

REINHOLD ENVIRONMENTAL®



2022 Reinhold/PCUG Round Table Presentation

Hosted by Duke Energy in the Charlotte Sheraton/Le Meridien
Hotel, Charlotte, NC on June 27-28, 2022

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Hosted by:
Chad Donner



Hosted by:
Ian Saratovsky, PhD
Jerry Hunt



The Version for the Biggest DSI Fans!!

- > Team trivia event
- > Can receive up to five (5) points per question
- > Will have two (2) minutes to answer each question
- > Final question you will be able to wager your points
- > No using smart phones or computers to look up answers
- > You cannot phone a friend or poll the audience
- > No swapping teammates

DSI with hydrated lime gained interest in the early 2000s because of its ability to reduce the visible blue plume caused by $\text{SO}_3/\text{H}_2\text{SO}_4$. Over time it was determined that several balance of plant benefits were achieved by removing $\text{SO}_3/\text{H}_2\text{SO}_4$. Name three (3) balance of plant benefits associated with reducing $\text{SO}_3/\text{H}_2\text{SO}_4$ emissions.

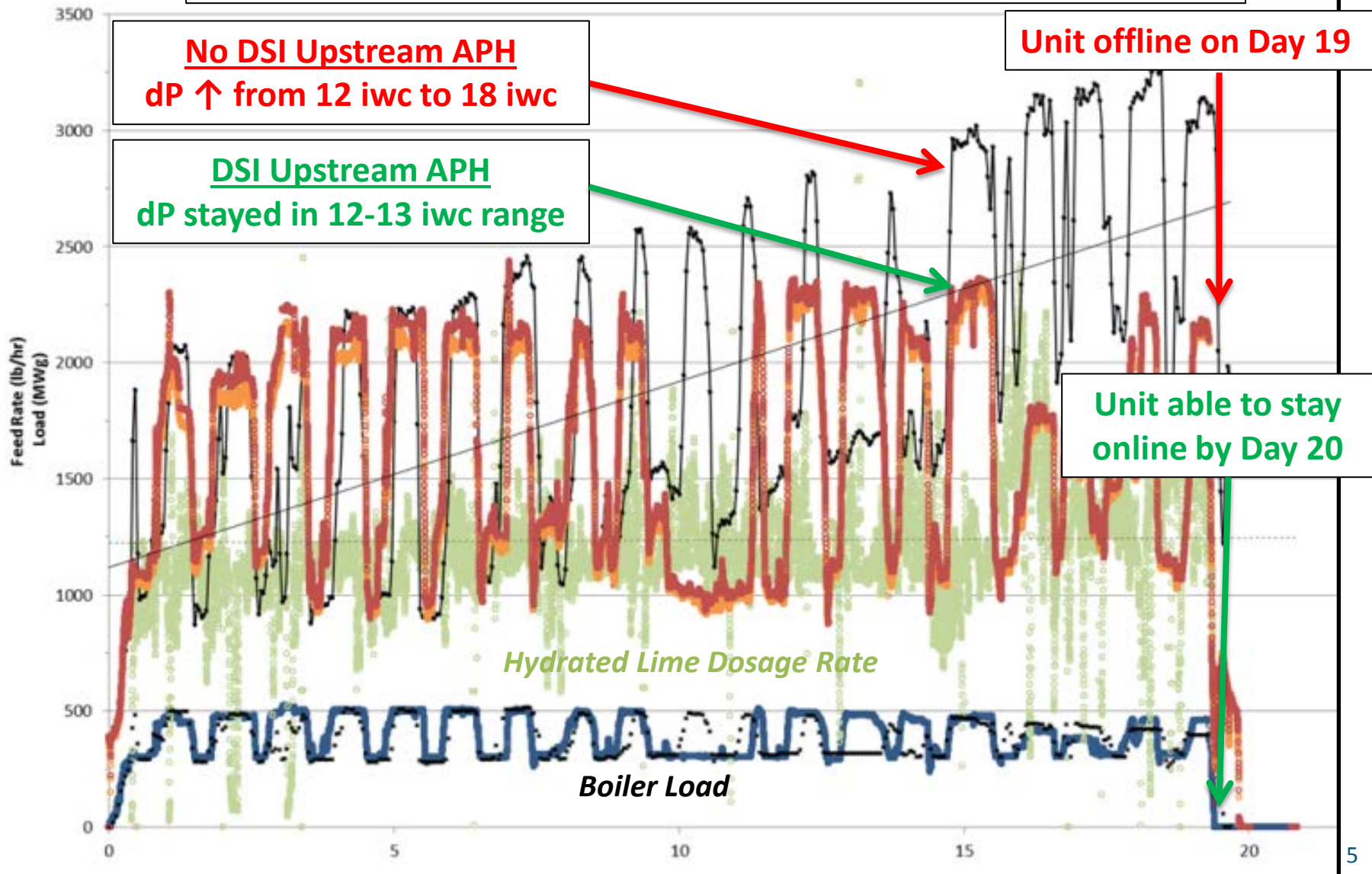
One (1) point for each correct answer. Two (2) bonus points if you get three (3) correct answers.



Correct Answers: Corrosion protection, PAC protection, reduced air heater fouling, heat rate improvement, reduced SCR MOT



APH dP Trend (DSI vs. No DSI over 20 Day Period)



The industry has decades of DSI operating experience and learned a lot regarding system reliability particularly around “hard scaling”. What reacts with hydrated lime to cause “hard scaling”? Name two (2) pneumatic conveying properties / design features that impact “hard scaling” rate of formation.

One (1) point for each correct answer. Two (2) bonus points if you get three (3) correct answers.



Question #2

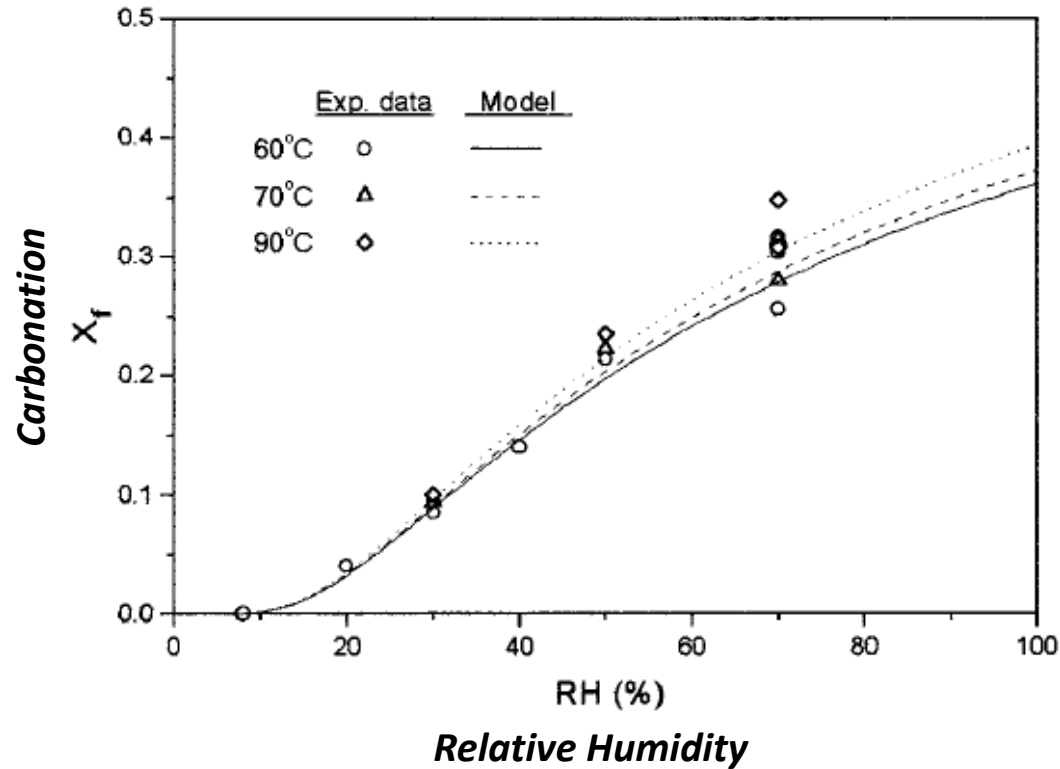
Correct Answers:

Part 1 – Carbon dioxide



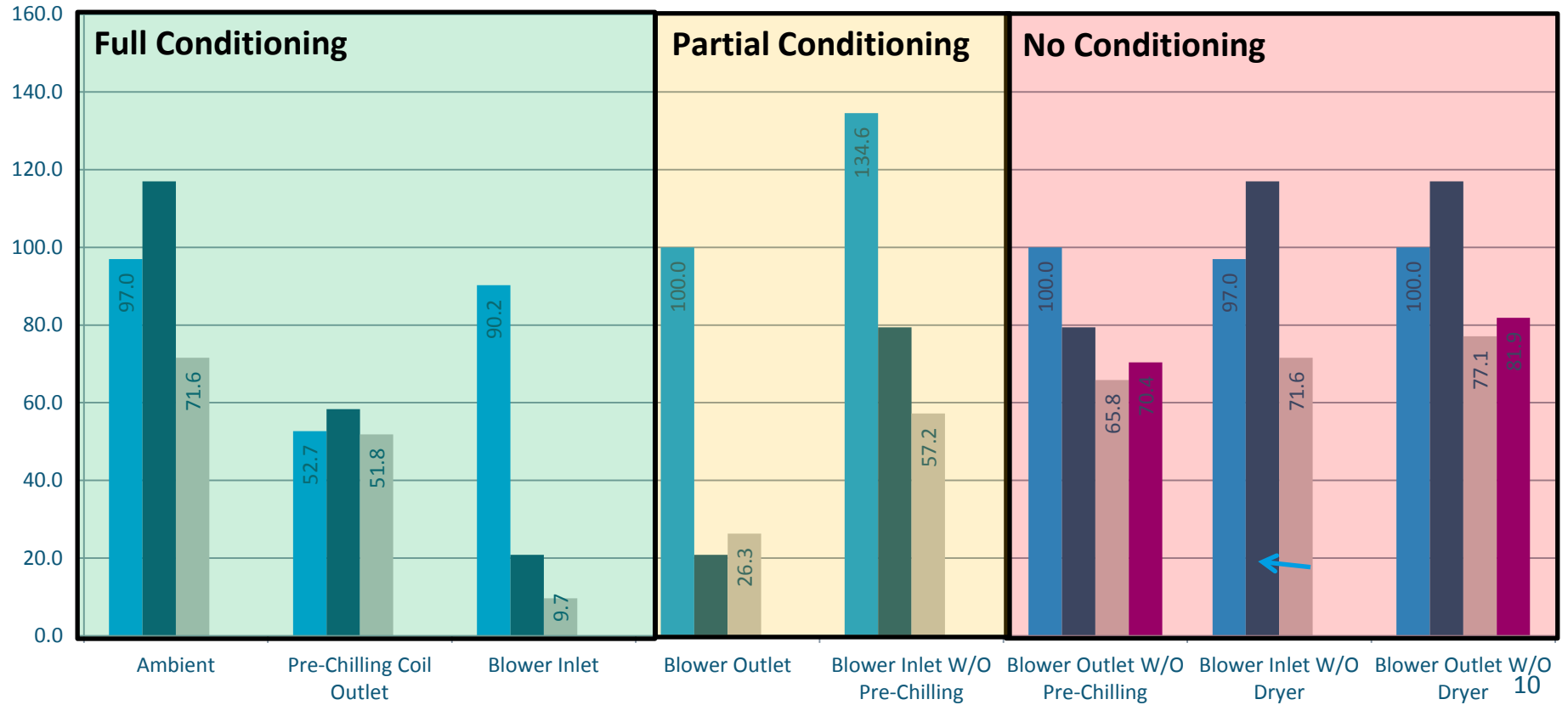
Part 2 – Conveying air velocity, temperature and moisture (relative humidity) are properties that impact “hard scaling”. Some design features that also impact “hard scaling” include elbow bend radius, materials of construction, connection design.





“Relative humidity is a deterministic factor affecting the reaction of $\text{Ca}(\text{OH})_2$ with CO_2 . The reaction occurs only when the relative humidity is higher than a critical value of 8% and the reaction rate and final conversion of $\text{Ca}(\text{OH})_2$ increase with increasing relative humidity. The reaction is slightly dependent on the reaction temperature and is zeroth order with respect to gas phase CO_2 concentration.”

Air Quality Comparison of Conveying Equipment



■ Temperature (Deg. F)

■ Dewpoint (Deg. F @ 3psi)

■ Moisture (Gr. H2O / Lb. of Air)

■ Dewpoint (Deg. F @ 6psi)

Ideal moisture range of 10-30 grains H₂O/lb. of air equivalent to ~8% relative humidity

Question #2

2016
Carbon Steel Elbows



Required cleaning
every 6-8 weeks



2+ years without
cleaning or replacement



2021
Polyurethane Hose Elbows

Sorbent dispersion is critical to DSI efficiency. Various technologies have demonstrated the ability to improve sorbent-to-acid gas contact and thus DSI performance. Name three (3) technologies used to improve sorbent dispersion in DSI applications.

One (1) point for each correct answer. Two (2) bonus points if you get three (3) correct answers.



Correct Answers: United Conveyor Corporation Cobra Lances, Nol-Tec Sorb-Tec Injectors, Static Mixers (i.e., Delta Wings) and Mark Thomas Lance Design with Integral Mixing Plate (refer to Workshop #2)

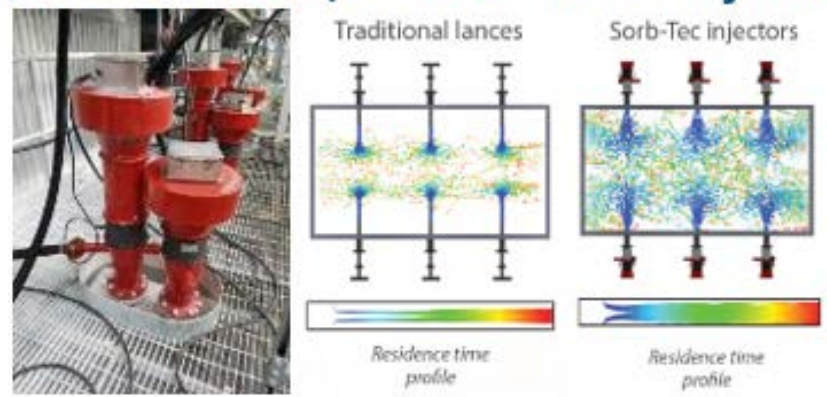


Distribution Plate Technology

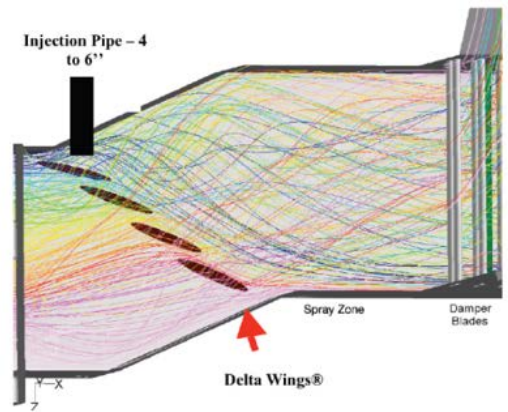
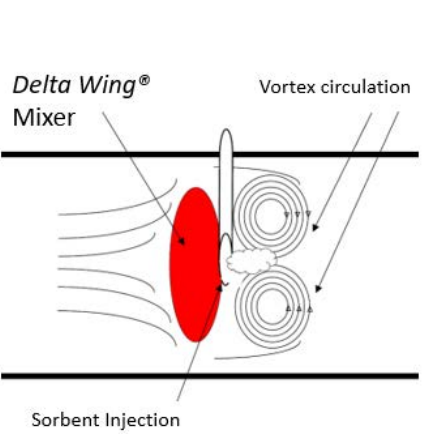


