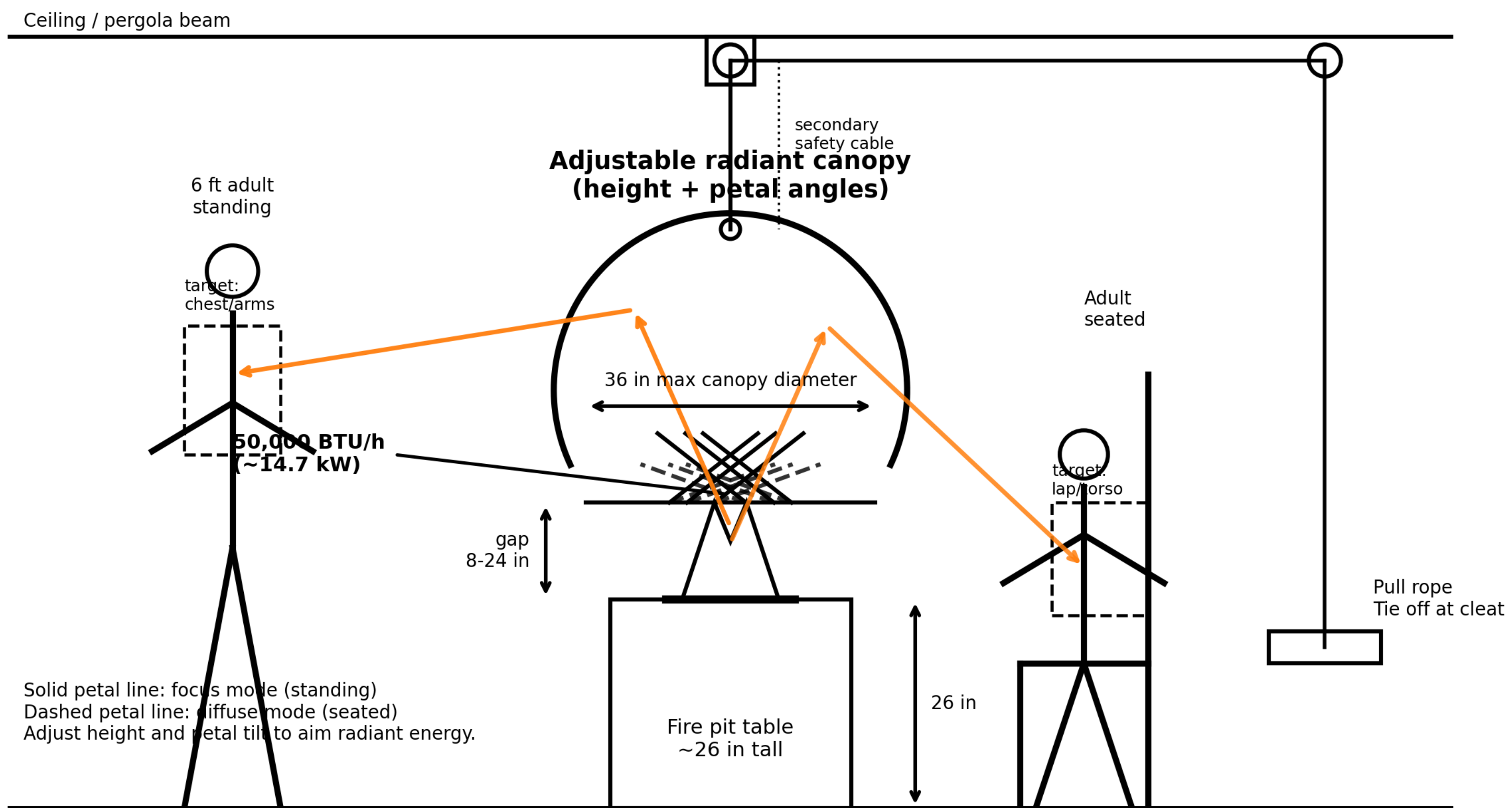
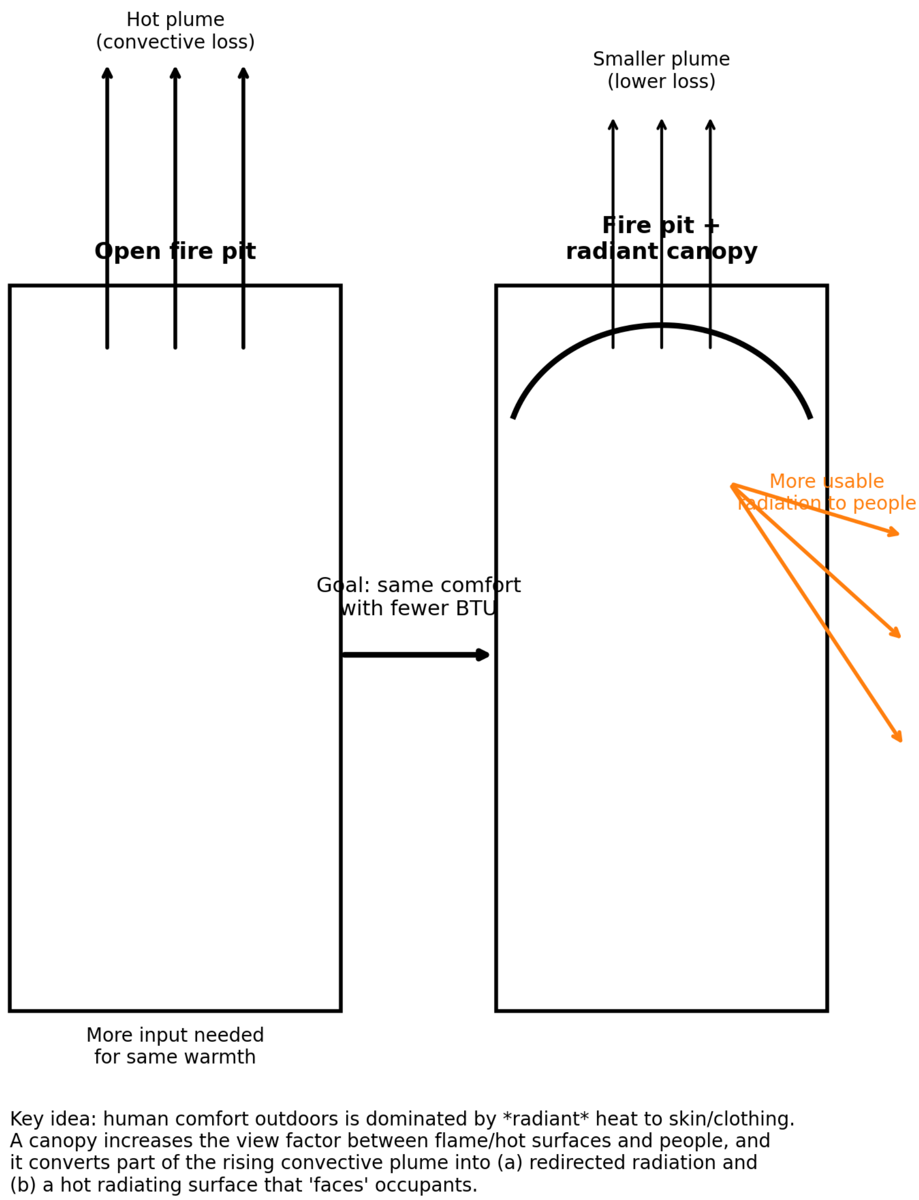
Adjustable Radiant Canopy for Patio Fire Pits

