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ZEECO SteamForce HC

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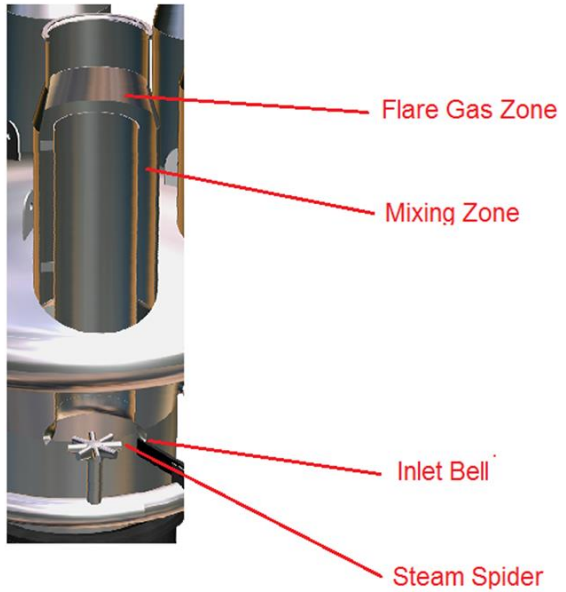
Current Next Generation Steam Flare Technology

- Single steam inlet
  - No need for multiple connections for upper, lower, and center
- Multiple combustion nozzles – increases the amount of surface area of the gas/steam/air mixture
  - Allows for much lower steam requirements on max smokeless rates
- Fewer steam nozzles means lower total cooling steam required.

Current Steam Injection Technology

- Steam is injected into inlet bell, drawing air in as well.
- Steam and air combination mix with the flare gas inside the overall tube, allowing for thorough mixing prior to tip exit
- The momentum of the total mixture exiting the tips help pull in air from the outside around each tube.