Courtesy of UCC © 2017 United Conveyor Corporation - UCC

Boosted Air, Lance-less Injector



Courtesy of Nol-Tec Systems ©2017 Nol-Tec



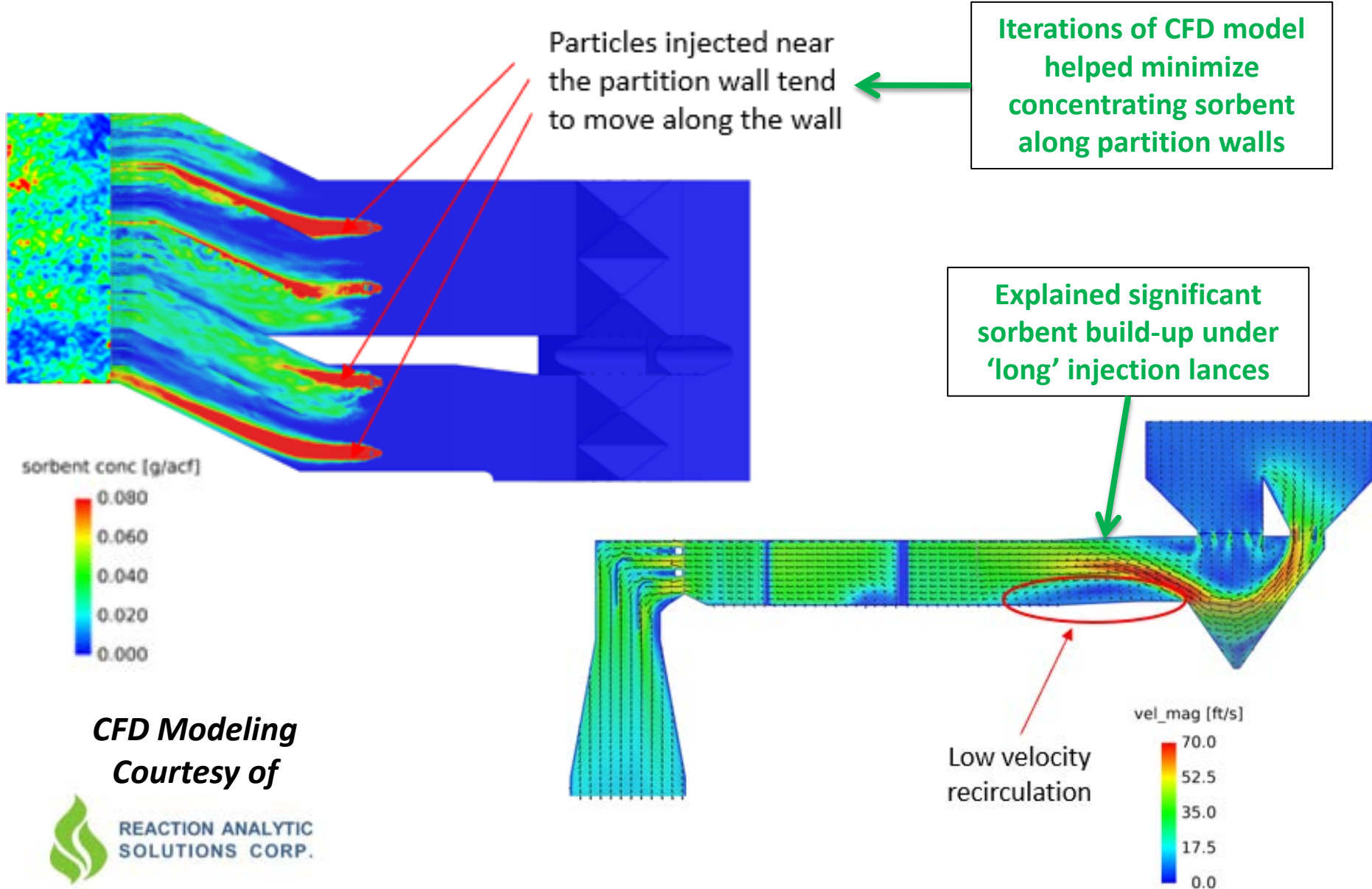
Courtesy of BPEI © 2017 Babcock Power Environmental

In-Duct Static Mixer Technology



Courtesy of BPI © 2017 Blender Products, Inc.

Question #3



Question #4

“SO₃ affects everything, and everything affects SO₃”. One critical aspect of SO₃ emission control is understanding what can create SO₃ emissions. Minor changes can result in non-trivial impacts to SO₃ emissions. Name three (3) things that can impact uncontrolled SO₃ emissions.

One (1) point for each correct answer. Two (2) bonus points if you get three (3) correct answers.



Correct Answers: Coal sulfur content, SCR catalyst design, SCR inlet gas temperatures, boiler slagging, furnace oxygen, coal iron content.



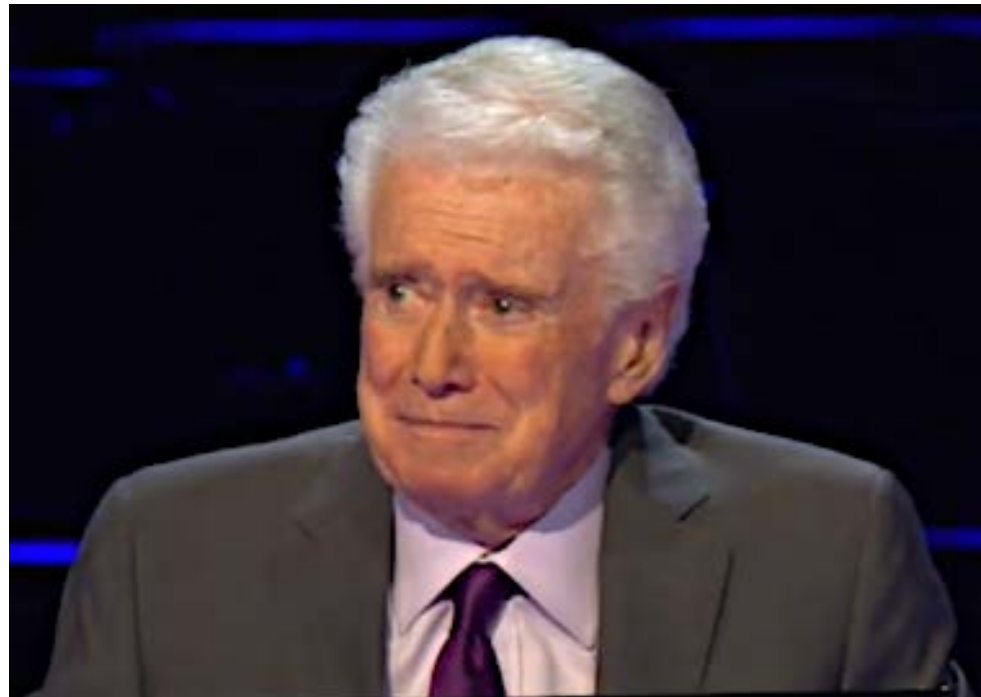
Date	Sorbent	Dosage	Load	SCR Inlet Temp	Stack H ₂ SO ₄
		lb/hr	MWs	F	lb/MMBtu
15-Feb	Sorbacal SP	2,252	750	730	0.0181
15-Feb	Sorbacal SP	2,275	750	731	0.0173
15-Feb	Sorbacal SP	2,311	751	734	0.0198
17-Feb	Sorbacal SP	2,292	749	695	0.0086
17-Feb	Sorbacal SP	2,340	750	696	0.0075
17-Feb	Sorbacal SP	2,280	750	699	0.0097

Plant operators weren't soot blowing tubes sufficiently and SCR inlet gas temperature was 30-40°F above 'normal' and did not achieve historical stack H₂SO₄ emissions (< 0.01 lb/MMBtu)

Corrective actions taken and SCR inlet gas temperature back to typical target (< 700°F) and all else equal achieved historical stack H₂SO₄ emissions (< 0.01 lb/MMBtu)

One evolution of the DSI solution is engineering physical (i.e., pore volume) and chemical properties of hydrated lime to further enhance DSI performance. Name three (3) benefits observed using “enhanced” hydrated lime over “standard” hydrated lime in DSI applications.

