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Solids maldistribution in parallel cyclones

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Fluidization XV
Fairmont Le Chateau Montebello
Quebec, CANADA

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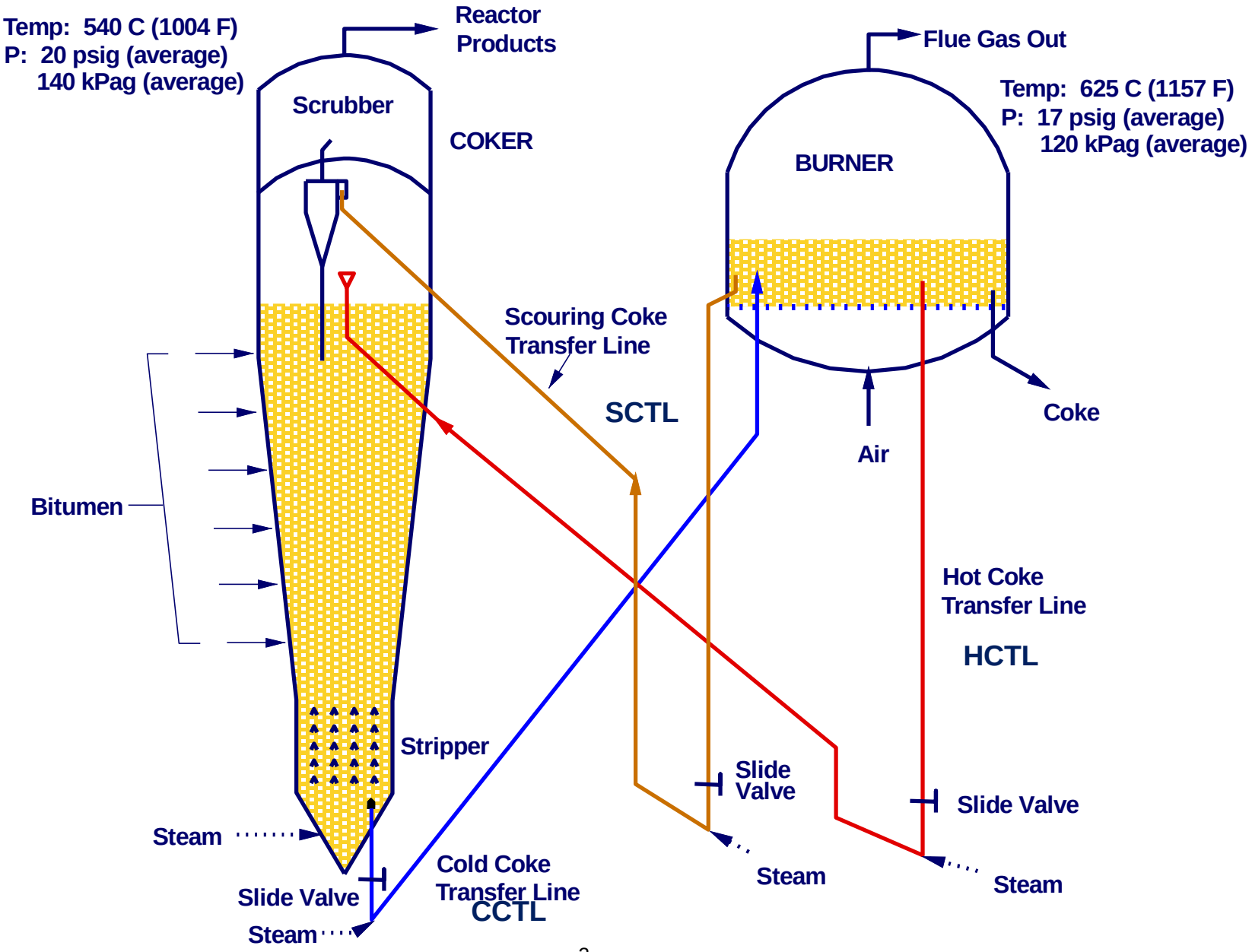
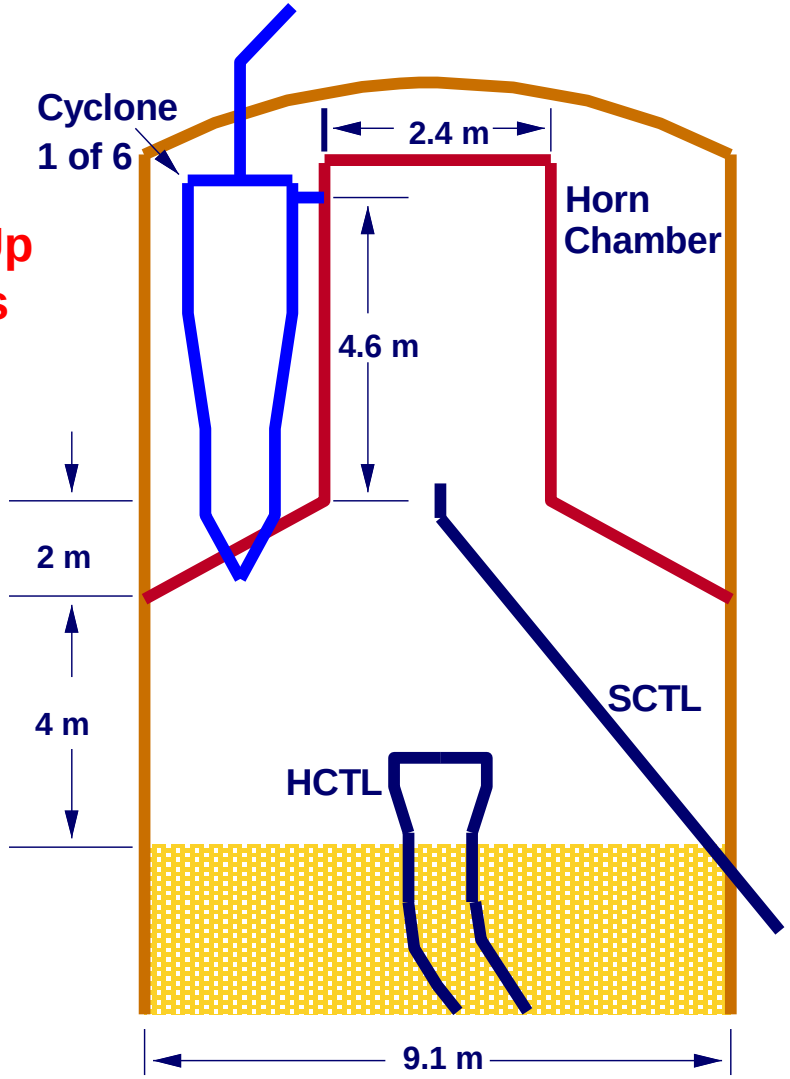
SYNCRUDE FLUID COKING PROCESS