Zeeco Low Consumption Steam Flare
SteamForce HC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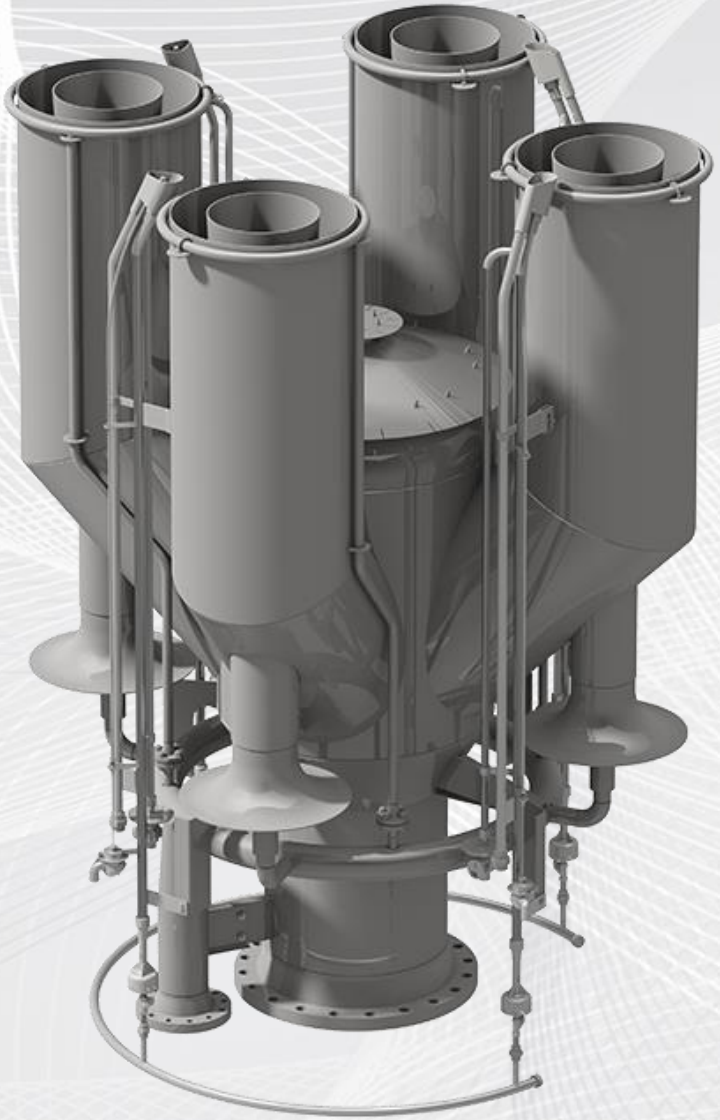
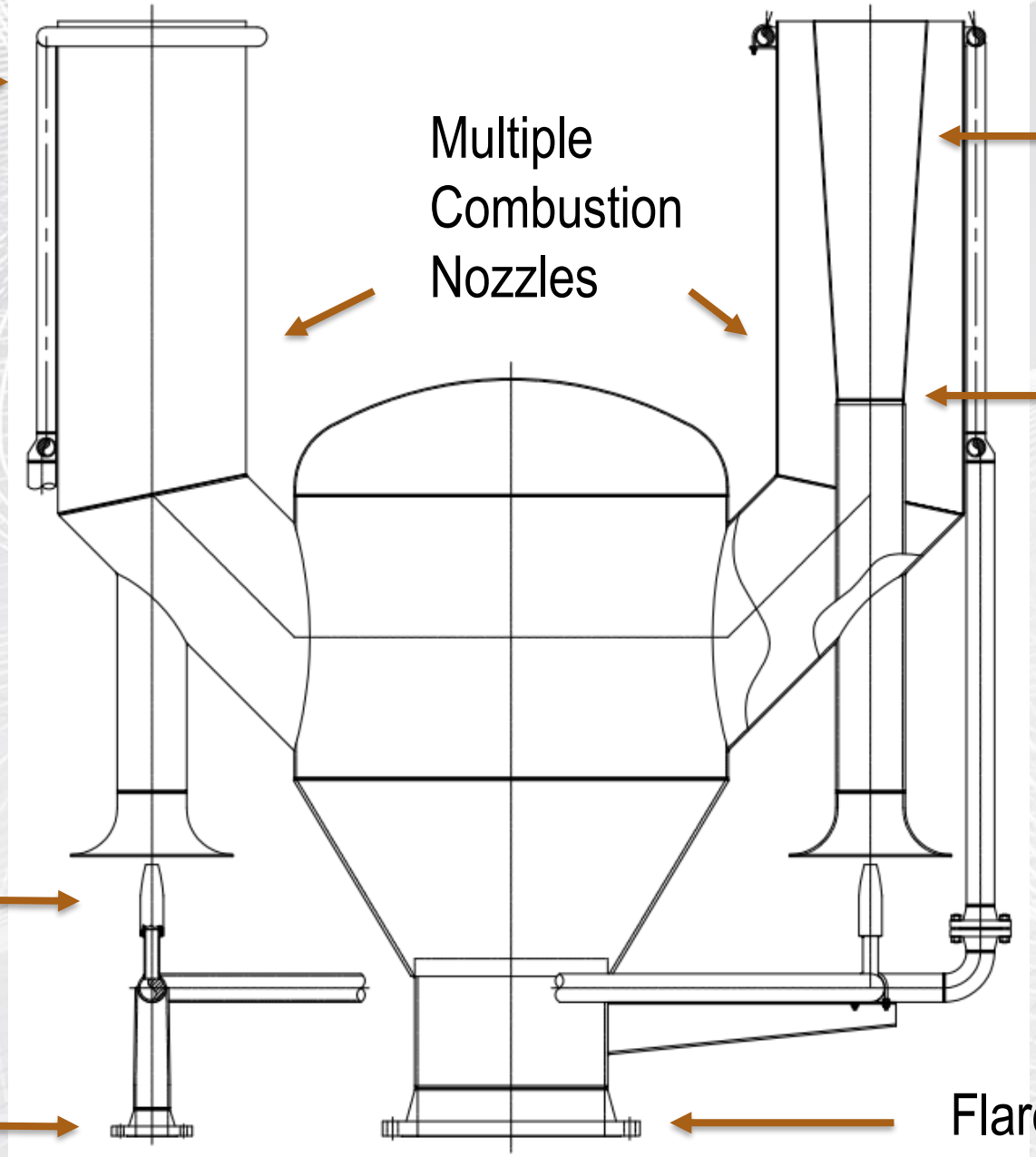
SteamForce HC Review