Capture rising plume + redirect IR using height and angle-adjustable petals (3 ft max diameter).



Why fewer BTU can feel warmer outdoors

Shift energy from convective plume loss to radiation directed at people (skin/clothing).



Two efficiency levers:

1) Increase the *radiant view factor* from hot surfaces to occupants (more of the thermal radiation they can 'see').
2) Reduce *uncontrolled buoyant plume* volume (less hot air escaping straight upward).

Comfort is approximated by a radiative heat-flux term:

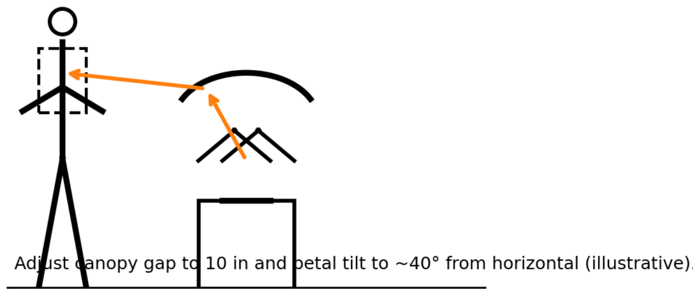
$$q_{rad,person} \approx \varepsilon_{person}\, \sigma\, (T_{hot}^4 - T_{surround}^4) \cdot F_{hot\rightarrow person} \cdot A_{exposed}$$

where $F_{hot\rightarrow person}$ increases when a canopy 'faces' people instead of the sky.

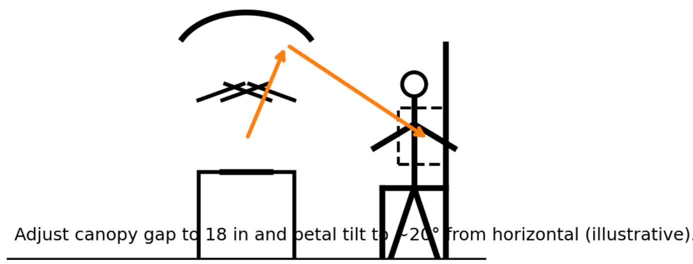
Adjustability: height + petal angle = aim, focus, or diffusion

Law of reflection (specular) plus controlled diffusion enables standing and seated comfort zones.

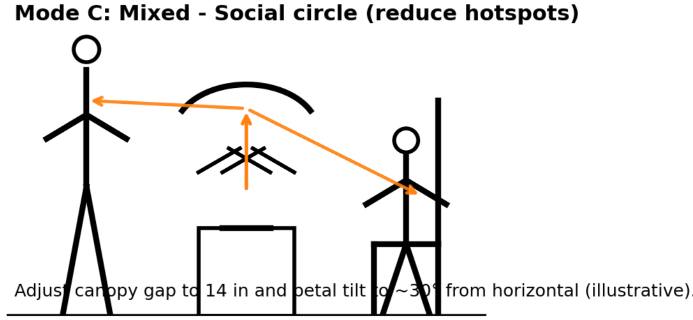
Mode A: Focused - Standing (aim at torso)



Mode B: Diffuse - Seated (spread over lap/upper body)



Mode C: Mixed - Social circle (reduce hotspots)



Geometric intuition: if the rising plume is approximately vertical, a petal tilted α degrees from horizontal has its surface normal tilted α from vertical, so the reflected ray leaves at ~2α from vertical (i.e., elevation $\approx 90°-2\alpha$ above horizontal). This makes α a direct aiming knob.

Practical control concept:

- Height (pulley): controls how much hot plume power is intercepted and how close occupants are to the hot canopy.
- Petal tilt (linkage or cam-ring): controls aiming and 'focus' versus 'spread' of the outgoing radiation.
- Surface finish (liner): specular for aiming; lightly textured for diffusion to avoid hotspots.

Reflectivity, soot, and how to keep performance in the real world

Reflectivity matters most for directional gain; soot shifts behavior from mirror-like to diffuse radiator.

Reflectivity is most valuable when you want the canopy to act like an IR 'lamp shade'—redirecting radiation into specific zones (torsos for standing, laps for seated). If the inner surface becomes soot-covered, IR reflectivity drops and the canopy behaves more like a matte blackbody: it absorbs more, runs hotter, and re-emits more diffusely. That can still feel warm, but with less directional reach per BTU.