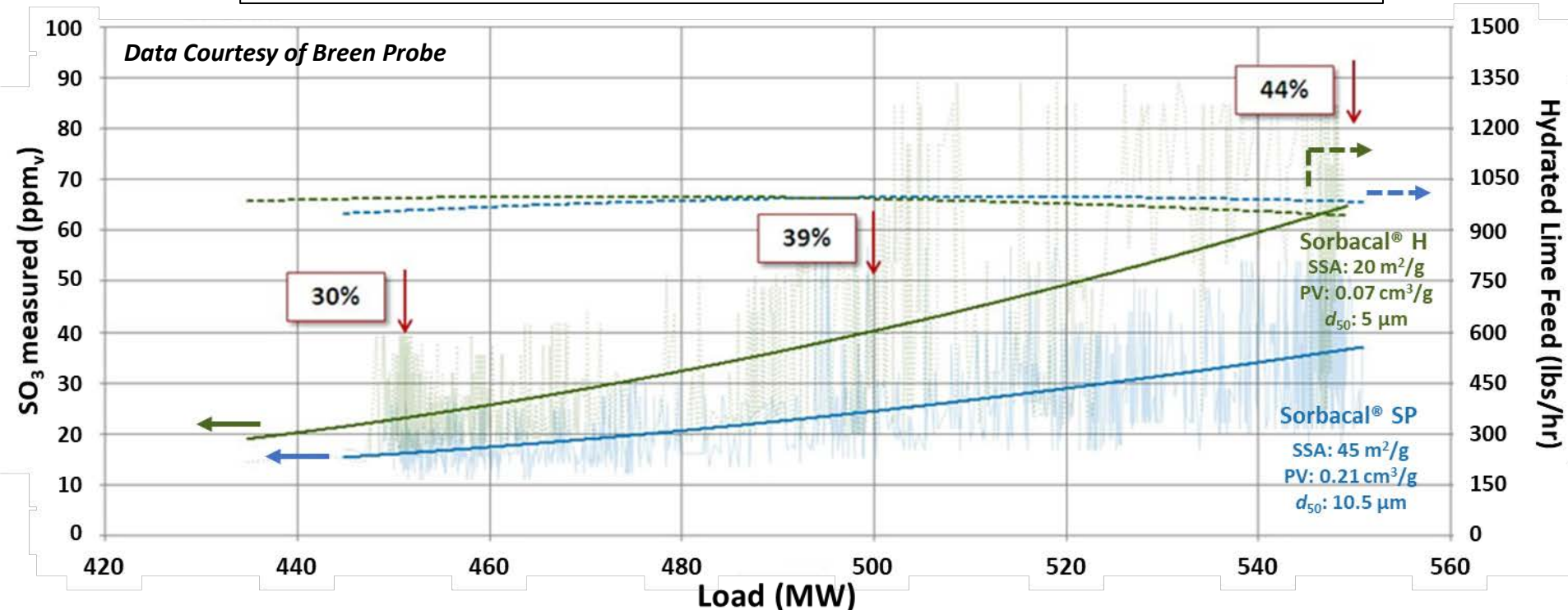
One (1) point for each correct answer. Two (2) bonus points if you get three (3) correct answers.



Correct Answers: Lower sorbent dosage rates, reduced residue generation (i.e., lower disposal costs), increased day storage within silo, fewer deliveries, increased fuel flexibility (i.e., higher acid gas removal efficiency).

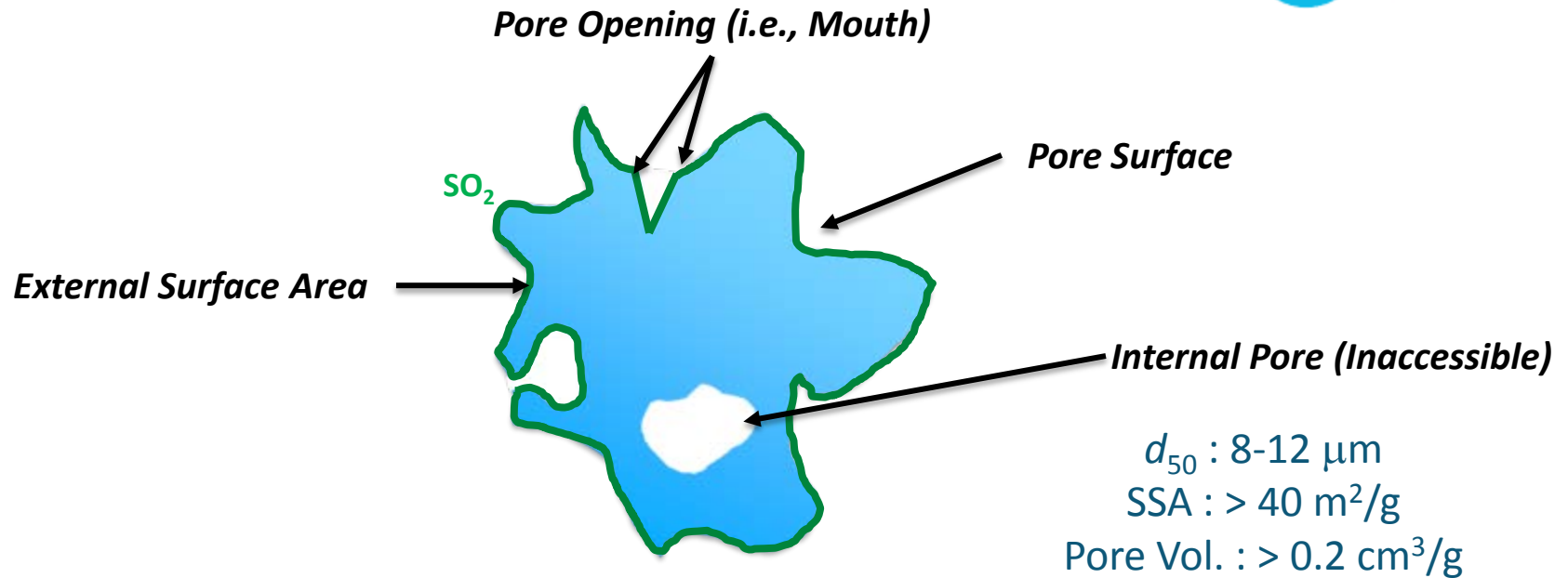


Reduction in Sorbent Consumption using Sorbocal® SP vs. Sorbocal® H for SO₃ Control Application



Sorbent dosage rates typically reduced by 30-50% using Sorbocal® SP/SPS vs. standard hydrated lime products (i.e., Sorbocal® H)

Question #5



Rates of reaction

- I. Gas film diffusion of $SO_2/HCl/SO_3$ to particle
- II. Pseudo-homogenous reaction (kinetics)
- III. Reaction at pore openings (diffusion)
- IV. Reaction inside pores (diffusion)

Reaction in internal pores (diffusion)

