

INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1941-TRP, Experimental Program to Update the ASHRAE Duct Fitting Database DFD

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 Committee 5.2, Duct Design

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

Scheduled Project Start Date: **April 1, 2027**, or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, Tuesday, December 15th, 2026. NO EXCEPTIONS. 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: 1941-TRP, *Experimental Program to Update the ASHRAE Duct Fitting Database DFD*, 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

Technical Contact
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For Administrative or Procedural Matters:

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Contractors who plan to submit a proposal must notify the Manager of Research and Technical Services (MORTS) via email by December 1st. This will ensure that they receive any late or additional information regarding the RFP before the bid due date. The deadline for submitting technical questions is also Tuesday, December 1st, 2026.

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 shammerling@ashrae.org. In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EST, Tuesday, December 15th, 2026. NO EXCEPTIONS.

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)

Griggs and Khodabakhsh-Sharifabad (1992) reported surface roughness values for galvanized steel rectangular ducts. In many instances the tests were performed on plywood analogs and did not use actual sheet metal ducts. Their investigation considered duct section lengths of 1.22 m (4 ft), where the sections were butted together. Instead, the DFDB correlates friction factors for galvanized steel rectangular ducts (designated as fitting CR11-1) that were based on data obtained from 1.83 m (6 ft) section lengths connected by flanges, as reported by Huebscher (1948). Neither Griggs and Khodabakhsh (1992) nor Huebscher (1948) clearly addressed the influence of duct connection spacing or design. Loss coefficient data for converging 30° and 45° wyes are reported in the DFDB; these are designated as fittings ED5-1 and ED5-2, respectively. The original data were obtained from Sepsy and Pies (1973). For many flow situations likely to be encountered in practice, the DFDB yields main and branch loss coefficients that are simultaneously negative. Kulkarni and Idem (2017) noted that the total energy loss must always be positive, suggesting that the data reported for fittings ED5-1 and ED5-2 are in error. Loss coefficient data obtained from UMC (1985) for exhaust fittings such as bullhead tees without vanes (ED5-4) and 60° symmetrical wyes (ED5-9) are also presumably erroneous, since for equal diameter branches possessing the same volume flow rate, the resulting loss coefficients calculated by the DFDB differ considerably. The testing and data analysis were performed prior to the publication of ASHRAE Standard 120 (2017), and therefore the experimental procedures and data reduction methods that were utilized did not conform to modern accepted practice. Concerns have also been expressed regarding angle correction factors utilized by the DFDB to evaluate loss coefficients for radiused, mitered, and gored elbows. Fittings suggested for further analysis were brought to the attention of TC 5.2 by subscribers of DFDB who noted the presumed anomalies.

Justification and Value to ASHRAE

The ASHRAE DFDB (2017) enables designers to predict pressure losses for over 220 fittings. It likewise permits the user to evaluate pressure losses for round, flat oval, rectangular, and flexible straight ducts. This widely used program has been available from ASHRAE for nearly 30 years. It is vital that HVAC system design professionals have access to duct fitting loss coefficient data that are accurate. Engineers will be able to use the information generated in this project to design efficient duct systems. The results of this project will be used to update the DFDB. Recently the DFDB underwent significant renovation to enhance its usability by facilitating navigation through the tree structure of the program, while still allowing access to duct design programs. During that process, a thorough review of the DFDB by TC 5.2 revealed inaccuracies in the data for several important cases. In other instances, subscribers have inquired about errors present in the DFDB. For example, gaps in reliable loss coefficient data were identified for elbows having included angles other than 45° or 90°. The objective of this research is to perform pressure loss testing for those fittings that have inadequate (or incorrect) data and thereby update the DFDB (2017). The tests will be conducted in compliance with ASHRAE Standard 120. Access to this data will allow designers to (1) accurately select fittings from a large diverse set of information, and (2) improve the use of automated duct design programs that utilize the database.

