INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1789-TRP, "Optical and thermal performance of hollow glass block units"

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 4.5, Fenestration

Budget Range: $197,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1, 2019** or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, December 17, 2018. NO EXCEPTIONS, NO EXTENSIONS. 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: 1789-TRP, "Optical and thermal performance of hollow glass block units", 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:

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Contractors intending to submit a proposal should so notify, by mail or e-mail, the Manager of Research and Technical Services, (MORTS) by December 3, 2018, 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 8:00 AM, EST, December 17, 2018. NO EXCEPTIONS, NO EXTENSIONS.**

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.

State of the Art (Background)

Hollow glass blocks (HGB) are architectural and interior design elements used in many building types as durable masonry envelopes, and fenestration systems to fulfill various functions. For exterior envelope applications (Figures 1 to 3), HGB admit glare-free natural light indoors, and connect occupants to the changing outdoor environment, beside providing structural support, acoustical insulation, fire protection, and aesthetic look to buildings. For interior applications, HGB are used as decorative partitions to separate interior spaces and provide privacy. Furthermore, HGB are used when conventional windows and skylights are not possible, particularly for curved walls and pavement roofs. In addition, HGB panels are highly durable and require very low maintenance. Estimates of the annual world-wide sales of glass blocks are about 114 million units, with 29.5 millions are used in Europe. More than half (16.2 millions) of the European sales of glass blocks are used for external envelopes (Corrao and Morini, 2013). Recent market research found out that the global production of glass blocks (number of units) has increased by 67% from 2011 to 2016, and it is forecasted to grow in future years (GCC, 2016). The global major industry players include Seves Group (Italy), Saint-Gobain (France), La Rochère (France), Roadstone (Ireland), Shackerley (UK), Star'Glass (Russia), Vitrosilicon S.A (Poland), Electric Glass Building Materials (Japan), Bangkok Crystal (Thailand), Mulia (Indonesia), Dezhou Jinghua Group (China), Hebei Jihengyuan Industrial (China). Seves Group possesses about 40% value share of the world glass block market (Seves Group, 2017).

HGB are made of two halves of recycled glass, or plastic hot or cold-sealed together to form square hollow units. Hot sealing is done when the block halves come out hot of the oven, whereas cold sealing is done at ambient temperatures. Cold sealing, thus, offers additional benefits to insert elements for enhancing the optical and thermal performance. HGB are joined together to form panels (or windows) using masonry mortar, adhesives or silicone sealant in the interface between the blocks. Metal mesh or frame inserted between the blocks is used to structurally reinforce HGB panels to sustain wind loads, but this will increase thermal bridging, and therefore decrease the energy efficiency of the panels. Acrylic blocks have recently emerged as alternative products with lower manufacturing cost and easier installation. Transparent adhesive or mortar has also been considered to increase the thermal and daylighting performance, and structural load support of HGB (Oikonomopouloun et al., 2014). HGB are made of various sizes ranging from 6" x 6 " to 12" x 12" with a nominal thickness of 3" or 4". HGB uses various glazing types, including clear, frosted, translucent and prismatic. Various colors are also used for decorative or aesthetic purposes.

Driven by building energy efficiency standards and market competition with flat glass windows, HGB have undergone various innovations to improve their optical and thermal performance. HGB with argon gas, cavity partition with low-e glazing or insulating material (e.g., aerogel), daylight redirecting elements, and solar cell integration are ones of the innovations. Seves Group (2017) commercializes a variety of such energy saving and producing glass block products.