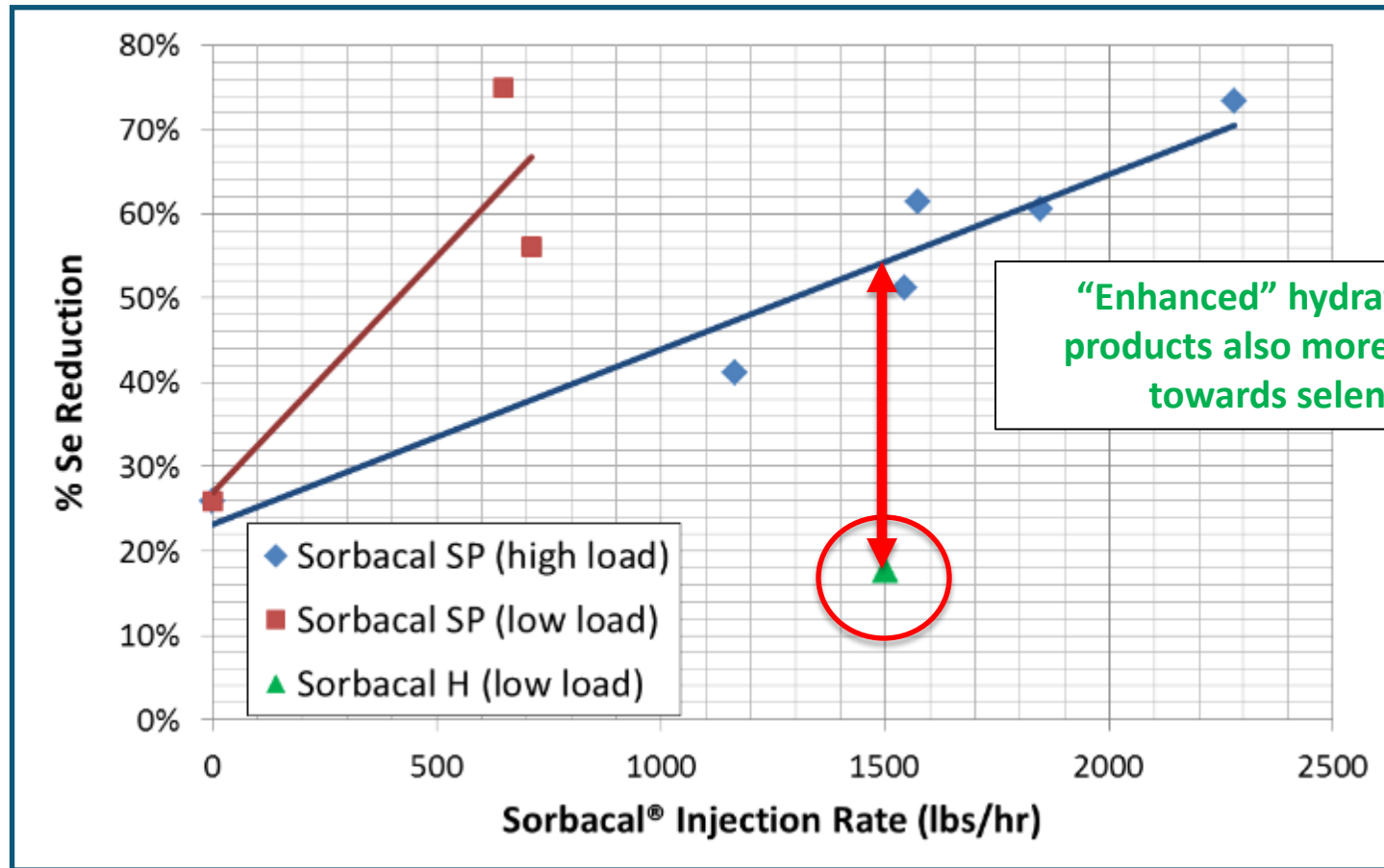
DSI is a highly flexible solution that has demonstrated multi-pollutant control while reducing balance of plant impacts. The Effluent Limitation Guidelines (ELG) provide further regulations on *water* quality requirements; however, DSI could be integrated into the ELG compliance solution. Name three (3) of the pollutants regulated by the ELG.

One (1) point for each correct answer. Two (2) bonus points if you get three (3) correct answers.



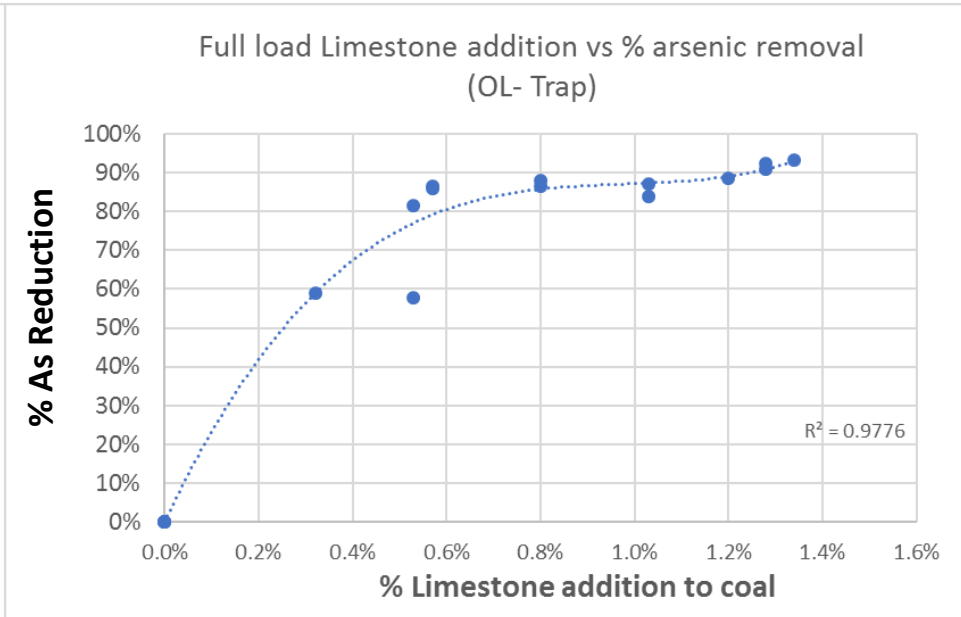
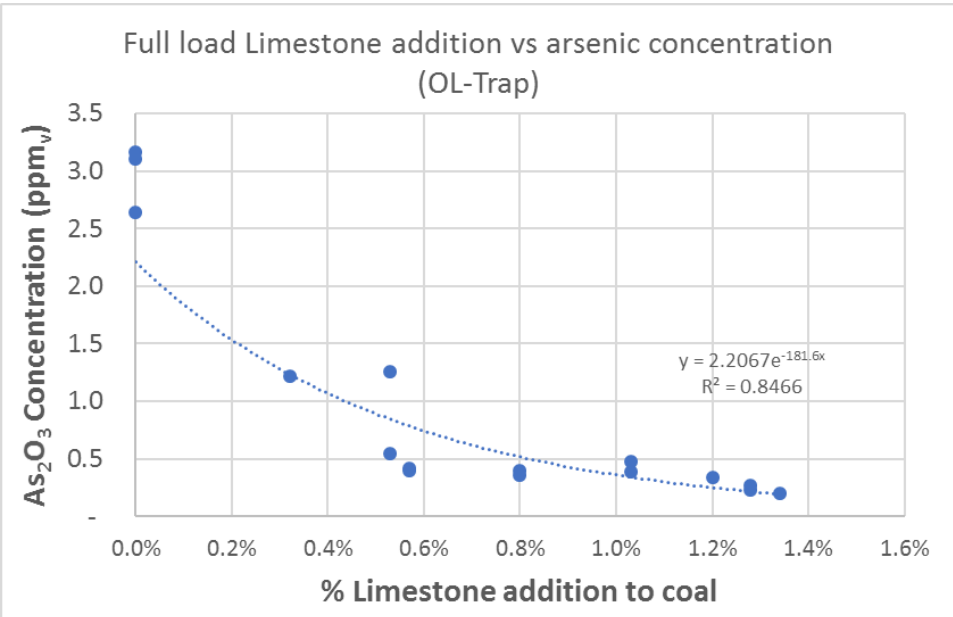
*Correct Answers: Arsenic, selenium, mercury,
nitrates/nitrites*





Already using DSI for acid gas emission control so maximizing economical gas phase heavy metal removal may simply be a function of optimizing DSI process design (i.e., sorbent, injection location, etc.)

Calcium can also mitigate impacts associated with arsenic



(1) Bookout, J. Mitigating Arsenic Poisoning of SCR Catalyst from Burning Gibson IB Coal. 2018 NO_x-Combustion Round Table, St. Louis MO. Workshop 08

Reliable sorbent logistics is a necessity for the DSI solution. Historically, the industry has utilized pneumatic trucking as the primary logistic supply choice. However, the US is experiencing an unprecedented shortage of truck drivers. How many truck drivers short was the US in 2021 (according to the American Trucking Association)?