Objectives

The results of this project will be used to update the DFDB. Engineers will be able to use the information generated in this project to design efficient duct systems. More reliable data and/or a large database of fitting loss coefficients will help ASHRAE members and others to better design ductwork for their clients, enabling more accurate pressure drop calculations and the use of lower safety factors. This will allow fans to be sized with more certainty, which in turn will reduce system energy use. It should also generate an increase in sales for the DFDB and the ASHRAE Duct Design Guide.

Scope:

The total scope of testing for this project is separated into three distinct tasks, as herein defined:

Task 1:

Pressure loss shall be measured in rectangular galvanized sheet metal ducts having section lengths of 1.52 m (5 ft) to determine the friction factor, and absolute and relative roughness values. The sections will be joined by slip and drive connections. The nominal duct cross sections shall include 610 mm × 610 mm (24 in. × 24 in.), 610 mm × 1219 mm (24 in. × 48 in.), and 406 mm × 1219 mm (16 in. × 48 in.), for a total of three required test setups. This configuration is designated as fitting CR11-1 in the DFDB. Minimum/maximum velocity limits in the test section will be maintained as prescribed by ASHRAE Standard 120. The contractor shall test the straight galvanized steel rectangular ducts with a test setup that conforms to Figure 1 (excerpted from ASHRAE Standard 120).

Task 2:

Pressure loss measurements will be conducted on exhaust fittings denoted as ED5-1, ED5-2, ED5-4, and ED5-9 in the DFDB. The contractor will determine straight and branch zero-length loss coefficients as a function of branch-to-common flow rate (Q_b/Q_c) and area ratios A_b/A_c and A_s/A_c . These exhaust fittings are depicted in Figures 2 through 5, respectively. The scope of tests for fittings ED5-1 and ED5-2 is summarized in Table 1, which indicates that 12 separate test setups are required for each of fittings ED5-1 and ED5-2. The range of tests for fittings ED5-4 and ED5-9 is summarized in Table 2, which implies that 14 distinct test setups are required for each of the fittings ED5-4 and ED5-9. All exhaust fitting tests will be performed with branch-to-common flow rate ratios ranging from 0.1 to 0.5 (or higher), while maintaining minimum/maximum velocity limits in each section as prescribed by ASHRAE Standard 120. The contractor will test these fittings with a test setup that conforms to Figure 6 (excerpted from ASHRAE Standard 120).

Task 3:

As summarized in Table 3, pressure loss will be measured for $r/D = 1.5$ die stamped elbows having included angles of 45° and 90° . In the DFDB, such a 90° elbow is designated as fitting CD3-1; refer to Figure 7. The 45° elbow is denoted as fitting CD3-3 in the DFDB. Referring to Table 4, pressure loss will be measured for $r/D = 1.5$ gored elbows having included angles of 45° (3-gore) and 90° (5-gore). In the DFDB, such a 90° 5-gore elbow is designated as fitting CD3-9; refer to Figure 8. The 45° elbow is denoted as fitting CD3-14 in the DFDB. In addition, pressure loss will be measured for $r/D = 1.5$ gored elbows having included angles of 30° (2-gore) and 60° (4-gore); data for these elbows are not available in the DFDB. The elbow tests shall therefore require 18 separate test setups. The contractor will test these fittings with a test setup that conforms to Figure 6 (excerpted from ASHRAE Standard 120). The contractor will determine zero-length loss coefficients for each included elbow angle and diameter and therein establish curve-fit expressions suitable for inclusion in the ASHRAE DFDB. Minimum/maximum velocity limits in the test section will be maintained as prescribed by ASHRAE Standard 120. The contractor shall test these fittings with a test setup that conforms to Figure 9 (excerpted from ASHRAE Standard 120).

For each task the unreinforced ductwork shall be constructed from 24 ga. galvanized steel. Each fitting will require a different test layout be assembled, tested for leakage, and instrumented per Standard 120. Prior to performing the fitting pressure loss tests, the straight duct tare pressure loss will be determined for each round duct cross section. This implies that six separate round duct configurations must first be tested. All data reduction calculations shall be in accordance with Section 9 of Standard 120. The contractor shall provide validated spreadsheets for the calculation of mass flow rates and loss coefficients to the Project Monitoring Subcommittee (PMS) for their approval.

