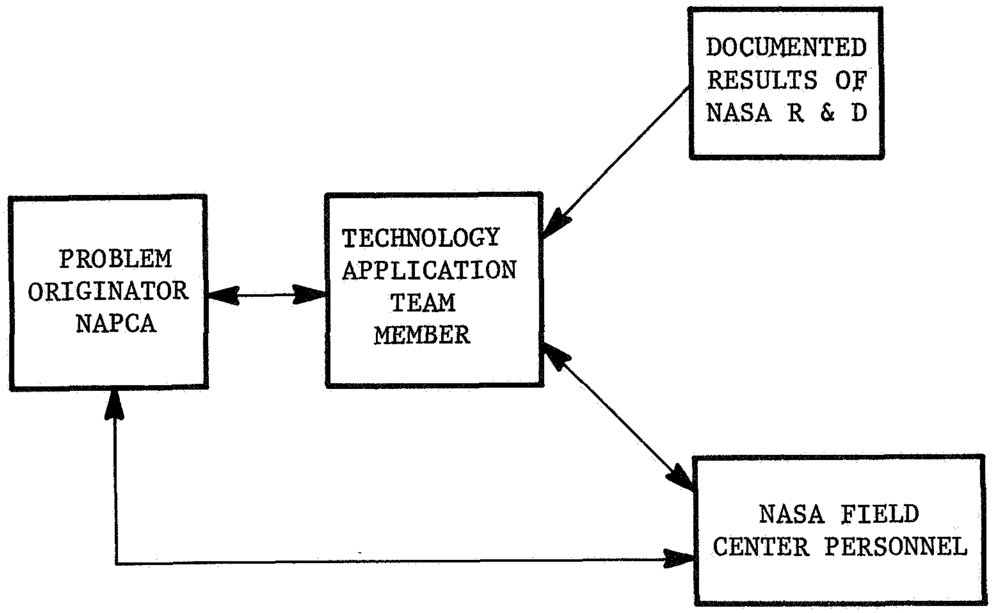

Figure 1. Possible Mechanisms for Transfer of Information/ Hardware.

Generally, technology relevant to specific problems is identified through two approaches: (1) manual and computer searching of the aerospace information bank created by NASA as part of its R and D effort, and (2) direct contact with the engineering and scientific staff at NASA Field Centers. Information describing technology representing potential solutions to problems is channeled through the team to the problem originator for evaluation and implementation as a solution to his problem. Alternatively, the team establishes a contact between the problem originator and NASA Field Center personnel, and thereby the transfer of information between NASA and NAPCA becomes more direct. The more direct the transfer of information, the more relevant, accurate, and complete is this transfer. Thus, the TATeam attempts to create these direct interchanges whenever appropriate and feasible.

It is stressed that the TATeam is an information transfer agent and not a mechanism for obtaining NASA hardware. The goal of the program is, nevertheless, the adoption of aerospace technology in monitoring and controlling air pollution and this frequently requires that potentially applicable technology be reengineered or adapted for specific applications. This reengineering and, more generally, the implementation of aerospace technology is the responsibility of the problem originator.

The successful transfer of information on aerospace technology to an individual or group followed by successful implementation of the technology with resulting benefits to the accomplishment of some objective in air pollution control is called a "technology transfer".

A specific methodology is applied by the Technology Application Team in its efforts to affect technology transfers. This methodology is discussed in the following section.

1.3 Methodology

The methodology used by the TATeam consists of four basic steps: problem definition, identification of relevant technology, evaluation of relevant technology, and documentation. This methodology can be better understood, however, if it is broken down into the seven steps shown in Fig. 2. These steps are described in the following paragraphs.

Problem screening -- Effective problem screening is at least as important to the success of the TATeam program as any of the operational steps identified in Fig. 2. Analysis of both the Biomedical Application Team and the Technology Application Team located at RTI indicates clearly that a very significant fraction of the problems which have been investigated unsuccessfully could have been rejected very early in discussions with problem originators. Problem selection criteria have been developed with the objective being to increase the average probability that a technology transfer can be accomplished for problems accepted by the team. At present, the following criteria are being applied:

> Solving the problem would enhance the realization of important objectives of the National Air Pollution Control Administration.

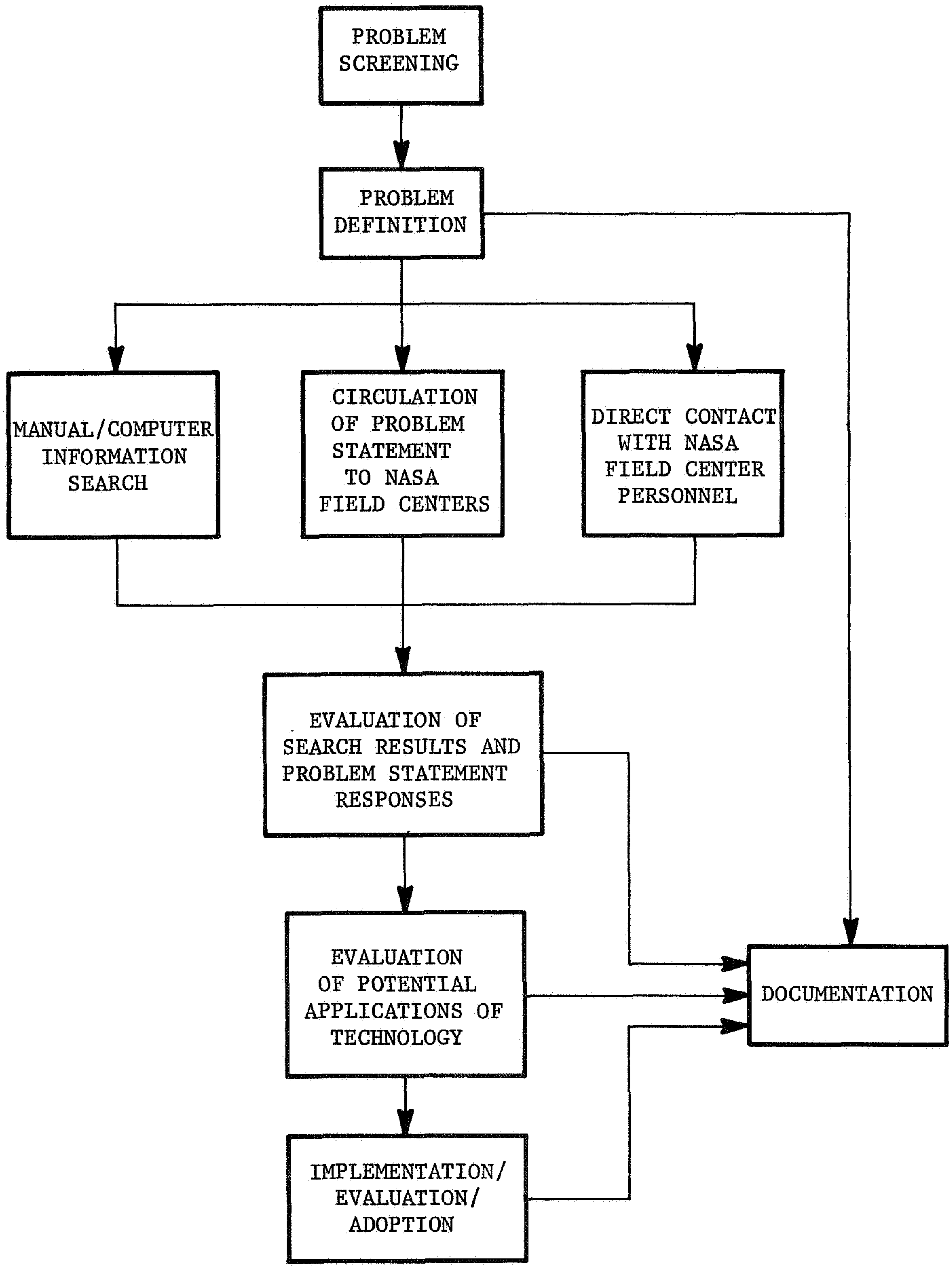

Figure 2. Flow Chart of Technology Application Team Transfer Methodology.

OR

The problem has been encountered in ongoing research and development or operational programs and is impeding progress of either program,

AND

Solving the problem is given high priority by the problem originator,

AND

The problem is one of at most two being investigated with an individual problem originator.

Problems which do not satisfy these criteria are rejected. Problems may also be rejected following partial completion of the next step, problem definition.

Problem Definition -- The objective of this step is to define precisely and accurately the characteristics of the technology required to solve a problem. It is important that all necessary constraints are included and equally important that no unnecessary constraints are included in characterizing the required technology. In many cases, following the characterization of required technology, it is found that the problem should be rejected or closed for any of a number of reasons. These reasons include, as examples, the following: (1) the problem can be solved using commercially available equipment; (2) the problem cannot be solved and an entirely different approach is indicated; (3) the problem is not related to aerospace technology; and (4) the requirements cannot be specified because insufficient information exists on the objective involved.

The end result of problem definition is the preparation of a problem statement. This statement, to be complete, must contain (1) a complete characterization of what is required to solve the problem, and (2) the related problem or objective and the benefits to be realized by solving the problem.

Identification of relevant aerospace technology -- Aerospace technology which may be relevant to the solution of a problem is identified by three approaches. First, a manual or computer search is made of the aerospace information bank. These searches are made at one of NASA's six Regional Dissemination Centers (RDC). The RDC used by the RTI TATeam is the North Carolina Science and Technology Research Center (NCSTRC) located in the Research Triangle Park, N. C. The information bank which can be accessed through the RDC's consists of the approximately 700,000 documents, articles, and translations which have been abstracted in the Scientific and Technical Aerospace Reports (STAR) and the International Aerospace Abstracts (IAA). Second, problem statements are circulated to NASA Field Center engineers and scientists who may be able to identify relevant technology and suggest possible solutions to problems. These statements are circulated in a highly selective manner with the distribution being determined by the TATeam, Technology Utilization Officers (TUO) at the Field Centers, and other individuals at the Field Centers. Third, the team in some cases contacts individuals at NASA Field Centers directly without circulating problem statements. This is done when one can identify a relatively few individuals at the Field Centers who should have a good overview of all NASA R and D which is related to the requirements of a specific problem.