Five (5) points: answer \leq 5%

Three (3) points: $5% <$ answer \leq 10%

One (1) point: $10% <$ answer \leq 20%

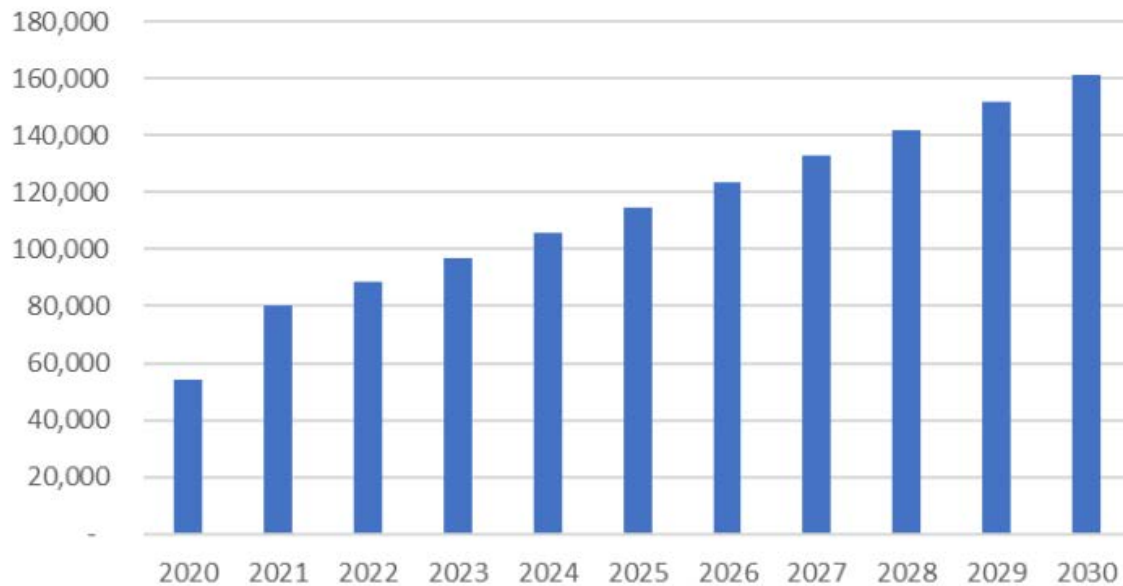


Correct Answers: 80,000

5 pts	5%	76,000	84,000
3 pts	10%	72,000	88,000
1 pt	20%	64,000	96,000



Truck Driver Shortage



[ATA Driver Shortage Report
2021 Executive
Summary.FINAL .pdf
\(trucking.org\)](#)

How will industry address supply chain?

1. Capital investment for more on-sight storage (silos)
2. Drop trailers? Storage PIGs?
3. Rail logistics
4. Improved communication
5. Remote inventory monitoring

We must address this with a team mentality

Question #8

The industry has growing interest in removing SO_3 upstream of the SCR to reduce the SCR MOT and operate at a lower loads. What does “MOT” stand for? What compound is produced via reaction with SO_3 to create the SCR MOT limitation? What is the optimal SO_3 concentration (ppmv) at the SCR inlet to ‘sufficiently’ reduce the SCR MOT?

One (1) point for each correct answer. Two (2) bonus points if you get three (3) correct answers.

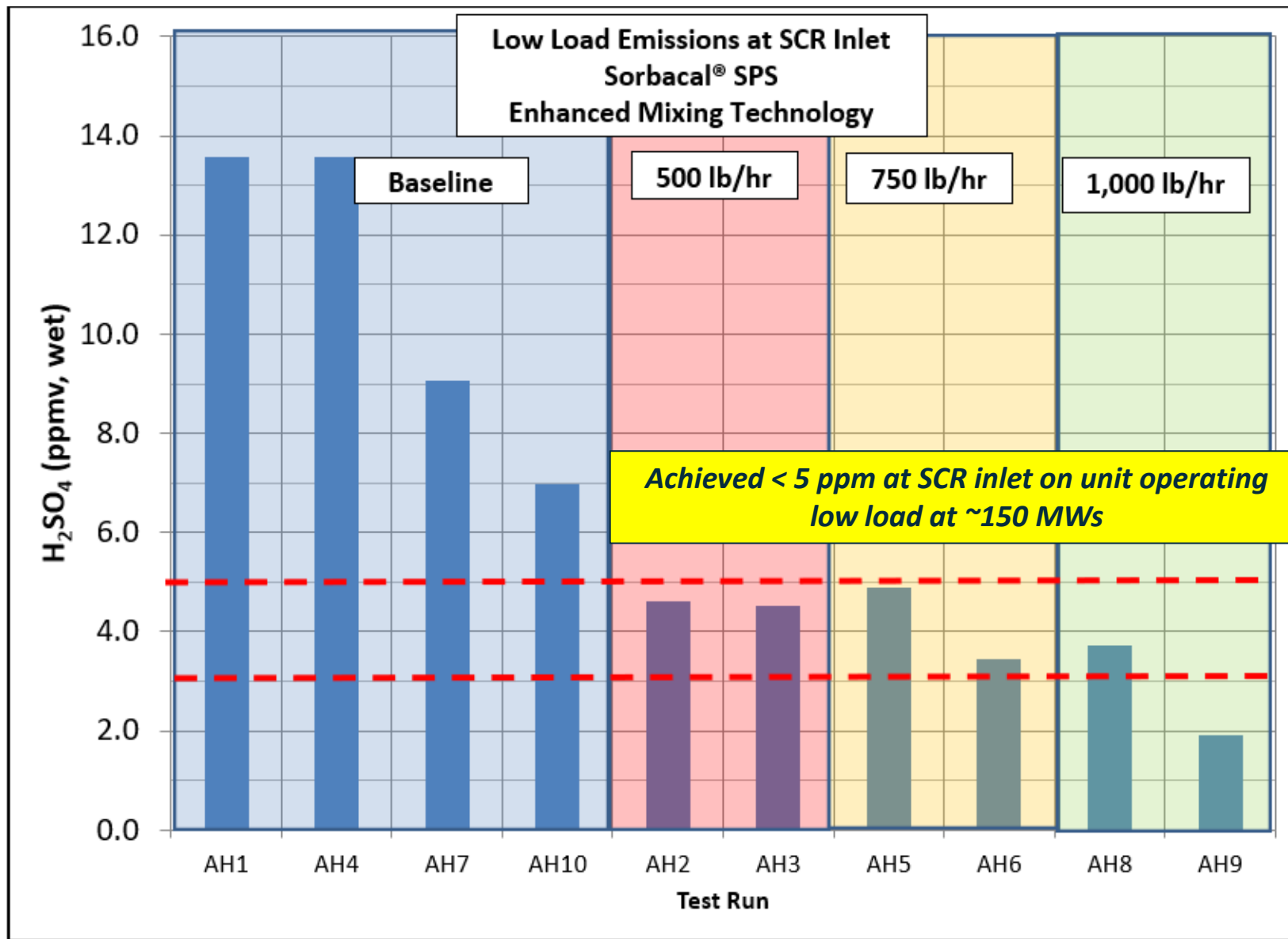


Correct Answers: Part 1 – Minimum Operating Temperature

Part 2 – ABS = ammonium bisulfate, $(\text{NH}_4)\text{HSO}_4$

Part 3 – 3 ppm_v at the SCR inlet





Place Wagers

Let's Check the Final Scoreboard



More consideration has been taken to assess DSI impacts on residue generated as beneficial use / disposal can have non-trivial cost impact. Name two (2) of the eight (8) RCRA metals. What is the upper pH limit (including reference temperature) for residue to still be classified as non-hazardous?