Additional Steam Clean-up Ring at Tip Exit



No Premixing of Gas/Steam

Venturi Nozzle for Steam/Air Mixture

Supersonic / Sonic Steam Injection Nozzles

Single Steam Inlet

Flare Gas Inlet

SteamForce HC – Venturi Nozzles

Advantages:

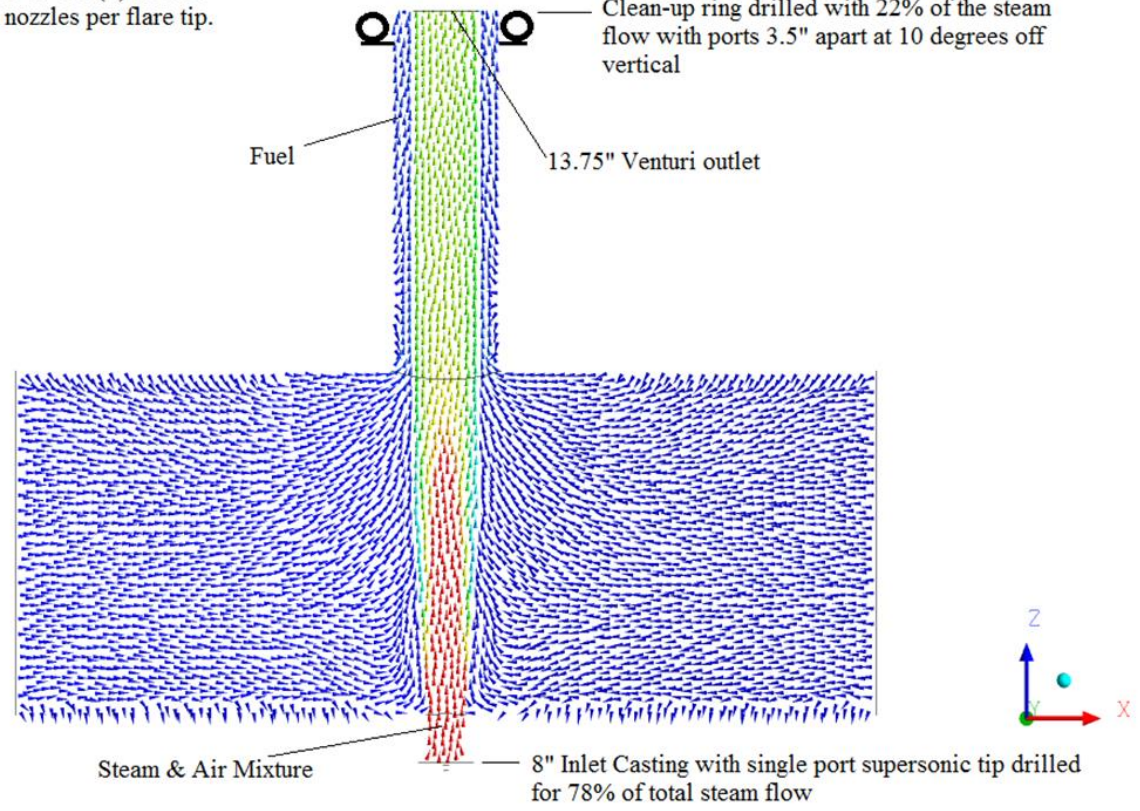
- Uses a venturi to pull more air per pound of steam into flare mixing zone.
- Less steam consumption per pound of flare gas (higher efficiency)
- Does not mix flare gas, steam and air together within the flare nozzle (not premixed)

Note 1:

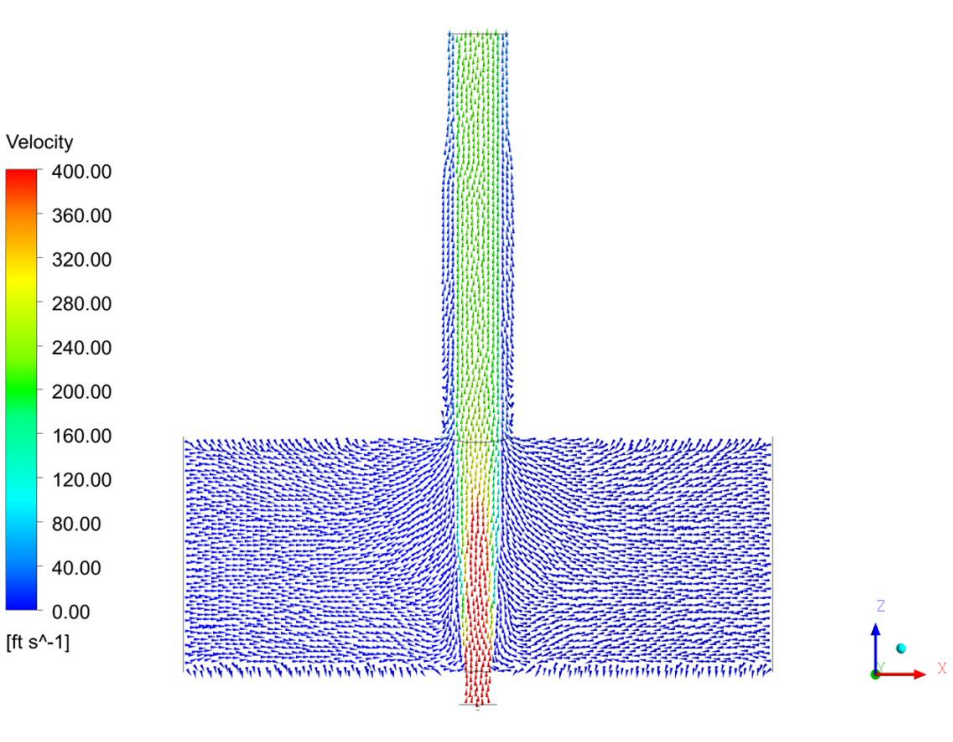
The Fuel Gas is not mixed with the Steam & Air mixture until the outlet of the flare tip.

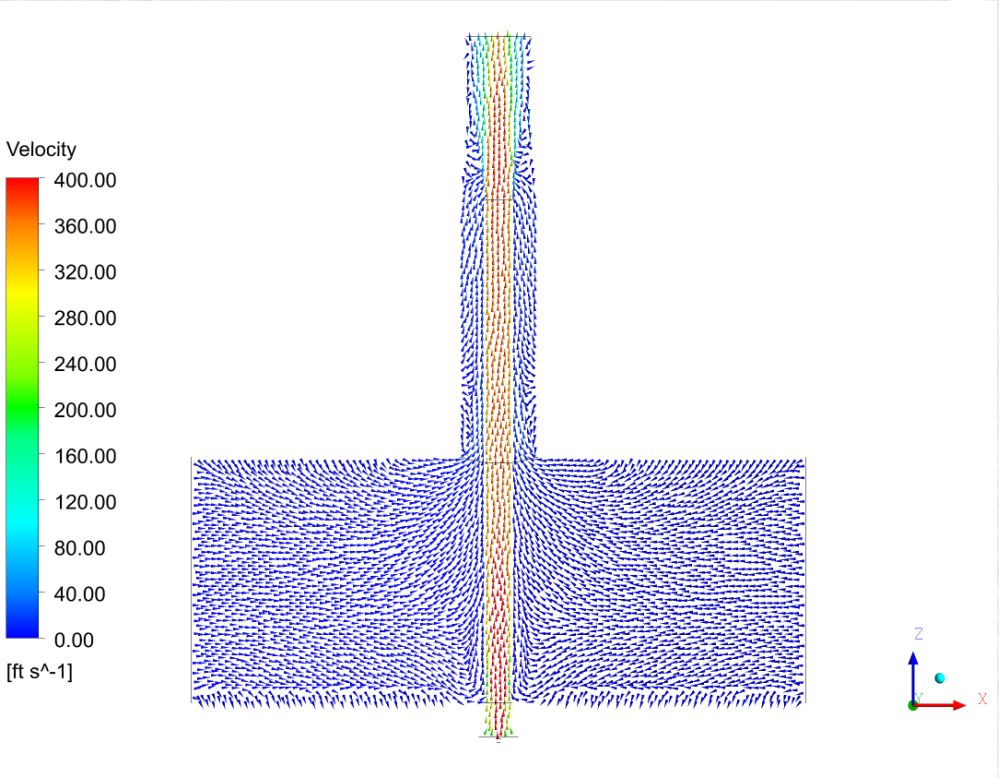
Note 2:

The view at the right is of one (1) nozzle. There will be six (6) nozzles per flare tip.