Cyclones Coke Up at Different Rates

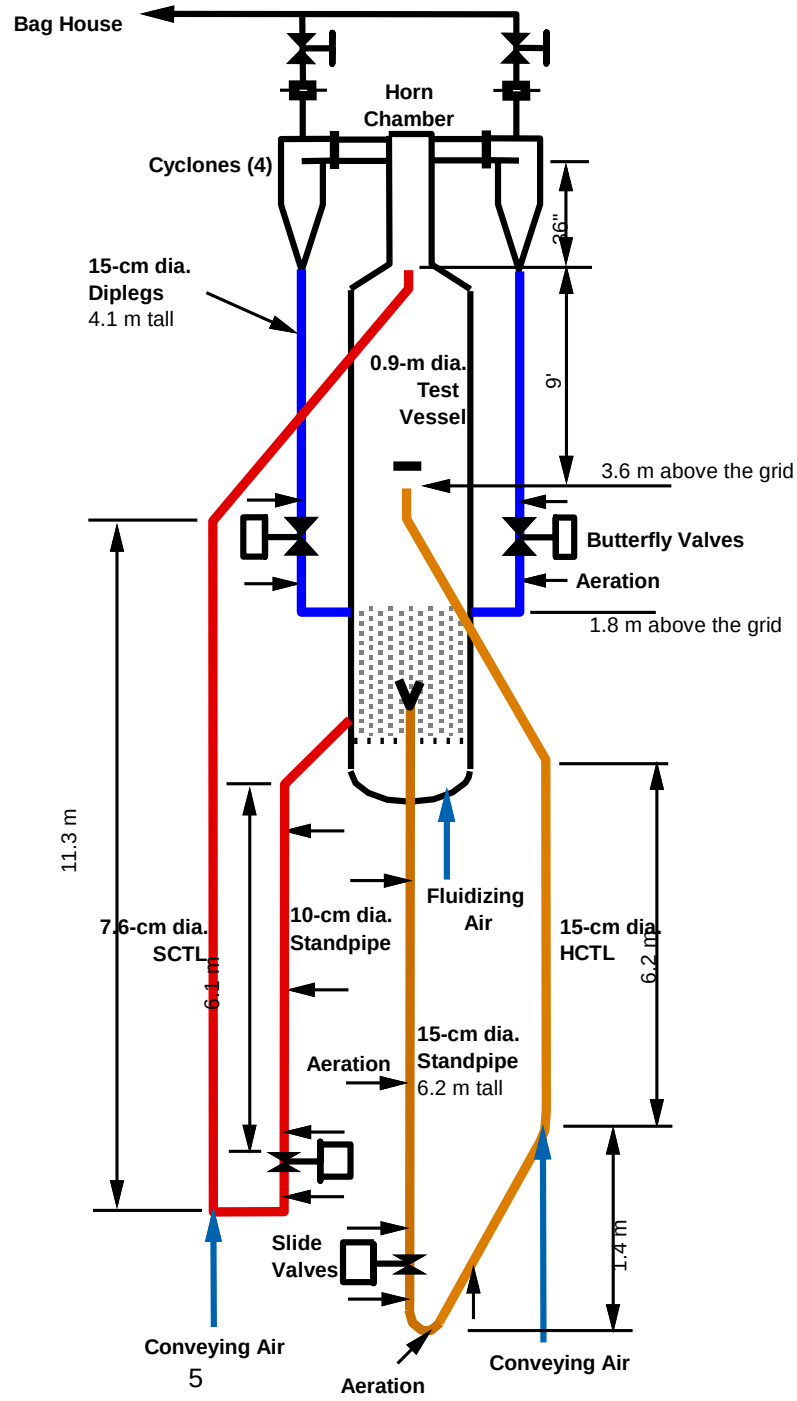


Syncrude Reactor Horn Chamber Dimensions

Objective

- **The Primary Objective of This Work was to Identify Why Solids Distribute Unequally in Parallel Cyclones, and to Attempt to Develop Techniques to More Equally Distribute the Solids**

Schematic Drawing of Test Unit



Cyclones

- The Test Unit Cyclones Were 0.3 m in Diameter and 4 Cyclones in Parallel Were Used

- The Coker Has 6 Cyclones in Parallel That are 1.8 m in Diameter

Test Coke Particle Size Distribution

Size, microns	Cumulative Wt% less than stated dp	
44	0.25	
53	0.73	
63	1.61	
75	5.51	Sauter Mean Diameter: 138.6 microns
88	9.19	
106	17.85	Median Diameter (d_{p50}) = 156 microns
125	30.90	
150	44.54	
177	69.75	
250	93.72	
425	98.31	
600	98.62	
825	100.00	

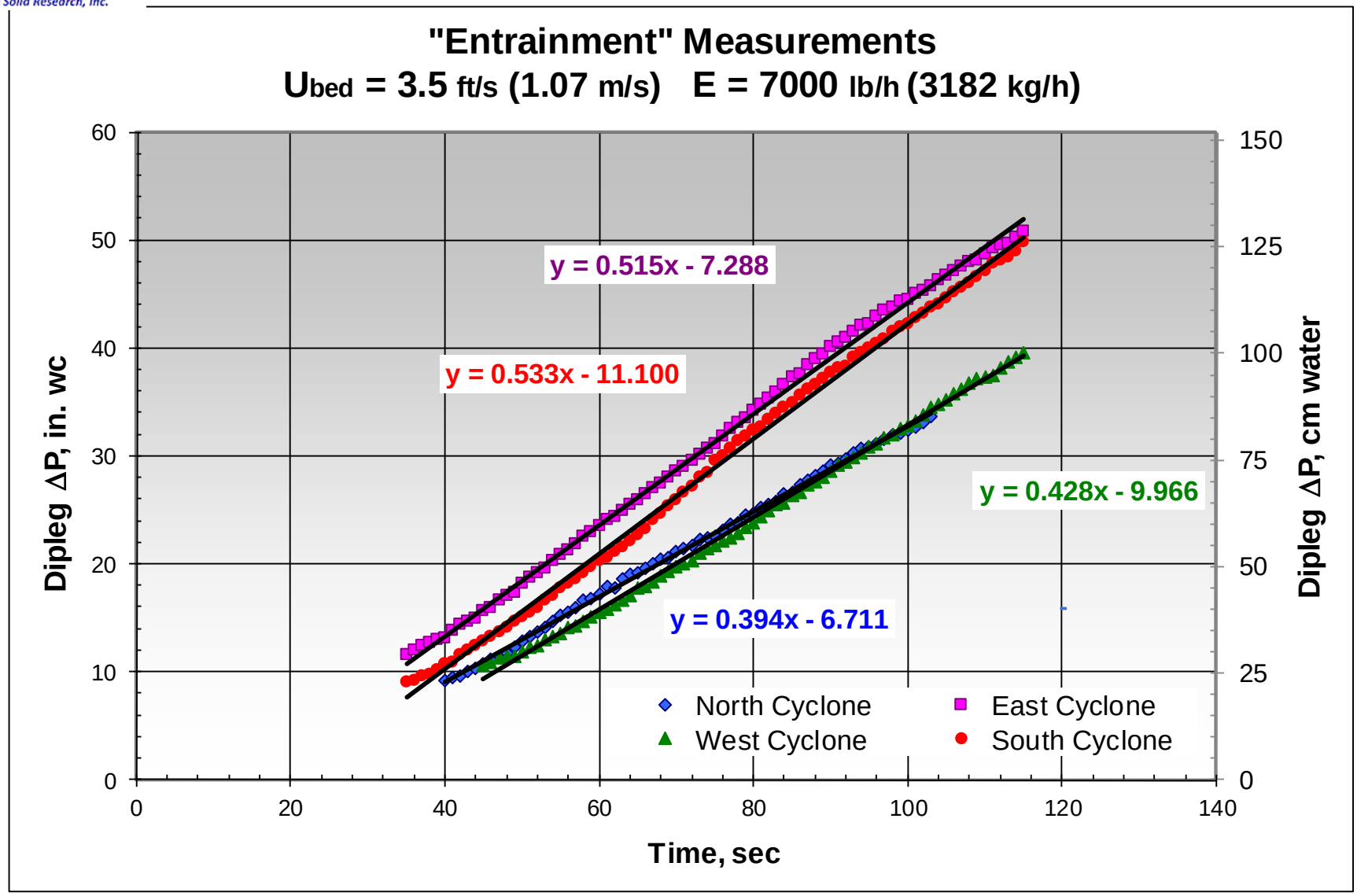
Solids Distribution in Cyclones

- The First Testing was Conducted With No Solids Flow Through the HCTL and SCTL Lines

- Then, Solids Flow was Added Through the HCTL and the SCTL to See the Effect of This Flow

Solids Distribution in Cyclones

- The Solids Flow Rate Through Each Cyclone was not Equal – Even with no Solids Flowing Through the HCTL and SCTL