First evaluation -- All potentially relevant technology identified in the preceding step is evaluated by the TATeam to determine if a potential solution to a specific problem has been found. Those items of technology which represent potential solutions to problems are presented to problem originators along with available supporting data and information.

Second evaluation -- The problem originator must then evaluate potential solutions. His decision to implement a proposed solution will depend upon a number of factors including: (1) his assessment of the validity of the proposed potential solution, (2) the cost of implementing the potential solution, and (3) the potential benefits to be gained. The team may be asked to supply additional information and technical details in this evaluation.

Implementation, final evaluation, adoption -- The final step in the transfer process is implementation and experimental evaluation of potential solutions. This is the responsibility of the problem originator. The team is available for assistance in this step when required. Hopefully, when a potential solution is shown to be a valid solution to a problem, this solution is adopted by the problem originator and the transfer is complete.

Documentation -- Documentation is an integral part of the TATeam methodology; it is involved at most steps in the process as indicated in Fig. 2. Documentation allows analysis of the transfer process and assessment of the program in general. At present, the teams report on a weekly, monthly, and semiannual schedule. Effective communications is vitally important between TATeams and potential problem originators and other individuals who are in a position to make use of information resulting from transfers accomplished by the TATeams.

1.4 Technology Application Team Composition and Its Interface with the National Air Pollution Control Administration

The RTI TATeam is a multidisciplinary group of engineers and scientists. During the reporting period, the following individuals have been involved in this program:

Dr. J. N. Brown, Jr.	Electrical Engineer and Manager of Systems Engineering Department, Engineering and Environmental Sciences Division (EESD)

Mr. C. E. Decker	Air Pollution Chemist in the Engineering Physics Department, EESD
Mr. F. Smith	Engineer in Engineering Physics Department, EESD
Mr. B. W. Crissman	Research Assistant in Environment Sciences Department, EESD

The experience and special capabilities of other individuals of RTI and particularly those of the Engineering and Environmental Sciences Division are frequently used in the TATeam program on an as-needed basis.

At the present time, the RTI TATeam is working with all three bureaus in NAPCA (i.e. Bureau of Criteria and Standards, Dr. Delbert Barth, Chief; Bureau of Engineering and Physical Sciences, Mr. Paul Spaite, Chief; and Bureau of Abatement and Control, Mr. Robert Harris, Jr., Chief.) Within the Bureau of Criteria and Standards, the activities of the RTI TATeam have been concentrated in the Division of Health Effects Research and the Division of Air Quality and Emission Data. Within the Bureau of Engineering and Physical Sciences, the TATeam interface extends across all four divisions: Chemistry and Physics Division, Meteorology Division, Process Control Engineering Division, and the Division of Motor Vehicle Research and Development. Within the Bureau of Abatement and Control, activities have been initiated with the Abatement Division. It is anticipated that initial contacts with two other divisions (i.e. Control Agency Development and Motor Vehicle Pollution Control will be made during the next 6-month reporting period. When this technology utilization program was initiated early in 1969, it was decided jointly by NAPCA, NASA, and the RTI TATeam that these divisions represented that part of NAPCA having the greater potential for applying aerospace-developed technology.

During the last six months NAPCA has been undergoing major reorganizations and will most likely be affected by the formation of the new Environmental Protection Agency. Personnel shifts, promotions, and shifts of entire sections from one division to another, and shifts in responsibilities have affected the efficiency with which the TATeam has been able to function, as an interface between NASA and NAPCA. In the last month, two problem originators have changed jobs and seriously affected the outcome of five problems. If the persons replacing these problem originators retain the problems and become enthusiastic about them, then some useful transfer of technology may occur. Otherwise, the team will have to begin anew with other problems. In either case valuable time is expended. It is anticipated that personnel changes and changes in assignments will continue for several months. Only until NAPCA's organizational structure becomes finalized and stabilized can the TATeam be 100 percent effective.

1.5 List of Definitions

In the Technology Application Team program, a number of terms have evolved which describe the elements and processes referred to in this program. Because of their number and unfamiliarity to the majority of readers, these terms are listed and defined in this section for easy and quick reference.

Problem originator -- An individual actively involved in an effort to reach a specific objective in air pollution control and faced by a specific technological problem which is impeding progress toward that objective.

Technology Application Team (TATeam) -- A multidisciplinary group of engineers and scientists engaged in problem-solving activities in biology and medicine with the specific objectives of (1) effecting the transfer of aerospace technology to solve or aid in solving problems in the public sector, and (2) understanding and optimizing the methodology for effecting such transfers of technology. The methodology used by the TATeam involves (1) problem selection, definition, and specification; (2) identification of potential solutions to problems by manual and computer information searching, circulation of problem statements to NASA Field Centers, and contacts with NASA engineers and scientists; (3) evaluation of potential solutions; (4) implementation and adoption, by problem originators of aerospace technology as solutions or partial solutions to problems in the public sector; and (5) documentation.

Problem -- A specific and definable technological requirement that cannot be satisfied with known commercially available equipment or through the application of information or knowledge available to the problem originator through routinely used information channels. Problems accepted for investigation by the team are subject to problem screening criteria which are discussed in Section 1.3. Within the context of the Technology Application Team program as it relates to the National Air Pollution Control Administration, it is explicitly assumed that problems investigated by the team are those which are impeding progress toward reaching an objective that involves reducing air pollution in the United States and maintaining reduced levels of air pollution.

Technology transfer -- The implementation and adoption of an item of aerospace technology by a problem originator to solve or aid in solving a problem in the public sector. The public sector application involved is one which is different from that application for which the aerospace technology was originally developed.

Problem statement -- A concisely written statement of a problem for communicating to information search specialists sufficient details to assist them in performing a computer search, and for communicating to NASA engineers and scientists sufficient information to motivate them to consider possible solutions to the problem and allow them to determine if and in what way they can assist in solving the problem.

Computer information search -- A computerized information search of the aerospace information bank established by NASA and made available through six Regional Dissemination Centers in the United States. This information bank consists of the approximately 700,000 documents which have been indexed and abstracted in the Scientific and Technical Aerospace Reports (STAR) and International Aerospace Abstracts (IAA). Applications engineers at these centers design search strategies using information in problem statements. These search strategies allow one to identify those documents in the information bank which are relevant to the solution of a specific problem.

1.6 List of Abbreviations

TATeam	Technology Application Team
BATeam	Biomedical Application Team
NCSTRC	North Carolina Science and Technology Research Center
RDC	Regional Dissemination Center
RTI	Research Triangle Institute
STAR	Scientific and Technical Aerospace Reports
TUO	Technology Utilization Officer
LRC	Langley Research Center
MSFC	Marshall Space Flight Center
NAPCA	National Air Pollution Control Administration
NCAR	National Center for Atmospheric Research
ESSA	Environmental Science Services Administration

2.0 TRANSFERS AND POTENTIAL TRANSFERS OF AEROSPACE TECHNOLOGY TO APPLICATIONS IN AIR POLLUTION.

2.1 Summary

Of the 66 technological requirements which have been identified and specified by the RTI TATeam in working with the National Air Pollution Control Administration, potential solutions have been identified for 26 requirements. These 26 potential solutions have involved 16 items of NASA-generated aerospace technology, three items of nonaerospace related technology, one item of technology resulting from an R and D program in Japan, and one instrument developed at the University of Minnesota (funded by NASA) for a total of 21 different items of technology. These figures do not include items of technology which have been uncovered by the TATeam and are being evaluated by the problem originator, have been presented to him and have been rejected due to cost of implementation, or have been presented to the problem originator with no action being taken by him.

Of the 66 technological requirements which have been identified and accepted as problems for investigation by the TATeam, seven have resulted in technology transfers. These were reported in a previous RTI report*. During the period 15 March 1970 to 30 September 1970, no transfers of technology were accomplished by the RTI TATeam. Three potential transfers were documented during this period and 10 potential transfers were deactivated.

2.2 NASA Technology Relevant to Solutions of Problems in Air Pollution Control

In this section is briefly discussed NASA technology which has been identified by the RTI TATeam as relevant to the solution to 5 of the 26 problems presently being investigated. The specific problems involved are in various stages of the transfer progress and are described in Section 2.0. All potential solutions described in this section are considered active.

RTI/AP-26, "Development of Advanced Pollutant Sensor for Total Hydrocarbons"

A need was determined in NAPCA for the development of an inexpensive, advanced sensor capable of measuring total hydrocarbons in ambient air, auto exhaust, and stack effluents. A potential solution involving an indium-

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*"Application of Aerospace Technology in Air Pollution Control", Semi-Annual Report, September-March 1970, Research Triangle Institute, Research Triangle Park, North Carolina.

oxide thin-film detector developed under contract to NASA by General Electric Company was suggested by Mr. T.N. Marshall, Marshall Space Flight Center. The principle of operation is based on the change in electrical resistance of the indium-oxide thin-film when exposed to various concentrations of a combustible gas. Although developed for detecting hydrogen, the device will respond to hydrocarbons and methane; however, its maximum sensitivity and detection range is unknown.

A device utilizing the indium-oxide thin-film sensor was obtained from General Electric and received at RTI on 3 April 1970. A preliminary evaluation was done and the results appeared to be encouraging. A copy of the patent claim covering the device has been forwarded to the problem originator, Mr. R. K. Stevens. Mr. Stevens has agreed to evaluate the device for possible use as an advanced sensor for hydrocarbons. On 30 September 1970, this sensor was recommended as a candidate for application engineering to NASA Headquarters. The potential solution for AP-26 was identified by circulation of the problem statement to NASA Field Centers. Mr. T. N. Marshall at MSFC, Huntsville, Alabama responded to the problem statement.

RTI/AP-33, "Working Fluids for Rankine Cycle Engines"

A need was determined by NAPCA for an optimum working fluid for use in Rankine cycle propulsion systems for passenger vehicles. The identification and development of suitable work fluids for use in such an engine is a critical area of concern, since many of the design parameters of the engine depend directly on the physical characterisitics of the working fluid. Technical Applications Search No. T0003D (111 citations) was forwarded to Mr. Ray Machacek in early March. To date, forty-four relevant NASA documents were ordered and forwarded to him. It appears that the abundance of material uncovered in this search assures the success of a technology transfer in this area. At the time of writing this report, evaluation of the documents forwarded to the problem originator have been completed; however, the problem originator, Mr. Ray Machacek, has gone back to school. His replacement is reviewing the material and will notify us of his findings.