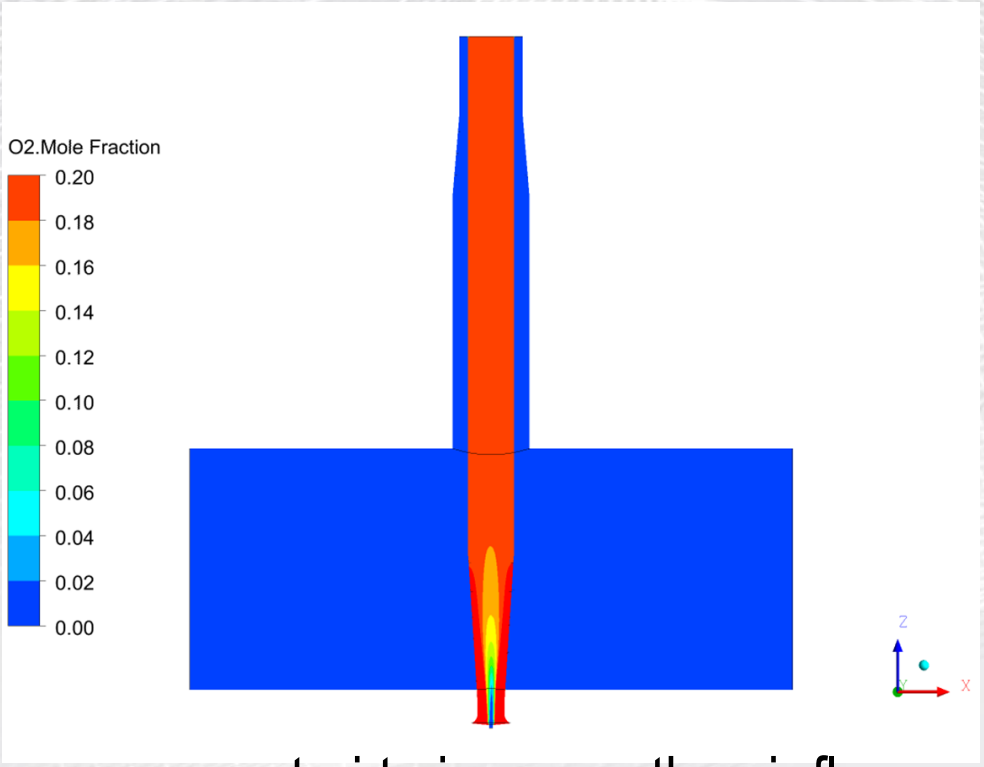
Comparison:
SteamForce HC vs. Current Next Generation Steam Technology