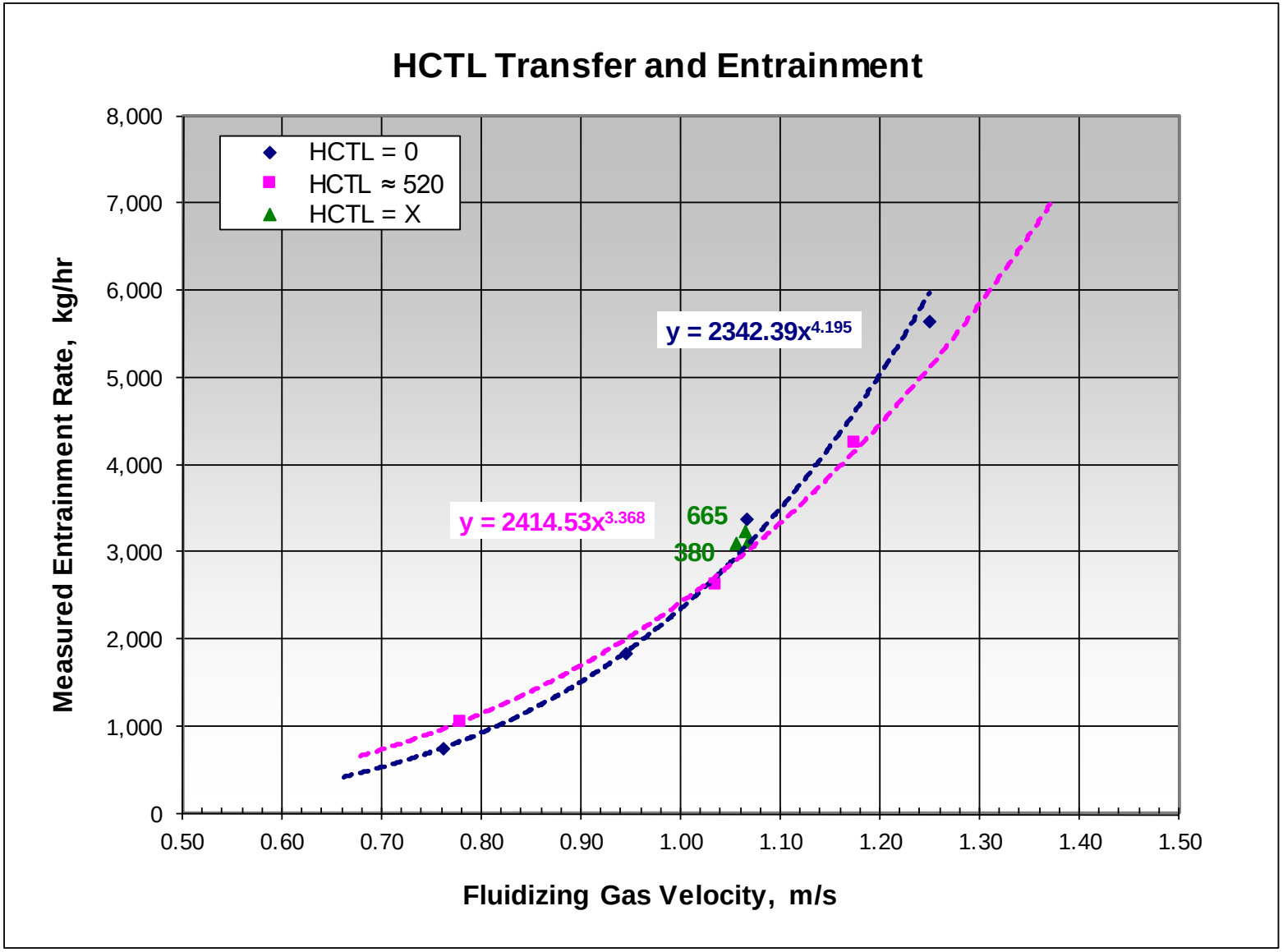


Solids Collection in Diplegs as a Function of Time
(No Solids Flow Through the HCTL or SCTL)

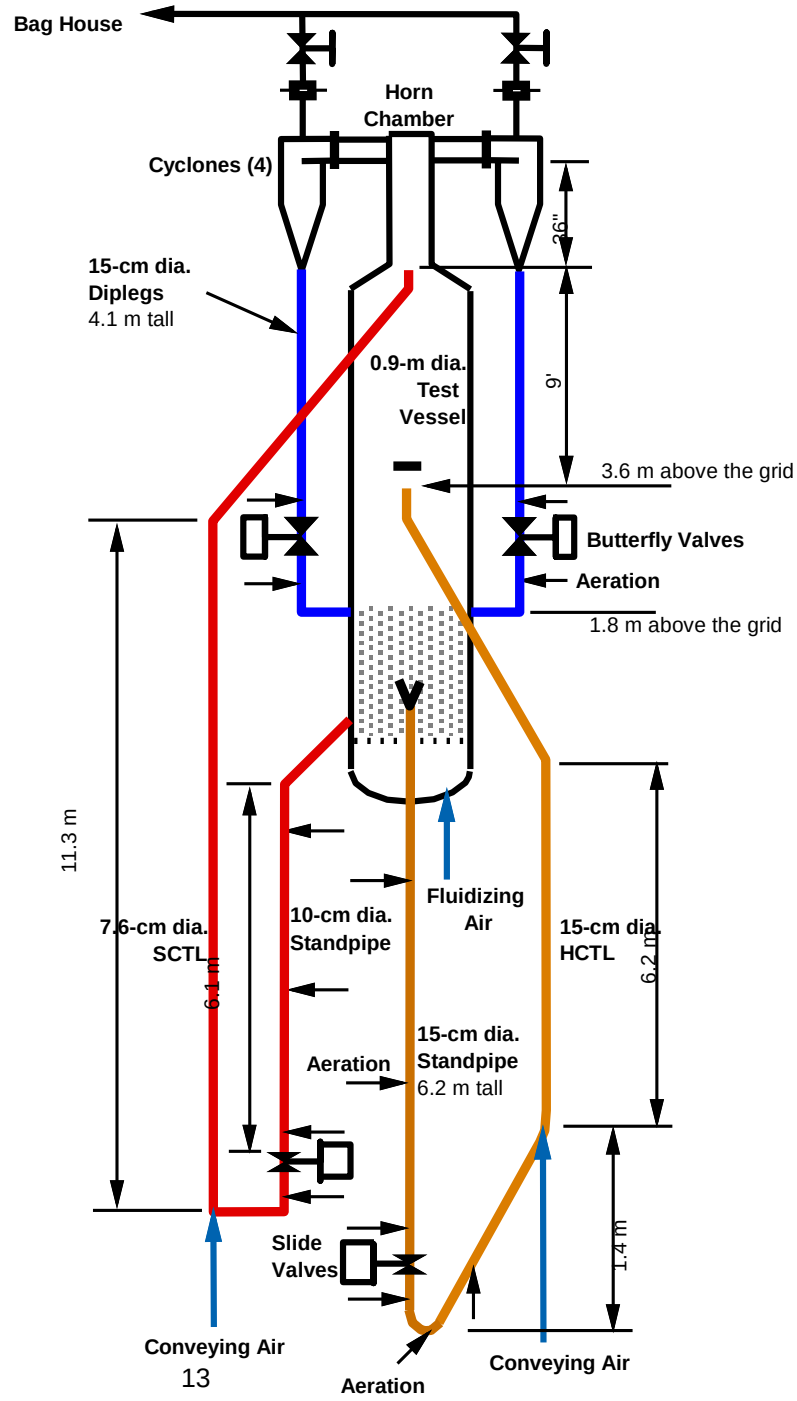
HCTL Flow Effect

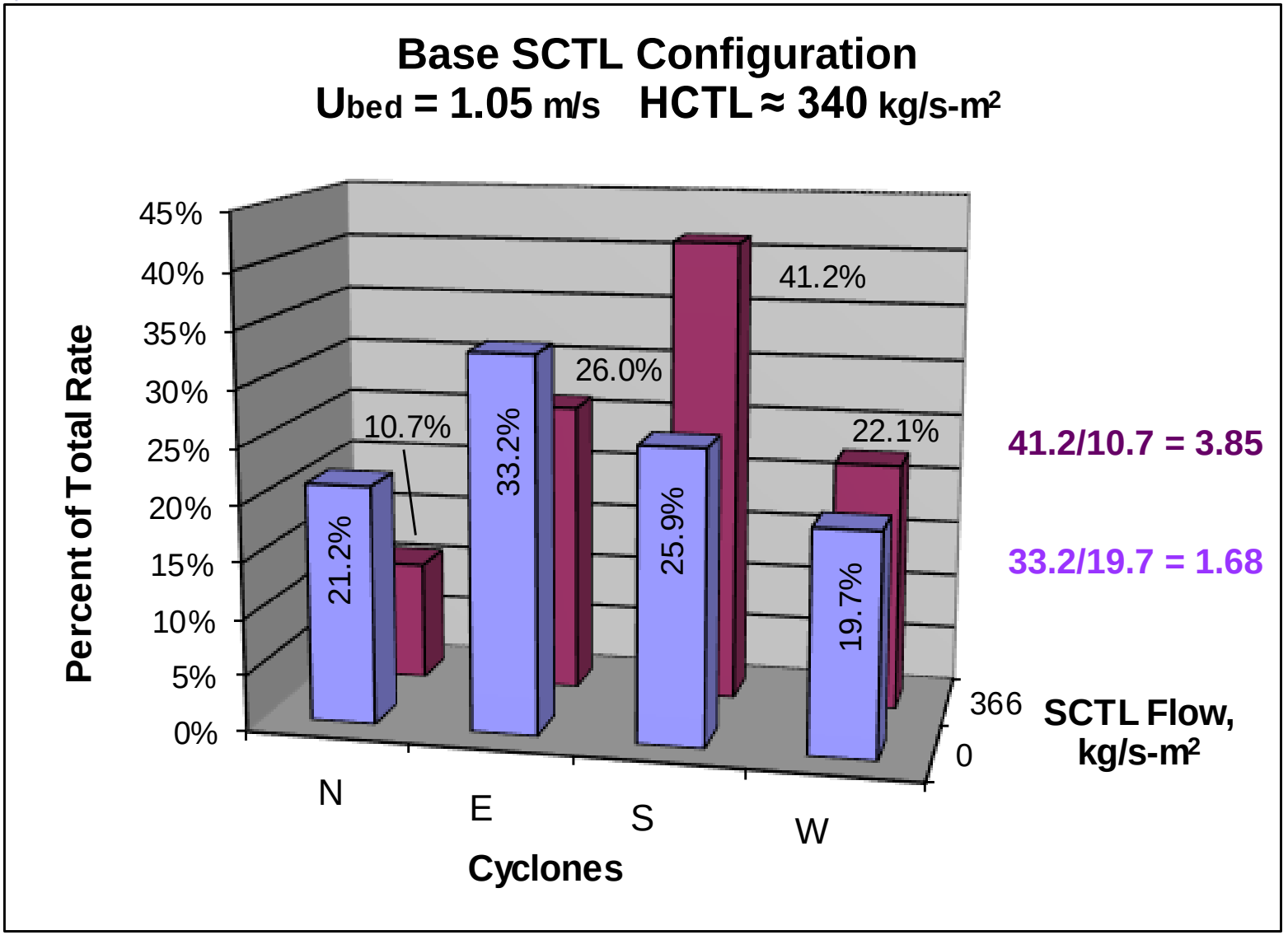
- Adding Solids Flow Through the HCTL did NOT Increase the Entrainment Rate Collected by the Cyclones