RTI/AP-42, "Development of Lightweight Furnace Refractory Material"

Air pollution resulting from unburned hydrocarbons produced in cycling domestic oil furnaces may be reduced through incorporation of lightweight refractory material as a lining material for the firebox. Refractory materials with good insulting properties are also needed for insertion between fireboxes and the heat exchanger to prevent erosion of the base plate of the heat exchanger. Dr. John Buckley, Langley Research Center, suggested that sheets of aluminum or zirconium oxide would be applicable to the solution of the problem of an insulation material to fit between the heat exchanger and firebox. Both materials are machineable and have melting points well above the temperature requirements of 2000°F maximum for the firebox. This information was given to the problem originator and it has been reviewed by him.

Due to the cost of implementing this technology (i.e.≈ \$2000-5000 to insulate firebox) the potential transfer for AP-42 was inactivated; however, the problem was not closed. Plasma jet spraying techniques of ceramic materials and silicon carbide compositions are being evaluated by the problem originator as possible solutions. Documentation will be submitted shortly describing another potential transfer for AP-42.

RTI/AP-48, "Modifications to Mass Spectrometry to Enhance Its Performance in Air Pollution Monitoring"

A need was determined in NAPCA to develop modifications which could be applied to mass spectrometry to enhance its performance in air pollution monitoring. Difficulties encountered in applying mass spectrometry in air pollution monitoring have limited the use of this highly selective analytical technique. The primary limitations are lack of sensitivity to measure ambient levels of air pollutants, high cost, size of the instrumentation, lack of data analysis capability, and simple, automatic sampling. Improvement in any one of these three areas would broaden the applicability of mass spectrometry in air pollution research.

Four potential solutions were reported in the last semiannual report:

Potential Solution No. 1

Dr. Tom Edwards of Marshall Space Flight Center has been working on the use of mass spectrometers in measuring contaminants in the upper atmosphere. The contribution of his work appears to be in the area of spectroanalyses using a signature storage and comparison approach. A relatively inexpensive mass spectrometer may be used in the system. Data are analyzed using large computer programs; however, data handling costs are expensive. As of 30 September 1970, Dr. Edwards has not been able to get his system on line. No further action will be taken until such a time as he can provide a demonstration of his system.

Potential Solution No. 2

Mr. Wesley Easley of Langley Research Center has been developing methods of improving the resolution and overall sensitivity of mass spectrometers by sample concentration techniques. His approach is essentially the mating of gas chromatography and mass spectrometry. This is a sampling technique where gases are absorbed on a column over a period of time and subsequently released during a temperature cycle of about 100°C. This technique can increase the sensitivity of mass spectrometers. Development work is continuing on this technique to simplify the operational procedures and to automate the data analysis.

Potential Solution No. 3

NASA has been able to reduce the size of mass spectrometers through miniaturization of electron devices and development of the quadrapole analyzer.

The convenience and cost savings which result from the reduced size may make this instrument feasible for air pollution monitoring in those cases where the lower limit of detection can be achieved.

Potential Solution No. 4

Dr. Peter H. Dawson and Mr. Jon Hedman are responsible for the development of a "Wire Mesh Analyzer" instrument at General Electric Company, Weslyn, Massachusetts. This analytical instrument is very small and weighs approximately two ounces. It consists of three opposing electrodes in a high vacuum system. The top and bottom electrodes approximate paraboloids of revolution with a circular electrode in the center. Ionized gases of the particular mass are stored for a period of time and then pulsed through holes in one of the electrodes and detected by a photomultiplier. This three-dimensional quadrapole electric field device differs from other electric field mass spectrometers. It is estimated that the price of such a unit can eventually be reduced to the order of hundreds of dollars which would be a major breakthrough in mass spectrometry.

Mr. Clifford Burrous, Ames Research Center, is evaluating the device for use in NASA's real-time contamination analyzer for detecting contamination around spacecraft. Further developments are expected in the near future.

RTI/AP-55, "Wind Tunnel Design Criteria"

A need was determined in NAPCA to construct an on-site low-speed wind tunnel at the interim NAPCA facilities in Durham, N. C. The tunnel would be used to simulate and evaluate flow characteristics of particulates as would be encountered in stack gases. Criteria is needed in order to incorporate the best combination of design factors to obtain the optimum configuration, eliminate wall effects, and minimize the size of the tunnel. Information Search No. 2107 contained 16 documents relevant to AP-55. Eleven of these have been forwarded to the problem originator. Of the 11 documents, five pertained to low-speed, low-cost wind tunnels which have been used by NASA and others to study particulates. Document No. N68-20894 which described the wind tunnel facilities at McGill University appeared to be directly applicable to the solution of this problem. The problem originator is in the process of reviewing these documents at the present time. A potential solution for AP-55 was documented during the reporting period. It is estimated that a transfer can be documented within three months. NAPCA should have the design for their wind tunnel completed by then.

2.3 Potential Transfers Inactivated During Reporting Period

RTI/AP-10, 11, 22, 25, 27, 41 (Composite Title-Advanced Sensors for CH_4, SO_2, F^-, CO_2, CO, NO_x)

In October 1969, potential transfers were claimed for AP-10, 11, 22, 25, 27, and 41; however, no transfer reports were submitted.

Each of these problems dealt with development of advanced pollutant sensors for various air pollutants. Four potential solutions were also reported in the potential transfer report for AP-48, "Modifications to Mass Spectrometry to Enhance Its Performance in Air Pollution Monitoring." A transfer on AP-48 utilizing any of the four solutions would have meant an immediate transfer on AP-10, 11, 22, 25, 27 and 41, since mass spectrometry is applicable to detecting all the pollutants described under these problem numbers. It was on this basis that potential transfers were inadvertantly claimed and carried forward with no documentation being submitted. In the interest of clarity, these potential transfer claims were inactivated to such a time that technology transfers in these areas were realized.

RTI/AP-42, "Development of Lightweight Furnace Refractory Material"

The reason for inactivation of the potential transfer for AP-42 (described previously in 2.2) was due to the cost of implementation of the solution (i.e., use of zirconium oxide inorganic fibers as insulation and refractory material for domestic oil furnace fireboxes was prohibitive. Otherwise, a transfer would have resulted. This problem was, however, not closed.

RTI/AP-47, "Feeder System for Particulates in Gases"

A method for introducing and controlling the concentration and size of particulates in an air stream is needed to prepare standard concentrations of particulates for calibration of particulate monitoring instrumentation. Mr. Chester Lanzo of NASA's Lewis Research Center for problem AP-35 suggested two particulate feeder systems in his laboratory which might be applicable to AP-47. One system was a modification of a DC arc system which is made by Thermo Dynamics, Inc., of Lebanon, New Hampshire. The second system was built in his laboratory using a glass annulus which allowed the particulate laden gas under study to be accelerated to Mach 1 conditions. The shock wave at the annulus is effective in deglomerating the submicron particles in the gas.

Both techniques were reviewed and evaluated by the problem originator, Mr. Don Felton, and neither approach provided him with a system significantly better than the one he is presently using.

RTI/AP-49, "Development of Improved Gas Flow Rate Control System for Air Pollution Monitoring Equipment"

An improved device for measuring and/or controlling gas flow rates in air pollution monitoring instrumentation is required for more accurate determination of trace gases in ambient air. One of the most serious limitations of air pollution monitoring instrumentation is the inability of the air flow control devices to maintain constant gas flow rates over a given time interval. Rotameters and critical orifices are commonly used; however, neither perform satisfactorily and contribute to erroneous or unreliable data. The requirements for such a device are that it have a range of from 100 cc/min. to 5 l/min, be able to withstand corrosive gases, operate at atmospheric pressure and ambient temperatures, and be relatively inexpensive.

Mr. Brad Wells, MSFC, suggested a laminar flow element as a possible solution to AP-49. Flow rates through the laminar flow element are controlled and are a linear function of the pressure maintained across the device. Mr. Wells' system incorporates an accurate low pressure regulator between the laminar flow element and the vacuum pump. The regulator is used to admit or bleed air into the system to maintain a constant pressure drop across the laminar flow element. This information was presented to the problem originator and reviewed.

The potential transfer for AP-49 was inactivated because this approach was judged as not being a significant improvement over currently available techniques by the problem originator. The problems involved with controlling and maintaining the pressure drop across the laminar flow element are objectionable to him.

3.0 PROBLEM STATUS

During the period 15 March 1970 to 30 September 1970, the RTI Technology Application Team accepted 11 new problems for investigation. These problem statements are attached to this report as Appendix B.

During the reporting period, nine problem statements, RTI/AP-38, RTI/AP-42, RTI/AP-47, RTI/AP-49, RTI/AP-50, RTI/AP-54, RTI/AP-58, and RTI/AP-60, were circulated to NASA Field Centers. Because of the nature of some of these problems, it was possible to identify individuals at the centers who, because of the job responsibilities should be able to respond to particular problems. In these cases it was recommended to the NASA Technology Utilization Officers (TUO) that certain individuals should receive the problem statements. Distribution lists compiled from the NASA Flash Index and Field Center Directories were suggested to the TUO's. In other cases, circulation was left up to the discretion of the TUO.

At present, the team is attempting to identify technology relevant to the solution of 26 problems. These 26 problems are listed in Table 1 under five categories or impact areas. "Impact area"refers to that area of air pollution control activities which would be most affected by finding a solution of the problem. From the table, it can be seen that most of the presently active problems are in the areas of gas pollution monitoring techniques (7 problems) particulate pollution monitoring techniques (7 problems), and air pollution control techniques (6 problems).

Also indicated in Table 1 is the problem status which refers to the particular phase of the transfer process to which the effort to solve the problem has progressed. The key to the letter designations used appears at the end of the table.

