

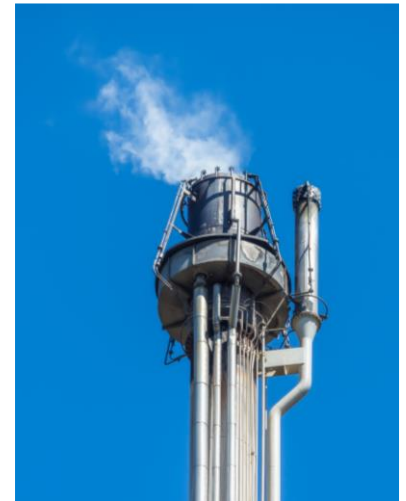


ZEECO SteamForce HC

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Ultra-Low Steam Consumption, High Capacity Smokeless Flaring

- SteamForce HC technology is to:
 - Lower steam consumption
 - Normal operation & flaring scenario
 - Meet MACT CC regulations effectively
 - Robust, lasting equipment



The Impetus for New Generation Technology

Ensuring 98% DRE

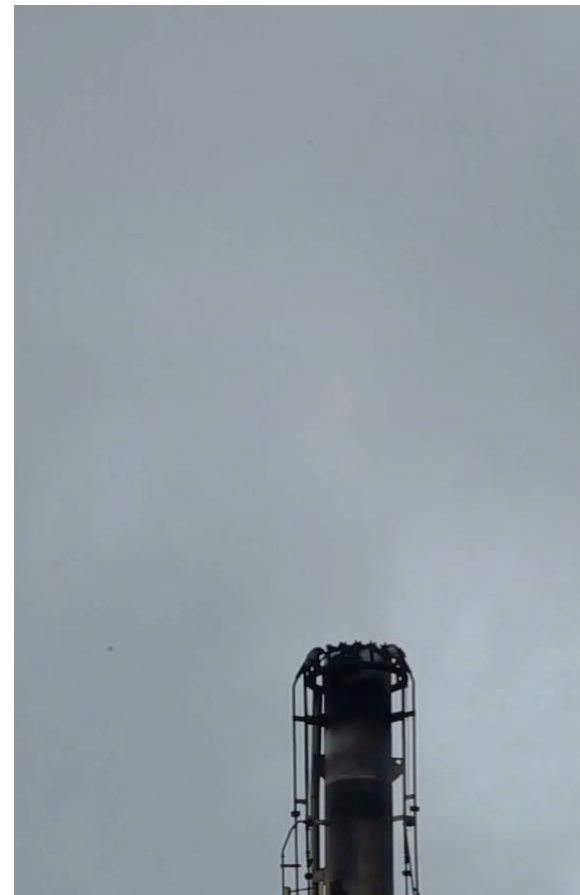
- Turndown case governs

Combustion zone vitality (NHVcz, NHVdil)

