

# Air Noise Silencers, Mufflers & Lagging

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## Modification of fluid flow noise in pipes

- Source: turbulence of high velocity fluid
  - Noise passes thru walls
  - Vibration by pipe of adjacent structures sets up noise
- Reduce flow velocity
  - Liquid: less than 30 fps (180 ft/min)
  - Gases: less than  $100 \times (\text{specific volume})^{0.5}$   
(specific volume =  $1/\text{density}$ )
- “Streamline” flow
  - No hard turns
  - No sharp edges

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## High-Velocity Airflow Noise

- From air valves, solenoids, air cylinders
- Used to actuate or move components within a machine and to blow off debris or eject finished parts
- Sound intensity prop to 8<sup>th</sup> power of velocity (class should verify)
- Solutions
  - Reduce flow speeds (i.e., reduce pressures)
  - Avoid sharp edges

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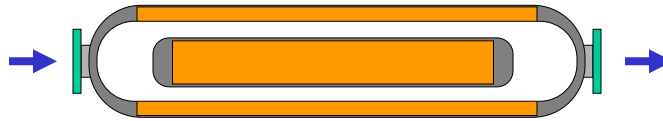
## Silencers

- Inserted in flowing medium (usually air) to reduce downstream sound level
- Necessary when cannot reduce flow
- Different names for silencers
  - Mufflers: internal combustion engines
  - Attenuators: hi-pressure gas systems
  - HVAC: sound traps, “plenum chambers”, baffles
- Types
  - Dissipative
  - Reactive

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## Dissipative Silencers

- Porous sound-absorbing materials surrounding the primary air passage
- Absorbs sound
- Often little change in direction for air
- Modest pressure drop
- Reduces wide range of frequencies, but primarily middle to high



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## Dissipative Silencers-- continued

- May require protective facing
  - May be need to:
    - Prevent fibers (especially fiberglass) from detaching and moving downstream
    - Reduce effects of abrasive or solvent contaminants
    - Hold shape (e.g., perforated metal holding fiberglass in place)
  - Get less noise reduction
    - Mylar and Tedlar affect high frequency absorption little
  - Perforated metal
    - Protects against moisture and oil, to a degree
    - Can become plugged, itself, if concentration is high
- All should be routinely inspected and replaced, if necessary

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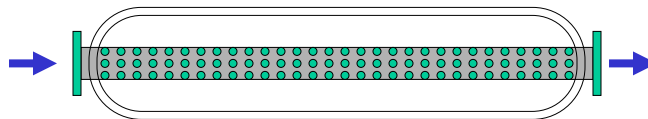
## Dissipative Silencers-- continued

- Often used with multiple elements or baffles mounted parallel to each other

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## Reactive Silencer

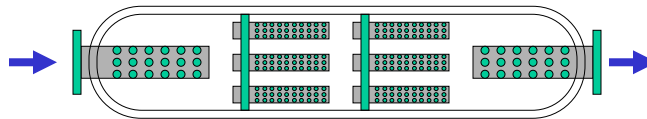
- Sound reflections and cross-sectional area changes reduces noise
- Sound waves expanding through inner perforated area reflect off the outer reflective shell and interfere with incoming waves
- Components
  - Multiple expansion chambers
  - Side-branch resonators or tuned resonators for narrow band of low frequencies
  - Inlet pipe perforated with many small holes
  - Bends used to allow long flow path over compact length



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## Reactive Silencer -- continued

- May have more SP drop than some dissipative
- More effective for low-frequency noise
- Since no delicate absorbing material, can be used for harsh temperatures, corrosion, etc.
- Type below has larger SP than straight through



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## Silencers -- continued

- Can add absorber to reactive to get both low frequency and high frequency reductions
  - Often add fiberglass to outer shell
  - Now have fragility of absorber to consider
- Selecting silencers; consider:
  - Acoustical performance requirements
    - Need at least octave band quality of info
  - Aerodynamics of the flow
    - Minimize flow disturbances and back pressure
    - SP requirement usually increases with effectiveness
    - Reduction and SP will vary with velocity
  - Physical limitations of size and weight
  - Temperature and flow contaminants

