Design of Flexible-duct Junction Boxes

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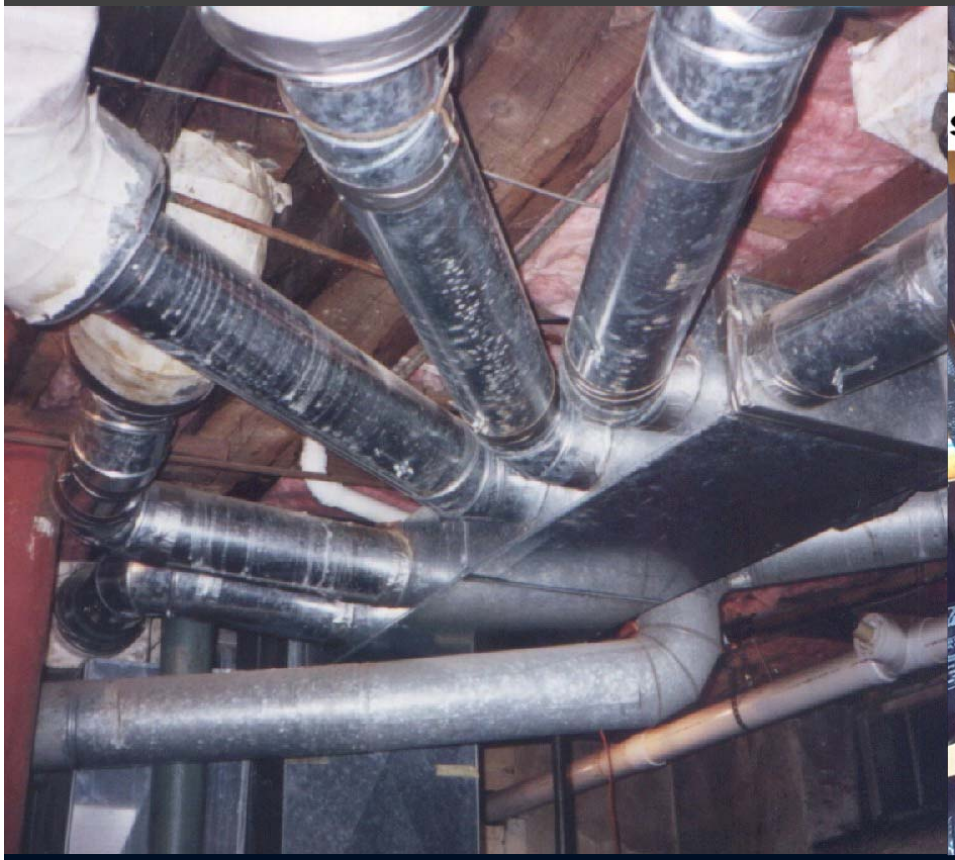
Presentation Outline

- Current Standards and Practice
- Analysis Methods
- Recommendations

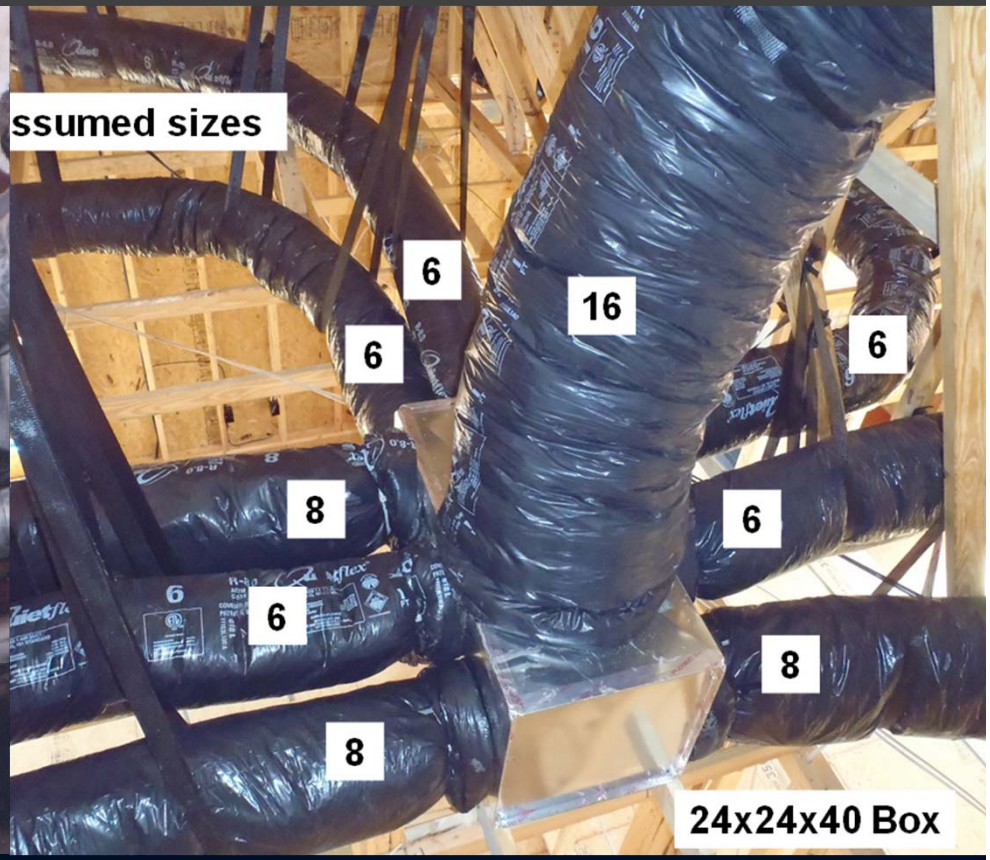
- Detailed report is in peer review anticipated to be published T3 this year.
  - http://www1.eere.energy.gov/library/default.aspx?page=2&spid=2.
- Measure guide to be part of Building America Solutions Center
  - http://basc.pnnl.gov/