- Decrease inert flows
- Increase combustibles

Overall steam reduction

- Operational and environmental savings



Technical Solution: SteamForce HC

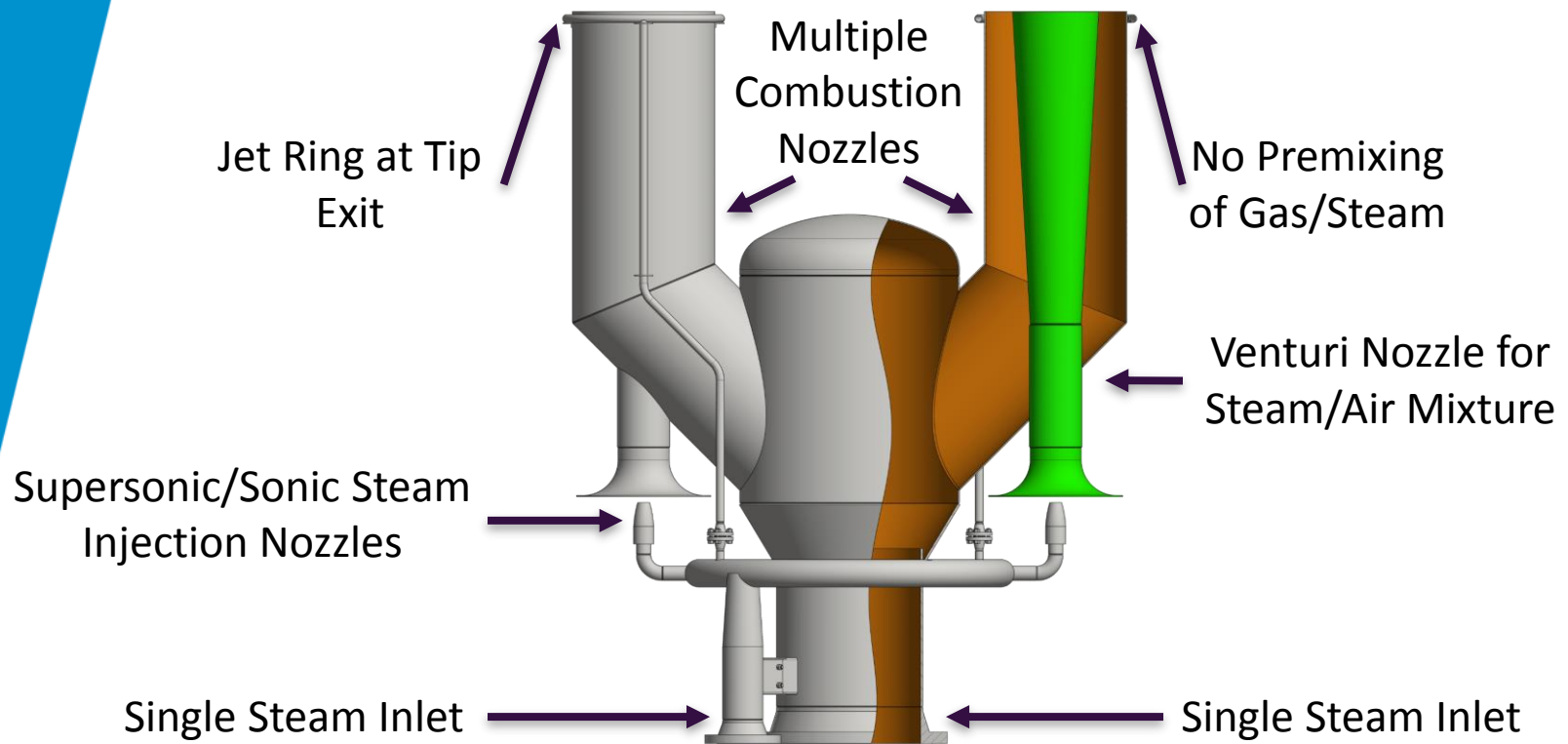
- Increase air aspiration
 - True venturi employed
- Interaction between air and hydrocarbon
 - Jet ring
 - Independent of flare pressure
- Limit minimum steam requirement
 - Number, location of injection points
- Single steam connection and control