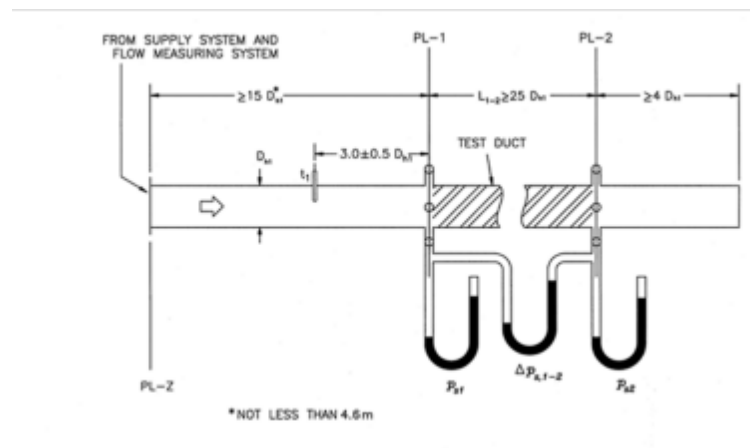


Figure 1. Straight Duct Test Apparatus (ASHRAE Standard 120)

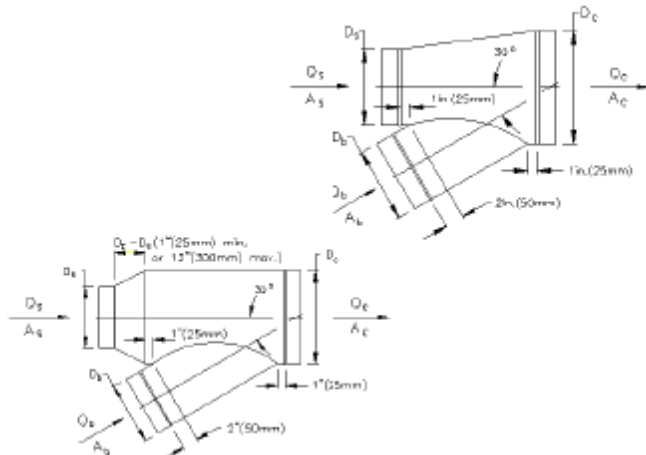


Figure 2. ED5-1 Wye, 30 Degree, Converging (ASHRAE DFDB)

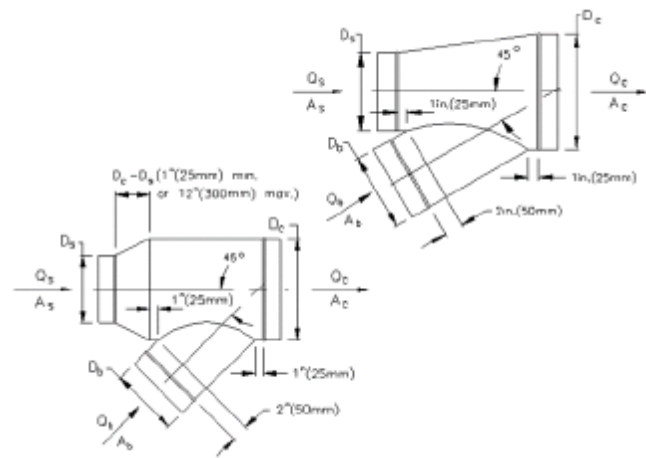


Figure 3. ED5-2 Wye, 45 Degree, Converging (ASHRAE DFDB)

