

**The “Next Generation” Environmental Chamber  
Facility for Air Quality Research:  
Summary of Progress and Current Status**

**Bourns College of Engineering  
Center for Environmental Research and Technology  
University of California, Riverside**

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**Summary**

The purpose, accomplishments, and current status of the project to develop a new advanced facility for environmental chamber research are described. The original \$2.9 million Federal investment has resulted in the successful development of a facility that greatly advances the state of the science, but continuing support of \$1 million to \$2 million per year is requested to fully utilize its capabilities and make it available as a national resource. Significant co-funding from California is available and other funding is anticipated from regulatory agencies and public sector groups that will leverage the Federal investment and assure that it is effectively used to the greatest benefit to develop optimum control strategies to achieve air quality goals.

**Purpose**

Despite improvements in urban air quality in recent years, unacceptable levels of ground-level ozone and atmospheric particulate matter (PM) continues to be widespread and persistent. Ozone is formed from atmospheric reactions involving oxides of emitted nitrogen (NO<sub>x</sub>) and volatile organic compounds (VOCs), and these reactions are also major contributors to the smallest PM particles that are of greatest concern. However, all the “easy” VOCs and NO<sub>x</sub> controls have already been implemented, so the additional controls will necessarily be increasingly burdensome unless more optimal control strategies can be developed.

The reactions that form ozone and PM are very complex, and effects of VOC and NO<sub>x</sub> on air quality can vary significantly with conditions. Controls that are effective in one region or set of conditions can be ineffective or even counterproductive in others. In addition, the thousands of types of VOCs that are emitted vary greatly in their effects on air quality (reactivity), so controlling some is much more effective than controlling others. Regulations that do not properly take this into account will not be cost-effective and could even be counter-productive.

The development of effective control strategies requires an ability to accurately predict how changing emissions will affect air quality. However, our understanding of these processes is incomplete, and the models used to predict how control strategies affect air quality contain many assumptions and approximations. Because of this, we cannot rely on the accuracy of the models unless we have the information needed to test and improve their predictive capability.

Environmental chambers, where pollutants are irradiated with light simulating sunlight under highly controlled conditions, are the best means available to test and improve our ability to

predict effects of reactions of pollutants on air quality. Existing chambers have been used to develop the models now used to predict ozone formation, and are beginning to provide data concerning formation of PM. However, we have reached the limits of the capabilities of current chamber facilities, and improvements are needed if significant further progress is to be made. For example, current chambers require use of relatively high pollutant concentrations, but data at low concentrations are needed to predict how we can attain ozone and PM standards.

Because of this, in 1999 Congress made \$2.9 million available through the EPA for the University of California at Riverside (UCR) to develop a “next generation” chamber facility to simulate atmospheric processes under more controlled and realistic conditions than previously possible. UCR was chosen for this because for decades it has been one of the world’s pre-eminent locations for atmospheric chemistry and environmental chamber research, and it is at the forefront of using environmental chambers for VOC reactivity assessment.

In addition to constructing and evaluating the new facility, a research plan was developed to utilize the new facility for priority research in the following areas:

- Improving our ability to predict effects of NO<sub>x</sub> and the major types of VOCs on O<sub>3</sub> and PM formation under conditions more representative of ambient and near-attainment environments than current data, with varying temperature, humidity, and pollutant levels.
- Determining how best to use ambient measurement data for predicting effects of control strategies and evaluating the reliability of ambient measurement instrumentation.
- Evaluating ozone and PM impacts of VOC emissions from specific sources such as architectural coatings and low reactivity solvents being proposed for substitutions.

The Reactivity Research Working Group (RRWG), a public-private partnership to provide an improved scientific basis for reactivity-related regulatory policies, is serving as an oversight group for assuring that the research effectively addresses regulatory priorities. Key participants are the EPA, the California Air Resources Board and other regional agencies, the American Chemistry Council, and representatives of solvents, coatings and other industry groups, and various researchers in atmospheric chemistry and airshed modeling. They are currently reviewing a detailed research plan that was prepared earlier this year.

## **Accomplishments to Date**

The program was initiated with a successful international workshop held in Riverside, California concerning atmospheric chemistry and environmental chamber research, where useful input concerning this project was obtained from researchers from the United States and Europe. Near-term needs for measurement instrumentation were assessed, and equipment was purchased and evaluated. Extensive experiments were constructed using small test reactors to evaluate material for construction, to test design parameters, and to evaluate the new instrumentation. The results showed that if appropriate steps are taken it is possible to conduct experiments under NO<sub>x</sub> conditions at least an order of magnitude lower than existing data, thereby providing results that better represents ambient air pollution. There was some skepticism when this project was proposed such low NO<sub>x</sub> experiments might not be feasible.

Private-sector funding was obtained to finance construction of a new building needed to house the chamber facility, with the chamber located on the second floor and the laboratory and offices underneath it. The chamber consists of a 16,000 cubic ft temperature-controlled “clean room” enclosure fitted with a 300 KW argon arc light source, with space for two up to 8,000 cubic ft reactors where the reactions will be monitored. The reactors are constructed of Teflon film fitted on specially designed moveable frameworks, with an associated high volume mixing system suitable for injecting low volatility materials, and a computer-controlled sampling and calibration system for the analyses. A high capacity air purification system is used to keep the enclosure clean and provide highly purified air for the experiments. Photographs of the building and laboratory and reactor are shown on Figure 1, and a diagram of the reactor is shown on Figure 2.