Of the 66 problems accepted from NAPCA, 20 were closed or inactivated during this reporting period. The reasons these problems were closed are tabulated in Table 2. The reason that the great majority of problems were closed was because they were considered to have a low priority (Category K), or because they had been defined improperly and are now included in new problems (Category L), or the researcher found his own solution. It is significant that 7 out of the 20 closed problems resulted from the researcher finding his own solution or judging the problem to have a low priority. This emphasizes the difficulty encountered when working with a group, such as NAPCA where problem originators are extremely aware of what has been and is being developed throughout the scientific community. Another explanation for problems closed in Categories K and L may be that these problems were active for a relatively long period of time and either the problem priorities shifted, or as the related programs progressed, the major technological problems and requirements were changed. Organizations such as NAPCA and NASA which are strongly based on technology tend, when necessary to meet objectives, move around problems which are not solved in a reasonable time. In other organizations such as, for example, those in the medical field, problems tend to be long term and relatively stable. In fact, in the latter case, it seems that certian problems seem to assume greater importance than the end objective. These considerations indicate that in transferring technology to the public sector area of air pollution control, the time required to identify potentially relevant technology must be minimized.

Table 1. Active Problem Status

Problem Number	Problem Category/ Problem Title	Problem Status
	1. Gas Monitoring Techniques	
RTI/AP-10	Advanced Pollutant Sensor for Methane	D
RTI/AP-26	Advanced Pollutant Sensor for Total Hydrocarbons	E
RTI/AP-27	Advanced Pollutant Sensor for Carbon Monoxide	D
RTI/AP-41	Advanced Pollutant Sensor for Oxides of Nitrogen (NO_x, NO, NO_2)	D
RTI/AP-48	Modifications to Mass Spectrometry to Enhance Its Performance in Air Pollution Monitoring	E
RTI/AP-50	Improved Techniques for the Preparation of Standard Concentrations of Carbon Monoxide and Methane	C,D
RTI/AP-60	Portable Carbon Monoxide Analyzer	C,D
	2. Particulate Monitoring Techniques	
RTI/AP-38	Measuring Techniques for Airborne Particulates	D
RTI/AP-47	Feeder System for Particulates in Gases	C,D
RTI/AP-52	Hi-Volume Multistage Fractionating Particulate Sampler	B,D
RTI/AP-53	Continuous Particle Counting Instrument	B,D
RTI/AP-54	Evaluation of Automatic Instrumentation for the Measurement of Mass Flow of Particulates from Combustion of Coal and Residual Fuel Oil Sources	B,D
RTI/AP-57	Analytical Techniques for Trace Metals in Combustion Effluents from Coal and Residual Fuel Oil Sources	C,D
RTI/AP-66	Differential Pressure Transducer for Isokinetic Stack Gas Sampling	B,D

Table 1. (Continued)

Problem Number	Problem Category/ Problem Title	Problem Status
	3. Air Pollution Control Techniques	
RTI/AP-42	Development of Lightweight Furnace Refractory Material	D
RTI/AP-58	Direct Measurement of Flame Temperature in Combustion Processes	C,D
RTI/AP-59	High Temperature Sampling Techniques for Kinetic Studies in Combustion Processes	A
RTI/AP-61	Effect of Turbulence (Mixing) on Localized Flame Temperature	A
RTI/AP-62	Reduction of Exhaust Emission of Nitrogen Oxides from Gas Turbine Engines	A
RTI/AP-64	Increased Efficiency of Gas Turbine Engines	A
	4. Health-Related Techniques	
RTI/AP-39	Gas Exchange Capacity of the Lung	D
RTI/AP-65	Functional Effects of Chemical Agents and the Application of Reference Procedures in Relation to Interlaboratory Comparison of Results	A
	5. Other	
RTI/AP-33	Working Fluids for Rankine Cycle Engines	D
RTI/AP-49	Improved Gas Flow Rate Controls Systems for Air Pollution Monitoring Equipment	D
RTI/AP-55	Wind Tunnel Design Criteria	E
RTI/AP-63	Low Cost Materials for Gas Turbine Engines	A

Table 1. (Continued)

Key to Problem Status Designation

A. Problem Definition

Problem definition includes the identification of specific technology-related problems through discussions with investigators and the preparation of functional descriptions of problems using non-disciplinary terminology.

B. Information Searching

Information relevant to a solution is being sought by computer and/or manual information searching.

C. Problem Abstract Dissemination

An information search has revealed no potential solutions, and a problem abstract is being circulated to individual scientists and engineers at NASA Centers and contractor facilities to solicit suggestions.

D. Evaluation

Potentially useful information or technology has been identified and is being evaluated by the team and/or the problem originator.

E. Potential Transfer

Information or technology has been evaluated and found to be of potential value but has not been applied.

F. Follow-up Activity

A technology transfer has been accomplished, but further activity (i.e., documentation, obtaining experimental validation of utility, continuing modification, etc.) is required.

Table 2. Problems Closed

Category	RTI Problem Number	Number Closed
A	AP-21, 28, 43, 56	4
B	AP-50	1
C	AP-2, 3, 11, 19, 45	5
D		
E	AP-16, 22	2
H		
I	AP-51	1
J		
K	AP-4, 18, 25	3
L	AP-31, 34, 44, 51	4
M		
	Total	20

Categories

A -- Transfer was accomplished.

B -- Researcher has no further interest in the problem.

C -- Researcher has found his own solution.

D -- As a result of personnel transfer in the NAPCA, the problem has either been closed or transferred to another institution along with the investigator and has been given a new number.

E -- No present or foreseeable future NASA technology applicable.

H -- Satisfactory solution identified by team and verified by researcher but transfer cannot be completed by researcher for reasons of economy or lack of resources.

I -- Problem as originally stated was too broad or general.

J -- Problem is too difficult; i.e., the problem as given to the RTI Technology Application Team is presently the focus of large expenditures of money and/or research and development effort, making the likelihood of success by the Technology Application Team low.

K -- Problem priority is too low. Factors involved are cost-to-benefit ratio, team resources available, researcher's resources, and enthusiasm.

L -- Problem grouped with other related problems under another number.

4.0 INFORMATION SEARCHES

During the reporting period, the RTI TATeam initiated nine computer information searches at NCSTRC and evaluation of five bibliographies were completed. Thirteen computer information searches were initiated through NASA's internal computer search system, RECON. The RECON system has been used by the TATeam to complement the results obtained from NCSTRC and has proven to be effective. Five RECON searches have been evaluated by the problem originator and team member. Based on the findings of Dr. William Clingman, the RTI TATeam has taken a more active role in discussing the problem with the applications engineers at NCSTRC and RECON and suggesting possible search terms for the search strategy.

It has become readily apparent to the TATeam from talking with problem originators that the importance of the literature search in relation to his research has not received the recognition that it deserves. In many cases a majority of problems that the TATeam accepts from NAPCA personnel, say in Process Control Engineering, are related to efforts which eventually are contracted out to qualified research institutes or industrial firms. In order to maintain control and monitor the contract, the project officer must have up-to-date information regarding current state-of-the-art methodology and technology. The TATeam efforts have demonstrated that this service of providing information unattainable by the NAPCA researcher from other sources has been invaluable to the problem originator. Too often this part of the transfer mechanism is minimized in favor of hard instrument transfers.

5.0 MEETINGS AT NASA HEADQUARTERS, NAPCA FACILITIES, SYMPOSIUM ATTENDANCE

During the six months ending 30 September 1970, numerous visits were made to NAPCA facilities in Cincinnati, Ohio, Durham, N. C., and Raleigh, N. C. Contacts were made with all active problem originators in all three bureaus of NAPCA. These visits were coordinated with the activities of the problem originators to best utilize his and the TATeam's time. Presentations of the NASA Technology Utilization Program were made to several sections previously not contacted by the TATeam. These include the Behavioral Toxicology Section, Veterinary Medicine Section, Biochemistry Section, Biological Research Branch, Health Effect Research Division; and the Emission Survey Section, National Inventory of Air Pollutant Emission and Control Branch, Division of Air Quality and Emission Data.

Early in May 1970, a questionnaire was prepared and forwarded to Dr. Kay H. Jones, National Air Pollution Control Administration, Office of Science and Technology. This questionnaire was designed to assist Dr. Jones in assessing the potential value of NASA's Technology Application Team program in the area of air pollution control. It is anticipated that Dr. Jones will send this questionnaire to all NAPCA engineers and scientists who have participated in this program with the RTI Technology Applications Team. The information derived from the completed questionnaires should provide valuable information as to the effectiveness of the Technology Utilization Program, the adequacy of the methodology used in the transfer process, and the applicability of aerospace technology to air pollution control. The finalized copy of the questionnaire is included in Appendix B. It will be sent out by Dr. Jones on 1 October 1970 and the completed questionnaire is to be returned to Dr. Jones by 1 November 1970.

On 10 June 1970, Mr. Decker attended a meeting on remote detection of air pollution at NASA Headquarters. Attendance was limited to a selected group of NASA, NAPCA, and university personnel with invited speakers from NASA, NAPCA, NCAR, ESSA, General Dynamics/Convair, General Electric, Barringer Research, University of California, and University of Wisconsin. Each of the ten speakers had expertise in the field of remote sensing and presented a synopsis of his activities to data as related to remote detection of air pollution. Each presentation was followed by a period of comments and discussion by the panel members with some audience participation. The objective of the meeting was to facilitate an exchange of information between people working in the field of remote sensing in NASA, NAPCA, industry, and universities and to formulate ideas as to what NASA should be doing in the near future with respect to remote detection of air pollutants.

The agenda for the meeting included the following speakers:

(1) Dr. M. Tepper, NASA - Introductory comments.

(2) Dr. P. Hanst, NASA/ERC - Brief discussion of I. R. Spectroscopy and its application to remote sensing from satellites. Presented work for

last 11 years, and discussed the long term effects of man's activities (i.e., increase in CO_2 concentration) on the environment and heat balance. Raised objections to measuring air pollution from satellites due to costs and difficulties of instrument calibration, repairs, etc.

(4) Dr. C. Ludwig, General Dynamics/Convair - Discussed global monitoring of air pollutants (CO, CO_2, CH_4, SO_2, NO_2, NH_3) from satellites using an optical correlation spectrometer.

(5) Dr. Stevens, University of California - Presented data obtained in Los Angeles area on hydrocarbons, aldehydes, and other organics using gas chromatographic analysis and data on particulates as related to haze ($10^6/cm^3$ of 0.3μ particles will cause haze.)