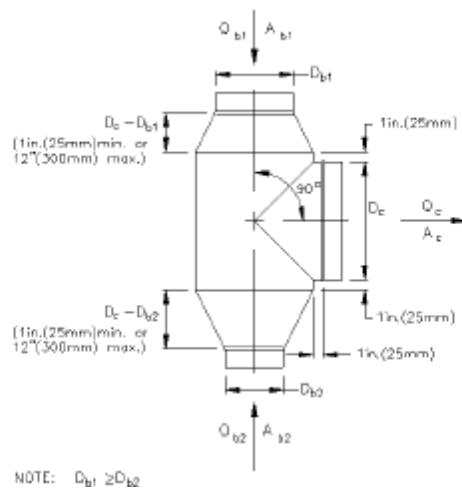
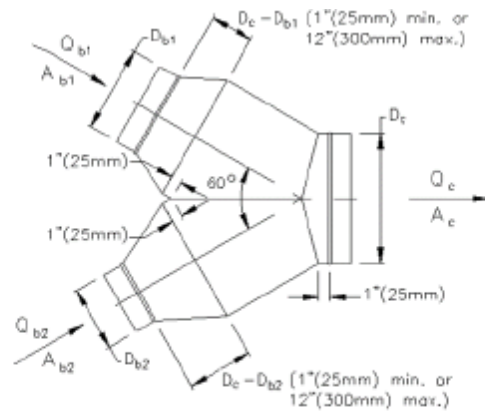


Figure 4. ED5-4 Bullhead Tee without Vanes, $D_{b1} \ge D_{b2}$, Converging (ASHRAE DFDB)



NOTE: $D_{b1} \geq D_{b2}$

Figure 5. ED5-9 Symmetrical Wye, 60 Degree, Db1 > or = Db2, Converging (ASHRAE DFDB)

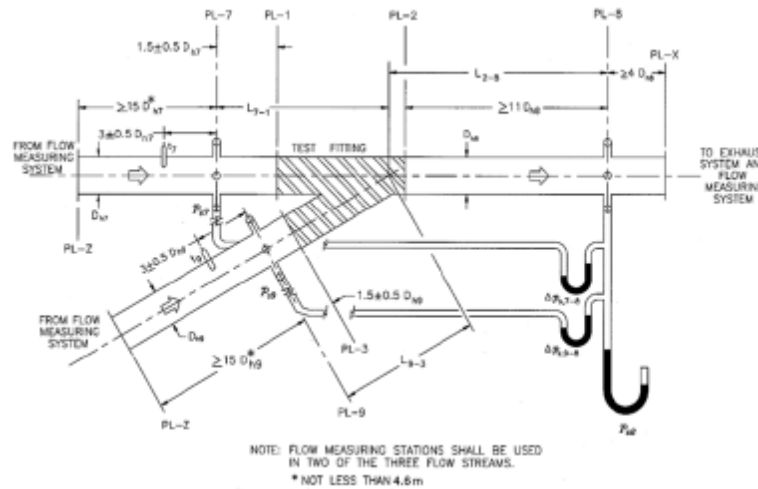


Figure 6. Divided Flow Fitting Test Apparatus (ASHRAE Standard 120)

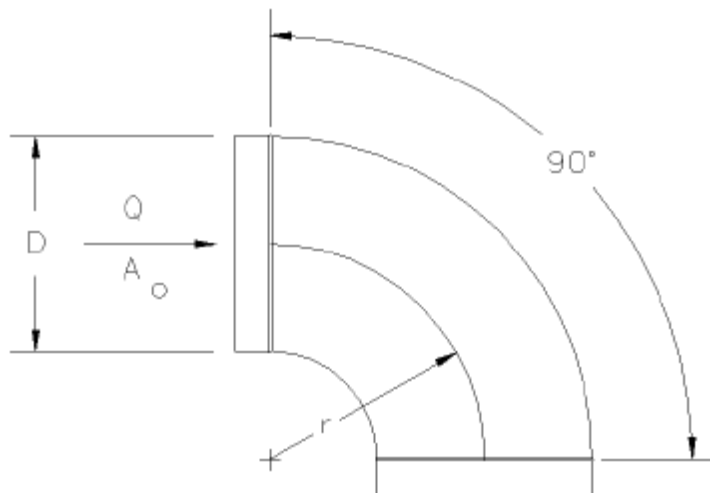


Figure 7. CD3-1 Elbow, Die Stamped, 90 Degree, $r/D = 1.5$ (ASHRAE DFDB)