The first experiment in the new facility, using a preliminary light source and reactor configuration, was carried out in February of 2002. The first experiment with the arc lights and the near-final configuration for a single reactor was conducted in July. The second reactor and the final mixing and sampling system is expected to be in place and operational by September. The initial experiments included evaluations of background effects, the performance of the light source, temperature control system, and analytical instrumentation in the current configuration. These characterization and performance evaluation studies, which are still underway, provide essential data needed for evaluating computer model predictions of the effectiveness of control strategy for reducing ozone and PM. Model evaluation experiments with simple chemical systems should begin in the fall of 2002, with simulations of more realistic systems beginning in early to mid 2003.

## **Current Situation**

Although these accomplishments are significant, as with most groundbreaking research and development projects the time and cost required was greater than initially estimated. We had hoped to complete the facility in 2001 for about \$2 million, and use the remaining EPA funds to support operating the facility when conducting the research outlined above. However, we presently project that the Federal funds will be expended by January 2003, by which time we will have only begun conducting experiments of direct relevance to regulatory modeling.

We estimate that the annual cost of operating this facility at a minimal level to be approximately \$750K per year, with approximately \$1.5 - \$2 million per year being required to take full advantage of its unique capabilities. We do have approximately \$200K for a 3-year project from the California Air Resources Board (CARB) to conduct experiments on architectural coatings VOCs, and may obtain comparable funding from the California South Coast Air Quality Management District (SCAQMD) to conduct additional reactivity-related experiments. Private sector support related to ozone and PM impacts of specific solvents is expected once the EPA clarifies its regulatory policy concerning VOC reactivity, which is currently being re-evaluated.

However, the CARB funding was obtained with the expectation that the EPA funds would cover the costs of the needed characterization experiments and support the basic infrastructure, and the productivity of this and any future projects would be significantly reduced if project funds had to be used for this purpose. In addition, the public and private agencies with

limited research funds may not be able to take advantage of this facility if their project had to support the full cost of operating this facility at its full capability.

## **Proposal**

The initial \$3 million Federal investment has enabled development of a unique, state-of-the-art environmental chamber facility that has been much needed for some time. However, a continuing investment of \$1-\$2 million per year will be necessary to take full advantage of its capabilities. Although this cost is small compared to the cost of poor air quality and the emissions controls needed to improve it, obtaining this level of funding from the limited research budgets of mission-oriented regulatory agencies or private sector groups is very difficult. However, the regulatory agencies and enlightened private sector groups know they need this research and will support it to the extent that their budgets permit.

It is requested that the Federal investment in this facility continue at least \$1 million and optimally \$2 million per year to assure continued operation of this facility and to fully leverage the support from the mission-oriented agencies and public sector groups. This would be used to cover the support staff and ongoing characterization and quality control, and permit continued acquisition and use of the advanced equipment needed for making critical measurements that would not otherwise be possible. The mission-oriented funding agencies will support for the focused experiments that address the specific policy-relevant research needs. Even if the Federal investment provides the majority of the funding for the facility, continued support from these groups is essential to assure that the most relevant and needed work is carried out.

This continuing support will permit this laboratory to be a resource for academic scientific research as well as for mission-oriented research for industry and government. UCR will administer and operate the facility, but researchers from throughout the world will be able to use it for their research at an affordable cost. It also will serve as an important training tool for students in engineering and the sciences from UCR and other institutions.

## **Additional Information**

Additional information, the original proposal for this project, and a detailed progress report and research plan prepared earlier this year is available at the project's web site at <http://www.cert.ucr.edu/~carter/epacham>. Progress reports and information about the CARB coatings project that will utilize this chamber is available at <http://www.cert.ucr.edu/~carter/coatings>. Information about the Reactivity Research Working Group that is providing policy-relevant oversight of this project is available at <http://www.cgenv.com/Narsto/reactinfo.html> and <http://www.cert.ucr.edu/~carter/RRWG>.

The Principal Investigator for the EPA chamber project is Dr. William P. L. Carter, whose phone number is (909) 781-5797 and email address is [carter@cert.ucr.edu](mailto:carter@cert.ucr.edu). Further information about his research is available at <http://www.cert.ucr.edu/~carter>.

The EPA project officer for this program is Dr. Deborah Luecken, whose phone number is (919) 541-0244, and email address is [Luecken.Deborah@epamail.epa.gov](mailto:Luecken.Deborah@epamail.epa.gov).

