Innovation in Metals Processing

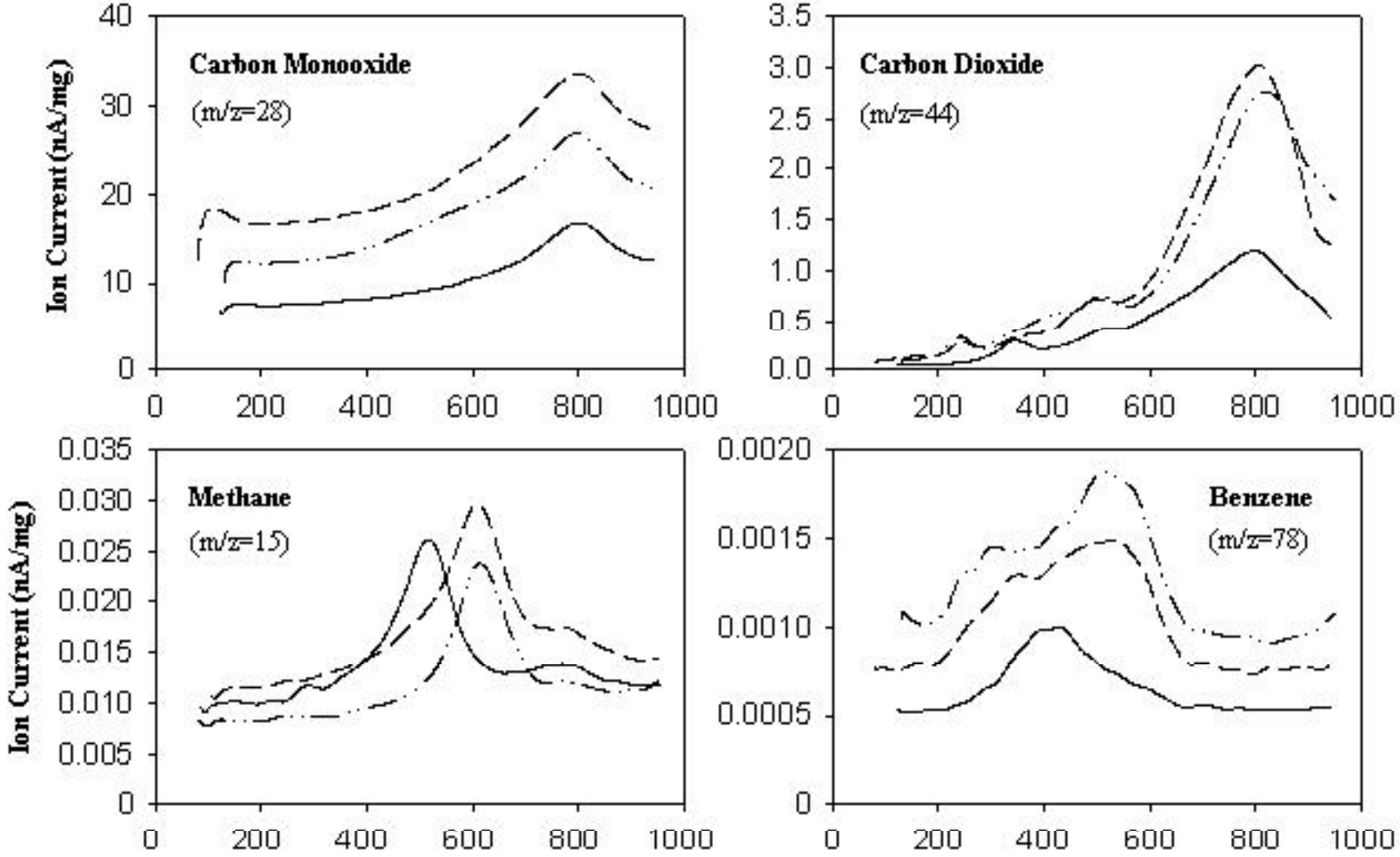
Significant Improvements in the Production of Foundry Cores

Jim Furness

Brief History

- Penn State University investigation
- Regulatory pressure - foundry odors
- Re-think decades old core making process
- Successful application at multiple foundries

A better understanding of Bio Solvent removal leads to improvements in all types of core making



National Science Foundation,
Environmental Science & Technology

We started small. . .