Table 1. ED5-1 and ED5-2 Fittings to be Tested

Fitting Designation	Common Diameter mm (in.)	Straight Diameter mm (in.)	Branch Diameter mm (in.)		
ED5-1	305 (12)	305 (12)	152 (6)	203 (8)	254 (10)
	406 (16)	406 (16)	203 (8)	254 (10)	305 (12)
	610 (24)	406 (16)	203 (8)	305 (12)	406 (16)
	610 (24)	610 (24)	203 (8)	305 (12)	406 (16)
ED5-2	305 (12)	305 (12)	152 (6)	203 (8)	254 (10)
	406 (16)	406 (16)	203 (8)	254 (10)	305 (12)
	610 (24)	406 (16)	203 (8)	305 (12)	406 (16)
	610 (24)	610 (24)	203 (8)	305 (12)	406 (16)

Table 2. ED5-4 and ED5-9 Fittings to be Tested

Fitting Designation	Common/Straight Diameter mm (in.)	Branch Diameter Combinations mm (in.)	
ED5-4	305 (12)	203 (8)	203 (8)
		203 (8)	254 (10)
		254 (10)	254 (10)
	406 (16)	203 (8)	203 (8)
		203 (8)	254 (10)
		254 (10)	254 (10)
		254 (10)	305 (12)
		305 (12)	305 (12)
	610 (24)	203 (8)	203 (8)
		203 (8)	305 (12)
		203 (8)	406 (16)
		305 (12)	305 (12)
		305 (12)	406 (16)
		406 (16)	406 (16)
ED5-9	305 (12)	203 (8)	203 (8)

		203 (8)	254 (10)
		254 (10)	254 (10)
	406 (16)	203 (8)	203 (8)
		203 (8)	254 (10)
		254 (10)	254 (10)
		254 (10)	305 (12)
		305 (12)	305 (12)
	610 (24)	203 (8)	203 (8)
		203 (8)	305 (12)
		203 (8)	406 (16)
		305 (12)	305 (12)
		305 (12)	406 (16)
		406 (16)	406 (16)

Table 3. ED5-4 and ED5-9 Fittings to be Tested

Fitting Designation	Elbow Diameters mm (in.)		
	203 (8)	254 (10)	305 (12)
90° Die Stamped CD3-1	203 (8)	254 (10)	305 (12)
45° Die Stamped CD3-3	203 (8)	254 (10)	305 (12)

Table 4. Gored Elbows to be Tested (r/D = 1.5)

Fitting Designation	Elbow Diameters mm (in.)		
	203 (8)	406 (16)	610 (24)
90° 5-Gore CD3-9	203 (8)	406 (16)	610 (24)
60° 4-Gore ---	203 (8)	406 (16)	610 (24)
45° 3-Gore CD3-14	203 (8)	406 (16)	610 (24)
30° 2-Gore ---	203 (8)	406 (16)	610 (24)

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.

The following deliverables shall be provided to the Project Monitoring Subcommittee (PMS) as described in the Scope/Technical Approach section above, as they are available:

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. Unless otherwise specified, electronic copies of the final draft report shall be furnished 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.

a. Research Paper(s)