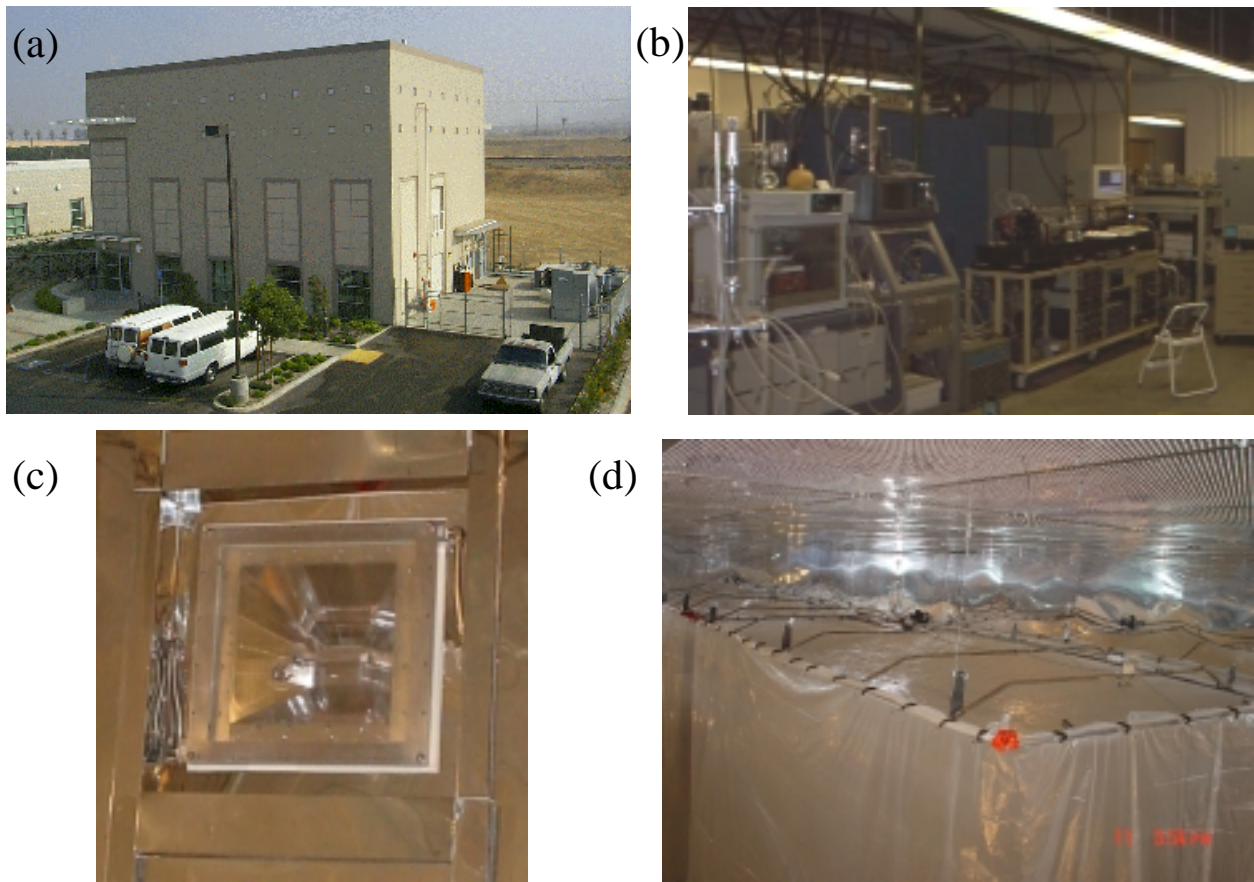


Figure 1. Photographs of the new chamber facility. (a) Outside view of building. (b) Laboratory area downstairs. (c) Argon arc light inside the chamber enclosure (d) Prototype reactor (constructed of polyethylene for engineering testing)

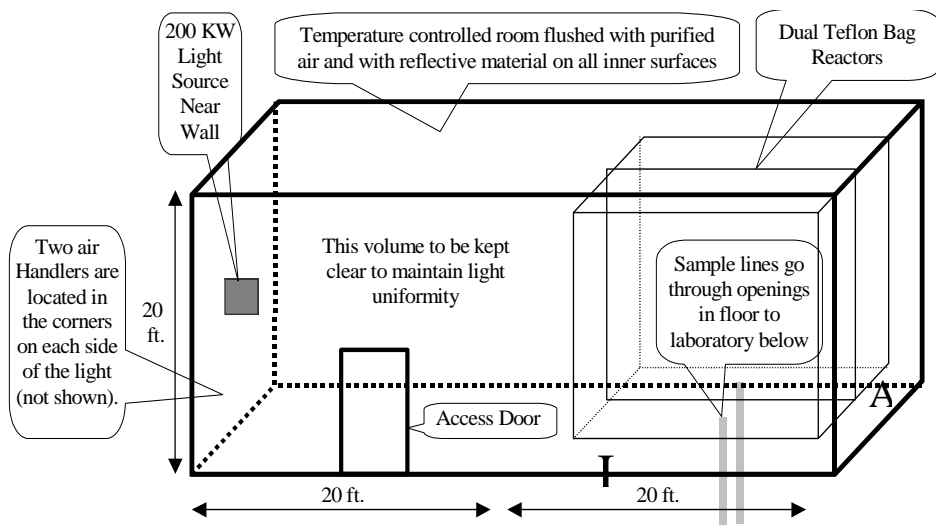


Figure 2. Schematic of the temperature-controlled enclosure housing the reactor.