SteamForce HC

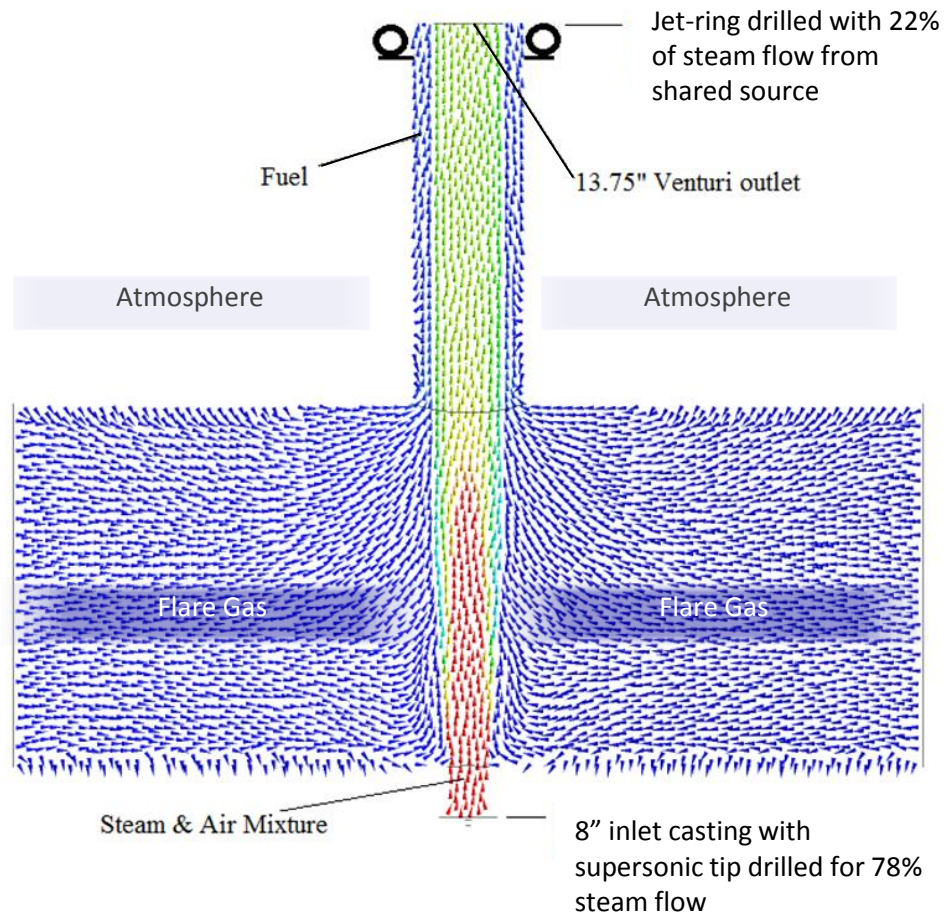
Technical Development



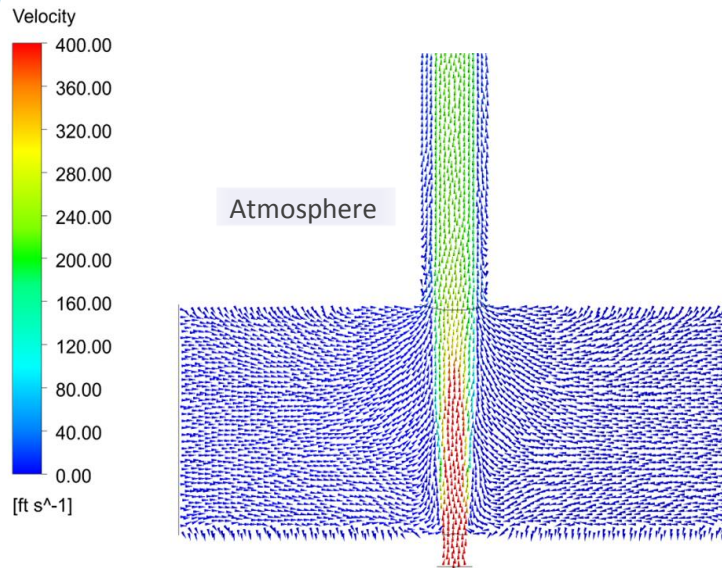
SteamForce HC – Venturi Nozzles

- Advantages:
 - Uses a venturi to pull more air per pound of steam into flare mixing zone.
 - Less steam consumption per pound of flare gas (higher efficiency)
 - Does not mix flare gas, steam and air together within the flare nozzle (not premixed)