(6) Dr. J. Nader, NAPCA - Presented NAPCA's long range instrument development goals. Discussed optical techniques for measuring particulates and gases in plumes. NAPCA has let two contracts for building a high resolution scanning infrared spectrometer and a multichannel filter spectrometer for use in remote sensing. Objective of NAPCA's development work is to provide field instruments for monitoring pollutants to state and local air pollution control agencies.

(7) Dr. V. Suomi, University of Wisconsin - Discussed effect of pollution on climate.

(8) Dr. M. Bartner, General Electric - Discussed effect of CO on life and raised questions about fate of CO in the atmosphere. Reiterated need for CO data on global scale and suggested possible CO sinks.

(9) Dr. A. Barringer, Barringer Research Lab - Discussed development of the correlation interferometer and its application to remote detection of pollutants from aircraft. Presented NO_2 and SO_2 data for several cities surveyed using an airborne correlation spectrometer. Correlation spectrometry can successfully measure NO_2 and SO_2 in the visible and the UV range.

(10) Dr. V. Derr, ESSA - Discussed application of LIDAR to tropospheric probing and weather predictions. Presented laser techniques for temperature and wind velocity measurements in the atmosphere.

(11) Dr. E. Allen, NCAR - Presented discussion of activities at NCAR on remote sensing.

(12) Dr. H. Reichle, NASA - Summarized activities for the day.

Following the presentations an open panel discussion was held on the role satellites should play in remote sensing of air pollution. Consensus of opinion was that the use of satellites offered the best solution for immediate monitoring of global air pollution where cooperative monitoring from ground station networks would require 20 years to develop. It was decided that a small committee comprised of some of the participants in the meeting be formed to further discuss and make recommendations to NASA on future needs for remote detection of air pollutants.

On 29 June 1970, Mr. Decker attended the Technology Utilization Meeting at NASA Headquarters. All phases of the aerospace technology transfer process were discussed and innovations for improvement of the program were proposed.

Mr. Decker attended the 3rd Annual Symposium on Air Pollution held in Raleigh, N. C., and sponsored by the Triangle Universities Consortium on Air Pollution and the Industrial Extension Service, N. C. State University 23-24 September 1970. The objectives of the symposium were to discuss in detail control technology issues as they affect industrial and utility plants; to provide industrial and governmental control officials with guidelines for air pollution control, applying the best available control techniques; and to provide a forum of exchange regarding the problems and solutions presently existing to achieve acceptable air quality. Session Number One dealt with control techniques for gaseous and particulate air pollutants. Session Number Two involved state-of-the-art control technology for mobile and stationary combustion sources. Session Number Three dealt with state-of-the-art control technology for selected industries, which were asphalt batching, brick and tile, textile, crushed stone, woodworking, rendering, fertilizer, and pulp and paper.

6.0 RESPONSE TO PROBLEM STATEMENTS

During the period 15 March 1970 to 30 September 1970, 14 problem statements were submitted to NASA Headquarters for review and 9 were subsequently distributed to the NASA Field Centers for circulation to NASA scientists and engineers. A total of 10 responses to these nine circulated problem statements have been received as of 30 September 1970. A summary of response to problem statements, including date of circulation, time lag for receiving response, and applicable utility code letters identifying the evaluation of each response, is included in Table 3. The utility code for evaluating responses to problem statements is included in Figure 3. The data indicate that approximately two months are required to receive a response to a circulated problem statement. From Table 3, it can be seen that the TATeam has received 10 responses to nine circulated problem statements for an average of 1.1 response/problem statement. Of these 10 responses, seven were evaluated as being relevant and suggested a practical solution, two were relevant but did not suggest a practical solution, and one was relevant but suggested a technique currently in use or rejected by the problem originator.

As of 30 September 1970, all responses had been presented to the problem originators for their evaluation.

TABLE 3

RESPONSES TO CIRCULATED PROBLEM STATEMENTS

PROBLEM NUMBER	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	UTILITY CODE** A	B	C	D	E	TOTAL
AP-42	*		2					2					2
AP-49	*		3				1	3	1				4
AP-57					*								0
AP-60					*		2	2					2
AP-38						*							0
AP-47						*			1				1
AP-50						*							0
AP-54							*						0
AP-58							*1			1			1
Totals								7	2	1			10

*Month Circulated

**See Figure 3 for Explanation of Code Letters.

Applicability/Utility Code: For use by BATeam/TATeam members in reporting (in monthly reports) initial evaluation of responses to problem statements.

Code

A. Relevant and suggests a practical solution.

B. Relevant but does not suggest a practical solution or the technique involved is unlikely to be applicable.

C. Relevant but suggests a technique in current use by the problem originator, or one which has been tried and rejected.

D. Suggestion is impractical.

E. Suggestion is irrelevant.

Figure 3. The Utility Code for Evaluating Responses to Problem Statements

7.0 CONCLUSIONS AND RECOMMENDATIONS

The most effective method of identifying relevant technology continues to be responses to problem statements and other approaches to establishing direct contact with NASA Field Center personnel. To this end, the number of problem statements circulated to the NASA Field Centers and/or contacts with NASA personnel have increased significantly during the reporting period. It has also become apparent to the TATeam that considerable effort of the TATeam had been devoted to identifying solutions to problems which have been eventually inactivated because they were active for relatively long periods of time and shifts occurred in priorities within NAPCA, and because of ineffective problem screening in the early stages of the RTI TATeam program. It was concluded during the last reporting period that to be effective, the team must significantly reduce the time between problem acceptance and identification of potentially relevant technology. During this reporting period, the TATeam has attempted to reduce this time interval by more direct contact with NASA scientists and engineers.

Information searching using NASA's RECON system has been continued with good success. By taking a more active role in discussion of search strategy and index terms with RECON and RDC engineers, the quality and usefulness of the information searches have improved. As of 30 September 1970, the authorization for RTI to receive documents included in the limited distribution document file has not been given to the NASA Scientific and Technical Information Center. It is recommended that the limited distribution file be included in the RECON searches for the BATeam/TATeam.

The TATeam's approach to problem solving, needs to be carefully evaluated with regards to better compliance to problem acceptance criteria, reduction of the time interval from problem acceptance to solution or inactivation of a problem, closer contact with NASA Field Centers, and stricter requirements on NAPCA problem originator's responsibility towards documentation of how the information received was used.

The reorganization taking place in NAPCA and the forthcoming incorporation into the Environmental Protection Agency have affected the ability of the TATeam to work as effectively as it otherwise could have worked with NAPCA problem originators. Changes in personnel assignments and shifts in job describtions have caused problems which the TATeam had not previously encountered. It is not anticipated that this situation will exist for long.

APPENDIX A

NASA Technology Application Team Questionnaire

NASA Technology Application Team Questionnaire

Name ______________________________

Division ___________________________

I. Please identify the problems by number, title, or subject which have been or are being investigated for you by the TATeam.

____

____

____

____

____

____

II. Do the TATeam Problem Statements describing the problems listed in I. accurately represent the problems?

______ Yes

______ Partially

______ No

If you checked partially or no, please indicate the kind of inaccuracies which have occurred.

____

____

____

____

III. Number below in order of greatest effectiveness in your opinion the means of transferring technological information from NASA to NAPCA through the TATeam. Number one (1) should indicate the most effective.

______ NASA contractor reports and published papers

______ Telephone conversations

______ Person-to-person conversations

______ Special, brief technical reports related to specific NAPCA problems and prepared by the TATeam (Note: Such reports have not been used in the TATeam program to date).

IV. To what degree has the information you received through participation in the TATeam program been useful? (Please indicate one or more categories and the number of problems in each category).

_______ Problems solved with no engineering effort required.

_______ Problems solved with additional engineering or development effort.

_______ Cost of applying technology excessive compared to potential benefits.

_______ NAPCA already aware of technology identified by TATeam.

_______ Technology identified by TATeam not relevant to solution of problem.

V. Please state briefly the action taken at NAPCA as a result of information received through the TATeam. Please include the application of or plans to apply technology identified by the TATeam as well as any changes in NAPCA programs resulting from information identified by the TATeam.

VI. What recommendations can you make concerning ways of improving the effectiveness of the TATeam's efforts to transfer NASA technology to applications in air pollution control?

APPENDIX B

Problem Statements Prepared During Reporting Period

RTI/AP-56
January 1970

PROBLEM STATEMENT

"Techniques and Mechanisms for Removal of Pollutants from Gas Streams"

What is Needed

A need was determined in NAPCA for obtaining performance data and information relating to removal mechanisms for sulfur compounds, acid gases, and oxides of nitrogen from carrier gas streams.

Background

Adsorption and absorption techniques have been used extensively for preparing pollutant-free carrier gas streams for use in calibration of air pollution monitoring equipment. Removal mechanisms and data regarding removal efficiency, temperature effects, and removal capacity of materials for specific pollutants, such as sulfur compounds, acid gases, and oxides of nitrogen are not available. In the past, activated carbon has been the most frequently used adsorbent for removing these compounds. Adsorption with accompanying chemical reactions by various types of solid materials is promising in many areas.

Constraints and Specifications

None

Characteristics of Relevant Technology

Techniques and removal mechanisms amenable to removal of sulfur compounds, acid gases, and oxides of nitrogen would be applicable to the solution of this problem.

RTI/AP-57
March 1970

P R O B L E M   S T A T E M E N T

"Analytical Techniques for Trace Metals in Combustion Effluents from Coal and Residual Fuel Oil Sources"

What is Needed

Analytical techniques for the determination of trace metals in combustion effluents from coal and residual fuel oil sources are needed.

Background

A knowledge of the concentration of metallic air pollutants is necessary in assessing health hazards, damage to vegetation, economic and geophysical effects, and others. The researcher desires to measure the concentration of air pollutants containing trace metal components in order to determine the special requirement for control of emissions containing such components. At the present time there are no techniques available for *in situ* analysis of trace metals in stack effluents. Stack sampling procedures for extracting samples from combustion effluents and analytical techniques for determining trace metals in the extracted sample are, however, available. The desired solution to this problem would be analytical techniques for *in situ* analysis; however, new analytical techniques not suited for *in situ* analysis but amenable to analysis of metals in extract samples would be of interest to the researcher. Flame emission and atomic absorption techniques are commonly used for analysis of extracted samples.

