INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1447-TRP, "Performance of Pressurized Stairwells with Open Doors" (Re-bid)

Attached is a Request-for-Proposal (RFP) for a project dealing with a subject in which you, or your institution have expressed interest. Should you decide not to submit a proposal, please circulate it to any colleague who might have interest in this subject.

Sponsoring Committee: TC 5.6 Fire and Smoke Control

Budget Range: $180,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: September 1, 2013 or later.

All proposals must be received at ASHRAE Headquarters by 5PM EDT, May 15, 2013. Electronic copies must be sent to rpbids@ashrae.org. Electronic signatures must be scanned and added to the file before submitting. The submission title line should read: 1447-TRP, "Performance of Pressurized Stairwells with Open Doors" *and "Bidding Institutions Name"* (electronic pdf format, ASHRAE's server will accept up to 10MB)

If you have questions concerning the Project, we suggest you contact one of the individuals listed below:

For Technical Matters
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Contractors intending to submit a proposal should so notify, by mail, fax or e-mail, the Manager of Research and Technical Services, (MORTS) May 1, 2013 in order that any late or additional information on the RFP may be furnished to them prior to the bid due date.

All proposals must be submitted electronically. Electronic submissions require a PDF file containing the complete proposal preceded by signed copies of the two forms listed below in the order listed below. **ALL electronic proposals are to be sent to rpbids@ashrae.org.**

All other correspondence must be sent to ddaniel@ashrae.org and mvaughn@ashrae.org. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 5PM EDT, May 15, 2013.**

The following forms (Application for Grant of Funds and the Additional Information form have been combined) must accompany the proposal:

(1) ASHRAE Application for Grant of Funds (electronic signature required) and
(2) Additional Information for Contractors (electronic signature required) ASHRAE Application for Grant of Funds (signed) and

ASHRAE reserves the right to reject any or all bids.

1447-TRP, "Performance of Pressurized Stairwells with Open Doors"

State of the Art (Background)

For many years the building codes in the US and Canada have required pressurized stairwells in a number of different types of occupancies. The intent of these pressurized stairwells is to maintain tenable conditions in the stairwell during a building fire. Traditionally this has been accomplished using positive pressurization with the intent of preventing smoke migration into the stairwell. Systems are designed to maintain pressure differences in an acceptable range. The minimum pressure difference is a value intended to prevent smoke migration into the stairwell, and the maximum pressure difference is a value intended to prevent excessive door opening forces.

When a stairwell door is opened, the pressure difference can drop significantly, resulting in the pressure difference across the stairwell door on the fire floor being below the minimum design value. Many pressurized stairwells have been built that can maintain pressures in the acceptable range by compensating for doors opening and closing. A number of these pressure compensating systems have been developed as discussed in the ASHRAE smoke management book by Klote and Milke (2002). This book also provides detailed information about methods of analysis applicable to both pressure compensating systems and non-pressure compensating systems.

The extent to which pressure compensating systems should be used is a topic of debate within the engineering community. Many engineers feel that there is no need to use pressure compensating systems because they are not explicitly required by the model building codes, and probably the majority of pressurized stairwells are non-pressure compensating. Other engineers feel that pressurized stairwells must have pressure compensating systems to provide assurance that tenable conditions are maintained inside the stairwell as doors are opened and closed. Recently the NFPA Smoke Management Committee voted to require that pressurized stairwells be required to maintain acceptable pressure differences thus indirectly requiring pressure compensating systems.

ASHRAE RP-1203 (Klote 2004) used computer methods of analysis to study the effect of stairwell doors being improperly propped open on tenability conditions in the stairwell and in the building. Eighty scenarios were analyzed considering many factors including weather, stair geometry, building leakage, fire type, fire location and number and location of open doors. Buildings were 7 stories and 21 stories. Only non-pressure compensating systems were studied. Analysis of tenability considered visibility and exposure to heat and toxic gases.