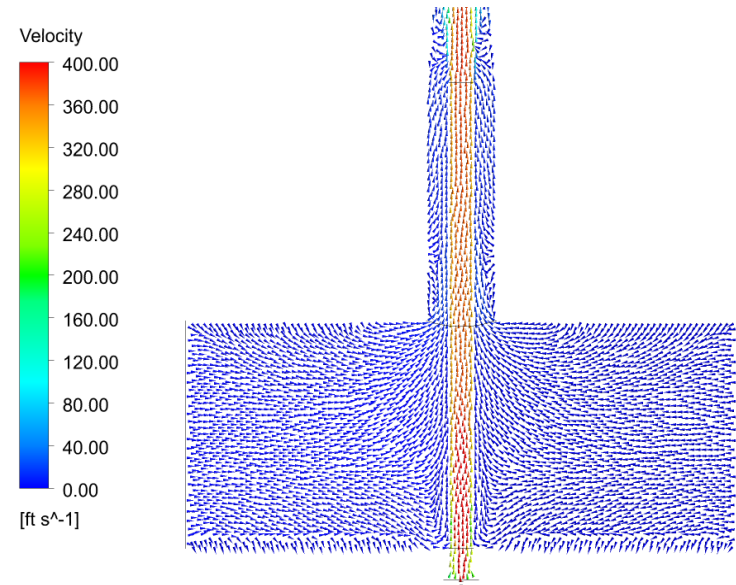
SteamForce HC – Venturi Nozzles



SteamForce HC vs. Other Next Gen. Steam Technology

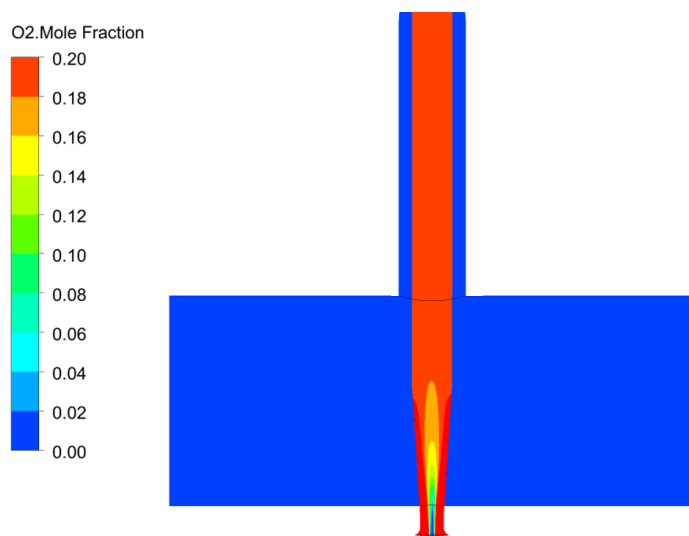


SteamForce HC venturi design increases the air flow / lb. to around 14 lbs. air / lb. steam.

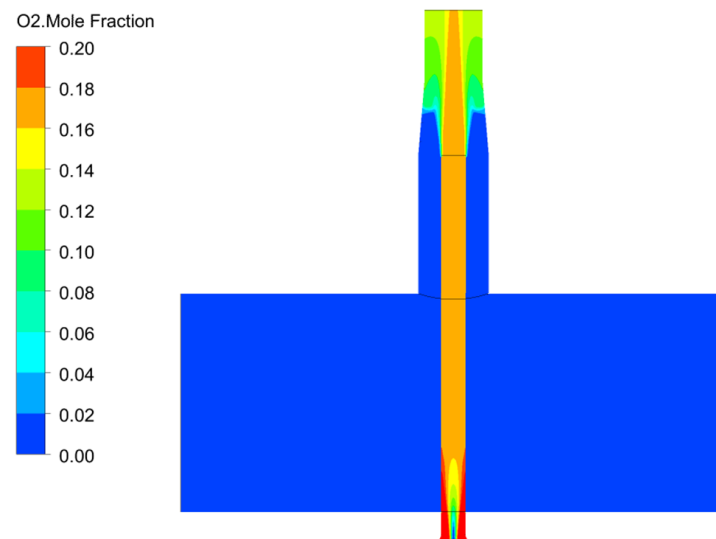


A traditional straight tube, even next gen. tech, educts 8 lbs. air/ lb. steam as shown in CFD.

SteamForce HC vs. Other Next Gen. Steam Technology



SteamForce HC venturi design increases the air flow / lb. to around 14 lbs. air / lb. steam.