The researcher's priority of interest in these pollutants is as follows:

1st Priority	2nd Priority	3rd Priority
Arsenic	Barium	Iron
Asbestos	Chromium	Manganese
Beryllium	Vanadium	Selenium
Cadmium		Lead
Mercury		
Nickel		

These substances will be found either in the solid or vapor phase of various combustion effluents. These metallic pollutants may occur as the primary constituent of the fuel or may be added to enhance or control combustion or to reduce other pollutant emissions.

Constraints and Specifications

The technique should be amenable to analysis of metals in stack effluents having gas velocities between 20-120 ft/sec. and temperatures up to 2000°F. Applicable techniques should be capable of detecting microgram quantities of metals.

Characteristics of Relevant Technology

Analytical techniques involving x-ray diffraction, microprobe analysis, nuclear activation analysis, or new technology would be applicable to this problem.

RTI/AP-58
July 1970

PROBLEM STATEMENT

"Direct Measurement of Flame Temperature in Combustion Processes"

What is Needed

A direct, noninterfering technique is needed for measurement of flame temperature in combustion processes.

Background

Of the several oxides of nitrogen which can occur, nitric oxide (NO) and nitrogen dioxide (NO_2) are considered to be of significance in their contribution to air pollution. Nitrogen dioxide is one of the reactants in the photochemical formation of eye irritating smog. Such smog has been experienced by most major cities at various times in the past.

Cyclic domestic oil furnaces is one of many sources emitting nitrogen oxides as pollutants. Even though emissions from a single domestic furnace may be low, the large number of furnaces in operation combine to create a significant problem. Experiments conducted by NAPCA personnel have shown that the level of production of nitrogen oxides is a function of burner design, flame temperature, and oxygen concentration. By maintaining a fixed oxygen concentration the influence of this variable can be eliminated. Thus, to test the hypothesis that nitrogen oxide emissions can be minimized by selection of proper burner design and flame temperature the researchers must be able to study and map temperature profiles and patterns in the flame without disturbing the flame itself.

At the present time, thermocouples are used to measure flame temperature; however, insertion of the thermocouple into the flame disturbs the flame, thus creating a nonideal situation.

Constraints and Specifications

The preferred technique would yield a point value of flame temperature; however, an acceptable alternate would be a technique for looking at sections of the flame to get two-dimensional profiles of height and length.

Any acceptable technique must be direct, noninterfering, capable of measuring temperatures in the range of 1500 to 4000°F and suitable for measurement of flame temperatures in fireboxes with minimum dimensions of 10" x 10" x 28". Also, suitable calibration procedures are required for any accepted technique.

Characteristics of Relevant Technology

Photographic, spectrographic, and other techniques based on new technology would be applicable to the solution of this problem.

RTI/AP-60
July 1970

PROBLEM STATEMENT

"Portable Carbon Monoxide Analyzer"

What is Needed

A portable, battery-operated carbon monoxide analyzer is needed for use in emergency episode monitoring.

Background

A knowledge of the concentration of toxic air pollutants is necessary in assessing potentially hazardous situations during emergency air pollution episodes. The National Air Pollution Control Administration has the responsibility of formulating emergency episode plans and obtaining reliable, portable instrumentation for use during these situations. Potentially dangerous situations can result from explosions at chemical plants; derailment of railway tank cars carrying poisonous gases; pollution buildup on crowded freeways, in traffic jams, and under adverse meteorological conditions (i.e. temperature inversions and stagnation periods); and from accidental discharge of pollutants into the atmosphere due to failure of control equipment. To effectively avert disaster, NAPCA must be able to go quickly into the area, identify and determine the extent of the problem, and take effective measures. Portable, reliable instrumentation is required to determine pollutant concentrations in the affected area.

The researcher needs a portable, lightweight carbon monoxide (CO) analyzer for determining the concentration of CO in ambient air during an air pollution episode. The concentration range of interest is from 10 to 50 parts per million (ppm). Normal background levels of CO range from approximately 0.2 to 1 ppm. Adverse health effects and automobile driver fatigue has been documented when exposure levels exceed 20 to 30 ppm. Carbon monoxide concentrations in ambient air are usually monitored by nondispersive infrared techniques; however, these analyzers are not portable. According to NAPCA, no commercial device as described above is available. Under an emergency episode condition, the instrument would be flown to the site of the problem, set up in an automobile, and used to measure the concentration of CO in the area.

Constraints and Specifications

The CO analyzer must be lightweight, portable, operable on battery power, relatively inexpensive (i.e., less than $3,000), reliable, easily maintained, amenable to sampling from a moving automobile, and rugged. The concentration range of interest is from 10 to 50 ppm; however, a range of 0-100 ppm or 0-500 ppm would be satisfactory, provided the sensitivity of the instrument was 0.5 ppm CO or better.

Characteristics of Relevant Technology

The following comments are in no way intended to bias reviewers from other lines of approach. New technology in the area of thin-film sensors should be applicable to the solution of this problem. Conventional systems using nondispersive infrared would be applicable, if they could be made portable and the cell path shortened without loss of sensitivity.

RTI/AP-61
October 1970

PROBLEM STATEMENT

"Mathematical Models for Prediction of Pollutant Formation During Combustion"

What is Needed

A mathematical model is needed that will allow the researcher to determine which variables are the most critical to pollutant formation during combustion.

Background

One of the objectives of NAPCA personnel in the Division of Process Control Engineering is to control emissions of nitrogen oxides and combustible particulates (carbon, hydrocarbons, etc.) by modification or control of the combustion of fossil fuels in domestic, commercial, and industrial boilers. Specific interest is in coal, oil, and gas burning systems. Experiments run by NAPCA personnel have shown that variables which affect formation of these pollutants during combustion are fuel atomization, evaporation, or particle size, burner and combustion chamber design, chamber materials, fuel/air ratio, flame temperature and turbulence or mixing.

Because of the large number of variables, the researcher needs information that will allow him to determine which of the variables are the most critical to pollutant formation. This can be accomplished by a mathematical model which describes the combustion process. Although such a model will probably require many simplifying assumptions, it should be able to predict the effects of numerous critical variables on the temperature, concentration and velocity profiles within the flame.

The researcher is aware of five such basic computer programs which have been developed by the Interagency Chemical Rocket Propulsion Group (ICRPG) to predict various aspects of the combustion process. They are coded, ODE, ODK, TBL, TDE, and TDK. The researcher would like to know the assumptions, limitations, and applications of these programs, and their latest modifications, condensations, and utilization. A demonstration of the ability of these models to predict experimental data would also be useful. In addition the researcher would like to know what agencies or groups within NASA and what NASA contractors are most adept in the utilization of these or the modified programs to predict the chemistry and aerodynamics within the flame or combustion chamber.

In addition to a mathematical model, the researcher is interested in available experimental results which can provide similar information sought through a mathematical model.

Constraints and Specifications

Maximum combustion temperatures of interest are those less than 2000°F, and information should be confined to liquid-vapor or solid-vapor systems.

Characteristics of Relevant Technology

Mathematical models and experimental data which will allow the researcher to relate variables affecting combustion to pollutant formation would be applicable.

RTI/AP-62
July 1970

PROBLEM STATEMENT

"Reduction of Exhaust Emission of Nitrogen Oxides From Gas Turbine Engines"

What is Needed

A technique is needed for reducing the exhaust emission of nitrogen oxides from gas turbine engines.

Background

The emission of unburned hydrocarbons, carbon monoxide, and nitrogen oxides from motor vehicles is recognized as a major contributor to air pollution. Several methods are being considered to reduce or eliminate this source of pollution. One approach being pursued is the development of an engine, with low emission characteristics, which could supplant the gasoline spark ignition engines in passenger cars.

One possibility is the gas turbine engine which has already been tested in a number of conventional and nonconventional passenger cars. A gas turbine's total emitted pollutants in grams/mile is well below that of a piston engine employing the latest control devices. Specifically, the gas turbine produces much less carbon monoxide and unburned hydrocarbons than does the piston engine, while the emission of nitrogen oxides is about the same (1-5 grams/mile) for the two engines.

Any technique significantly reducing the emission of nitrogen oxides without increasing the level of carbon monoxide and unburned hydrocarbons, would, from the standpoint of air pollution, make the gas turbine a very attractive automobile power plant.

Constraints and Specifications

The technique should reduce the emission of nitrogen oxides by 75-90 percent without adversely changing the emission level of carbon monoxide and unburned hydrocarbons. It must not significantly reduce the efficiency or reliability of the engine. The weight, volume and cost of any device has to be compatible with a 100-300 horsepower automobile power plant.

Characteristics of Relevant Technology

Flame afterburners, exhaust recycle, fuel treatment, catalytic mufflers, and new technology developed for aircraft applications may be applicable.

RTI/AP-63
August 1970

PROBLEM STATEMENT

"Low Cost Materials for Gas Turbine Engines"

What is Needed

Low-cost materials suitable for use in gas turbine engines are needed.

Background

In the United States internal combustion engines produce an estimated 60 percent of all air pollution. One means of reducing the level of pollution from this source would be to replace the piston engines in passenger cars with gas turbine engines. Present gas turbines have a lower emission level of pollutants than a piston engine outfitted with the latest pollution control devices.

The gas turbine, in its present state of development, can be built to compete with the relatively expensive heavy-duty diesel truck engine, but some of the materials and fabricating methods make it cost more for passenger cars than the gasoline piston engine. The availability of low-cost materials would increase the economic feasibility of introducing the gas turbine as an engine for passenger cars. This, in turn, would reduce and help control future air pollution levels.

Materials that are now being used are high nickel steel costing approximately $1.50 per pound.

Constraints and Specifications

Structural materials must have a high strength-to-weight ratio. They must be economic, reliable, and in adequate supply.

Characteristics of Relevant Technology

Alloying, dispersion strengthening, prealloyed powder technology, and thermomechanical processing are some of the techniques being investigated that would be applicable to this problem.

PROBLEM STATEMENT

"Increased Efficiency of Gas Turbine Engines"

What is Needed

A technique is needed for increasing the efficiency of gas turbine engines.

Background

There has been much discussion in the technical literature in the past years concerning the feasibility of the gas turbine engine as a means for reducing air pollution resulting from exhaust emissions of automotive engines. A gas turbine engine powered vehicle produces less pollution (grams/mile) than does a piston engine vehicle employing the latest pollution control devices.