Typical Installations

As Plenum



As Monster

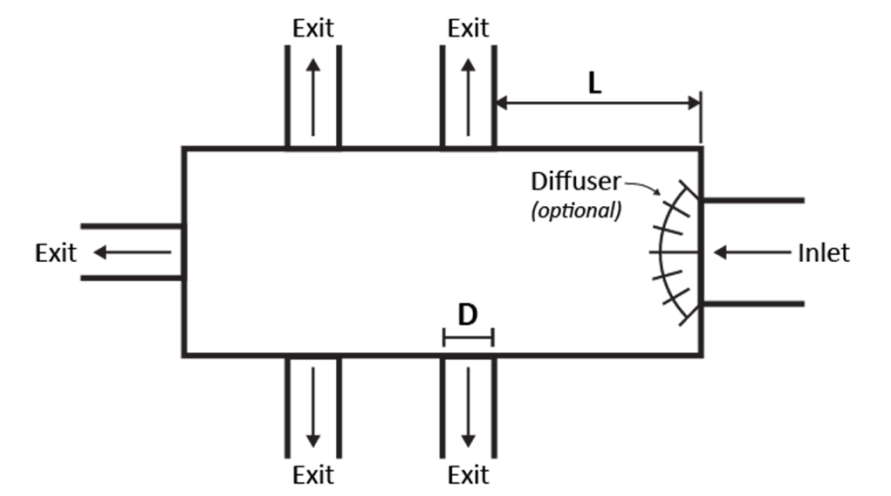


Current Standards

- ASHRAE 2012 HVAC Systems and Equipment, *Box Plenum Systems Using Flexible Duct*
  - Constrains Box Width to 2-3x Entrance Width
  - Constrains Box Length to 2 x Box Width
  - Flat Pressure Loss = 0.05 in. of water (50 ft of EL)
  - Mentions Entrance Fitting
- ACCA Manual D, Residential Duct Systems (2009)
  - Residential Industry Standard for Sizing Ducts (if done at all)
  - *Group 11, Flex-duct Junction Boxes and Radius Bends*
- Gilman reference – 1951 etc. U of I bulletin (*https://www.ideals.illinois.edu/handle/2142/4424*)

ACCA Manual D, Group 11 Fittings

- Recommendations:
  - Entrance has a diffuse fitting that recovers velocity pressures and prevents swirl (optional)
  - Straight approach and straight exit
  - Exit opening on side (no top or bottom exits)
  - Exit opening at least two diameters from entrance (L)
  - Make box as small as possible, but comply with
  - L = 2 x D



Velocity In Flex Duct (fpm)	Equivalent Length (ft)
400	20
500	30
600	40
700	60
800	75
900	95

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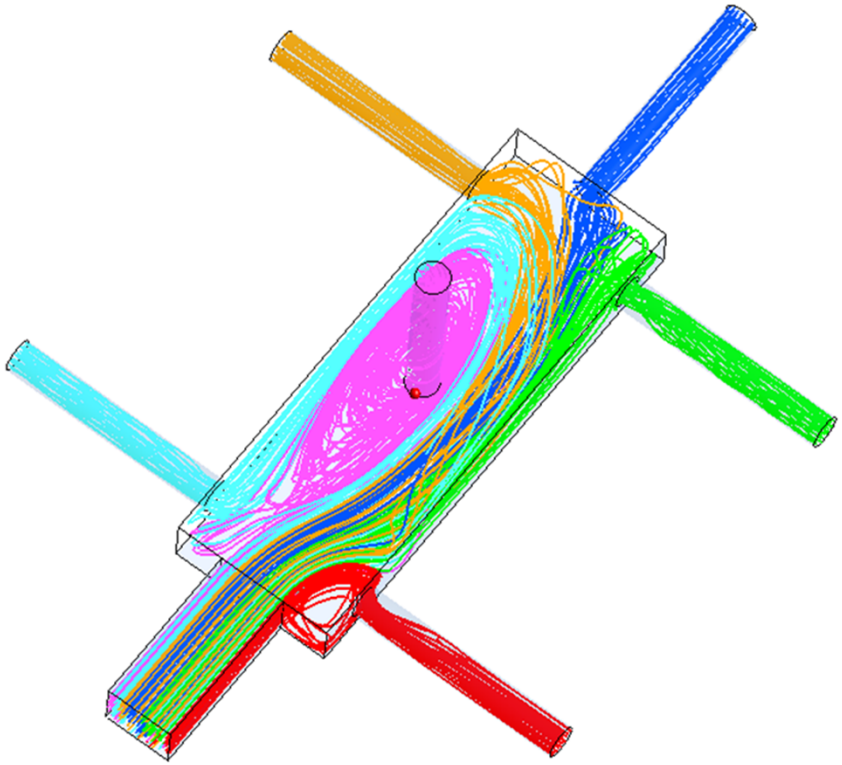
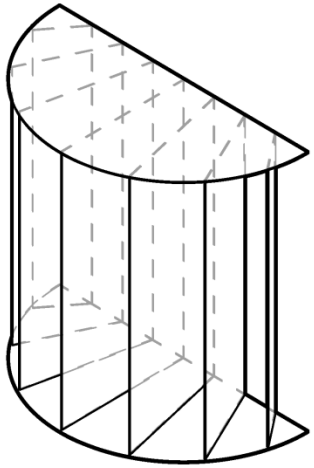
University of Illinois: Gilman Study

