DCC Draw-Through Wind Tunnel

DESIGN CENTER COLORADO

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Background & Motivation

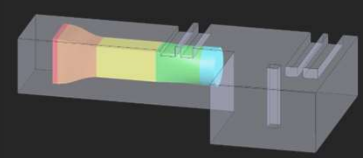
- No wind tunnels larger than 1'x1' currently accessible for undergraduate use at CU
- Provides accessible test environment for CU's Collegiate Wind Competition (CWC) Team and Mechanical Engineering students
- Designed for near laminar flow and adjustable flow velocity.
- Foster academic growth by offering hands on experience in aerodynamics, fluids, and renewable energy.

Requirements

- Near laminar flow though test section
- 4' tall x 4' wide x 8' long test section
- 16 – 36 ft/s flow velocity
- Velocity output precision within ± 3ft/s
- CWC turbine compliant mount
- Universal mounting system
- User-friendly controls and means of data output
- Meets noise and egress safety requirements: OSHA 1910.95 and OSHA 1910.36

Challenges

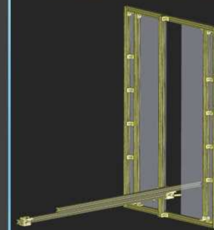
- Manufacture of contraction cone and diffuser
- Installation into MBE Room 52
  - Room Height = 7ft
  - Room Length = 43.5ft
  - Modular design to accommodate moving components through standard single 34" door



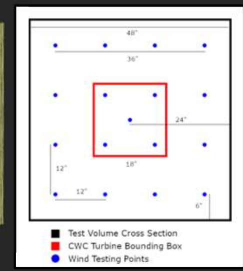
Model of Room 52

Calibration & Testing

- Calibration setup fits into existing door openings in test section.
  - Gantry system allows for x and z translation
  - 0.25" step size allows for development of complete cross-sectional flow profiles
- A 17-point profile will be created for 6 speeds.
- Speeds range from 16-36 fps in 4 fps increments.
- Turbulence intensity is calculated using the population mean and data collected.

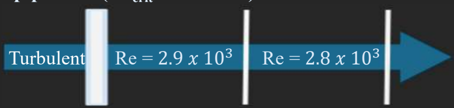


Calibration Gantry



Settlement Chamber

Straightens turbulent air into laminar flow. Designed to target critical Reynolds number for pipe flow ($Re_{crit} = 2.3 \times 10^3$)

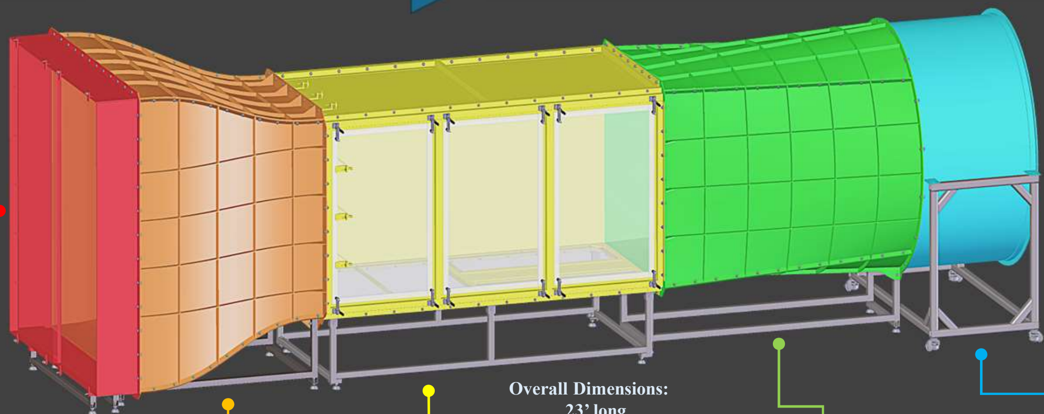


Honeycomb
- 9mm cell, ω_{cell}
- 96.7 % Porosity, β_h
- 2.12" Length, L_h

Screen(s)
- 0.25" cell
- 82.1% Porosity, β_s

$$6 \le \frac{L_h}{\omega_{cell}} \le 8 \qquad \beta = \frac{A_{flow}}{A_{total}} > 80\%$$

DIRECTION OF FLOW

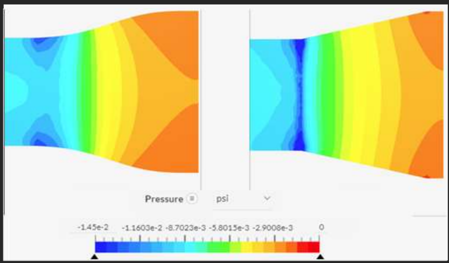


Overall Dimensions:
23' long
7' tall
6' wide

Contraction Cone

Increases flow velocity via decrease in cross-sectional area and maintains laminarity of flow.

- 4ct. Aluminum rib & lattice panels
- Smooth 5th-degree polynomial curve minimizes boundary layer separation at inlet and outlet
  - Industry standard for low-speed wind tunnels.
- 6' x 6' inlet (maximum size given 7' roof height in MBE Rm. 52.)
- 4' x 4' outlet to match test section.



Comparison of 5th order polynomial (left) vs. linear (right) profile pressure gradient

Test Section

Portion where flow is constant, and objects are tested.

- 4' x 4' cross section, 8' length
- 4ct. Welded steel frame pieces to fit size constraints.
- Smooth interior minimizes turbulent boundary layer growth.
  - ≈ 2-inch boundary layer growth across length
- Pitot tube array at inlet to measure flow rate through test section.
  - 9 pitot tubes mechanically average via manifold.
- 3 removable polycarbonate doors for access to interior.
- CWC spec turbine mount and t-slot rails for test object mounting options
- Wire mesh debris filter at outlet.

Diffuser

Minimize pressure drop across fan and slowing the flow's velocity.

- 5° conical angle, 6' length – Reduces pressure drop
- 4ct. Aluminum straight-to-circular rib & lattice panels
- Reduces work done by fan by raising pressure back towards atmospheric pressure.

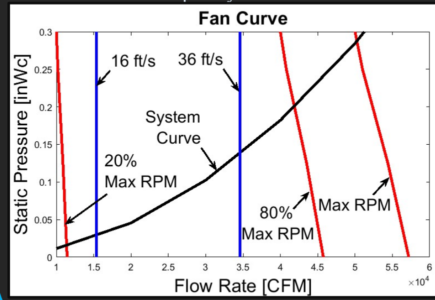
$$v_e = \arctan\left(\frac{1}{2} * \frac{\sqrt{A_r - 1}}{\frac{L}{D_{h1}}}\right)$$

$$A_r = \frac{A_{outlet}}{A_{inlet}} < 2.5$$

Fan & Controls

Draws air through the tunnel.

- System Curve – The amount of pressure needed to move air through the tunnel.
- 60" Diameter - CSA ≥ Test Section CSA
- 10 HP – 3-Phase – 480V
- 57200 CFM – 880 RPM
- Turn down 1/6th Max RPM
- Custom Fan Casing Width – 33"
- Variable Frequency Drive Controller
  - User friendly
  - Adjustable in .1 Hz (1.45 RPM) increments
  - Emergency stop switch
  - Resonant frequency lockouts



Target Flow Rate Within 20%-80% Power

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