- It Appears that the Gas From the Bed is Saturated with Solids (at its Saturated Carrying Capacity) and Adding Solids to it From the SCTL Does Not Significantly Result in Additional Carryover to the Cyclones

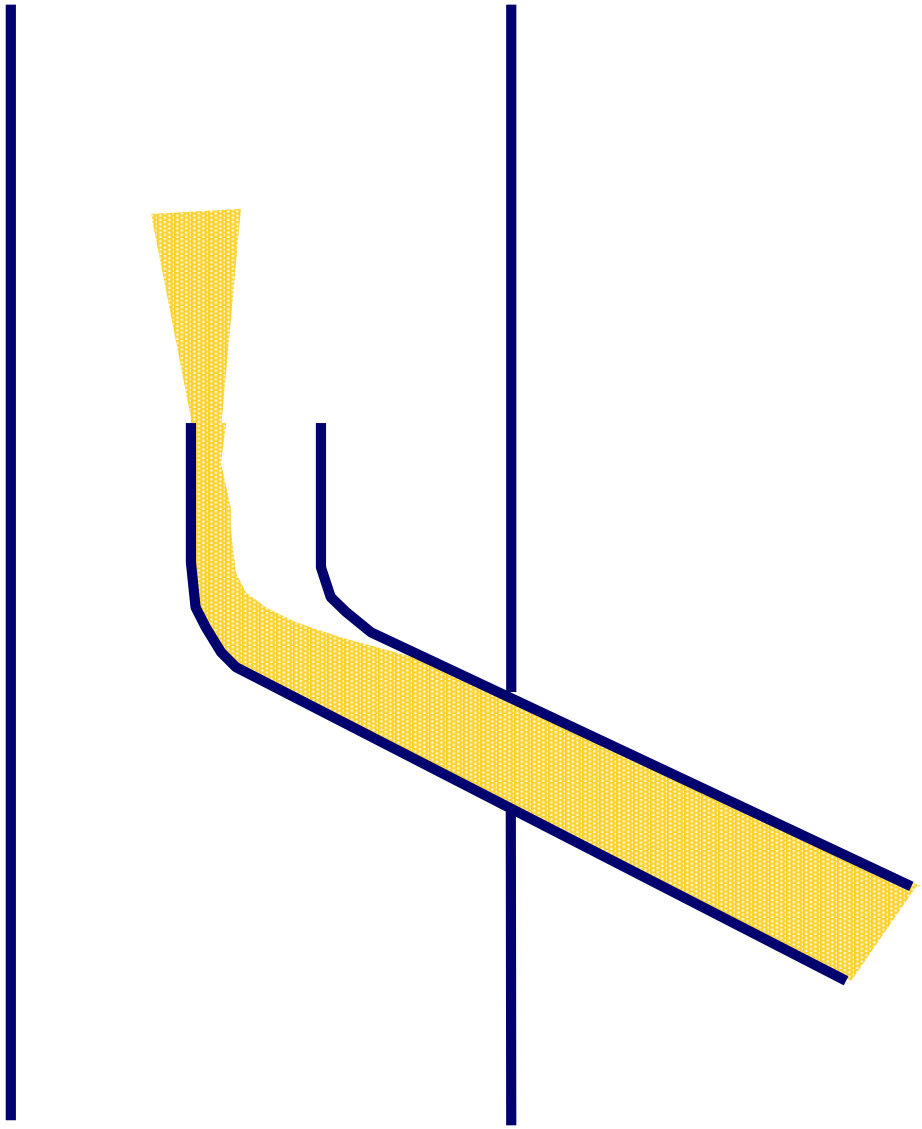

HCTL Transfer and Entrainment
HCTL = 0
HCTL ≈ 520
HCTL = X
y = 2342.39x^4.195
y = 2414.53x^3.368
665
380
Measured Entrainment Rate, kg/hr
Fluidizing Gas Velocity, m/s
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50

Schematic Drawing of Test Unit

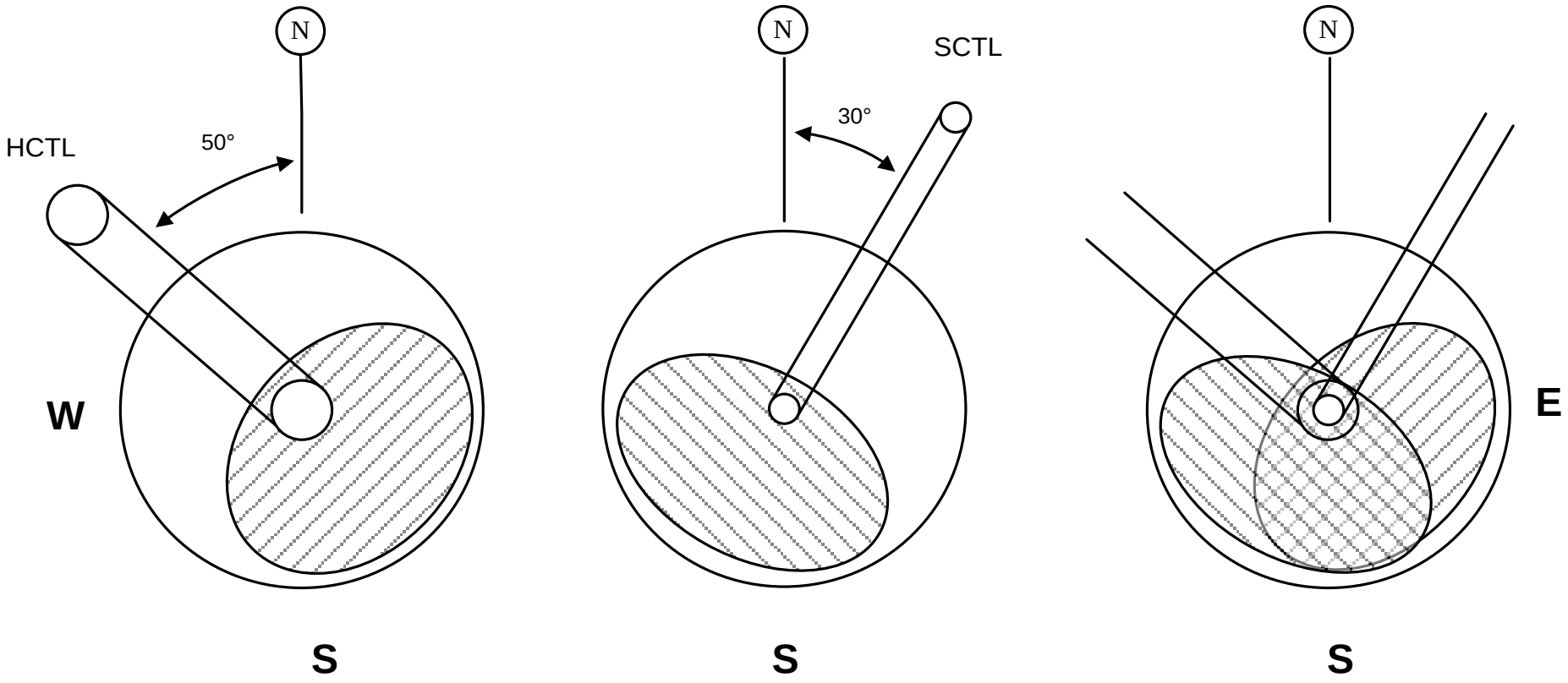




Effect of Adding Solids to the SCTL and HCTL on Solids Distribution in the Cyclones