RP-1203 indicated that tenable conditions were maintained in the stairwell a) for sprinklered and shielded fires with all stairwell doors closed, and b) for unsprinklered fires with the stairwell door on the fire floor and an exterior stairwell door also open. These findings are very encouraging, but do not address the commonly-occurring condition where the door on the fire floor is closed but some other door in the stairwell is open. RP-1203 also found that with a non-compensating stairwell pressurization system, an open door on the fire floor often resulted in untenable conditions in portions of the stairwell. No data was generated for a pressure-compensating stairwell pressurization system with an open door on the fire floor.

The results of RP-1203 have intensified the discussion about the need for pressure compensating systems. The method of analysis used for RP-1203 was a combination of zone fire modeling and network modeling which is the only practical method of analysis currently available for such applications. While the results of this analysis resulted in valuable insight, the report of RP-1203 indicated that this analytical method has some significant limitations.

Justification and Value to ASHRAE

The 2009 Statistical Abstract of the United States reports that in 2006 the cost of office and health care construction in the US was about $90 billion. The International Building Code, which has been adopted in all 50 states, requires high-rise buildings to have pressurized stairwells or smokeproof stairtowers using vestibules or balconies open to the exterior to protect exit stairs in the event of an emergency. The vast majority of buildings are constructed using pressurized stairwells.

While it does not explicitly require pressure compensating stairwell pressurization systems, NFPA 92A, *Smoke Control Systems Utilizing Barriers and Pressure Differences*, states "with the number of doors used in the system design open, the pressure difference across each remaining closed door shall be measured and recorded. No pressure difference shall be less than the minimum design pressure difference". Engineers who design stairwell pressurization systems are using the more expensive and complicated pressure-compensating approach in an effort to assure compliance with NFPA 92A, or to obtain a higher level of protection than that provided by non-pressure compensating systems. However, the results of RP-1203 cast doubt on the benefits of pressure compensating systems. For those who design non-pressure compensating systems, there is some concern about the potential liability of a system that might not provide the level of protection expected by owners and occupants.

The project of this Work Statement will provide considerable insight into the benefits of these types of systems. If it is shown that pressure compensating systems provide only an insignificant improvement, the requirements for these systems can be eliminated, and the potential liability associated with non-pressure compensating systems will be mitigated. It is anticipated that proposals reflecting what is learned from this project will be made to appropriate standards or codes, meaning that this project will have an impact on all who design or occupy buildings containing stairwell pressurization systems.

Objective

Conduct full scale fire experiments and tenability analysis of the experimental test results to determine whether pressure compensating systems are needed to maintain tenable conditions within pressurized stairwells when the door from the fire floor to the stairwell is closed and one or more other doors in the stairwell are open. Experiments will consist of fires representative of shielded fires and unsprinklered fires. If experimental results indicate that tenable conditions are maintained with both pressure compensating systems and non-pressure compensating systems, then a quantifiable comparison of tenability vs. time for the two approaches shall be developed.

Scope

1. Test Plan:

Bidders shall provide an initial Test Plan for the project. To allow the experimental data to be compared with and expand upon the data obtained from RP-1203, the physical arrangement of the tests and the tenability measurements recorded should correlate closely to the simulations performed in RP-1203.

The initial Test Plan shall include:

A) A description of the planned full-scale tests, including the number and configuration of tests proposed.
   a) The Test Plan shall include at least ten fire tests, but additional tests will be considered a plus.
   b) Tests shall be run under the winter design conditions described in RP-1203.
   c) The fire shall be located on the second floor, as indicated in RP-1203 for winter design conditions.
   d) Testing shall include at least the following configurations:

      (Note: In the following, the term stairwell door means a door between the stairwell and the building. The term exterior stairwell door means a door that is between the stairwell and the outside at the ground floor.)

      i) Stairwell door on the fire floor closed, and no other stairwell doors open (simulation #9 in RP-1203). This configuration shall be tested with a non-compensating stair pressurization system.
      ii) Stairwell door on the fire floor closed, and one non-fire floor stairwell door open. This configuration shall be tested with a non-compensating stair pressurization system.
      iii) Stairwell door on the fire floor closed, and the ground level exterior stairwell door open. This configuration shall be tested with both compensating and non-compensating stair pressurization systems.
      iv) Stairwell door on the fire floor closed, and three non-fire floor stairwell doors open. This configuration shall be tested with both compensating and non-compensating stair pressurization systems.
      v) Stairwell door on the fire floor closed, the ground level exterior stairwell door open, and one non-

fire floor stairwell door open. This configuration shall be tested with both compensating and non-compensating stair pressurization systems.