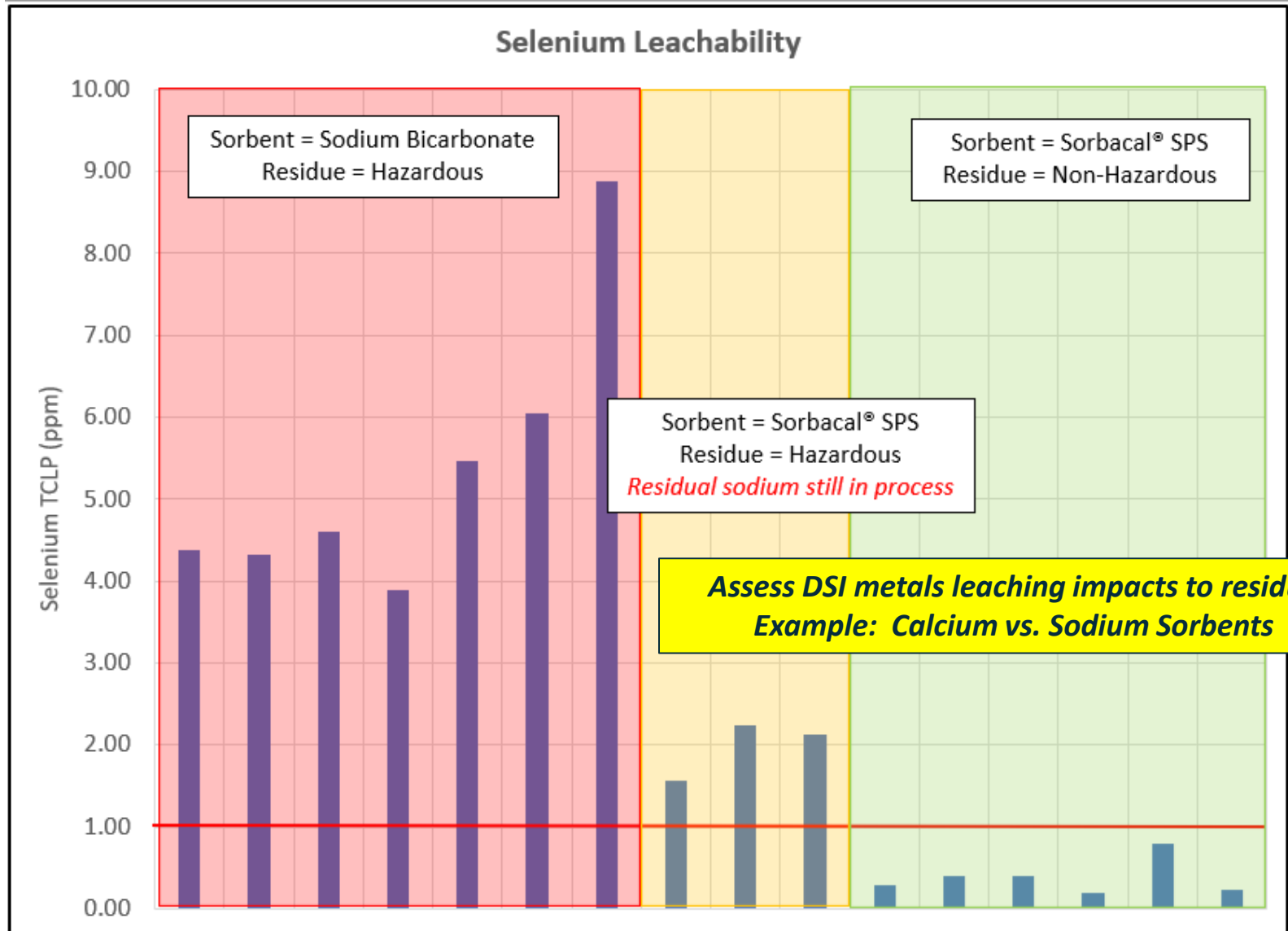
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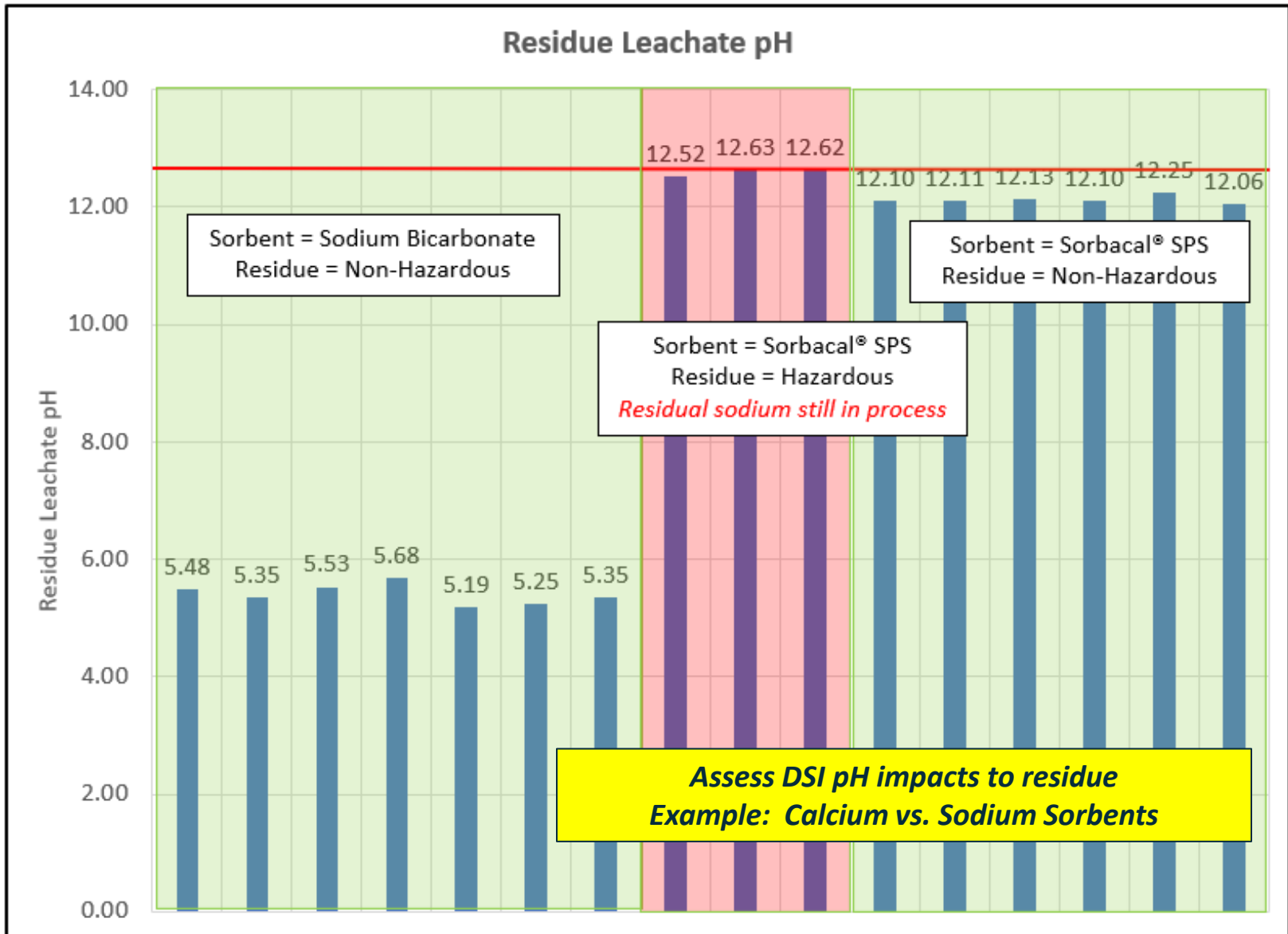


Correct Answers: Part 1 – Arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver

Part 2 – Hazardous material is at pH 12.45 at 25°C







Historically, users were concerned about using calcium sorbents in electrostatic precipitators (ESPs) due to concerns around detrimental impacts on the ESP. According to the 2016 MEGA Symposium paper by Great River Energy and Lhoist, what three (3) aspects of Sorbacal® SPS made it more 'suitable' for their ESP?