A traditional straight tube, even next gen. tech, educts 8 lbs. air/ lb. steam as shown in CFD.

Test Data: SteamForce HC

- Flare Gas = 100% Propylene
- Fuel Flow Rate = 10,136 lbs./hr.
- Steam Flow Rate = 3,040 lbs./hr.
- 0.3 lbs. steam/lb. fuel
- Wind at 5 mph



Note: Smokeless was achieved down to approximately 0.24 lbs. steam/lb. fuel

Test Data: SteamForce HC

- Flare Gas = 100% Propylene
- Fuel Flow Rate = 13,820 lbs./hr.
- Steam Flow Rate = 3,040 lbs./hr.
- 0.22 lbs. steam/lb. fuel
- Wind at 5 mph
- Incipient Smoke Point



Incipient Smoke Point

Test Data: SteamForce HC

- Flare Gas = 100% Propylene
- Fuel Flow Rate = 15,200 lbs./hr.
- Steam Flow Rate = 3,040 lbs./hr.
- 0.20 lbs. steam/lb. fuel
- Wind at 5 mph
- Smoke beginning to form, but still less than Ringelmann 1
- Ringelmann 1 at approximately 0.17 lbs. steam/lb. fuel



Ringelmann 1 Opacity

Smokeless Flow: SteamForce HC

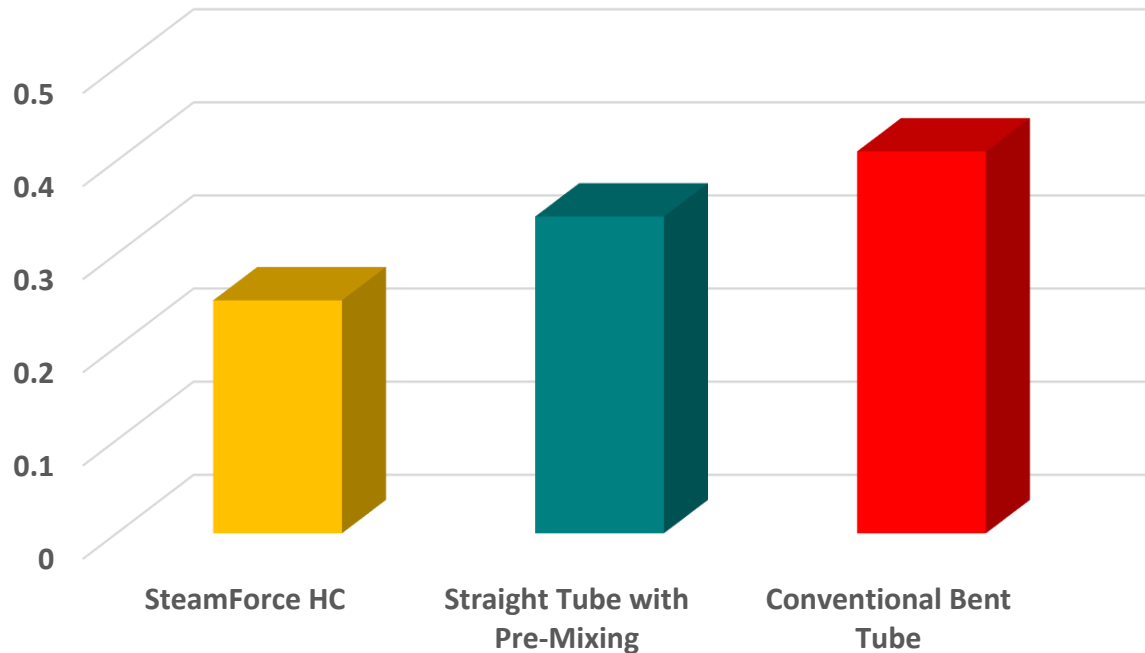
Illustration Example Based on a 24" Steam Assisted Flare

Flare Description	Injection Points	Propylene Flow (lbs./hr.)	S/HC Ratio
SteamForce HC	Four (4) Nozzles	40,316	0.25
Straight Tube with Pre-Mixing	Four (4) Nozzles	40,316	0.34
Bent Tube Device	Seven (7) Tubes	40,316	0.41
Upper Steam Only	Ten (10) Tips	40,316	0.50

Smokeless Defined at Incipient Point with 10 mph Wind.