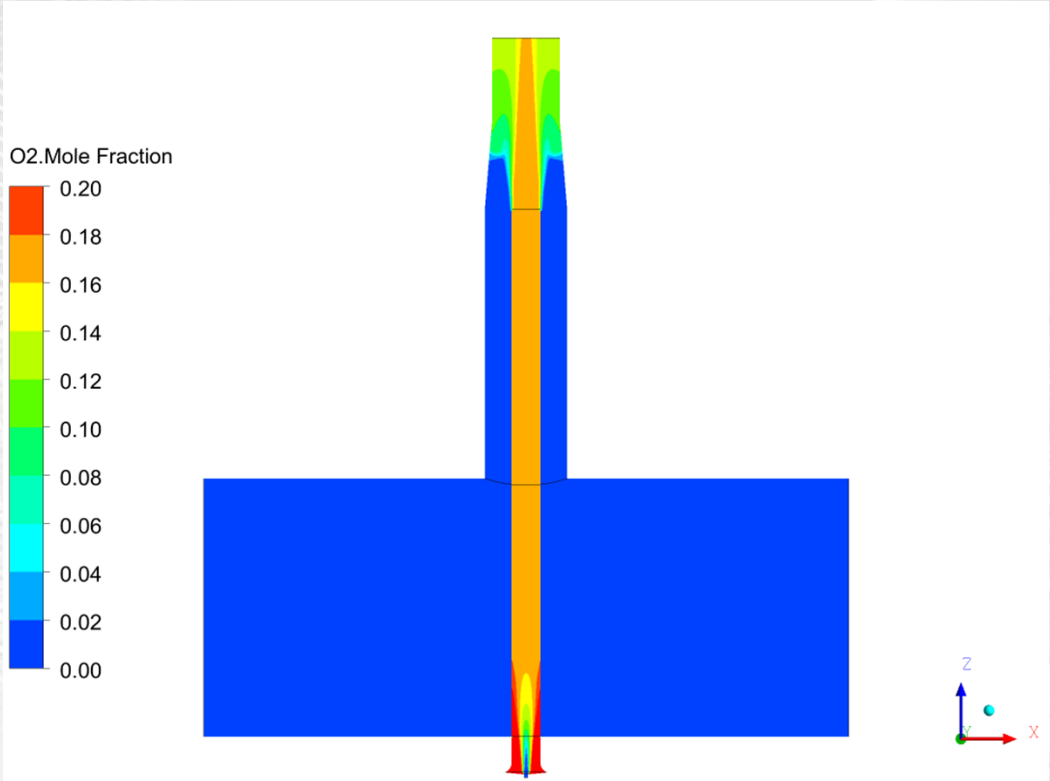




Zeeco uses a venturi to increase the air flow per lbs of steam used from around 8 lb air / lb steam for a traditional straight tube (shown on the right) to around 14 lb air / lb steam (see CFD on the left for Zeeco's SteamForce HC).

Comparison:
SteamForce HC vs. Current Next Generation Steam Technology

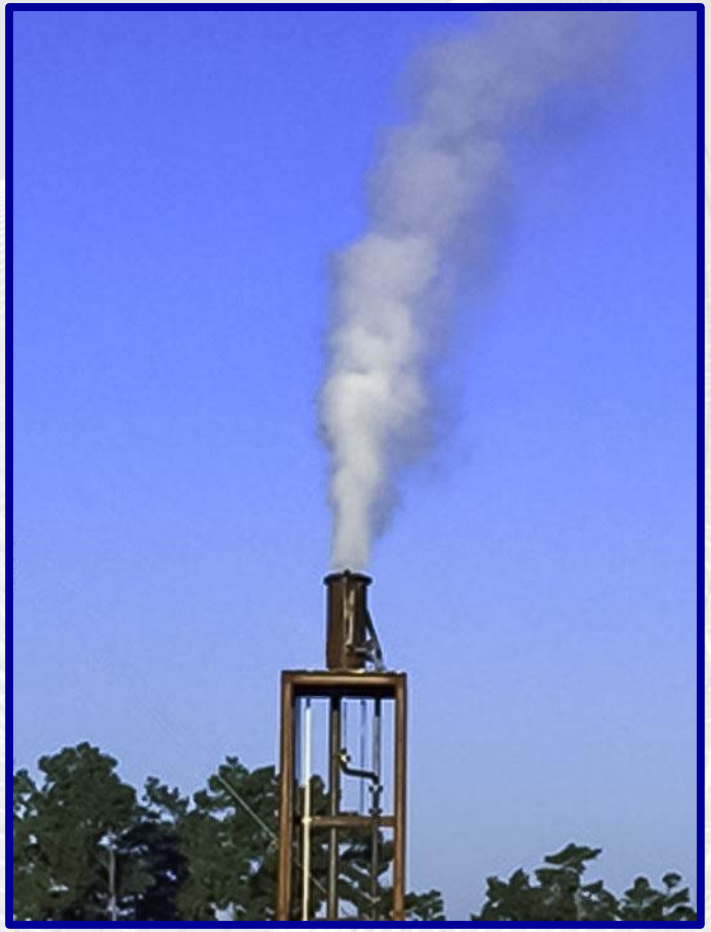




Zeeco uses a venturi to increase the air flow per lbs of steam used from around 8 lb air / lb steam for a traditional straight tube (shown on the right) to around 14 lb air / lb steam (see CFD on the Left for Zeeco's SteamForce HC).