Research studies to evaluate the optical and thermal performance of HGB are very rare. Zinzi et al. (2000) used large integrating spheres and gonio-photometer to measure the transmittance of three HGB samples. Tait (2006) carried out an ASHRAE project on the measurement of the optical and thermal performance of HGB panels, but the project results never made it to the ASHRAE HOF due to some inaccuracies in the measured results. Tait (2006) considered three types of HGB (clear, patterned clear and frosted) with dimensions of 7.5" (190.5 mm) x 7.5" (190.5 mm) x 3.875" (98.4 mm). The visible/solar transmittance was obtained using an approximate method in which two illuminance/irradiance sensors were placed on top and 4" below the HGB units, and the measurement was taken under clear sky conditions when direct sunlight was normal to the HGB surface. The SHGC was measured for HGB panels of 3 units x 3 units using static and tracking calorimeters under real outdoor conditions. The measurement was taken for at least two consecutive hours around noontime. Due to the high mass of HGB panels, Tait (2006) found out that the tracking calorimeter was better to minimize the transient effect of heat transfer on the SHCG measurement. The U-factor of the HGB panels was measured using the Guarded Hot Plate method. The measured U-factor was 2.186 W/($m^{2o}C$), about 25% lower than the older value of the ASHRAE HOF (ASHRAE, 2013). Tait (2006) pointed out some issues during the measurement, notably the yellowing of the cement that was used to fix the thermocouples to the HGB panels, which could have resulted in higher temperatures than normal. Soehartono et al. (2010) conducted outdoor experiments using a one-meter cubic box to measure the lighting performance (illuminance distribution at floor and ceiling surfaces) of three texture types of HGB (grid, wave and diamond) placed on one facade of the box. The measurement found out that the surface textures of the tested HGB samples reduced their lighting performance compared to a clear HGB. Binarti et al. (2013) investigated the effects of laminated glazing and air cavity types (closed, or open) of HGB on the ratio of VT to SHGC (LSG). They used the simple box method to measure VT, and SHGC, and conducted CFD simulations to compute the U-factor of HGB. The polyvinyl butyral (PVB) interlayer was found to increase LSG. ASHRAE HOF (ASHRAE, 2013) includes very old data for SHGC and U-factor of some typical mortar sealed HGB panels. The SHGC data were derived from measurement under direct sun, and therefore included the transient effect of HGB mass (Pennington et al., 1965). Furthermore, the HOF data need to be updated to include recent innovations in HGB such as low-e glazing inserts in HGB cavities, gas fills, metallic inserts in the mortar interface between blocks, and the use of adhesives instead of mortar. ISO-15099 standard (ISO, 2003) does not cover HGB, but provides useful correlations for the convective heat transfer in shallow cavities, which typically exist in HGB. These correlations with detailed radiation model were implemented in THERM 7 program to compute U-factor of window frames. NFRC procedures (NRFC 100/200:2014) use measurement to determine VT, SHGC and U-factor of HGB panels. Furthermore, it is not clear how HGB panels are treated in the NFRC simulation procedures (LBNL, 2013). HGB are treated as monolithic single glazing with measured effective thermal conductivity, but there is no reference on how the interface between the blocks is treated in THERM to compute the U-factor of HGB panels. European standards for HGB (EN 1051-2:2007 (CEN, 2007) use the flat glass window standards for VT (ISO 9050; EN 410) and U-factor (EN 673). VT and U-factor are, however calculated only for HGB without the interface material between blocks. Furthermore, the glass protruding edges of HGB are not accounted for in the U-factor. Manufacturer's performance data (Seves Group, 2017) show that large sizes of HGB have lower U-factors than low sizes due to reduced thermal bridge effects. Furthermore, the interface material between blocks has a significant effect. For example, HGB joined by adhesives have lower (10%) U-factors than regular mortar joined blocks.

Justification and Value to ASHRAE

This research is intended to produce validated computational algorithms to:

- Assess the performance of HGB windows
  - Support the update of North-American and international fenestration rating standards (e.g., NFRC-100:2014; NFRC-200:2014; EN-1051-2)
  - Increase the capability of fenestration design software (e.g., LBNL's WINDOW and THERM programs), ASHRAE load toolkit, and building-energy simulation software (e.g., EnergyPlus which drives WINDOW for window performance calculation).

Building design professionals and engineers will be better able to specify energy-efficient HGB products in commercial and residential buildings with more confidence, and to show compliance with the current building energy codes and energy efficiency standards.

This research will provide useful results to update the section on HGB of the Fenestration Chapter of future editions of the ASHRAE HOF by including performance data of current HGB products.

HGB manufacturers would benefit from lower costs to rate HGB products using simulation as compared with the high cost of the current measurement procedure.

Objectives

The aim of the project is to develop simplified models for implementation in existing fenestration design tools and building energy simulation software to enable glass block industries, building design professionals and engineers generate design performance data and comply with the requirements of relevant building energy efficiency standards and building energy codes. The specific objectives are:

1- To conduct literature review on the technological development and performance of HGB. A summary of research gaps will be established to develop a detailed research plan for discussion and approval by PMS.