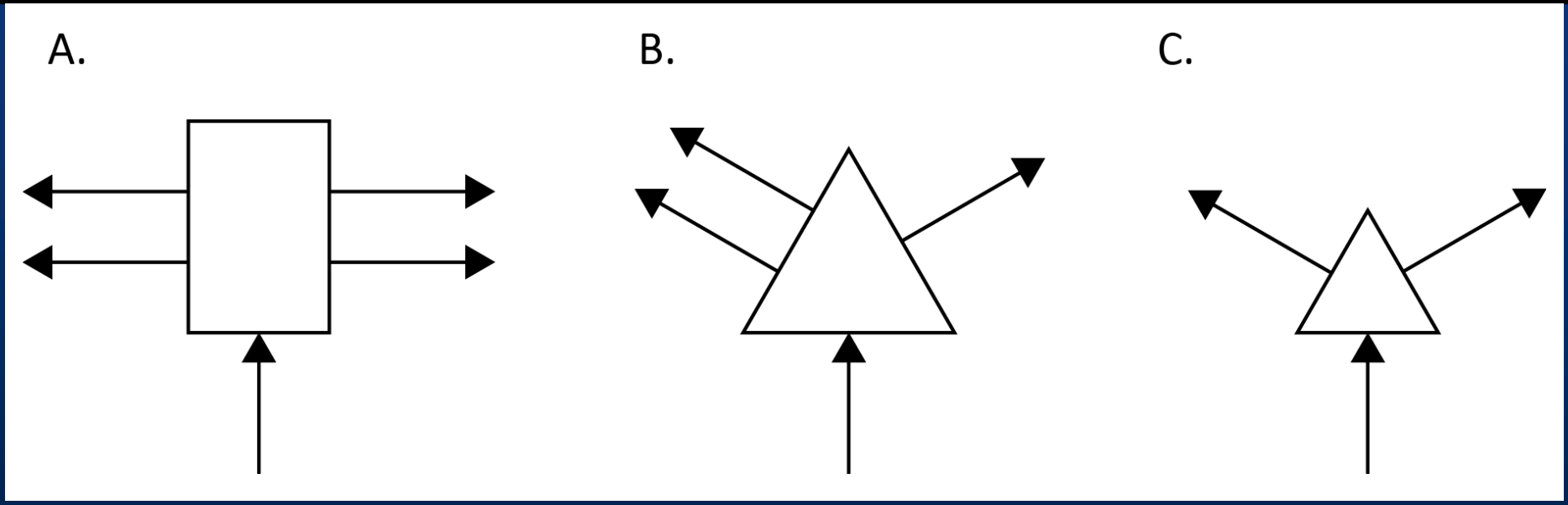
Flow Instability



Entrance Diffuser

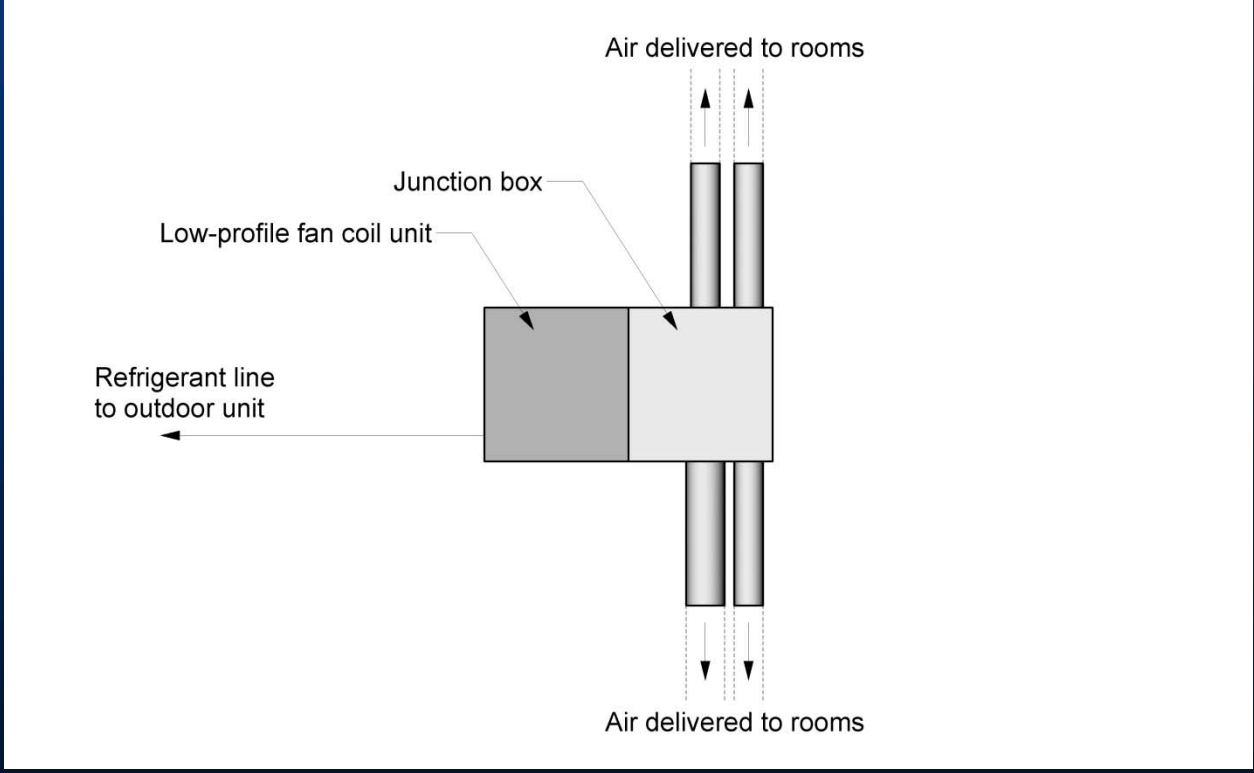


What did we look at?



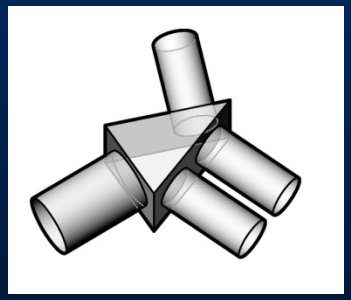
- Three configurations to limit variation
  - 2, 3 or 4 outlets
  - Outlets with 10, 150 or 250 cfm
  - Ducts Sized to 0.08 IWC / 100 ft design friction rate

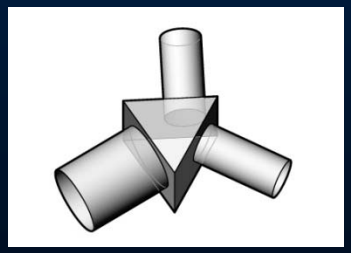
Small fan coil applications



What did we look at?

- We simulated using CFD over 50 configurations in 7 different sets.