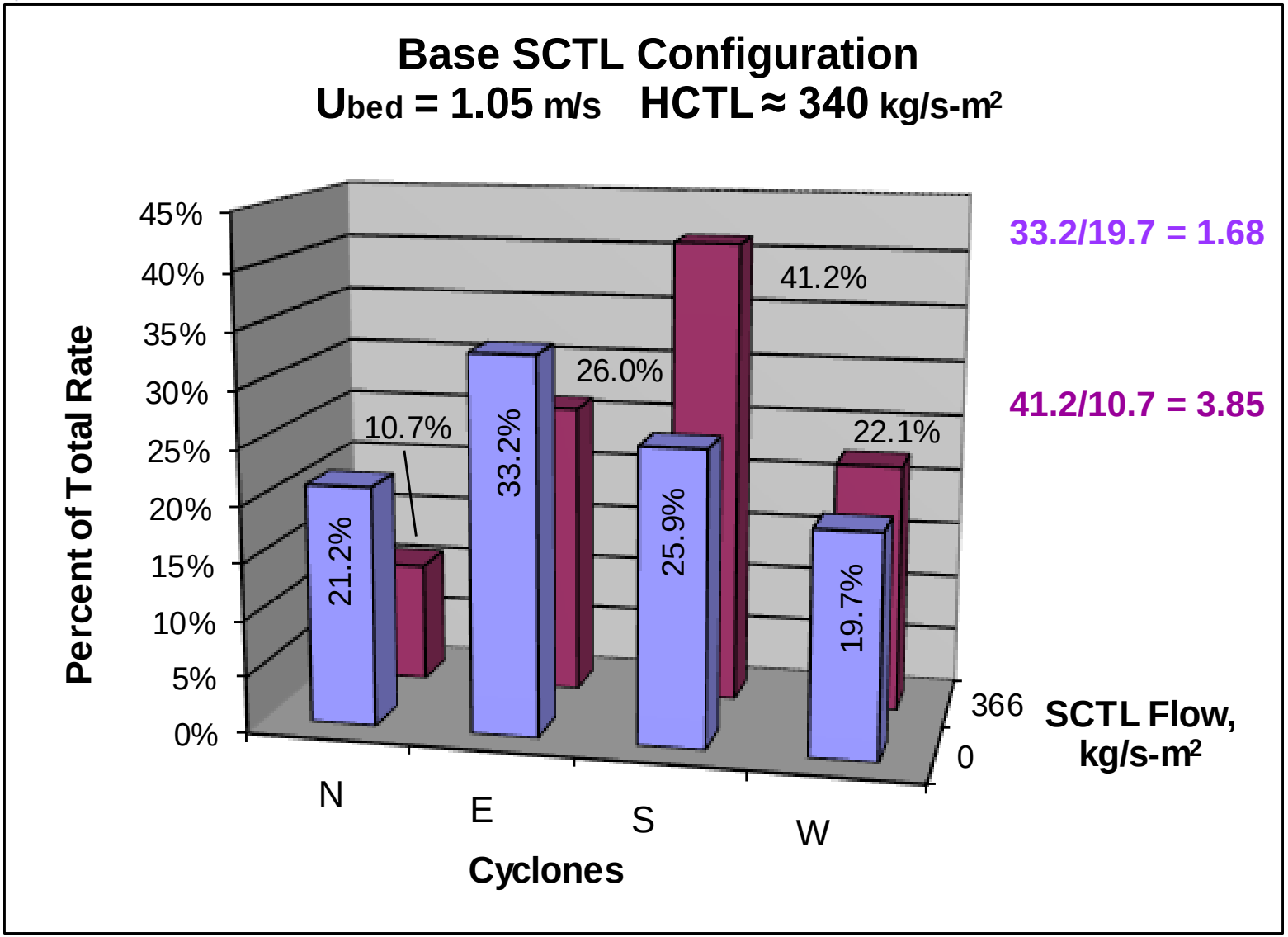
Schematic Drawing of Solids Flow Around the SCTL/HCTL Bend



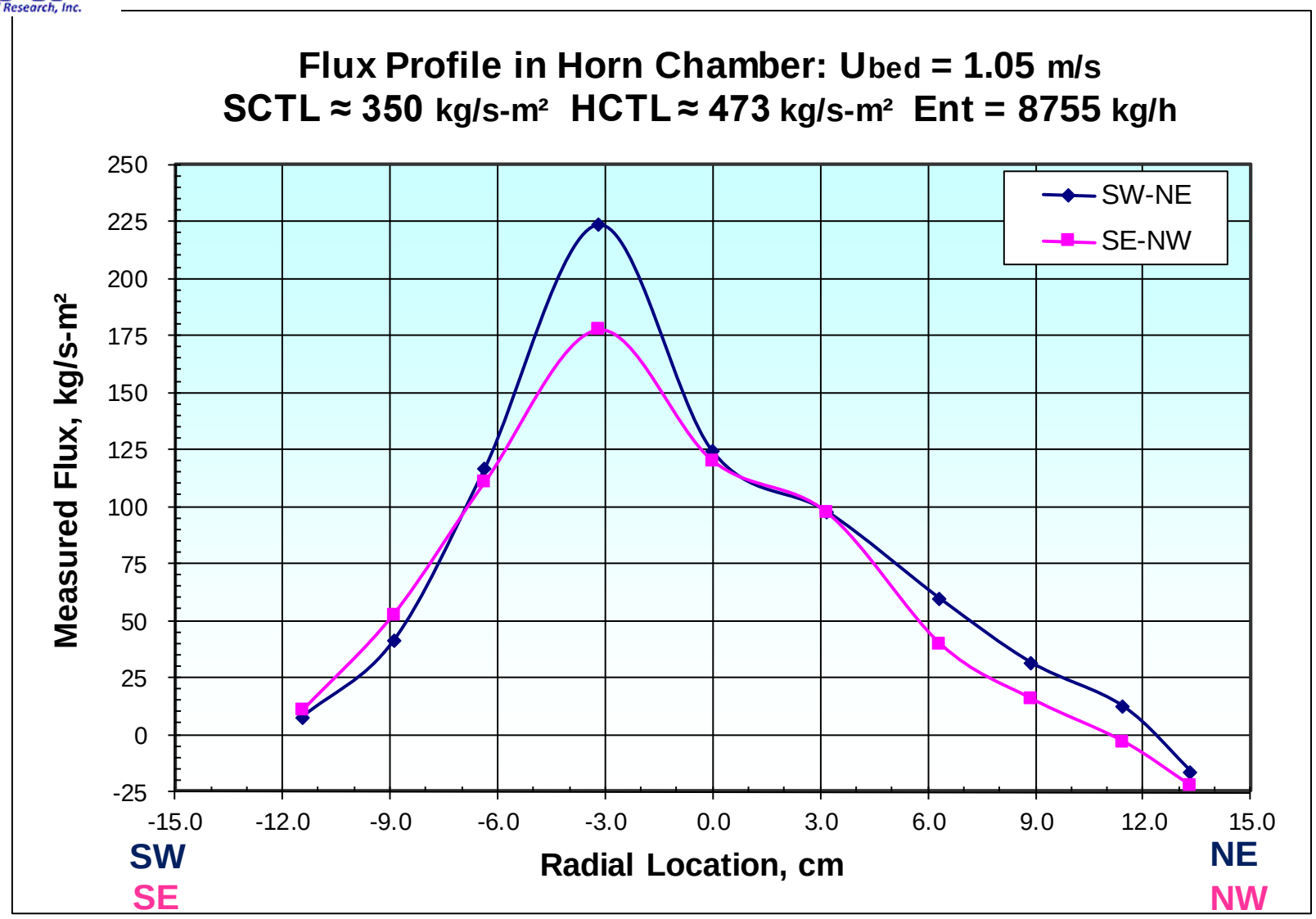
Relative Locations of the HCTL and SCTL and Possible Influences on Solids Distribution

Orientation of the HCTL and SCTL

- The HCTL Enters the Test Unit From the Northwest Approximately 50 Degrees from the North
- The SCTL Enters the Test Unit from the Northeast Approximately 30 Degrees from the North
- Because of the Nature of Solids Flow in the HCTL and SCTL Line Bends, it Could be Expected That the Solids Would be Concentrated in the South and East Quadrants of the Horn Chamber. That is What was Observed in the Testing