- **Modernizing heater and control design**
  - Improved solvent removal (water from silicate)
  - Up to a 40% improvement in core room efficiency (after additional refinement) in turbocharger castings
  - Reduced binder and catalyst usage
  - Reduced significant gas related scrap
  - Eliminated core post bake
  - Improved melting energy & core making efficiency
- **Setting the stage to use modern silicates**

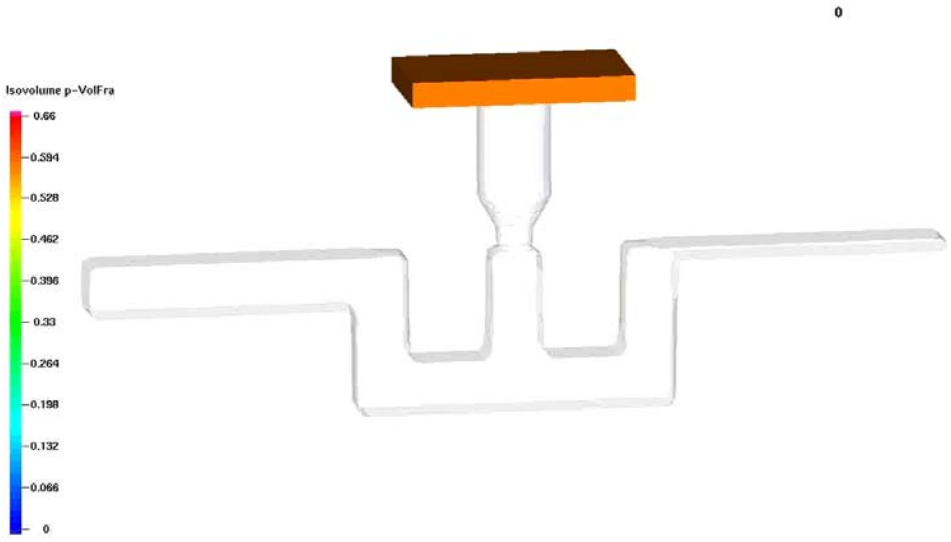
Rethinking core making

- **Some findings:**
  - Old sand blowing, venting and curing practices are major limiting factors in using low emission binders.
  - High speed data acquisition to measure, monitor and model sand core production led to “Smart Core Box” concept.
  - *Emissions*, not **Odors**, drove earlier, less successful work**.**
  - There are differences between “sales” and “science”, but we still need cores…