Set	Name
1	Four Outlets with an Entrance Diffuser
2	Four Outlets, Equal Flows
3	Four Outlets, Unequal Flows
4	Four Outlets, Equal Flows, High Velocities
5	Three Outlets, Unequal Flows, Equilateral Triangle Box
6	Three Outlets, Unequal Flows, Isosceles Triangle Box
7	Two Outlets, Unequal Flows, Equilateral Triangle Box

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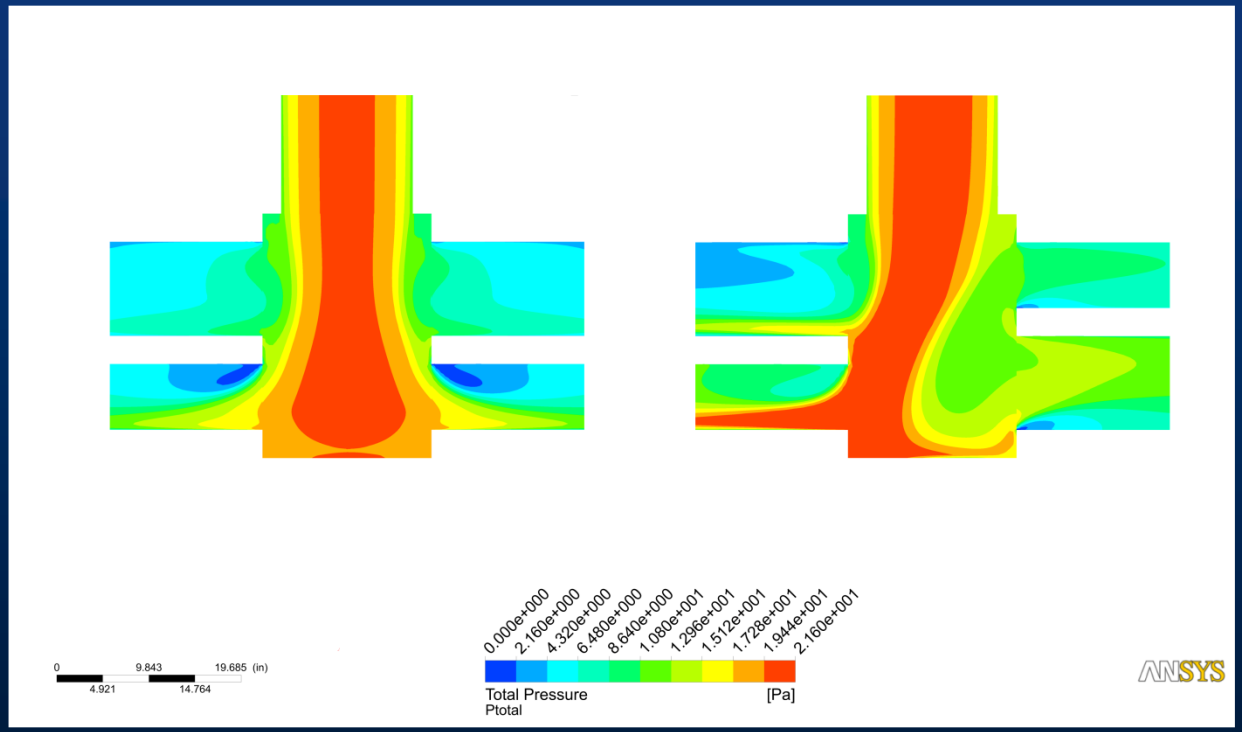
Analysis Method

- Computational Fluid Dynamics (CFD)
  - Potential alternative to physical testing
  - Used to determine pressure loss of box configurations
  - Calculates pressures within system consisting of Inlet Duct, Junction Box and Outlet Ducts
  - Designs were reconfigured and measured to determine variations in pressure due to changes in configuration.



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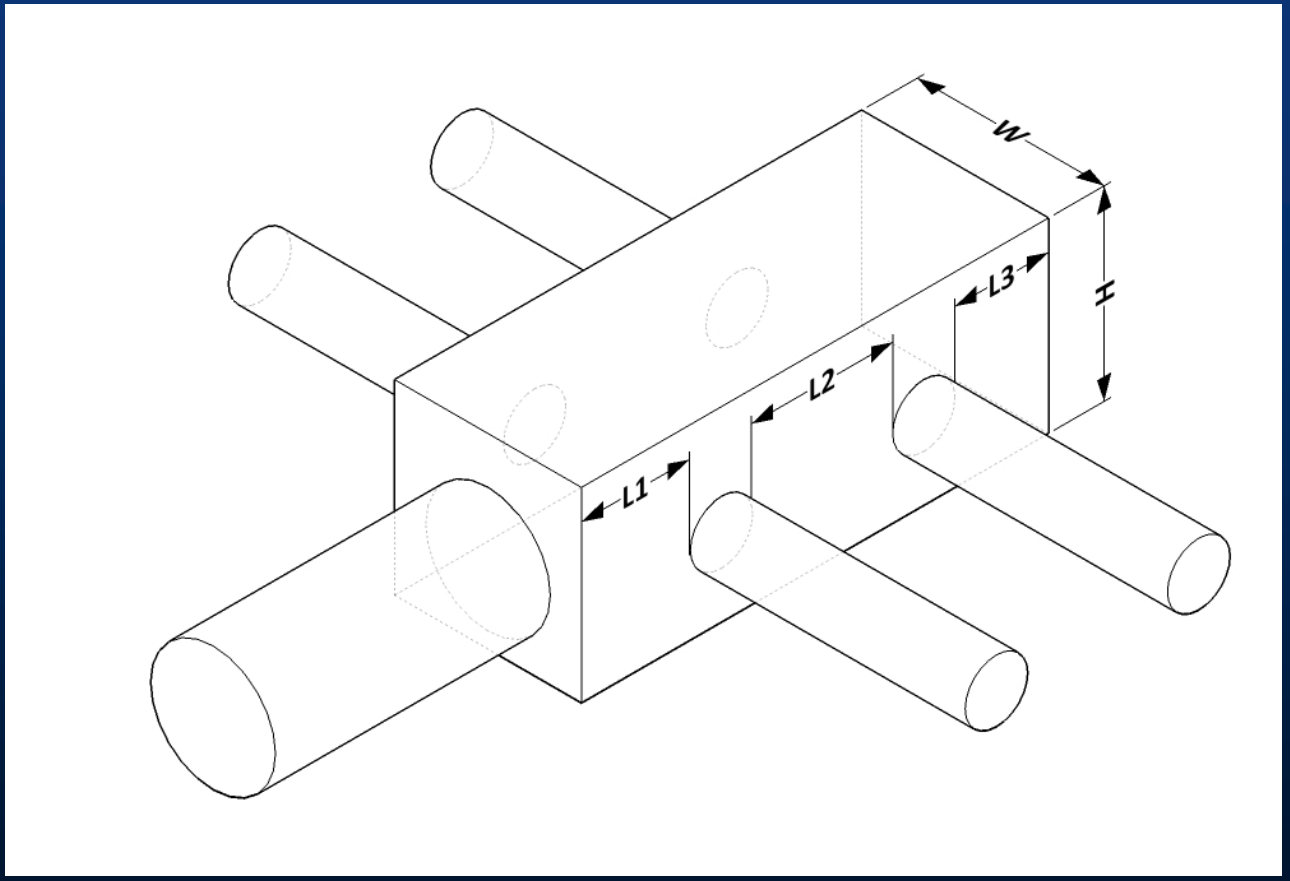
Typical Simulation Configuration