Smokeless Flow: Steam Force HC

Steam Consumption Rate at Incipient Point of
Smoke Formation



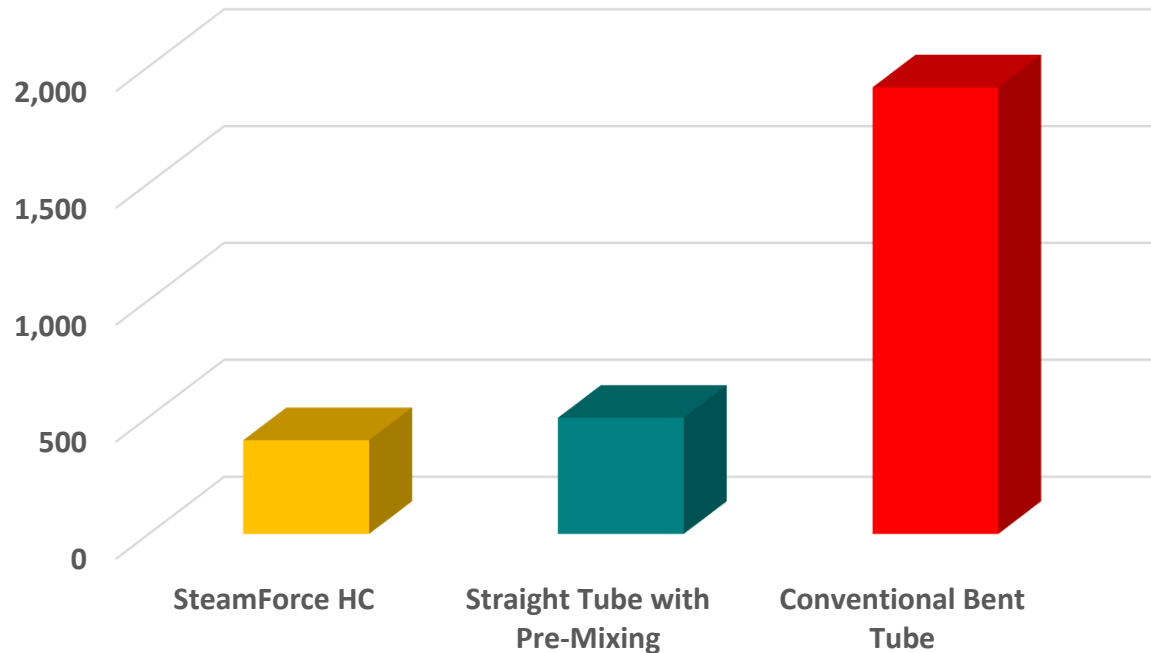
Minimum Steam Flow: SteamForce HC

Illustration Example Based on a 24" Steam Assisted Flare

Flare Description	Fuel (lbs./hr.)	Steam (lbs./hr.)	Case
SteamForce HC Using Four (4) Nozzles	18	400	Purge with Min. Cooling/Warming Steam
Straight Tube with Pre-Mixing Using Four (4) Nozzles	18	496	Purge with Min. Cooling/Warming Steam
Bent Tube Device	18	1,910	Purge with Min. Cooling/Warming Steam

Purge Data: Steam Force HC

Steam Consumption Rate at Normal Purge Rate
Conditions



Cost of Ownership: SteamForce HC

- COO: normal rates largely govern op-ex
 - Purge 95% hourly consumption
 - Flaring 5% hourly consumption
- Steam costs only
- Consider refinery vs. petrochemicals