vi) Stairwell door on the fire floor closed, the ground level exterior stairwell door open, and three non-fire floor stairwell doors open. This configuration shall be tested with both compensating and non-compensating stair pressurization systems.

e) Test configurations with zero or one door open shall investigate unsprinklered fires.
f) Test configurations with more than one door open shall investigate shielded fires.
g) The bidder may identify additional test scenarios that will be run to provide additional supporting data. Additional tests with the fire floor door closed are at the bidder's discretion. If additional tests are proposed with the door open on the fire floor, those tests should directly correlate to one of the test simulations in RP-1203.
h) Compensating stair pressurization systems shall be designed to keep the pressure across any closed door in the stairwell between 0.10 and 0.35 in. w.g. for zero to the number of open doors used in the simulation.
i) Non-compensating stair pressurization systems shall be designed to keep the pressure across any closed door in the stairwell between 0.10 and 0.35 in. w.g. for zero or one open door. If the simulation calls for more doors to be open, it is expected that the pressure in the stairwell will drop below the design pressure difference.
j) Air used to pressurize the stairwell shall be supplied from at least two injection points; one near the top and one near bottom of the stairwell.

B) The methods that will be used to analyze the data to evaluate tenability.
   a) The evaluation of tenability needs to include the effect on occupants of exposure to heat and toxic gases, as well as loss of visibility.
   b) The primary goal of the tests is to determine whether non-pressure compensating stairwell pressurization systems can reliably maintain tenable conditions in the stairwell with the door on the fire floor closed and one or more other doors in the stairwell propped open during a fire.
   c) A secondary goal of the project is to provide experimental results comparing tenability in the stairwell when using a compensating stairwell pressurization system to that with a non-compensating stairwell pressurization system. This comparison should include tenability levels as a function of time, and should be presented in a manner that helps designers determine the level of benefit that might be obtained in choosing one method over the other.

For each proposed test, the parameters described in the Test Plan shall include: (1) fire size, (2) sprinklered or non-sprinklered fire, (3) location of the fire, (4) compensating or non-compensating pressurization system, (5) height of the stairwell, (6) location of air supply to the stairwell, (7) number and location of doors open, (8) measurements of factors affecting tenability (temperature, visibility, toxicity, etc.), and (9) measurements of factors affecting repeatability (pressure differences near the top and bottom across the closed stairwell door on the fire floor, temperature measurements on both sides of the closed stairwell door on the fire floor, the leakage area around the closed stairwell door on the fire floor, the airflow going past the closed stairwell door on the fire floor).

Bidders shall indicate the general approach they plan to take in the Test Plan in dealing with these parameters to assure that the objective of the project is met. The bidder shall specify the criteria that will be used to determine the validity of the resultant data.

As the initial task for the project, the contractor shall develop a Detailed Test Plan for the project.

A) The Detailed Test Plan shall include:
   a) The items described in the Initial Test Plan, with additional detail or revision as necessary to ensure that the objectives of the project are met.
   b) A description of the tenability analysis to be used for the project.
   c) A description of the methods to be used to obtain the data regarding temperatures on both sides of the closed stairwell door on the fire floor; and pressure differences, leakage, and airflow across the closed stairwell door on the fire floor.

Once the Test Plan has been completed, the ASHRAE Project Monitoring Subcommittee (PMS) will review the Test Plan before the contractor continues work on this project.

2. Fire Tests:

This part of the project consists of conducting the experiments described in the Test Plan.