- For each individual configuration
- Induced flow into inlet
- Noted unbalanced flows out of each outlet
- Balancing resistance was added to match intended flows.



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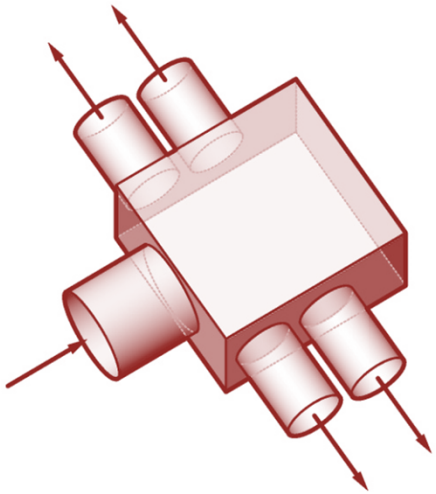
Conclusions

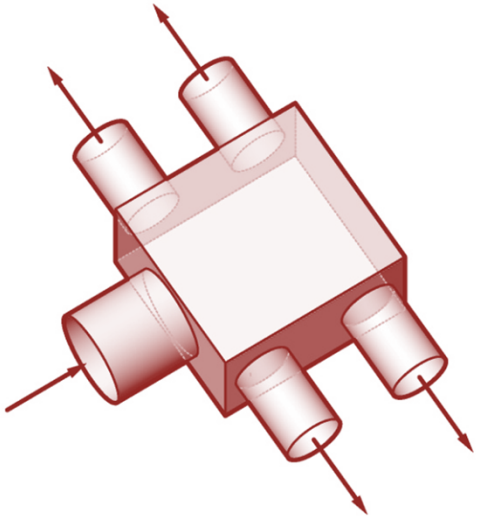
- Designers must recognize that junction boxes are cost effective but add more pressure to systems compared to trunk and branch designs.

- Pressures varied significantly with size of box, relative positions of outlets, air velocity and volumetric flow rate, friction rate of ducts, the number of outlets.

Recommendations



No space
between inlet and outlet



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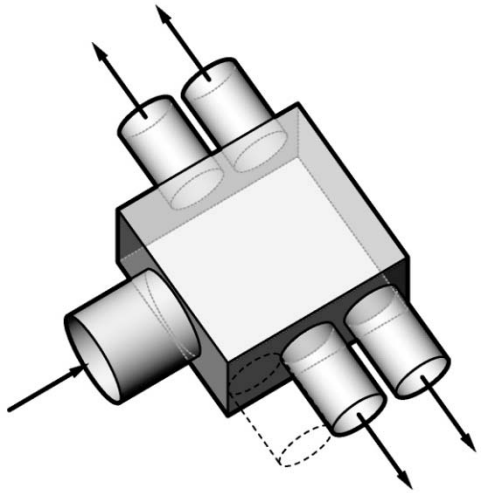
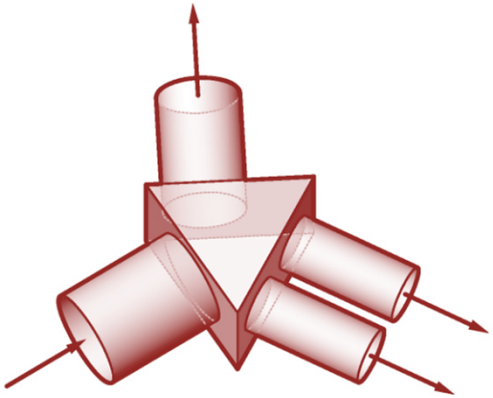
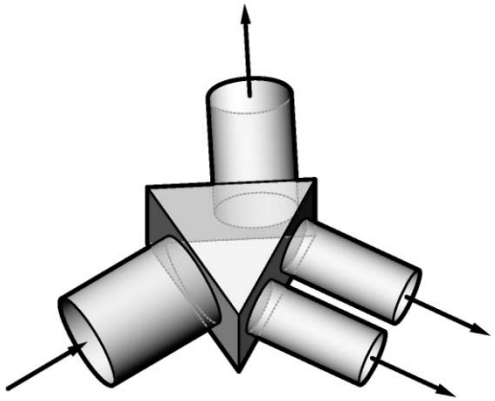