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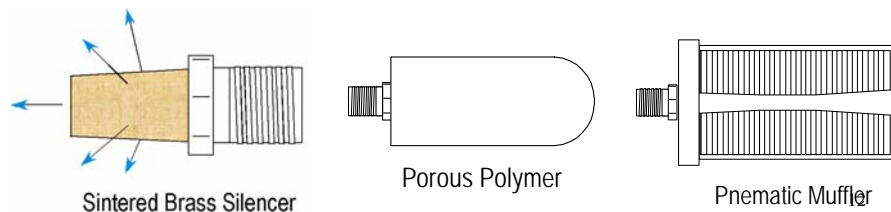
## Pneumatic and Compressed Air Systems

- High-velocity air important noise source
- Examples that simply exhaust air:
  - solenoid valves, air cylinders, air motors
  - one of simplest and easiest to control
- Reduce speed of exhaust air
  - If possible, simply reduce compressed air pressure (and therefore escape speed)
  - Otherwise, retrofit with diffuser silencer, which diffuses air over larger area to reduce speed

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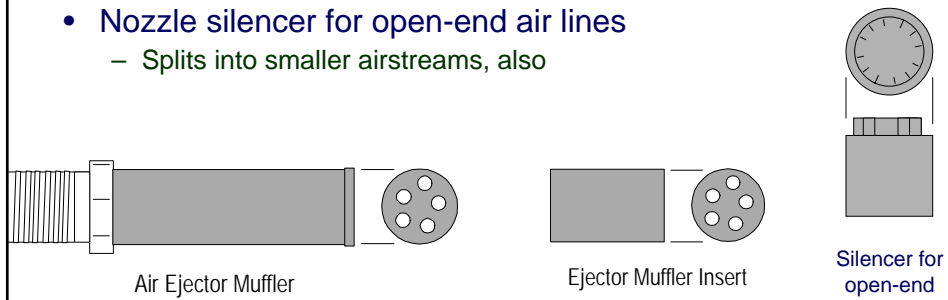
## Silencers

- Silencers
  - Sintered brass: high SP; can be washed out
  - Porous polymer: lower SP; can be washed out
  - Pneumatic muffler: (small pumps); porous composite; low SP



## Compressed Air Ejectors

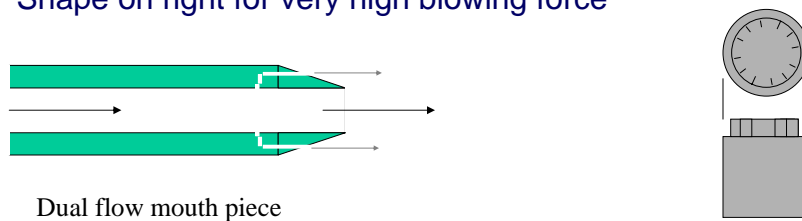
- Ejecting parts with high-speed air (compressed air jet)
- Often just use crimped tube to direct air
- Instead, should use ejector muffler
  - Divides air into several, smaller streams
  - Focused, conical airstream that can be shaped as needed
- Nozzle silencer for open-end air lines
  - Splits into smaller airstreams, also



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## Blowing Off

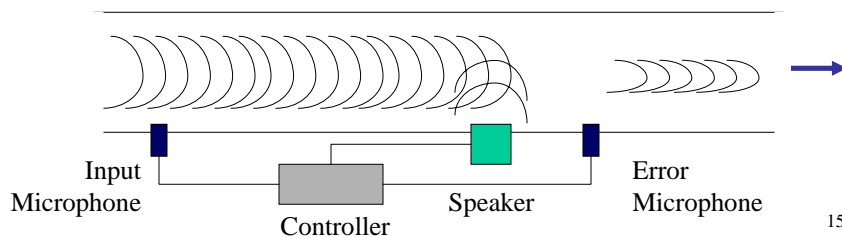
- Hollow tube with crimped end can be 90-115 dBA
  - High frequency noise
  - Louder with higher SP
- Instead, use dual flow mouth piece (on left) and lock pressure setting
- For line of compressed air, use slot shape
- Shape on right for very high blowing force



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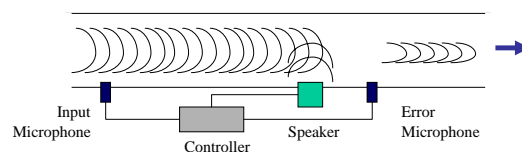
## Noise Cancellation

- Input microphone detects incoming sound wave and relays signal to controller
- Controller computes anti-noise signal needed
- Loudspeaker output timed to be 180° out of phase with noise
- Error microphone detects residual noise and relays to controller for adjustment to computations
- Effectively hunts down pure tones (20-30 dB drops)