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 for publication in the Science and Technology for the Built Environment (STBE). The paper(s) shall conform to the instructions posted in “Manuscript Central” for Science and Technology for the Built Environment papers. The paper title shall contain the research project number at the end of the title in parentheses, e.g., (1941-RP). ASHRAE Conference papers are **not** acceptable as deliverables from ASHRAE research projects unless explicitly approved by a vote of the PMS and TC and communicated to MORTS. Conference paper(s) shall conform to the instructions posted in “Manuscript Central” for ASHRAE Conference papers and the title shall contain the research project number at the end of the title in parentheses, e.g., (1941-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 proposed test program will require that the contractor perform pressure loss testing of three cross sections of rectangular sheet metal ducts. In addition, the fitting tests will necessitate pressure loss testing of an additional six diameters of round sheet metal ducts, to account for the tare pressure. The projected divided flow fitting test regime entails 52 distinct configurations, whereas the suite of planned elbow tests implies 18 separate designs. The contractor chosen for this project shall confirm that all pressure loss testing and data reduction will be performed strictly in accordance with ASHRAE Standard 120. Intermediate milestone reports will be presented to the Project Monitoring Subcommittee (PMS). Testing shall not proceed to the next phase of the project until the contractor has demonstrated that strict compliance with ASHRAE Standard 120 was maintained. A summary Final Report will be prepared and submitted to the PMS by the end of the contract period. The resulting data will be presented to the PMS in a manner that is suitable for inclusion in the DFDB.

The project anticipates four professional months for the principal investigators. The project duration will be 24 months, and the expected total cost is \$180,000. This assumes the monthly cost for the principal investigators shall be approximately \$10,000, for a total of \$40,000 for the duration of the project. Likewise, this supposes a monthly cost of \$2,500 for each of the two research technicians and/or graduate students, for a total cost of \$60,000 throughout the project. The remainder of the total cost will be accounted for by necessary overhead expenses. This total price corresponds to approximately \$2,275 per test setup. SPIDA has graciously agreed to provide the ducts, fittings, couplings, and appurtenances needed to construct the test setups, so the contractor need not factor those costs into their proposal. That contribution has an estimated value of \$36,000. Separate from the material donation, SPIDA has agreed to provide an additional \$10,000 in co-funding to support the project.

Proposal Evaluation Criteria:

No.	Proposal Review Criterion	Weighting Factor
1.	Contractor's understanding of Work Statement	15%
2.	Quality of methodology proposed for conducting research	15%
3.	Contractor's capability in terms of facilities	20%
4.	Qualification of personnel for this project	15%
5.	Student involvement	5%
6.	Probability of contractor's research plan meeting objectives of the Work Statement	25%
7.	Performance of contractor on prior ASHRAE projects	5%

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1.	Procurement of all required ducts and fittings; submission of data reduction programs to PMS for their approval	1
2.	Completion of all straight duct testing and data reduction; submission of progress report	6
3.	Completion of divided flow fitting testing and data reduction; submission of progress report	15
4.	Completion of elbow testing and data reduction; submission of progress report	21
5.	Completion of summary final report and preparation of research papers	24

References

1. ASHRAE. 2017. ASHRAE Duct Fitting Database, v. 6.00.05. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
2. ASHRAE. 2017. ANSI/ASHRAE Standard 120-2017, Method of Testing to Determine Flow Resistance of HVAC Ducts and Fittings. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
3. ASHRAE. 2021. Behls, H. Duct Systems Design Guide. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
4. ASHRAE. 2021. ASHRAE Research Strategic Plan. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

5. ASHRAE. 2021. Handbook of Fundamentals, Chapter 21 (Duct Design). Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
6. Griggs, E. I., and Khodabakhsh-Sharifabad, F. 1992. Flow Characteristics in Rectangular Ducts. ASHRAE Transactions, 98(1):116-127.
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8. Kulkarni, D. and Idem, S. 2017. Energy Balance Analysis of HVAC Divided Flow Fittings. Science and Technology for the Built Environment, 23(1):218-225.
9. Liu, W., Z. Long and Q. Chen. 2012. A Procedure for Predicting Pressure Loss Coefficients of Duct Fittings Using Computational Fluid Dynamics, HVAC&R Research, 18(6):1168-1181.
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12. Sepsy, C.F. and Pies, D.B. 1973. "An Experimental Study of the Pressure Losses in Converging Flow Fittings Used in Exhaust Systems." Prepared by Ohio State University for the National Institute for Occupational Safety and Health, Document PB-221-130.
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14. UMC. 1985. Converging flow fitting test program. Laboratory Report No. SRF785E, United McGill Corp., Westerville, OH.