One outlet diameter
between inlet and outlet

Recommendations

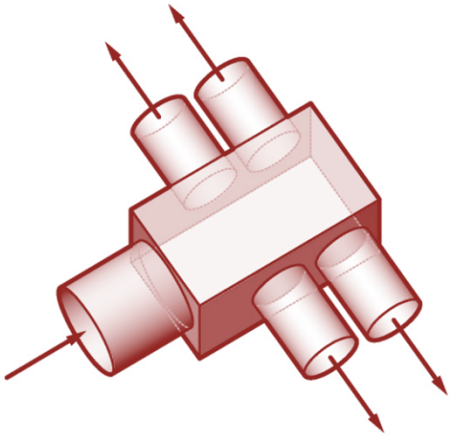


Outlet at front

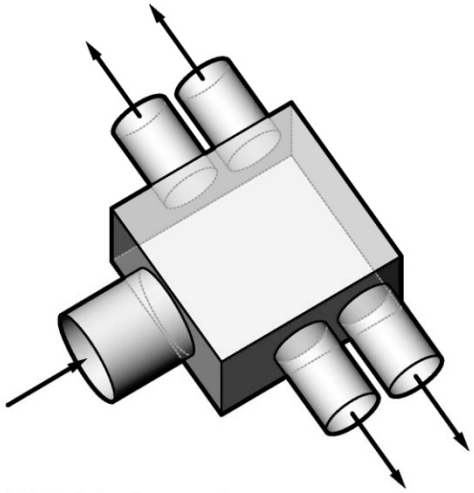


Outlet at back

Recommendations

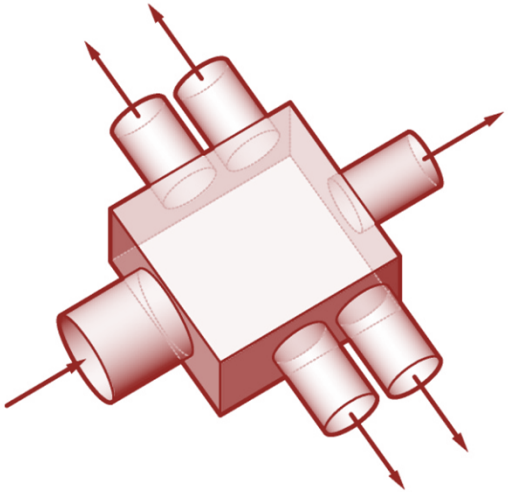


Width slightly larger
than inlet

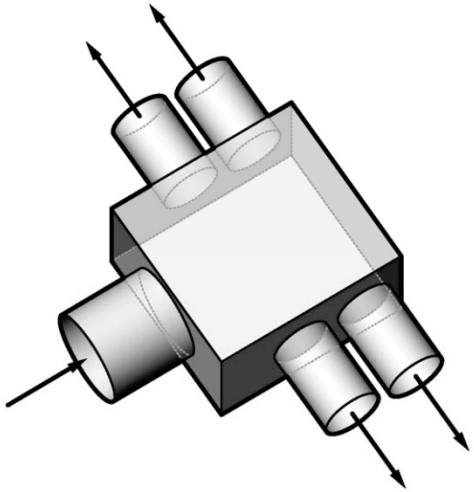


Width is twice
the inlet diameter

Recommendations

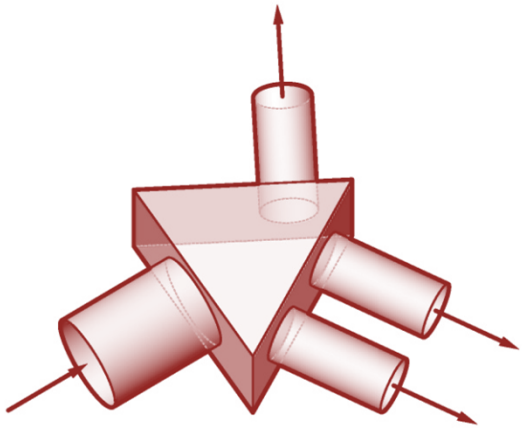


Outlet opposite the inlet

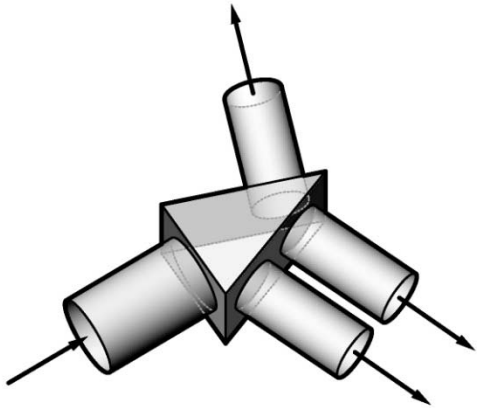


Outlets only on sides

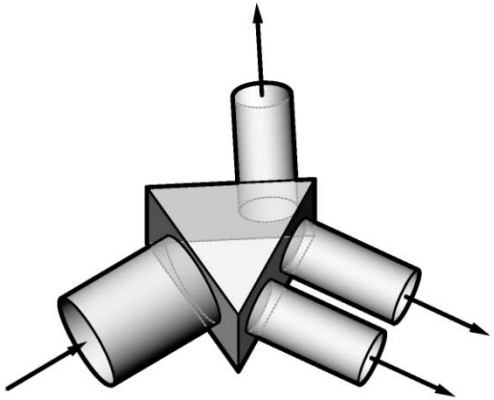
Recommendations



Larger Box