2- To develop a methodology to compute and measure the optical characteristics (transmittance, pane absorptance) of HGB and its component complex glazings at any incidence angle.

3- To develop a simplified methodology to compute the U-factor and SHGC of HGB panels (or windows), made of the blocks themselves and the interface materials between the blocks.

4- To conduct suitable experiments to validate the optical models (in particular transmittance) for the specific complex glazing types and HGB panels.

5- To conduct suitable experiments and CFD simulations to validate the thermal models (U-factor; or effective thermal conductivity) of HGB panels

Scope:
The scope of this project is limited to HGB windows (panels). HGB panels are made of a group of HGB units joined together with an interface material (1 to 3 cm thick, or thinner), which is typically mortar, silicone sealants, or adhesives. Panel reinforcing elements which are usually made of stainless (or galvanized) steel are placed horizontally in the interface joints at every other course of HGB. Expansion plastic (polyethylene) strips are inserted at the head and jambs of the panels. The strips replace mortar at these locations to cushion the glass block and allow the panels to expand and contract freely. Additional panel anchors are used to tie the panels to the surrounding framework if the expansion strips are not used (Figure 4). The panel anchors and expansion strips may be considered as part of the panel frame, and therefore are not included in this project.

HGB units are made of two or three glazing sheets separated by air or argon. HGB uses a variety of glazing types namely plain, colored, and textured glazing. These glazing may be categorized into three types (Figure 4):

(1) Clear (including colored clear) glazing: The glass includes insignificant portions of impurities with minimum effect on glass clarity. This type is used when the view-out is required.

(2) Scattering glazing: The glazing medium includes pigments to scatter light (e.g., opal or white glazing). Similarly, significant portions of glass impurities may affect light scattering, resulting in image distortion or blurring.

(3) Frosted glazing: Light is scattered at the surface of the glazing using random micro-structures. Typical glass frosting techniques use sandblasting, chemical etching, or grinding.

(4) Prismatic glazing: Periodic prismatic structures are implemented on the glazing surface to diffuse or re-direct light. Typical prismatic structures are either one-dimensional or linear (such as horizontal, vertical, or diagonal ribs) or two-dimensional such as cross-ribs or diamond structures.

HGB units are square and made of various sizes, typically ranging from 6" to 12" (height or width) with thicknesses from 3" to 4" (nominal sizes). Non-square HGB units with different sizes to accommodate corners and panel rough openings are also manufactured, but these are not included in the project scope. Table 1 summarizes typical nominal and actual sizes of HGB units.

Technical Approach

The technical approach of the project consists of the following tasks:

Task #1 – State of the art review

The literature review will include the following topics:

- Component materials of HGB, including glazing types (diffusing, frosted, prismatic) and materials (glass, acrylic), energy efficiency inserts (low-e glass, inert gas) in the cavity, between block interface materials (mortar, silicone sealants, adhesives), and any new technology integration in HGB such as photovoltaics.

- Current industry practice (measurement and simulation) to rate HGB windows
- Performance evaluation studies of HGB windows in buildings

- Optical models of HGB glazing and assemblies

- Convective heat transfer in short rectangular cavities (aspect ratio < 4).

The findings from the literature review will be used to identify the research gaps and develop a detailed plan of actions to execute the next project tasks. The work plan actions and a summary of the literature review task will be presented at the PMS meeting for discussion and approval.

Task #2 – Development of simplified optical models

Simplified optical models will be developed to compute the overall optical characteristics (visible/solar transmittance, reflectance and layer absorptances) of HGB at oblique incidence angles. These optical models are intended to be implemented in fenestration design software and building-energy simulation programs for energy performance certification and rating of HGB panels. For clear glazing sheets, the laws of optics may be used to predict the individual glazing optics at off-normal incidence angles. However, for complex glazing, new optical models for specific glazing types may need to be developed. The optical models will therefore include the following set of models for typical glazing types found in HGB (Figure 4):

Optical models for volume scattering glazing. Recycled glass of HGB usually includes impurities that render the glazing blurry or distorting. HGB glazing may also include pigments to diffuse or scatter light. Lighting scattering of pigments occurs in the volume of the glazing.

