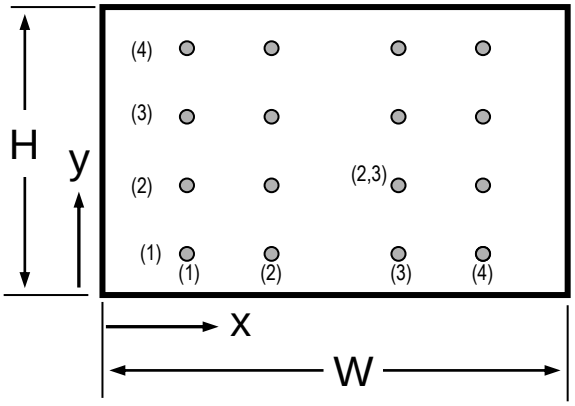
Centroids of Equal Areas: Where Are Those Points?

The most commonly used point location method for pipe or duct surveys to estimate flow rate is the Centroids of Equal Areas. For rectangular ducts, this approach distributes the points at the centroid of equal area sub divided rectangles. Generally, to determine the point locations, reference tables are consulted. However, if a greater number of points are required, the formula used to determine the point locations is given by:



$$x_i = \frac{W}{N}(i - 0.5) \quad \text{where i: 1}\rightarrow\text{N}$$

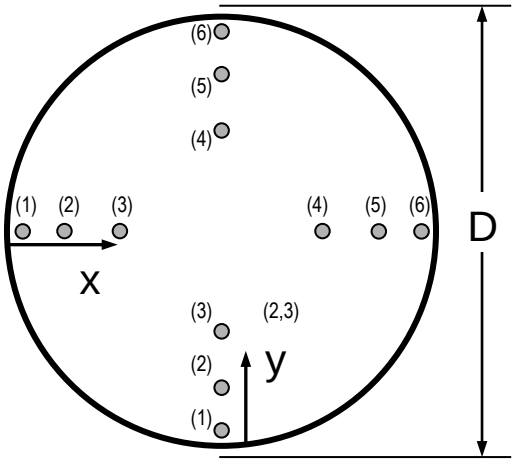
W is the duct width, N is the number of points along the row, and i is the location of the measurement point (1→4 as shown).

Similarly, for the y location points

$$y_i = \frac{H}{N}(i - 0.5) \quad \text{where i: 1}\rightarrow\text{N}$$

H is the duct height, N is the number of points along the row, and i is the location of the measurement point.

For circular ducts, the points are located at the radii of odd numbered rings of equal area, where the number of rings is determined by the desired number of points. For a two row survey, the point locations can be determined using:



$$x_i = \frac{D}{2} - D\sqrt{\frac{N - 2i + 1}{4N}} \quad \text{for i: 1} \rightarrow \text{N/2 and}$$

$$x_i = \frac{D}{2} + D\sqrt{\frac{2i - N - 1}{4N}} \quad \text{for i: N/2+1} \rightarrow \text{N}$$

where D is the duct diameter, N is an even number of points along the diameter, and i is the location of the measurement point (N=6 as shown on the figure).

Commonly used tables for rectangular and circular ducts are given below:

Rectangular Ducts – Centroids of Equal Areas							
Points	**Distance from wall, x/W or y/H**						
4	0.125	0.375	0.625	0.875			
5	0.100	0.300	0.500	0.700	0.900		
6	0.083	0.250	0.417	0.583	0.750	0.917	
7	0.071	0.214	0.357	0.500	0.643	0.786	0.929

Circular ducts – Centroids of Equal Areas												
Points	**Distance from wall, x/D or y/D**											
6	0.043	0.147	0.296	0.704	0.853	0.957						
8	0.032	0.105	0.194	0.323	0.677	0.806	0.895	0.968				
10	0.026	0.082	0.146	0.226	0.342	0.658	0.774	0.854	0.918	0.974		
12	0.021	0.067	0.118	0.177	0.250	0.356	0.644	0.750	0.823	0.882	0.933	0.979

The number of points to use in a survey is dictated by the duct size as well as the location of the measurement station from disturbances. Suggested locations are given in the ASHRAE Handbook, AMCA publication 203 and Code of Federal Regulations, 40 CFR 60, Append. A. A summary of results is given in the Table below.

Shape of Duct	ASHRAE	40 CFR 60
Circular	6 to 15 points per diameter (two perpendicular traverse rows)	4 to 8 points per diameter minimum (two perpendicular traverse rows). Required number reduces with distance from disturbance
Rectangular	25+ points. Should be no more then 6 inches apart	9 to 16 minimum. Required number reduces with distance from disturbance

References

1993 ASHRAE HANDBOOK
FUNDAMENTALS
I-P Edition
American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc.
1791 Tullie Circle, NE
Atlanta, GA 30329

AMCA
FIELD PERFORMANCE
MEASUREMENT OF FAN SYSTEMS
Publication 203
Air Movement and Control Association, Inc.
30 West University Drive
Arlington Heights, IL 60004-1893

CODE OF FEDERAL REGULATIONS
40 CFR 60, APPENDIX A
Method 1
Velocity Traverses for Stationary Sources
Method 2
Determination of Gas Velocity and Volumetric Flow Rate