A) The bidder shall describe the facility that will be used for the full-scale tests.
   a) The full-scale test facility needs to be of a size and arrangement so that the results of the full-scale tests can be closely correlated with the results from RP-1203.
   b) Minor differences between the test facility and the configuration used in RP-1203 may be acceptable if the bidder explains why the impact of those differences should be considered to be insignificant.
   c) If the proposed test facility is of a size and/or arrangement that does not allow correlation of test data with the results of RP-1203, the contractor shall provide CONTAM simulations corresponding to the proposed test facility and test scenarios to be run, as a prerequisite to running the fire tests for this project.

B) For each test, the fire shall be located on the second floor, as specified in the Scope/Technical Approach section above.
   a) The fire shall be separated from the stairwell by a fire door unless the configuration under test indicates that the door on the fire floor should be open.
   b) Fire growth characteristics shall closely resemble a fast T-squared fire that continues burning at a steady state upon reaching 600 Btu/s for shielded fires and 4100 Btu/s for non-sprinklered fires.
   c) To correlate the visibility data with the results of RP-1203, the test fire should produce smoke with a mass optical density of approximately 1400-1800 ft^2/lb.
   d) For purposes of drawing conclusions from these experiments, the shielded fire will also be considered representative of sprinklered fires since both fires have the same growth characteristics and maximum size. In reality, the sprinklered fire would be less challenging because the fire would normally decay over time due to sprinkler activation.
   e) Fire tests shall be run for a minimum of 30 minutes in order to correlate with the results from RP-1203. Longer tests may provide additional useful data for comparison between non-compensating and pressure compensating systems. Bidders shall specify the duration planned for each test.
   f) Fire tests may be terminated after the time specified in the bid, or when tenability measurements indicate fatality in the stairwell, whichever comes first.
   g) Data recorded during the tests shall be the data necessary to determine tenability, as specified in the bidder's proposal, and the data necessary to indicate the conditions across the stairwell door on the fire floor during the test, as specified in the Scope/Technical Approach section above.
   h) The non-compensating stairwell pressurization system shall be designed to provide a minimum of 0.10 in. w.g. and a maximum of 0.35 in. w.g. across all closed doors in the stairwell with 0 and 1 door open. No adjustment of the pressurization system is provided when additional doors are opened.
   i) The compensating stairwell pressurization system shall be designed to provide a minimum of 0.10 in. w.g. and a maximum of 0.35 in. w.g. across all closed doors in the stairwell with 0 to the number of open doors specified for the test.

Deliverables for this stage of the project include a status update indicating the number and configuration of fire tests that have been completed. This update should be provided to the PMS during each winter and annual meeting from the start of the fire tests until all fire tests have been completed.

3. Data Analysis and Final Report:

Tenability shall be determined for all test runs, taking into account temperature exposure, toxicity, and visibility for occupants of the stairwell. Conditions in the space are considered "tenable" if 1) temperatures in the stairwell remain below the thermal tolerance of humans (Klote, 2004, Fig. 8) for the duration of the test; 2) the Fractional Effective Dose (FED), when calculated as described in RP-1203, is less than a value of 0.50 at all locations in the stairwell; and 3) visibility is greater than 25 feet.

The contractor shall analyze the data from the tests and write a final report. The final report shall include:

A) Description of the tests in detail,
B) Description of the reasoning underlying the Test Plan,
C) The data recorded during the tests that was used to determine tenability,

D) The data recorded during the tests that indicate the conditions across the door on the fire floor during the test,
E) Description of the methods used to evaluate tenability,
F) Key points learned during this project that should be considered for inclusion in the ASHRAE Handbook, including answers to the following questions:
   a) Is tenability maintained in a non-compensated stairwell for at least 20 minutes under the test conditions?
   b) How do the tenability conditions in a non-compensated stairwell compare over time to those in a compensated stairwell?
   c) If compensated and non-compensated stairwell pressurization systems both maintain tenable conditions, are there other benefits received in exchange for the difference in cost (such as occupant comfort, safety margins, duration of protection)?

Deliverables:
Progress, Financial and Final Reports, Technical Paper(s), and Data shall constitute the deliverables ("Deliverables") under this Agreement and shall be provided as follows:

a. Progress and Financial Reports

Progress and Financial Reports, in a form approved by the Society, shall be made to the Society through its Manager of Research and Technical Services at quarterly intervals; specifically on or before each January 1, April 1, June 10, and October 1 of the contract period.