In spite of the turbine's attractiveness, for its low level emissions, it is felt that for automotive use, further reduction in fuel consumption must be accomplished, especially at part load. The efficiency of experimental models being tested by different automobile manufacturing organizations range from 20 to 26 percent at full load, and can fall as low as 14 percent at part load.

One area of research aimed at increasing the efficiency is directed toward increasing the allowable maximum cycle temperature either through improved metallurgy or turbine blade cooling arrangements. Other methods being used are improved afterburner and regenerator designs.

Constraints and Specifications

The technique should not cost more than it would save in one year of normal driving. The technique must be safe, reliable, and durable for the life of the engine. It must not add excessively to the weight or volume of the engine.

Characteristics of Relevant Technology

Metallic alloy systems, nonmetallic alloy systems, composite materials, filamentary composites, plastic or polymer matrix materials, and metallurgical alloying of metal matrix materials all with increased temperature capabilities may be applicable to this problem.

Also, afterburner and/or regenerator technologies would be applicable.

PROBLEM STATEMENT

"Functional Effects of Chemical Agents and the Application of Reference Procedures in Relation to Interlaboratory Comparison of Results"

What is Needed

More specific and sensitive functional tests and reference substances for interlaboratory comparison of results of these tests are needed to determine the effects of toxic substances on nervous system function.

Background

The Biological Research Branch (BRB) conducts systematic laboratory research to detect and evaluate toxicological effects of air pollution on biological systems. The Behavioral Toxicology Section of BRB is responsible for identifying the air pollutants that may influence the development and function of the brain and alter behavior and performance. Within this framework the researcher is interested in accessing what agents and circumstances in the environment affect the ability of people to perform efficiently at given tasks. To this end, various mammalian animal species are used as experimental models, thus permitting observations not possible in human subjects. Behavior characteristics, such as studies of learning, decision making, perception, memory, and motivation, are observed under different levels of pollutants that are acceptable for normal living and working conditions.

The researcher needs information regarding more sensitive and specific functional tests for determining effects of toxic substances on nervous system response and performance. To assess the significance of these functional tests, he also desires information regarding procedures for using experimental toxicological data in the form of coefficients of relative toxicity, expressing the effects of the studied substance in comparison with agreed upon reference standards (drugs, etc.). The use of reference substances would allow quantitative comparison of the efficiency of the test, as well as comparison and validation of data obtained in various laboratories throughout the world. Functional tests and agreed upon reference substances are of major importance in developing a worldwide collaborative testing program. The ultimate objective is to determine the effects of air pollutants on human behavior and bodily functions and to provide data necessary for establishing safe ambient air quality standards.

Characteristics of Relevant Technology

Information regarding functional tests for effects of toxic substances and the use of reference substances in assessing the sigificance of these tests, would be applicable to this problem.

RTI/AP-66
September 1970

P R O B L E M   S T A T E M E N T

"Differential Pressure Transducer for Isokinetic Stack Gas Sampling"

What is Needed

A differential pressure transducer suitable for use with stack sampling equipment is needed.

Background

Atmospheric particulate materials generated by industrial processes may contain or be composed of toxic, corrosive, and erosive compounds. Their presence in the atmosphere are known to effect visibility and cause damage to health, to appearance, and to plant life. To determine the amount of pollution emanating from process vents and stacks NAPCA has undertaken the task of measuring air pollutant emissions at their sources. The measurements are made to determine if an industrial process meets legal limitation or to obtain sufficient information about the nature of the particulate air pollutant to permit remedial action.

The Public Health Service has designed a compact, portable, sturdy stack sampling system capable of collecting solids, mists and gaseous pollutants from most chemical and combustion processes.
equipment requires continuous differential pressure measurements at three different points in the system. Two inclined/vertical manometers and one U-tube mercury manometer are used to make these measurements. During a data collection run, two of the manometers have to be visually monitored in order for adjustments to be made to insure that the sampling rate is isokinetic as it must be.

Replacement.of the manometers with transducers would make possible automatic digital or analog readout and automatic control of sampling flow rate, and should greatly increase the equipment's usefulness in the field.

Constraints and Specifications

The transducer must be capable of measuring differential pressure in the range of .001-10 inches of water with an accuracy of ± 10% for each pressure (i.e. ± 10% at 0.001 in. water). It should be insensitive to temperature changes between 0 and 125°F. The transducer must be lightweight, portable, simple, rugged and cost no more than $1,000. Data describing the performance characteristics of the transducer would be helpful.

Characteristics of Relevant Technology

Semiconductor strain-gauge, capacitance, piezoelectric, and piezoresistive transducers would be applicable to this problem.

APPENDIX C

Problem Statements Circulated to NASA Centers

RTI/AP-38
July 1970

P R O B L E M   S T A T E M E N T

"Measuring Techniques for Airborne Particulates"

What is Needed

A rapid technique is needed for measuring the size and concentration of flue-borne particulates from fossil fuel combustion.

Background

Particulate matter which originates in a wide variety of industrial and natural processes is a major air pollution problem. The size distribution and concentration of these particulates are related to several variables which are controllable in the combustion area. Therefore, a rapid means of measuring their size and concentration would allow adjustments to be made to minimize their emission.

In situ techniques for continuous monitoring are required to optimize the control process. However, if such techniques are not available, a rapid procedure for measuring extracted samples will be acceptable until *in situ* techniques can be developed. A system that also identifies the shape of particles would be a distinct advantage, but this is not a prime requirement.

Presently, light scattering techniques are used for determining size and concentration of particulates in ambient air. These techniques are limited however, to a sampling rate of about one cubic foot per minute and have a minimum detectable particle size diameter of about 0.3 microns. No techniques are currently available for *in situ* analysis.

Constraints and Specifications

The requirements of this type device are that it have a sampling rate in excess of 1 cu ft/min, be able to detect particle sizes from 0.01-60 microns, be amenable to analysis of particulates in stack gases with velocities up to 120 ft/sec and temperatures up to 900°F, and be relatively inexpensive.

Characteristics of Relevant Technology

Optical, acoustical, holographic, and radiometric techniques would be applicable to *in situ* determination of size and concentration of particulates from fossil fuel combustion.

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RTI/AP-42
August 1969

P R O B L E M   S T A T E M E N T

"Development of Lightweight Furnace Refractory Material"

What is Needed

Air pollution resulting from unburned hydrocarbons produced in cyclic domestic oil furnaces may be reduced through the development of a lightweight refractory material for the fire box.

Background

Although air pollution from a single domestic furnace is low, the large number of such furnaces in operation create a significant problem. It has been found that the output of unburned hydrocarbons from cyclic domestic furnaces is highest during initiation and again during extinction of the flame. At the latter period, the concentration is especially high. One explanation for this phenomena is that during these periods, the fuel oil dripping into the hot burner box vaporizes with partial burning. A reduction in the heating and cooling time for the furnace walls would alleviate this situation. This requires a good refractory material which combines low mass, good insulation, and good heat reflecting characteristics. Machineable refractory materials with good insulating properties are also needed for insertion between fire boxes and the heat exchanger to prevent erosion of the base plate of the heat exchanger.

Requirements and Constraints

Operating temperatures are between 2300°F and 3000°F. The refractory material should be bondable to metal or machineable in order that it can be made an integral part of the combustion chamber.

Characteristics of Relevant Technology

Refractory materials developed for aerospace applications should prove applicable to the solution of this problem. It should be noted that the upper limit of the temperature requirements for the material is only 3000°F.

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RTI/AP-47
July 1970

PROBLEM STATEMENT

"Feeder Systems for Particulates in Gases"

What is Needed

A method for preparing standard mixtures of particulates in gases is needed for dynamic calibration of particulate monitoring equipment.

Background

The success of any program designed to control air pollution will depend to a great degree on the ability to make quantitative measurements of the different pollutants. The experimental program of NAPCA related to the development of measuring techniques for airborne particulates, requires a reliable method for introducing and controlling the size and concentration of particulates in gaseous systems for calibration purposes.

A typical method involves the use of a screw feeder to introduce dry powder into a jet of air which is then mixed in a chamber simulating field conditions. Difficulties which are observed include the settling of larger and more dense particles in the powder as well as in the air stream. Also, the screw feeder has a tendency to pack and redistribute the known original size distribution. A problem common to all presently used methods is, after mixing with air, it is difficult to obtain a size density distribution over a large volume which remains constant either in time or space.

In the past, systems based on screw-type feeders or hydrosol generators have not been satisfactory for uniform generation of particulates.

Constraints and Specifications

The primary requirement of this feeder system is that it must introduce particles with a diameter between 0.1 and 60 microns with a concentration up to 10^8 particles per cubic foot. It must maintain a constant size distribution and particle concentration long enough to be sampled by particulate measuring instruments.

Characteristics of Relevant Technology

Techniques capable of introducing and controlling the size and concentration of particulates in a gas stream would be applicable to this problem.

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RTI/AP-49
January 1970

P R O B L E M   S T A T E M E N T

"Development of Improved Gas Flow Rate Control or Measuring Systems for Air Pollution Monitoring Equipment"

What is Needed

An improved device for measuring and/or controlling gas flow rates in air pollution monitoring instrumentation is required for more accurate determination of trace gases in ambient air.

Background

One of the most serious limitations of air pollution monitoring instrumentation is the inability of the air flow control devices used to maintain constant gas flow rates over a given time interval. Rotameters and critical orifices are commonly used to maintain or control air flow. These devices do not perform satisfactorily and contribute to erroneous or unreliable data. Inaccuracies in the setting of rotameters and the inability to read small changes are the main objections to the use of rotameters. Critical orifices, on the other hand, are subject to clogging by particulates and erosion of the orifice. Neither device can be monitored automatically nor provide a record of the total volume or the rate at which the air stream was sampled.

Constraints and Specifications

The requirements for such a device to control or maintain known flow rates are that it 1) be compact, 2) operate at atmospheric pressure or low vacuum and at ambient temperatures, 3) be able to withstand corrosive gases, and 4) have an operating range of from 100 cc/min to 5 l/min. It would be desirable, but is not required, that the device to be able to monitor itself or provide a record of gas flow.