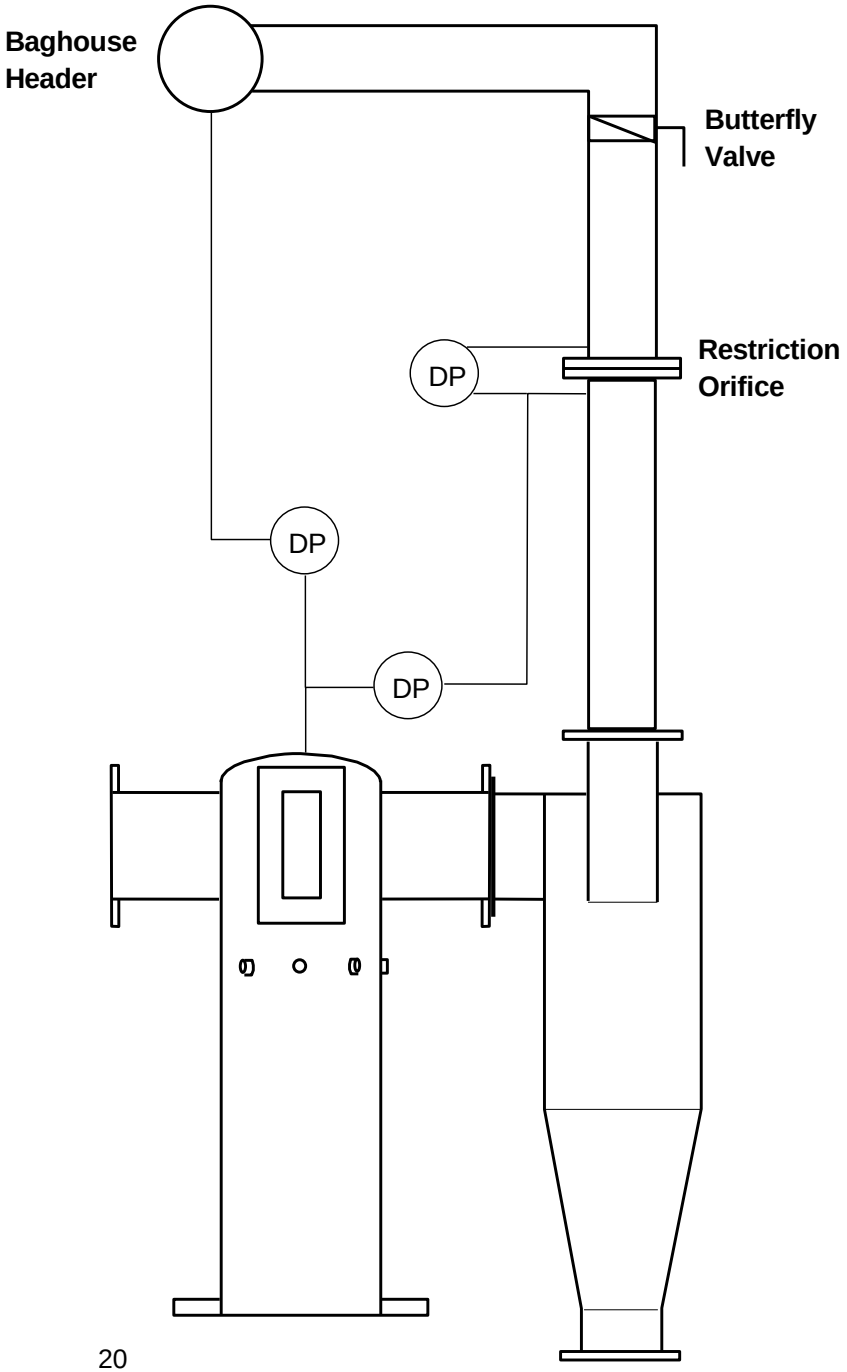


Effect of Adding Solids to the SCTL and HCTL on Solids Distribution in the Cyclones



Solids Mass Flux Profiles in the Horn Chamber (SCTL Solids Flux = 350 kg/s-m^2; HCTL Solids Flux = 473 kg/s-m^2)

Schematic Drawing of Cyclone Exit Line



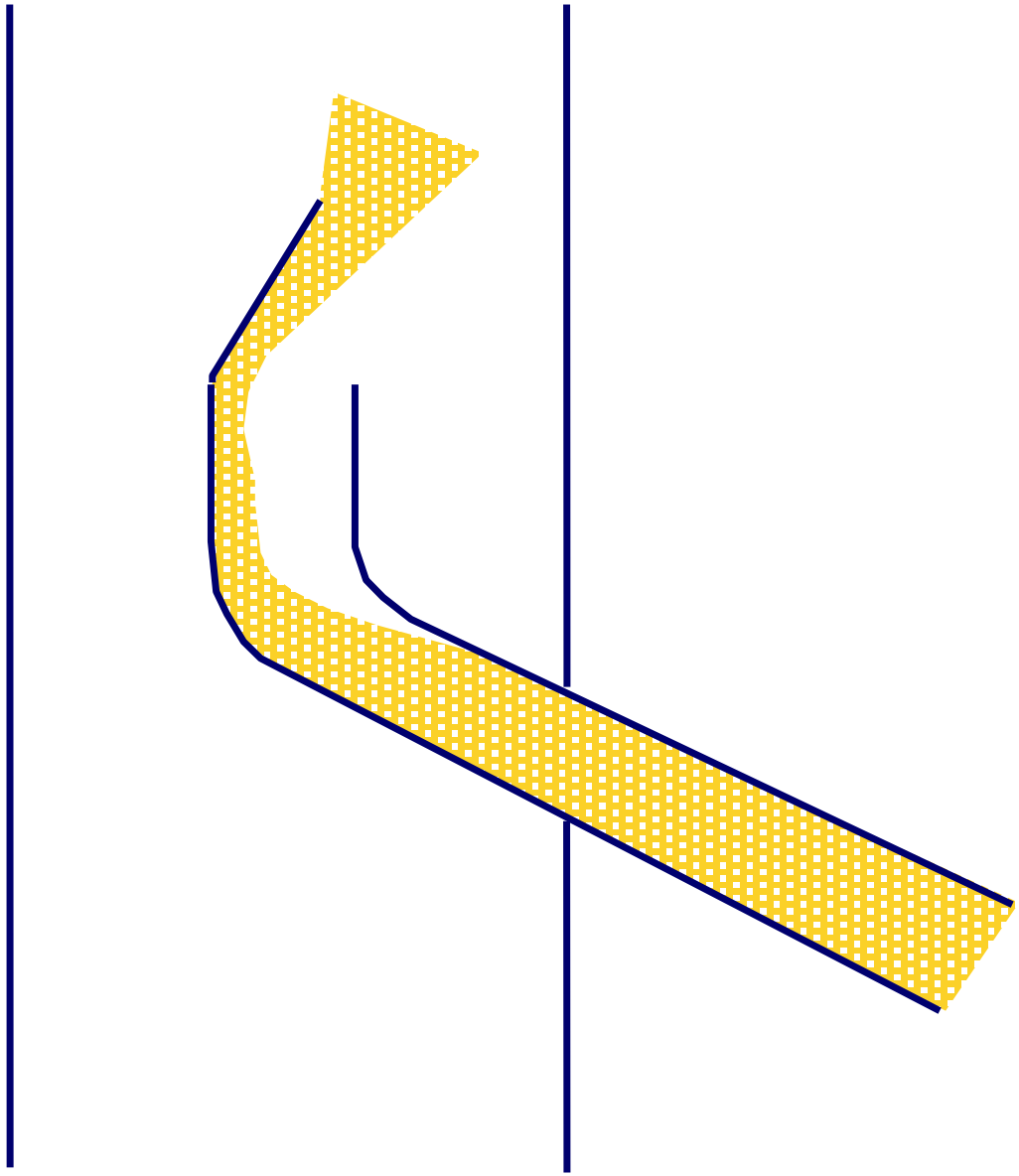
Gas Flow in Cyclone Outlet Lines

- The Gas Flow Rate Through Each Cyclone Was Determined by Measuring the Pressure Drop Across an Orifice in Each Cyclone Gas Outlet Line

- The Gas Flow Rate Through Each Cyclone Was Not Equal. The Gas Flow Rates Were Highest for the Cyclones With the Lowest Solids Flows *(N and W Cyclones)*