Test Data: SteamForce HC Flare

- Center Venturi with supersonic tip with 78% of steam flow.
- Clean up ring at tip exit with 22% of the steam flow.



Test Data: SteamForce HC Flare

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

Note: Smokeless was achieved down to approximately 0.24 # steam / # fuel

Test Data: Incipient Smoke Point

- Flare Gas = 100% Propylene
- Fuel Flow Rate = 13,820 #/hr
- Steam Flow Rate = 3,040 #/hr
- 0.22 # steam / # fuel
- Wind at 5 MPH
- Incipient Point

Incipient Smoke Point

Test Data: Ringelmann 1

- Flare Gas = 100% Propylene
- Fuel Flow Rate = 15,200 #/hr
- Steam Flow Rate = 3,040 #/hr
- 0.20 # steam / # fuel
- Wind at 5 MPH
- Smoke beginning to form, but still less than Ringlemann 1
- *Ringlemann 1 at approximately 0.17 # steam/# fuel*

Clinton Flare

- Gas Cases
- Smokeless goals: 30-40% of max rate
- Normal operation = 1610 lb/hr

	Mol %					
	Case 1 - Total Power Failure	Case 2 - Cooling Water Failure	Case 3 - Instrument Air Failure	Case 4 - Normal Operation		Steam
METHANE	3.76	3.90	4.54	30.94		
ETHANE	20.79	21.18	14.53	4.25		
PROPANE	0.90	2.26	0.74	0.50		
BUTANE	15.87	2.96	12.71	7.63		
PENTANE	0.02	0.15	0.02	0.63		
HEXANE	0.01		0.01			
HEPTANE						
OCTANE						
NONANE						
DECANE						
DODECANE						
TRIDECANE						
CYCLOPENTANE						
ETHYLENE	38.91	37.41	27.46	7.21		
PROPYLENE	4.92	7.13	4.02	0.90		
BUTYLENE	0.01	0.03	0.02	0.16		
ACETYLENE	0.18	0.21	0.12	0.04		
BENZENE	0.14	0.15	0.17			
TOLUENE	0.02		0.02			
XYLENE						
CARBON MONOXIDE						
CARBON DIOXIDE	0.01			1.17		
HYDROGEN SULFIDE						
SULFUR DIOXIDE						
AMMONIA						
AIR						
HYDROGEN	13.20	13.37	35.02	12.25		
OXYGEN				0.09		
NITROGEN				32.03		
WATER	0.69	10.66	0.34	0.02		100.00
BUTADIENE	0.53	0.55	0.24	0.79		
METHANOL						
Total	**99.96**	**99.96**	**99.96**	**98.61**		**100**
Mol. Wt.	30.35	25.99	23.32	24.05		18.02
L. H. V. (BTU/SCF):	1,619	1,302	1,287	802		0.0
Temperature (Deg. F):	106.8	197.9	78.5	54.1		
Avail. Static Pressure (psig):	5.00	5.00	5.00	0.25		350
Flow Rate (lbs/hr):	1,115,910	946,430	1,066,390	1,610		98,800
Smokeless Rate (lbs/hr):	VTA	VTA	VTA	VTA		

Clinton Flare Design

- Can be adjusted depending on whether maximum smokeless rate or minimum purge/cooling steam rates are more important
- Max Smokeless Rate = 370,000 lb/hr of Case 1
  - 33% of maximum
- Based on 8 Venturi Nozzles
- Max Steam Flow = 83,700 lb/hr
- Cooling Steam Rate = 70 lb/hr per nozzle
  - 560 lb/hr steam total (eight venturi nozzles)
- Purge Rate = 5400 SCFH natural gas
  - Assuming minimum of 920 Btu/SCF LHV

Smokeless Rates – Case by Case

	Case 1 – Total Power Failure	Case 2 – Cooling Water Failure	Case 3 – Instrument Air Failure	Case 4 – Normal Operation
Smokeless Rate (lb/hr):	370,000 lb/hr	312,322	351,909	1,610
Required Steam Rate (lb/hr):	83,700	66,560	77,500	Cooling Steam Sufficient (560 lb/hr)

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