Optical models for surface scattering glazing: This includes frosted (sandblasted or chemically etched) glazing and ground glass. Light scattering is due to the surface roughness which usually follows a random distribution.

Optical models for prismatic glazing. HGB includes glazing with periodic surface structures to diffuse or redirect light. Linear (one dimensional; such as ribs) or two dimensional (such as cross-ribs, diamond) prismatic structures are typically used in HGB.

Optical model for multi-layer HGB assemblies. These models may build on existing models developed for flat glass windows (e.g., Laouadi 2007; Laouadi et al., 2013) by accommodating the shallow shapes of HGB and accounting for the light reflection off the internal perimeter edge surfaces of HGB (which is neglected in window optical models), particularly for small sizes of HGB, scattering glazing, and oblique incidence angles.

The aforementioned optical models will need spectral (or broadband) measured optical data to compute the internal optical properties (e.g., index of refraction, haze, scattering constant, etc.) of HGB glazing describing the process of light refraction, reflection and scattering within each pane. The proposed approach will therefore need to describe the measurement procedure the HGB manufacturers should follow to get the spectral optical data using either the ISO-15099 standard methodology for complex glazing (two beam-beam and beam-diffuse components for transmittance/reflectance), or the bidirectional transmittance (reflectance) distribution functions (BT(R)DF).

Task #3 – Development of thermal models

Thermal model will be developed to compute the U-factor of HGB windows (panels) under given boundary conditions as specified by the applicable standards (such as NFRC 100-2014; ISO-15099:2003; EN 673). The models will be based on the thermal model of the ISO-15099 standard with some modifications to account for the unique geometries of HGB as follows:

Natural convection in air cavities with short aspect ratios (< 4). Suitable correlations for the convective heat transfer in such cavities (collected under Task #1, or from ISO-15099 standard) will be used.

Radiation heat transfer among the surfaces bounding the air cavity. These boundary surfaces include the perimeter edge surfaces and the cooled/heated plates in contact with the exterior and interior environments. Note that for flat glass windows (tall cavities with high aspect ratios > 40), the radiative heat transfer between the spacer (edge) surfaces and the glass plates is neglected. This is not the case for HGB. Surface to surface radiation exchange will thus be used in combination with the correlation-based convective heat transfer in the air cavity.

3-D conductive heat transfer through the interface between the block units. The interface material is not homogenous; it includes mortar/sealant, metallic mesh/rods and glass ends of HGB. 3-D CFD simulation should be used to derive the effective thermal conductivities of the interfaces between blocks. Alternatively, the current 2-D standard approach (NRC-100:2014) of the THERM program may also be explored for its accuracy as compared with the proposed 3-D modelling. Corrections factors to the 2-D approach may need to be developed if the procedure can be generalized to all sizes of HGB.

A procedure will therefore be devised in which the U-factor of HGB panels is assembled from the U-factors of the centre of glass and the interface between the blocks.

The SHGC is calculated according to the ISO-15099 standard methodology using the optical and thermal models (Tasks #2 and #3). The interface between blocks is assumed opaque to sunlight.

Task #4 – Validation of the optical models

The optical models (Task #2) developed for specific glazing types and HGB units will be validated with available data from literature and by conducting new laboratory measurement. For the experimental validation, the spectral (or broadband) transmittance measurement at oblique incidence angles will be conducted for selected glazing types (diffusing, frosted, prismatic) typically used in HGB and for at least three types of HGB units (clear, diffusing/frosted, prismatic) with typical sizes (chosen from Table 1). Small sizes of HGB combined with scattering glazing are expected to yield higher transmittance than large size blocks (due to light reflection off the edge surfaces), and are therefore suitable for the model validation. Spectrometers, small or large integrating spheres, gonio-photometers, or any other suitable apparatus may be used for the measurement.

Task #5 – Validation of thermal models

The thermal model for the U-factor of HGB panel will be validated using CFD simulation and laboratory measurement. A set of typical HGB panels or representative groups of HGB units (e.g., 1x2, 2x2) joined by mortar with horizontal steel reinforcement elements will be made for the measurement.