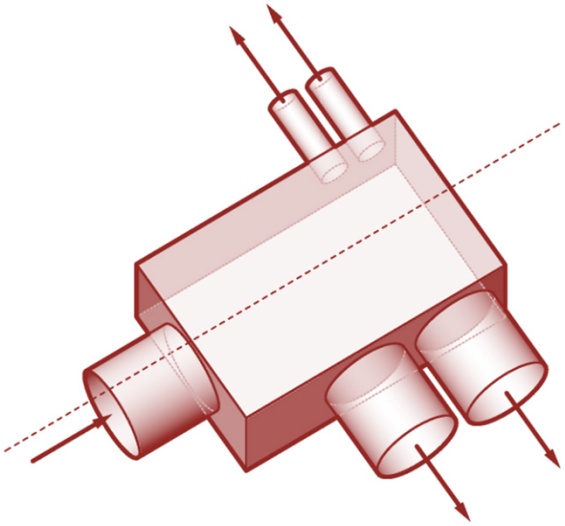


Minimal Box

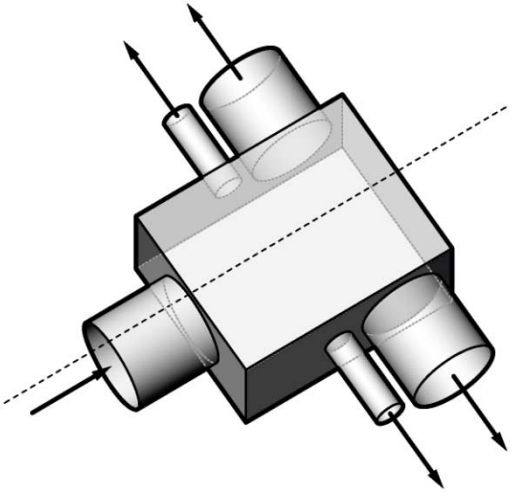


Wider Box

Recommendations

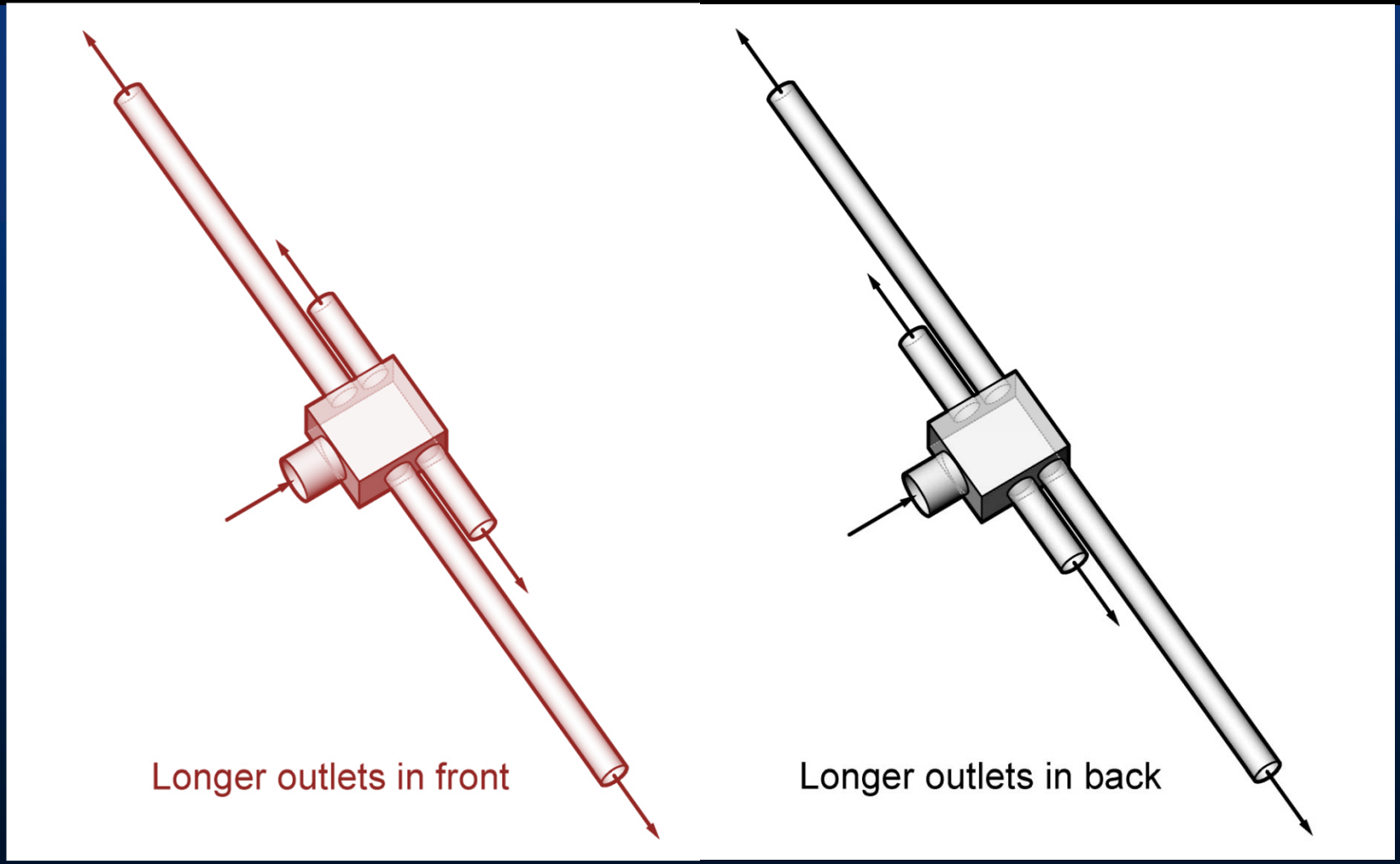


Assymmetrical
Flow Left < Flow Right

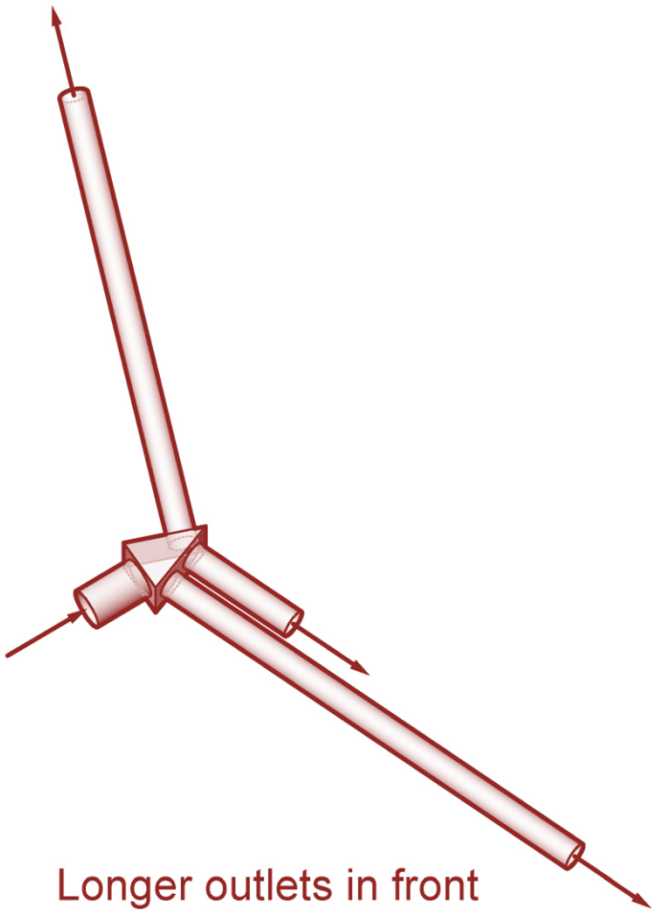


Symmetrical
Flow Left = Flow Right

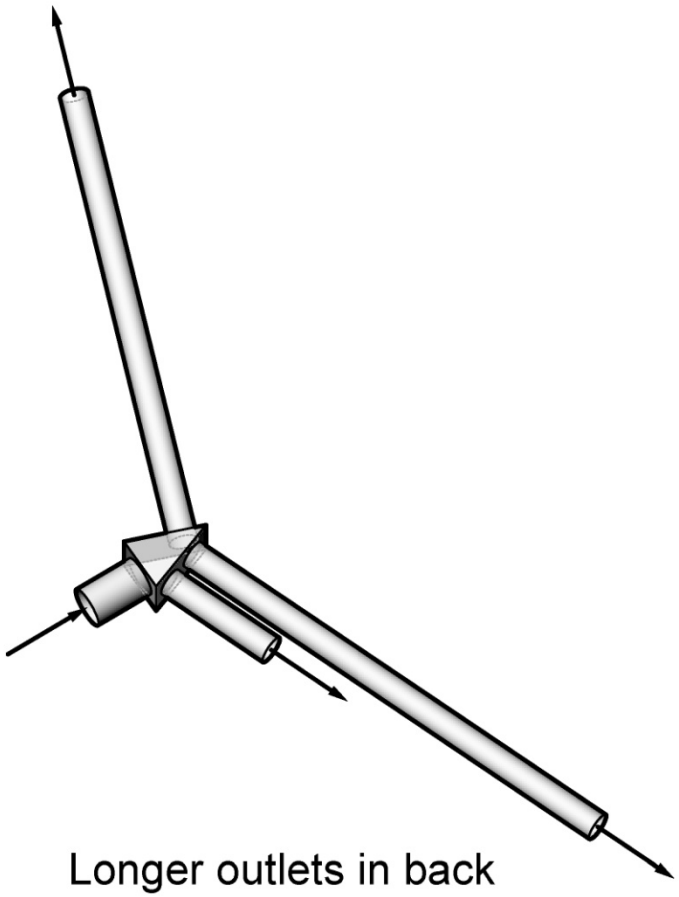
Recommendations



Recommendations

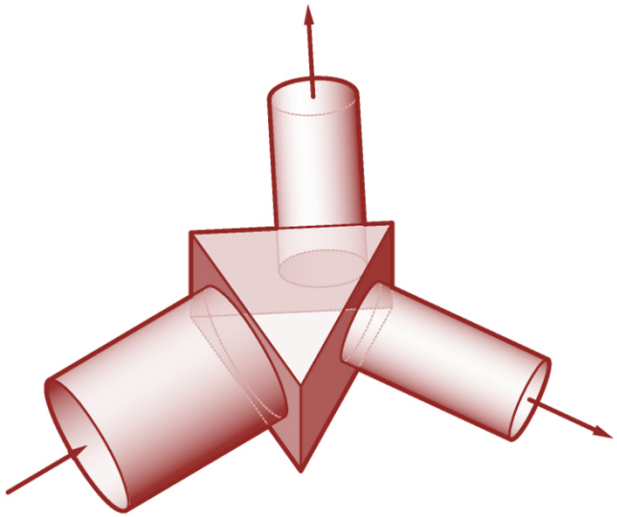


Longer outlets in front

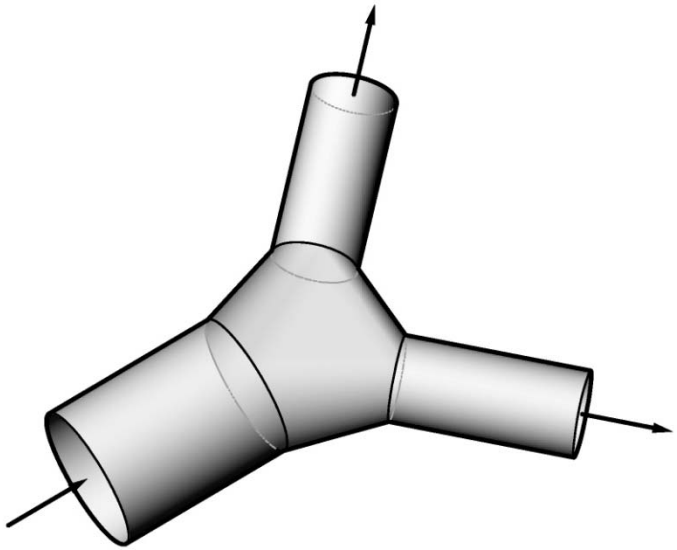


Longer outlets in back

Recommendations



2-outlet junction box



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Balancing Losses

- ACCA indicates a flat 0.03 IWC for each damper
- Balancing dampers are necessary due to uncontrolled factors at installation.

- Our maximum calculated balanced condition received only 0.016 IWC, most did not require balancing.

- In symmetrical cases 0.03 is highly conservative

Low Flow Cases

- Balancing losses generally increased with flow rate
- In low flow configurations (10 cfm outlet flows) balancing was greatly reduced. (most unbalanced flows were within 10% of targets)

Questions?

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