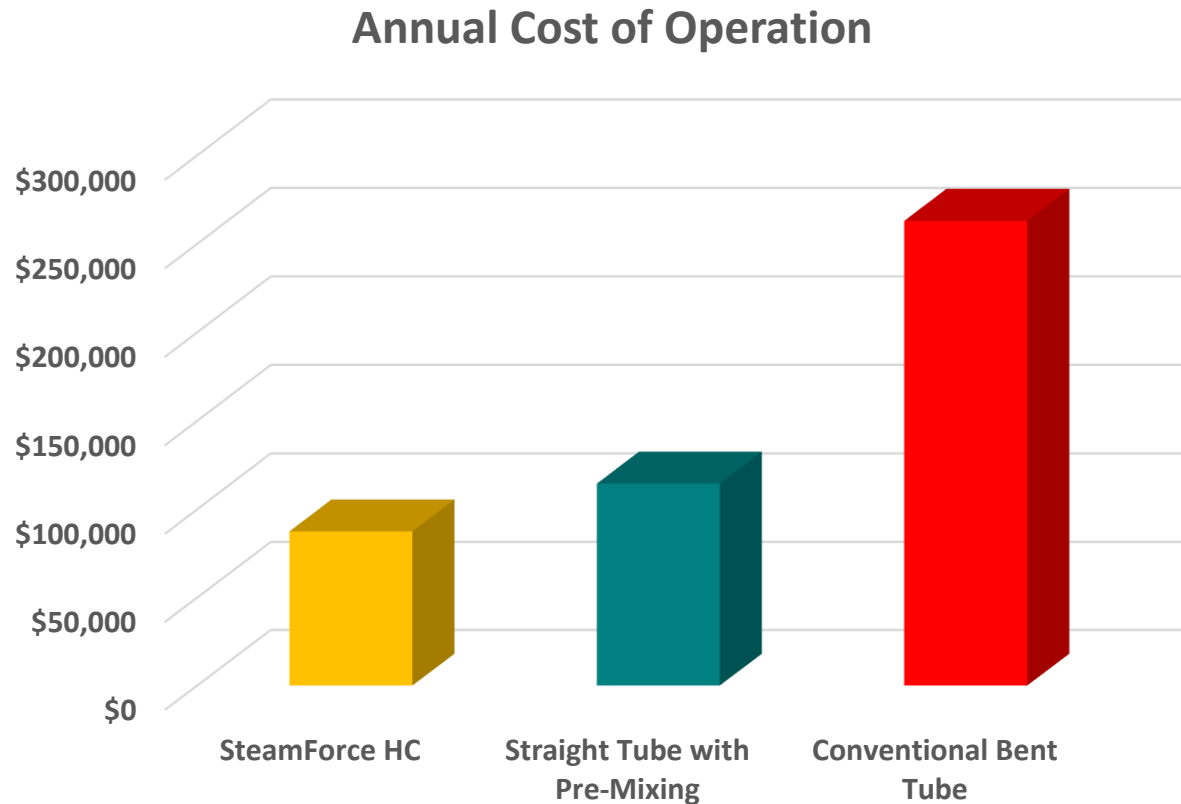
Smokeless Flow: SteamForce HC

Illustration Example Based on a 24" Steam Assisted Flare

Smokeless Flare Rate of Propylene (lbs./hr.)	Required Injection Ratio (lbs. Stm./lbs. Fuel)	Min. Steam Rate (lbs./hr.)	Smokeless Steam Rate (lbs./hr.)	% Time at Purge Rate	% Time at Smokeless Rate	Steam (lbs./year)	Steam Cost Factor (\$/1000 lbs. Stm.)	Cost USD (\$/year)
40,316	0.25	400	10,079	95%	5%	3,871,701	\$ 22.60	\$ 87,500
40,316	0.50	750	20,158	95%	5%	7,535,352	\$ 22.60	\$ 114,487
40,316	0.34	1,120	13,707	95%	5%	7,662,249	\$ 22.60	\$ 173,167

Smokeless Defined at Incipient Point with 10 mph Wind.

Cost of Operation: Steam Force HC



SteamForce HC Operational Longevity

- Vertical momentum only
 - Inner and outer inert flow
- Single steam connection and control
 - No operational capping
- Less radiation impingement
 - Reduce area head