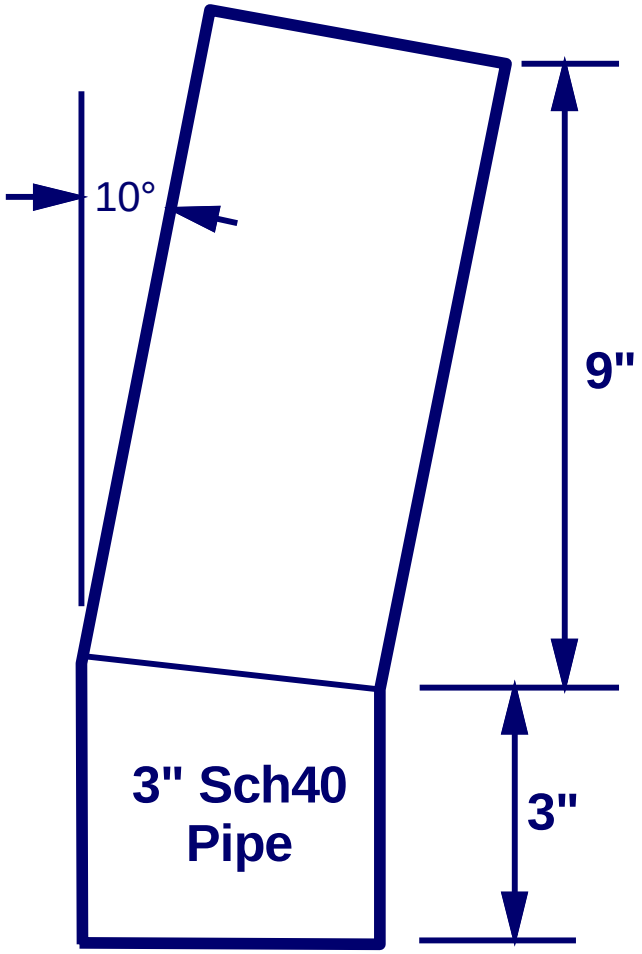
- The Gas Flow Rate Was Then Increased to Make All Gas Flows Equal. This Had a Minimal Effect on the Solids Flow Distribution in the Cyclones.

- Increasing the Gas Flow Rate to Various Cyclones Also Did Not Have Any Effect on the Solids Flow Distribution Through the Cyclones



Deflection of Solids to Influence Cyclone Solids Distribution

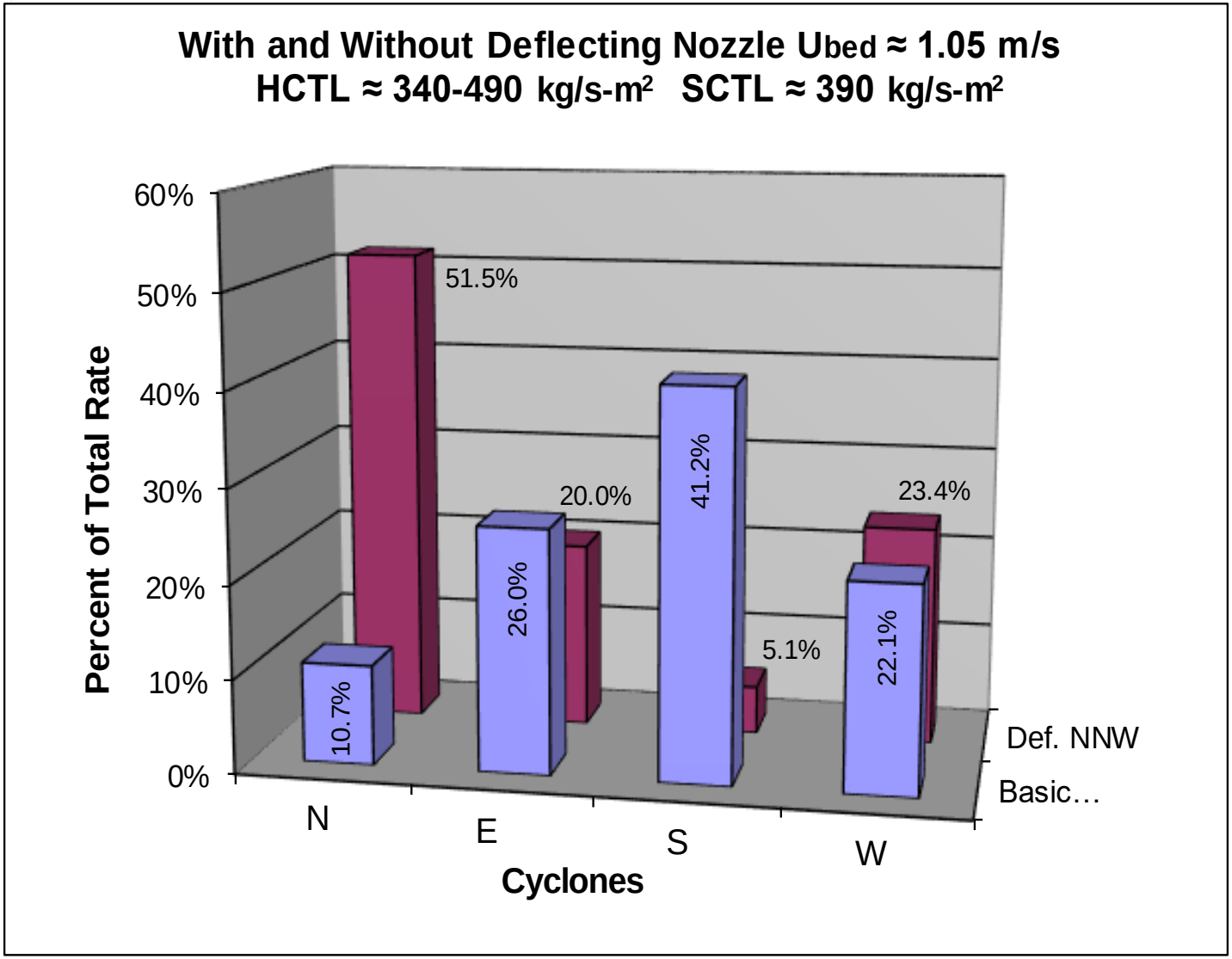
SCTL Pipe
Angled 10°



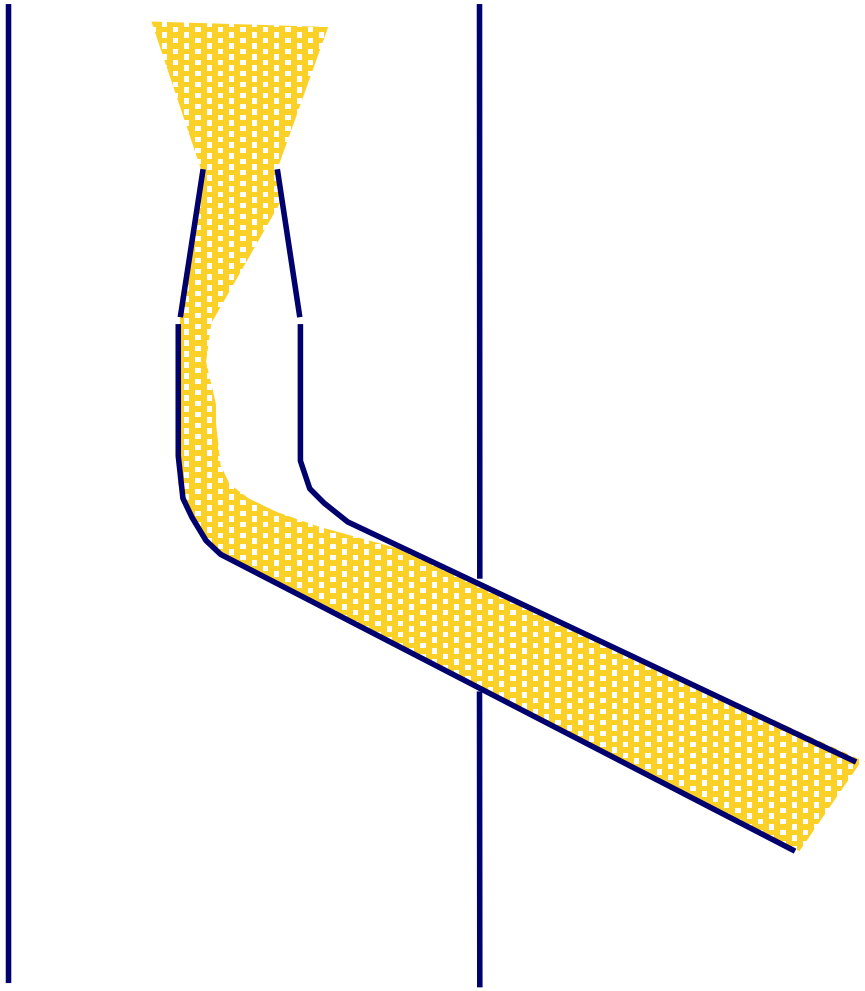
Deflection of Solids

- The Base SCTL Configuration Resulted in Solids Preferentially Flowing to the South and East Cyclones