Furthermore, the Institution's Principal Investigator, subject to the Society's approval, shall, during the period of performance and after the Final Report has been submitted, report in person to the sponsoring Technical Committee/Task Group (TC/TG) at the annual and winter meetings, and be available to answer such questions regarding the research as may arise.

b. Final Report

A written report, design guide, or manual, (collectively, "Final Report"), in a form approved by the Society, shall be prepared by the Institution and submitted to the Society's Manager of Research and Technical Services by the end of the Agreement term, containing complete details of all research carried out under this Agreement, including a summary of the control strategy and savings guidelines. Unless otherwise specified, the final draft report shall be furnished, either electronically or hardcopy format (6 copies) for review by the Society's Project Monitoring Subcommittee (PMS).

Tabulated values for all measurements shall be provided as an appendix to the final report (for measurements which are adjusted by correction factors, also tabulate the corrected results and clearly show the method used for correction).

Following approval by the PMS and the TC/TG, in their sole discretion, final copies of the Final Report will be furnished by the Institution as follows:

-An executive summary in a form suitable for wide distribution to the industry and to the public.
- One unbound copy, printed on one side only, suitable for reproduction.
- One bound copy
-Two copies on CD-ROM disks; one in PDF format and one in Microsoft Word.

d. HVAC&R Research or ASHRAE Transactions Technical Papers

One or more papers shall be submitted first to the ASHRAE Manager of Research and Technical Services (MORTS) and then to the "ASHRAE Manuscript Central" website-based manuscript review system in a form and containing such information as designated by the Society suitable for publication. Papers specified as deliverables should be submitted as either Research Papers for

HVAC&R Research or Technical Paper(s) for ASHRAE Transactions. Research papers contain generalized results of long-term archival value, whereas technical papers are appropriate for applied research of shorter-term value, ASHRAE Conference papers are not acceptable as deliverables from ASHRAE research projects.. The paper(s) shall conform to the instructions posted in "Manuscript Central" for an ASHRAE Transactions Technical or HVAC&R Research papers. The paper title shall contain the research project number (1447-RP) at the end of the title in parentheses, e.g., (1447-RP).

All papers or articles prepared in connection with an ASHRAE research project, which are being submitted for inclusion in any ASHRAE publication, shall be submitted through the Manager of Research and Technical Services first and not to the publication's editor or Program Committee.

e. Data

Data is defined in General Condition VI, "DATA"

f. Project Synopsis

A written synopsis totaling approximately 100 words in length and written for a broad technical audience, which documents 1. Main findings of research project, 2. Why findings are significant, and 3. How the findings benefit ASHRAE membership and/or society in general shall be submitted to the Manager of Research and Technical Services by the end of the Agreement term for publication in ASHRAE Insights

The Society may request the Institution submit a technical article suitable for publication in the Society's ASHRAE JOURNAL. This is considered a voluntary submission and not a Deliverable. Technical articles shall be prepared using dual units; e.g., rational inch-pound with equivalent SI units shown parenthetically. SI usage shall be in accordance with IEEE/ASTM Standard SI-10.

Intermediate Deliverables

In addition to Deliverables *a* through *e* above, the following deliverables are also required during the project:

a. Test Plan

As the initial task for the project, the contractor shall develop a Detailed Test Plan for the project. The Detailed Test Plan shall include:

- The information described in the Scope/Technical Approach section.
- A description of the tenability analysis to be used for the project.

b. Fire Tests

- A detailed description of the Test Facility shall be submitted prior to commencement of the first fire test.
    - If minor differences exist between the test facility and the configuration used in RP-1203, the Test Facility description must explain why the impact of those differences should be considered to be insignificant.
    - If the test facility is of a size and/or arrangement that does not allow correlation of test data with the results of RP-1203, the Test Facility description shall provide CONTAM simulations corresponding to the proposed test facility and test scenarios to be run, as a prerequisite to running the fire tests for this project.
- The PMS should receive notification, either verbally or in writing, upon commencement of the first fire test.
- Status updates indicating the number and configuration of fire tests that have been completed, as well as a brief summary of each test, should be provided to the PMS during each winter and annual meeting from the start of the fire tests until all fire tests have been completed
- The PMS should receive notification, either verbally or in writing, upon completion of the last fire test.