AFS 4N

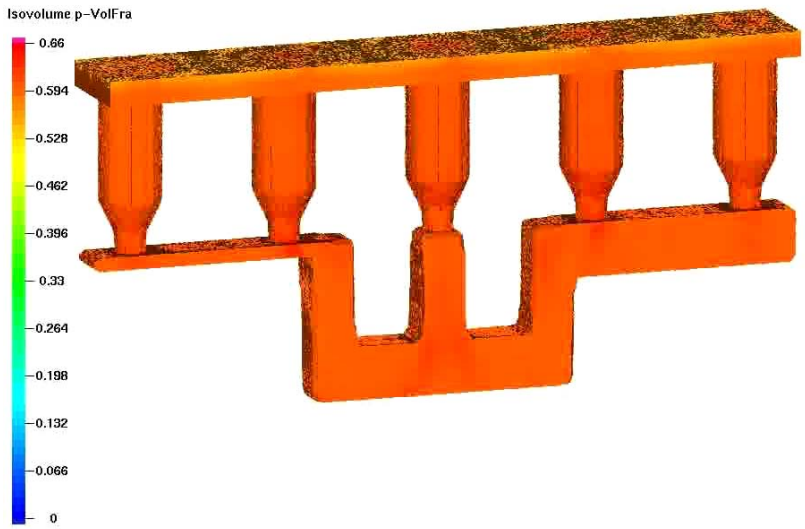
Pollution Prevention Committee

Typical
Phenolic-Urethane
Blow Practice



Start by filling
the core cavity

Alternative
Low Emission Blow
Practice



Roots of
“Smart” Blow Practice

Modeling of a core process gets complex

Part#	Core wgt	Total Vent Area IN^2	Sq. Inches of vent per # of core	Total Blow Tube Inlet Area IN²	Tube to Vent Ratio	Pounds of Blow Force	Binder %	CO_2 CFM	Gas Seconds	cuft CO_2	CO2 CFM per #binder	CO2 Dose per # binder
54aa00	11	3.64	0.33	3.78	1.04	265	3	18	12	3.6	10.91	2.50

To Calculate the total vent area of a corebox, enter the # of each size vents in the appropriate GOLD column

Wire Vents Size	# in core box		Super Vents Size	# in core box		Slotted Vents Size	# in core box					
1"		0	1"		0	1"		0				
3/4"		0	3/4"		0	3/4"		0				
5/8"	26	3.12	5/8"		0	5/8"		0				
1/2"	5	0.4	1/2"		0	1/2"		0				
3/8"		0	3/8"		0	3/8"		0				
5/16"		0	5/16"		0	5/16"		0				
1/4"	6	0.12	1/4"		0	1/4"		0				
	sub total a	3.64		*sub total a*	0		*sub total b*	0		Part Number		
							Area IN^2	3.64		54aa00		

Enter Inside Diameter of blow hole

I.D.	In^2	# in corebox	
	0.00		0.00
2"	3.14		0
1-1/2"	1.77	1	1.77
1-1/4"	1.23	1	1.23
1"	0.78	1	0.78
7/8"	0.6		0
3/4"	0.44		0
5/8"	0.31		0
5/16"	0.25		0
1/2"	0.2		0
3/8"	0.11		0
5/16"	0.08		0
1/4"	0.05		0

Core Wgt.	11
Blow PSI	70
CO_2 cfm	18

Manually Calculated value

Total Area 3.78

Sum the area of all blow inlets are auto entered in the value in the Decision Making worksheet.

For Reference only Size	Wire Vent Area In^2	Slotted Area In^2	Super Vent Area In^2
1"	0.31	0.1	0.338
3/4"	0.18	0.06	0.190
5/8"	0.12	0.04	0.132
1/2"	0.08	0.03	0.084
3/8"	0.04	0.015	0.047
5/16"	0.03	0.01	0.033
1/4"	0.02	0.006	0.021

Conditional Format

Silicate Core Performance Prediction

Vent Area in^2	in^2 vent/# core	Blow in^2	Blow : Vent	#Blow Force	Binder %	CO^2 CFM	Gas Sec.	cuft CO^2	CO^2 CFM per # binder	CO^2 Dose per # binder
3.64	0.33	3.78	1.04	264.6	3.00	18.0	12.00	3.60	10.91	2.50

Core making - key variables considered, measured, studied and/or tested:

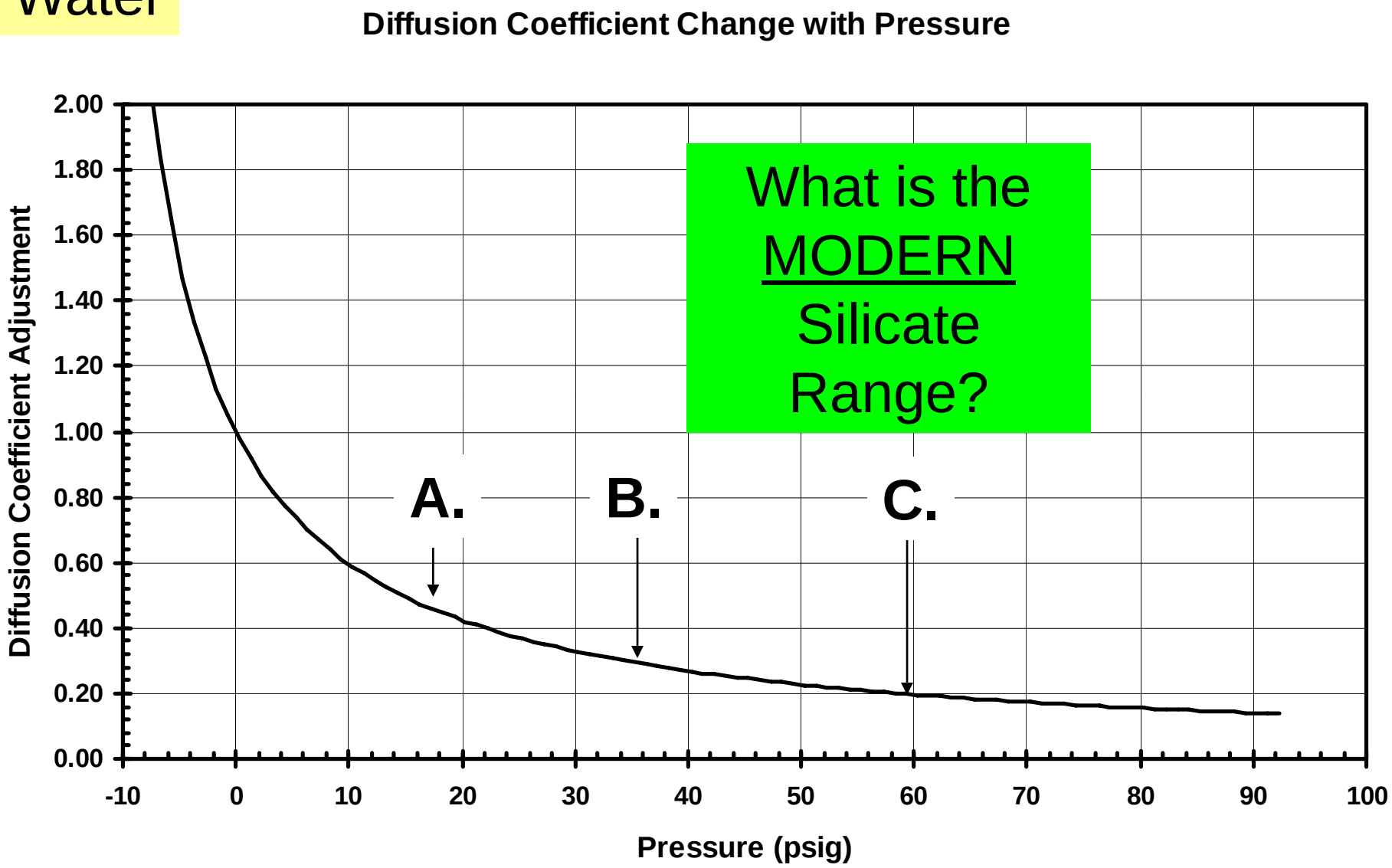
- Core weight influence on parameters
- Blow force
- Pressure profile
- Vacuum applied
- Timing sequence
- Vent plugging
- CFM of gasses
- Catalyst dose control
- Energy requirements
- Adiabatic effect
- Gas flow direction, distance & timing
- Vent area to blow area to pressure relationships
- Sand terminal velocity and impact force
- Variability of processed materials

Important Sodium Silicate Considerations

- CO_2 "gels" sodium silicate binders into an initial bond that rapidly gets stronger as it "dries".