- It was Found That the Solids Distribution Shifted From the South or East Cyclones to the North Cyclone After the Deflector Configuration was Added to the SCTL

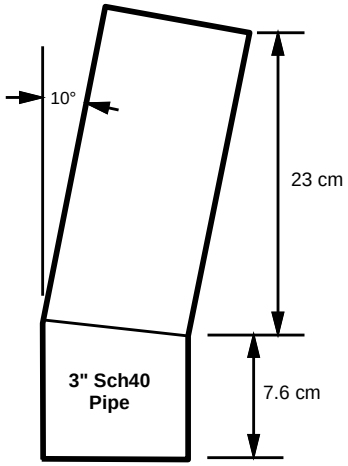


Solids Distribution in Cyclones With and Without Deflecting Nozzle



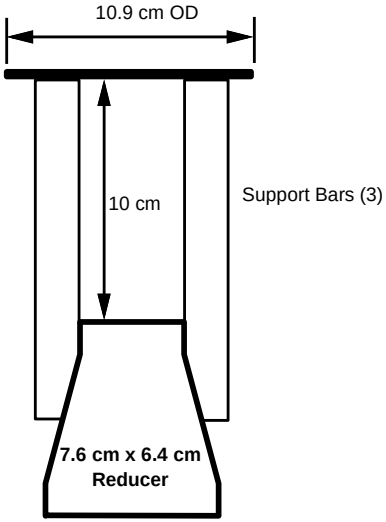
Centering Nozzle

SCTL Exit Configurations



SCTL Nozzle Angled 10 degrees

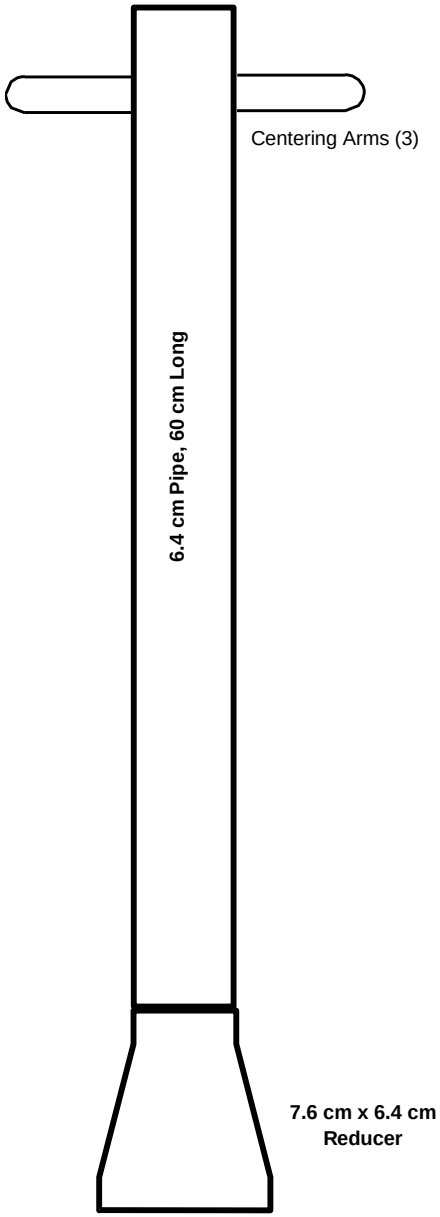
A



Concentric Nozzle with Impact Plate

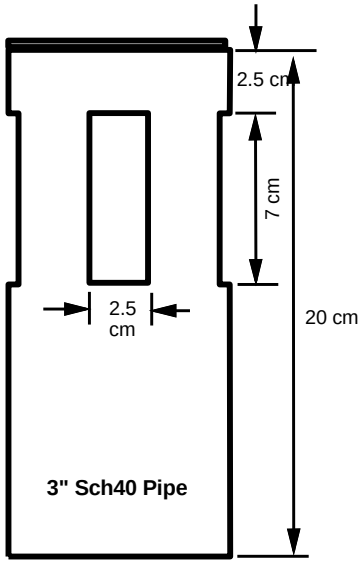
B

SCTL Exit Configurations



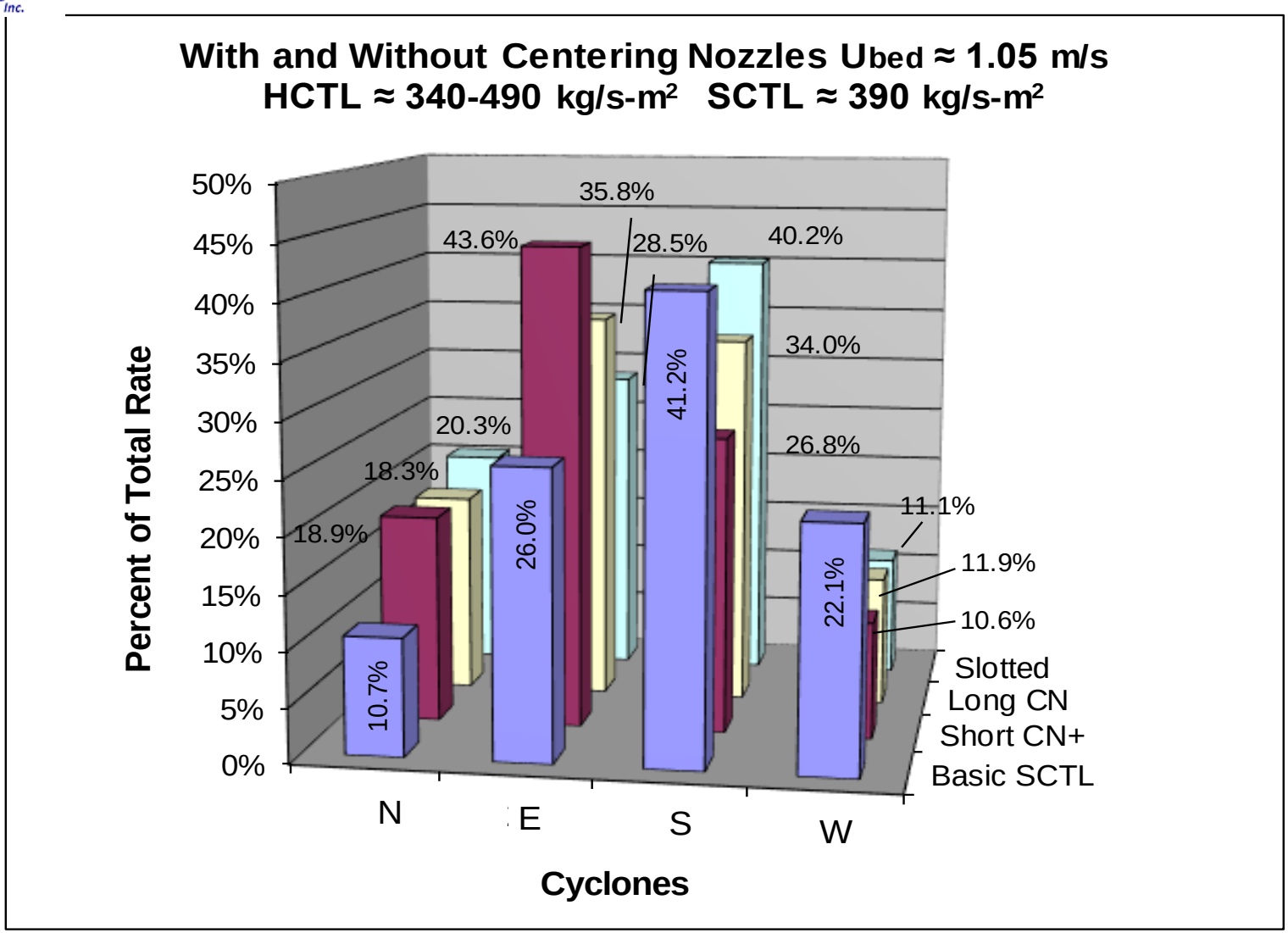
Long Centering Nozzle

A



Capped Pipe with Four Outlet Slots

B



Solids Distribution in Cyclones With and Without Centering Nozzles

Conclusions

- **It Appears That the Solids Distribute to the Cyclones Based on the Solids Distribution at the Entrance of the Cyclones** *(in this case caused by the asymmetry of the solids flow due to centrifugal force in the HCTL and SCTL bends)*
- **The Gas Flow Then Distributes Itself so That the Pressure Drop Across the Cyclones are Equal**
- **Changing the Gas Flow Rate Through the Cyclones Did not Affect the Solids Distribution Through the Cyclones**

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Thank You

Gracias

Merci