- A preliminary report should be submitted to the PMS indicating whether tenability was maintained during each test. (This deliverable may be waived if the preliminary and final reports would both be available at the same annual or summer ASHRAE meeting.)

Level of Effort

Anticipated project duration is about 24 months. Anticipated total cost is $180,000.

The anticipated costs assume:

1) The bidder's test facility is of a size and arrangement allowing the results of the full-scale tests to be closely correlated with the results from RP-1203.
2) Ten tests will be run, consisting of six shielded fires, and four non-sprinklered fires. Additional tests that assist in supporting the results are considered a plus.
3) Fires shall closely resemble a fast T-squared fire that continues burning at a steady state upon reaching 600 Btu/s for shielded fires and 4100 Btu/s for non-sprinklered fires. Fuel will be consumed for 30 minutes during each test.
4) Labor hours include time to prepare the test plan, setup and run the tests, analyze the data, write the report, and present the report at an ASHRAE meeting.
5) Incidental costs will include materials and instrumentation consumed during the tests, cleanup, and travel costs.

Other Information to Bidders (Optional):

This project requires expertise in full scale fire testing, stairwell smoke control, and other areas of fire science and fire protection engineering. Biographical data of the principal investigator and of the other key personnel needs to include their experience in full scale fire testing, tenability analysis, fire science and fire protection engineering.

Bidders should provide an initial Test Plan, which includes all the parts discussed above in the Scope/Technical Approach, to allow evaluation of their proposal by ASHRAE. The failure of a bidder to clearly and concisely provide all of the information needed for evaluation (see Proposal Evaluation Criteria below) will adversely impact the evaluation of that bidder's proposal.

Proposal Evaluation Criteria

Proposals will be evaluated on:

1. Contractor's understanding of Work Statement as revealed in proposal. 16%
   a. Logistical problems associated
   b. Technical problems associated
2. Quality of methodology proposed for conducting research. 20%
   a. Organization of project
   b. Management plan
3. Contractor's capability in terms of facilities. 20%
   a. Fire test facility (laboratory burn facility or other type of building)
   b. Managerial support
   c. Data collection
   d. Technical expertise
4. Qualifications of personnel for this project. 16%
   a. Project team 'well rounded' in terms of qualifications and experience in related work
   b. Project manager person directly responsible; experience and corporate position
   c. Team members' qualifications and experience including experience in full scale fire testing, tenability analysis, fire science and fire protection engineering
   d. Time commitment of Principal Investigator
5. Student involvement. 4%
   a. Extent of student participation on contractor's team
   b. Likelihood that involvement in project will encourage entry

into HVAC&R industry

6. Probability of contractor's research plan meeting the objectives of the Work Statement. 20%
   a. Detailed and logical work plan with major tasks and key milestones
   b. All technical and logistic factors considered
   c. Reasonableness of project schedule
7. Performance of contractor on prior ASHRAE projects (No penalty for new contractors.) 4%

References

1. Klote, J.H., and Milke, J.A., 2002. Principles of Smoke Management, ASHRAE, Atlanta, GA.
2. Klote, J. H. 2004. Tenability and Open Doors in Pressurized Stairwells, ASHRAE Transactions, Vol. 110. Part 1.
3. Statistical Abstract of the United States. November 17, 2008. US Department of Commerce. June 12, 2009 <http://www.census.gov/prod/www/abs/statistical-abstract.html> Tables 930-931.
4. International Building Code. 2009. International Code Council, Country Club Hills, Illinois.
5. NFPA 92A, Standard for Smoke Control Systems Utilizing Barriers and Pressure Differences. 2008. National Fire Protection Association, Quincy, Massachusetts.