Characteristics of Relevant Technology

One approach to the solution of this problem might involve a device that would maintain a cumulative record of the total volume sampled. Ideally, the most desirable solution would be a device that could maintain or control flow rates so accurately that visual monitoring or adjustments would be unnecessary. This device would be used to control flow rates on a variety of air pollution monitoring equipments having sampling rates of from 100 cc/min. to 5 l/min.

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RTI/AP-50
July 1970

PROBLEM STATEMENT

"Improved Techniques for the Preparation of Standard Concentrations of Carbon Monoxide and Methane"

What is Needed

An improved technique is needed for the preparation of standard concentrations of carbon monoxide (CO) and methane (CH_4) for use in dynamically calibrating CO and hydrocarbon analyzers.

Background

Continuous measurement of the concentration of minor atmospheric constituents is required in the study and control of atmospheric pollutants. Instruments have been developed which measure and record the concentration of CO and hydrocarbons in ambient air. However, these instruments suffer from a major fault in that techniques available for dynamic calibration are usually unacceptable for field use. Calibration mixtures of CO and CH_4 in air are commercially available and can be obtained with a certificate of analysis of the pollutant concentration by infrared analysis. These mixtures are currently used as primary standards; however, a direct technique for producing or introducing known quantities of gases into an air stream would be more convenient, less expensive and increase confidence in the calibration. Dilution and injection techniques have been used to prepare standard mixtures from the pure gas. These methods are often cumbersome and the accuracy questionable. Diffusion tubes for other gaseous air pollutants, such as sulfur dioxide, nitrogen dioxide, hydrogen sulfide, and certain hydrocarbons are available commercially. However, diffusion tubes, (i.e., teflon tubes containing liquified gas) are not available for CO and CH_4

Constrainst and Specifications

The requirement of an improved technique for preparing standard concentrations of CO and CH_4 are that the system be capable of accurately delivering microliter quantities of CO and CH_4 into an air stream, be reproducible, stable, temperature and pressure insensitive, relatively inexpensive, and portable.

Characteristics of Relevant Technology

Direct dynamic calibration of CO and CH_4 monitors in the field can be obtained by injecting small known quantities of CO or CH_4 into a stream of unpolluted diluent air. Several techniques are available which might be applicable to the solution of this problem. These techniques include:

(1) Diffusion through polymers
(2) Diffusion through metals
(3) Diffusion through ceramics
(4) Precision pressure valves

The range of interest for calibration of CO monitors is 0-50 ppm and for hydrocarbon analyzers is 0-50 ppm.

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RTI/AP-54
March 1970

PROBLEM STATEMENT

"Automatic Instrumentation for the Measurement of Mass Flow of Particulates From Combustion of Coal and Residual Fuel Oil Sources"

What is Needed

Automatic instrumentation is needed for monitoring mass flow of particulates from fossil fuel sources.

Background

Particulate matter which originates from combustion of coal and residual fuel oil sources is a major air pollution problem. In many municipal ordinances, allowable emissions from process vents and from power plant stacks are limited in terms of the mass of particles that can be emitted per unit volume of gas or, in terms of the mass that can be emitted per unit weight of input process material or per unit of power generated. The researcher desires to measure the mass flow of particulates in order to control their emissions, determine the efficiency of commercially installed particulate control equipment on a routine basis, and avoid manual testing.

In some systems the mass of emitted material is determined as a function of gas flow or of time. The gas velocity within the stack is measured, usually with a pitot tube, to insure isokinetic sampling. An isokinetic sample probe is inserted and is traversed across the stack. The sample particles are collected on a suitable filter tape, and the mass of particles per unit area of filter tape (correlative to unit volume samples) is determined by beta-ray transmission. This method is relatively expensive and time consuming.

In situ techniques are preferred for their potential cost reductions over present methods, as well as for their compatibility with automatic systems. If, however, *in situ* techniques are not achievable, at this time, an interim solution would be a rapid method of collecting and measuring extracted samples.

Constraints and Specifications

The technique must be capable of measuring the mass flow of particulates, liquid droplet and dry, from 0.1 to 15 grains/cu ft in stack effluents having gas velocities of 20-120 ft/sec and temperatures ranging up to 900°F. The ultimate cost of the measuring device should be less than $3,000.

Characteristics of Relevant Technology

Optical, acoustical, or other techniques based on new technology would be applicable.

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RTI/AP-57
March 1970

PROBLEM STATEMENT

"Analytical Techniques for Trace Metals in Combustion Effluents from Coal and Residual Fuel Oil Sources"

What is Needed

Analytical techniques for the determination of trace metals in combustion effluents from coal and residual fuel oil sources are needed.

Background

A knowledge of the concentration of metallic air pollutants is necessary is assessing health hazards, damage to vegetation, economic and geophysical effects, and others. The researcher desires to measure the concentration of air pollutants containing trace metal components in order to determine the special requirement for control of emissions containing such components. At the present time there are no techniques available for *in situ* analysis of trace metals in stack effluents. Stack sampling procedures for extracting samples from combustion effluents and analytical techniques for determining trace metals in the extracted sample are, however, available. The desired solution to this problem would be analytical techniques for *in situ* analysis; however, new analytical techniques not suited for *in situ* analysis but amenable to analysis of metals in extract samples would be of interest to the researcher. Flame emission and atomic absorption techniques are commonly used for analysis of extracted samples.

The researcher's priority of interest in these pollutants is as follows:

1st Priority	2nd Priority	3rd Priority
Arsenic	Barium	Iron
Asbestos	Chromium	Manganese
Beryllium	Vanadium	Selenium
Cadmium		Lead
Mercury		
Nickel		

These substances will be found either in the solid or vapor phase of various combustion effluents. These metallic pollutants may occur as the primary constituent of the fuel or may be added to enhance or control combustion or to reduce other pollutant emissions.

Constraints and Specifications

The technique should be amenable to analysis of metals in stack effluents having gas velocities of from 20-120 ft/sec. and temperatures up to 2000°F. Applicable techniques should be capable of detecting microgram quantities of metals.

Characteristics of Relevant Technology

Analytical techniques involving X-ray diffraction, microprobe analysis, nuclear activation analysis, or new technology would be applicable to this problem.

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RTI/AP-58
July 1970

PROBLEM STATEMENT

"Direct Measurement of Flame Temperature in Combustion Processes"

What is Needed

A direct, noninterfering technique is needed for measurement of flame temperature in combustion processes.

Background

Of the several oxides of nitrogen which can occur, nitric oxide (NO) and nitrogen dioxide (NO_2) are considered to be of significance in their contribution to air pollution. Nitrogen dioxide is one of the reactants in the photochemical formation of eye irritating smog. Such smog has been experienced by most major cities at various times in the past.

Cyclic domestic oil furnaces is one of many sources emitting nitrogen oxides as pollutants. Even though emissions from a single domestic furnace may be low, the large number of furnaces in operation combine to create a significant problem. Experiments conducted by NAPCA personnel have shown that the level of production of nitrogen oxides is a function of burner design, flame temperature, and oxygen concentration. By maintaining a fixed oxygen concentration the influence of this variable can be eliminated. Thus, to test the hypothesis that nitrogen oxide emissions can be minimized by selection of proper burner design and flame temperature, the researchers must be able to study and map temperature profiles and patterns in the flame without disturbing the flame itself.

At the present time, thermocouples are used to measure flame temperature; however, insertion of the thermocouple into the flame disturbs the flame thus creating a nonideal situation.

Constraints and Specifications

The preferred technique would yield a point value of flame temperature; however, an acceptable alternate would be a technique for looking at sections of the flame to get two-dimensional profiles of height and length.

Any acceptable technique must be direct, noninterfering capable of measuring temperatures in the range of 1500 to 4000°F, and suitable for measurement of flame temperatures in fireboxes with minimum dimensions of 10" x 10" x 28". Also, suitable calibration procedures are required for any accepted technique.

Characteristics of Relevant Technology

Photographic, spectrographic, and other techniques based on new technology would be applicable to the solution of this problem.

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RTI/AP-60
July 1970

PROBLEM STATEMENT

"Portable Carbon Monoxide Analyzer"

What is Needed

A portable, battery-operated carbon monoxide analyzer is needed for use in emergency episode monitoring.

Background

A knowledge of the concentration of toxic air pollutants is necessary in assessing potentially hazardous situations during emergency air pollution episodes. The National Air Pollution Control Administration has the responsibility of formulating emergency episode plans and obtaining reliable, portable instrumentation for use during these situations. Potentially dangerous situations can result from explosions at chemical plants; derailment of railway tank cars carrying poisonous gases; pollution buildup on crowded freeways, in traffic jams, and under adverse meteorological conditions (i.e.,temperature inversions and stagnation periods); and from accidental discharge of pollutants into the atmosphere due to failure of control equipment. To effectively avert disaster,NAPCA must be able to go quickly into the area, identify and determine the extent of the problem, and take effective measures. Portable, reliable instrumentation is required to determine pollutant concentrations in the affected area.

The researcher needs a portable, lightweight carbon monoxide (CO) analyzer for determining the concentration of CO in ambient air during an air pollution episode. The concentration range of interest is from 10 to 50 parts per million (ppm). Normal background levels of CO range from approximately 0.2 to 1 ppm. Adverse health effects and automobile driver fatigue has been documented when exposure levels exceed 20 to 30 ppm. Carbon monoxide concentrations in ambient air are usually monitored by nondispersive, infrared techniques; however, these analyzers are not portable. According to NAPCA, no commercial device as described above is available. Under an emergency episode condition, the instrument would be flown to the site of the problem, set up in an automobile, and used to measure the concentration of CO in the area.

Constraints and Specifications

The CO analyzer must be lightweight, portable, operable on battery power, relatively inexpensive (i.e., less than $3,000), reliable, easily maintained, amenable to sampling from a moving automobile, and rugged. The concentration range of interest is from 10 to 50 ppm; however, a range of 0-100 ppm or 0-500 ppm would be satisfactory, provided the sensitivity of the instrument was 0.5 ppm CO or better.

Characteristics of Relevant Technology

The following comments are in no way intended to bias reviewers from other lines of approach. New technology in the area of thin-film sensors should be applicable to the solution of this problem. Conventional systems using nondispersive infrared would be applicable, if they could be made portable and the cell path shortened without loss of sensitivity.

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