## Sound Cancellation Limitations

- Does little for non-pure tones
- Cannot be highly 3D space
  - Limited to long narrow channels (pipes and ducts)
- Requires max cross-sectional dimension of pipe or duct to be small:
  - $\text{Max} < \lambda/4$
  - Therefore, usually works best for  $f < 500$  Hz  
Which is not all bad since absorbers work poorly at low freq.
- Best application: reduces community noise complaints from stack noise
- Expensive; need speakers and computer controller



# Pipe Lagging

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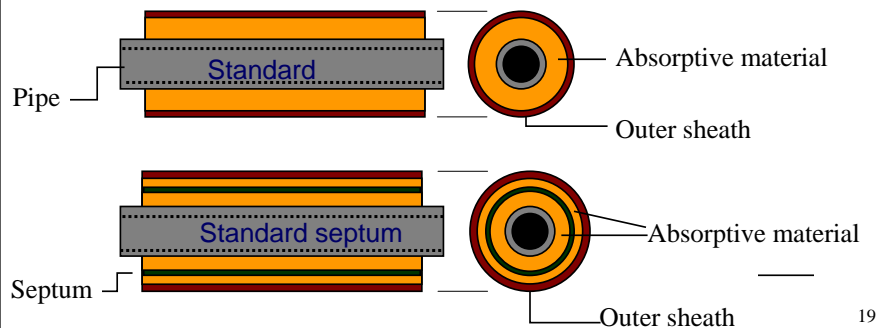
## Acoustical Pipe Lagging

- Pipe noise produced when:
  - Noise from the fluid in the pipe radiating noise thru the pipe wall or vibratory energy transferred to the pipe wall
  - Both result when vibratory energy transmitted by:
    - Operation of rotating equipment (pumps, fans, etc.)
    - Control valves
    - Excessive fluid velocity
    - Energy of transported solid particulates
- Most effective option when the pipe wall itself radiates dominant noise and inline silencer infeasible.

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## Acoustical Pipe Lagging – continued

- Wrap exterior surface of pipe with sound absorptive material (e.g., high density fiberglass)
- Cover absorptive material with high TL jacket.
- Two standard strategies:
  - Standard
  - Sandwiched septum layer:



## Configuration of Lagging

- Provide layer of resilient absorptive material between pipe surface and outer shell of treatment
- Avoid mechanical coupling between pipe surface and outer shell
- Seal all edges and joints airtight (0.1% opening can significantly reduce TL)
- Use special materials for high temperatures
- Avoid condensation for cold pipe
- For low-freq, thick layer of absorptive required (4-6 in.)

## Fabrication of Lagging

- For thin-shelled pipes (<1/4")
  - Apply layer of damping material directly to pipe to reduce resonant tones (thicker pipes eliminate resonant tones)
- Wrap pipe with absorptive material (Table 9.14)
- Encapsulate absorptive material with lightweight metal sheathing
- Compress acoustical material slightly
- Overlap outside shell edges and bond joints
- Fill in irregular cross-sections with loose acoustical material to form uniform outer surface

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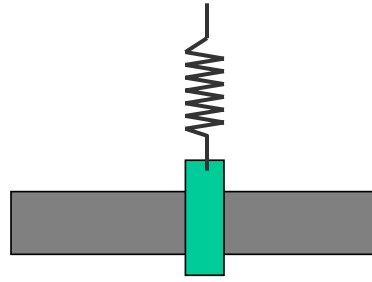
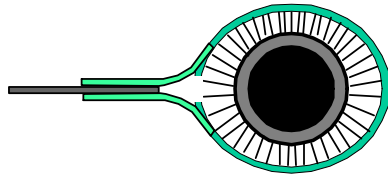
## Acoustical Pipe Lagging - Application

- For short pipe runs, lagging localized sections usually sufficient
- If most energy due to fluid, itself:
  - Can tell because noise does NOT drop across valves and other discontinuities
  - Inline silencer best
  - If silencer infeasible, must lag entire length of pipe
- If pipe wall has most of acoustical energy:
  - Can tell because noise DOES drop across valves, branches, etc.

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## Isolating Piping Vibration

- Isolate or absorb to avoid transferring vibration to brackets, pipe hangers
  - See Table 9.14



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# The End

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