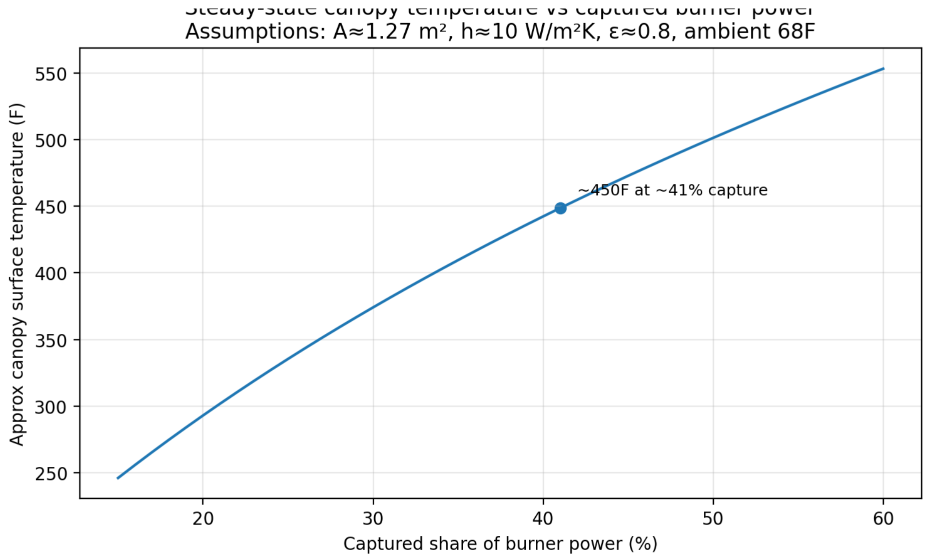
Inner-surface condition (illustrative)	IR reflectivity ρ	Emissivity ε	What you feel
Polished aluminum / Al-coated liner	0.85-0.95	0.05-0.15	Strong aiming; highest 'reach'
Polished stainless liner	0.65-0.85	0.15-0.35	Good aiming; robust outdoors
Ceramic enamel / light texture	0.30-0.60	0.40-0.80	More diffusion; fewer hotspots
Soot/ash coated (wood use)	0.05-0.20	0.80-0.95	Mostly diffuse re-radiation; less aiming

Mitigations (design for both gas and wood):

• Use a replaceable inner 'liner' (snap-in petals) made from polished stainless or aluminized sheet; clean or swap seasonally.
• Add a thin heat shield / baffle ring above the flame to keep soot-laden flow from impinging directly on the reflective surface.
• Provide a 'self-clean' mode: raise output for 10-15 minutes with canopy lowered to elevate liner temperature and burn off deposits (gas).
• For wood: accept soot, and rely on geometry + thermal mass; favor textured ceramic/enamel petals that stay effective when dirty.
• Ensure the exhaust path does not trap CO: leave perimeter gaps and avoid sealing the canopy to the fire pit.

Reaching ~450 F with a 50,000 BTU/h burner

Order-of-magnitude sizing using convection + radiation losses from a ~3 ft canopy.



Energy balance (steady state):

$f \cdot P \approx hA(Ts-Ta) + \varepsilon\sigma A(Ts^4-Ta^4)$

Assumptions for the curve: hemisphere area A≈1.27 m² (D≈0.91 m), ambient Ta≈68 F, h≈10 W/m²K, ε≈0.8 (outer surface

Result: reaching Ts≈450 F typically requires capturing on the order of ~40% of burner power (about 6 kW).

Implications for geometry and user height:

- A 36 in canopy usually needs an 8-14 in gap above the burner to intercept ~35-50% of the buoyant plume (wind dependent).
- For 6 ft standing adults at ~48 in radius: target chest/arm zone at 48-60 in height. Use focus mode (steeper petals, lower gap).
- For seated adults: target lap/torso zone at 24-40 in height. Use diffuse mode (shallower petals and/or slightly higher gap).
- Typical working ranges (illustrative): gap 10-16 in for standing, 16-22 in for seated. Petal tilt 30-55° from horizontal.

Note: exact temperatures and comfort depend strongly on wind, burner geometry, and surface emissivity. Treat numbers as sizing guidance.