At least four specimen of HGB panels or groups should be tested: three double glazed with nominal sizes of 6"x6"x3, 8"x8"x4", and 12"x12"x4"; and one triple glazed with low-e glazing insert and argon gas. The glazing type of HGB is not important for the U-factor measurement.

For the laboratory measurement, the heat flow meter (ASTM C-518) or the hot box (ASTM C1363) apparatus may be used. The heat flow meter measures the effective thermal conductivity of specimen, which can be converted to U-factor using the specified film coefficients at the interior and exterior surfaces. The hot box method directly measures the U-factor.

The CFD simulations will be carried out for the specimen under consideration.

<u>Deliverables</u>:
The project deliverables include the following:

Task #1 - State of the art review
Interim progress report
Summary of research gaps for PMS discussion and approval of the next steps
Full report

Task #2 - Development of simplified optical models
Interim progress reports for PMS discussion and approval, and agreement on for the next step to follow
Full report on the optical models for volume scattering glazing
Full report on the optical models for surface scattering glazing
Full report on the optical models for 1-D and 2-D prismatic glazing
Full report on the optical model for multi-layer HGB assemblies

Task #3 - Development of thermal models
Interim progress reports for PMS discussion and approval, and agreement on for the next step to follow.
Report on the CFD simulation
Full report on the thermal model of HGB panels

Task #4 - Validation of the optical models
Interim progress reports for PMS discussion and approval, and agreement on for the next step to follow.
Full report on the validation of the optical models for volume scattering glazing
Full report on the validation of the optical models for surface scattering glazing
Full report on the validation of the optical models for prismatic glazing
Full report on the validation of optical model for multi-layer HGB assemblies

Task #5 - Validation of thermal models
Interim progress reports for PMS discussion and approval, and agreement on for the next step to follow.
Full report on the validation of the thermal models of HGB

Final report
Final report including reports from all project tasks

In addition, 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, electronically 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.
-Two copies; one in PDF format and one in Microsoft Word.

c. *Science & Technology for the Built Environment* 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 (1789-RP) at the end of the title in parentheses, e.g., (1789-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.

d. Data

Data is defined in General Condition VI, "DATA"

e. 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.

Level of Effort

The project anticipates at least two expert professionals in the area of the optical and thermal performance of fenestration systems, and two research technicians for the measurement of the optical properties of materials and thermal performance of fenestration systems.

Professional -months: Principal Investigator (optical and thermal expert): 15 months
Professional -months: Heat transfer and CFD specialist: 6 months
Professional -months: Lab Technicians: 5 months
Expected project duration: 26 months
Estimated project cost: $197,000

Other Information to Bidders (Optional):

The contractor must have sound skills and experience in analytical modeling of heat transfer (radiation, convection, and conduction) and optical characteristics of complex fenestration systems.

The in-kind support from HGB industries is the responsibility of the contractor.

The contractor shall provide to the PMS at the Society meetings a detailed report of work accomplished and work yet to be done. The PMS shall give the contractor following these meetings a written report of the PMS's assessment of the contractor's progress and any requests for project changes deemed necessary to maintain the objectives and schedule of the project.

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	Performance of contractor on prior ASHRAE or other projects.	5
2	Full reports on the development of optical and thermal models (Tasks #2 & #3)	20
3	Full reports on the validation of the optical and thermal models (Tasks #4 & #5)	24

Proposal Evaluation Criteria

Proposals submitted to ASHRAE for this project should include the following minimum information:

No.	Proposal Review Criterion	Weighting Factor
1	Contractor's understanding of Work Statement as revealed in proposal. a) Logistical problems associated b) Technical problems associated	20%
2	Quality of methodology proposed for conducting research. a) Organization of project b) Management plan	25%
3	Contractor's capability in terms of facilities. a) Managerial support b) Data collection c) Technical expertise	15%
4	Qualifications of personnel for this project. 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 d) Time commitment of Principal Investigator	30%
5	Probability of contractor's research plan meeting the objectives of the Work Statement. a) Detailed and logical work plan with major tasks and key milestones b) All technical and logistic factors considered c) Reasonableness of project schedule	5%

6	Performance of contractor on prior ASHRAE or other projects.	5%

Proposal Evaluation Criteria

Proposals submitted to ASHRAE for this project should include the following minimum information:

References

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20. Seves Group. 2017. www.seves.com. Accessed in February 2017.
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