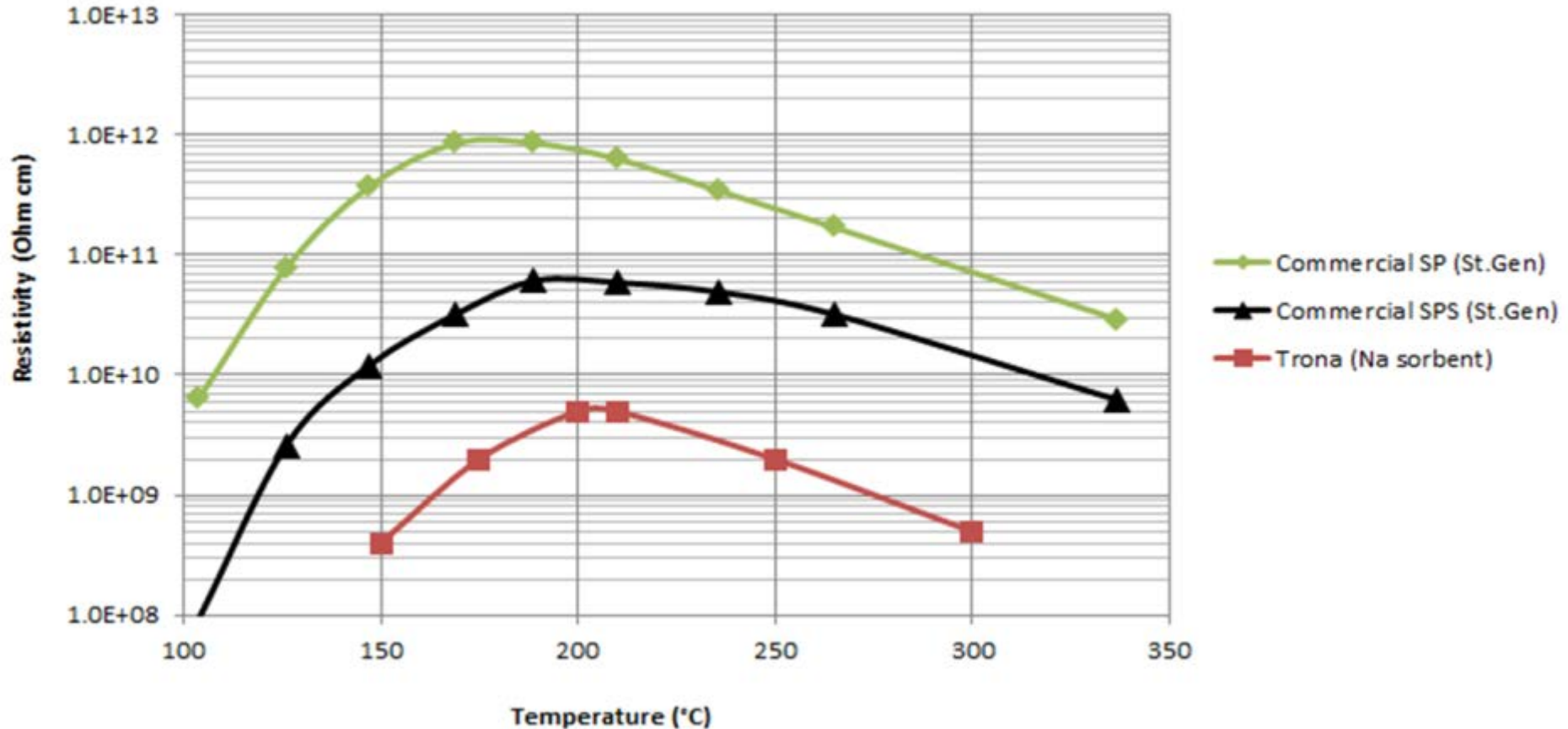
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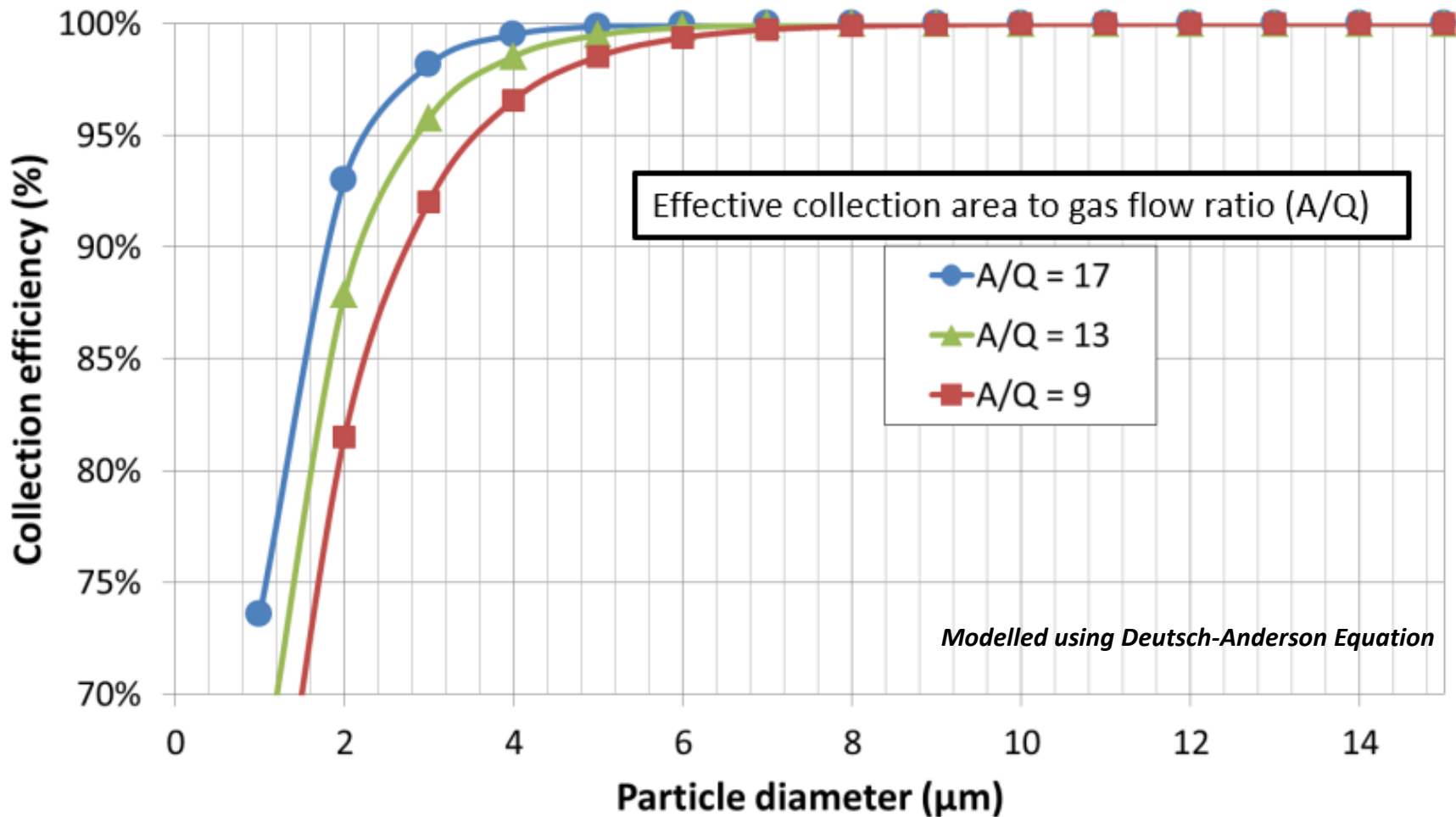
Correct Answers: Relatively coarse particle size distribution ($d_{50} \sim 10$ microns), lower electrical resistivity, lower mass loading (i.e., lower dosage rates)



Bonus Question #2



Sorbacal® SPS has order of magnitude lower resistivity than Sorbacal® SP (comparable to other hydrated lime products)



Model indicates that ESP particulate collection efficiency decreases for particles < 6 microns

Effect of particle size on ESP efficiency

Modelled using Deutsch-Anderson equation

Particle sizes below 6 μm are detrimental to ESP collection efficiency