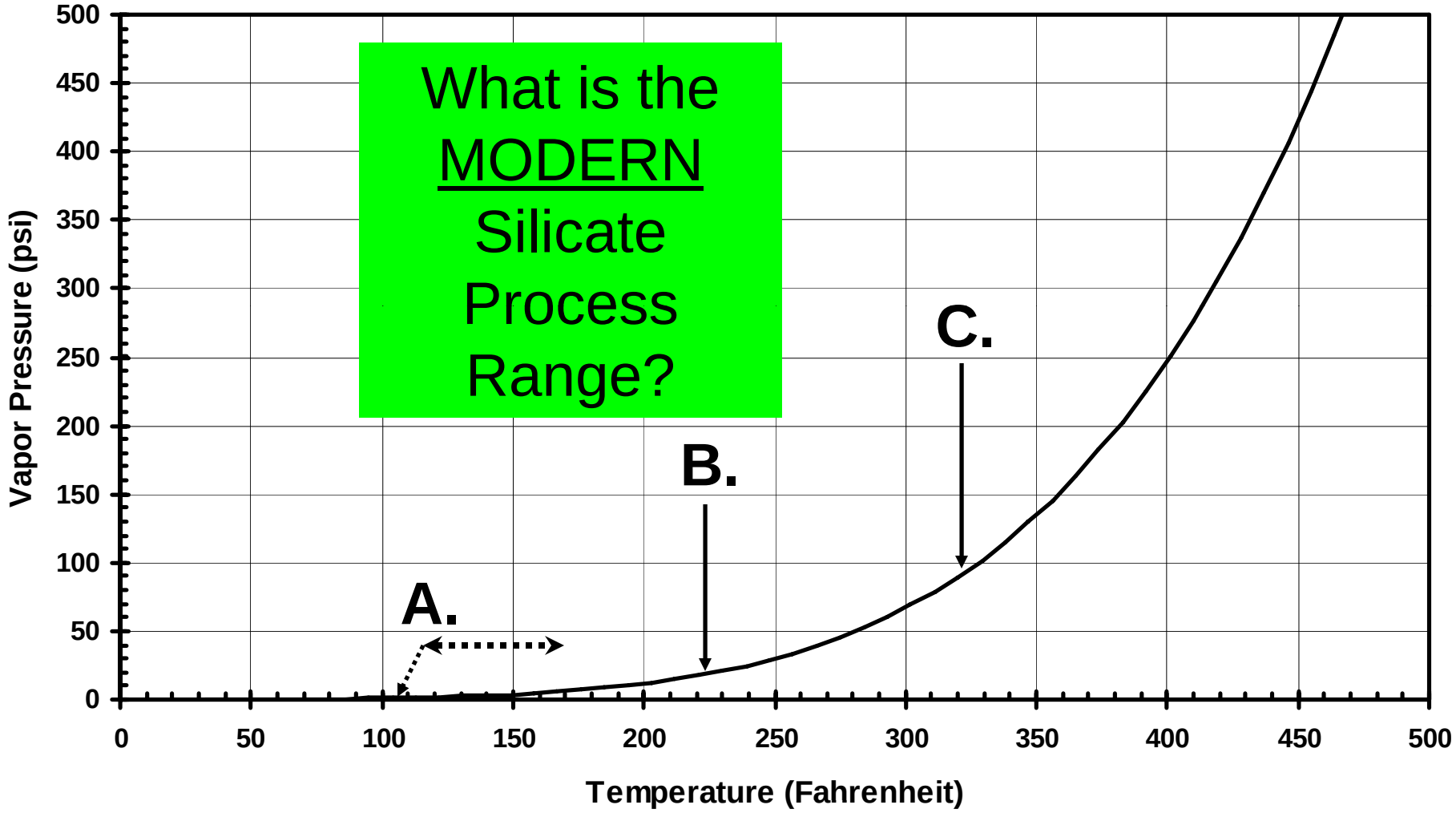
- When too much CO_2 is used, the core will be "dried" and have higher out of box strength. ***<u>HOWEVER</u>, sodium bicarbonate can form and dramatically degrade the humidity resistance.***

Water

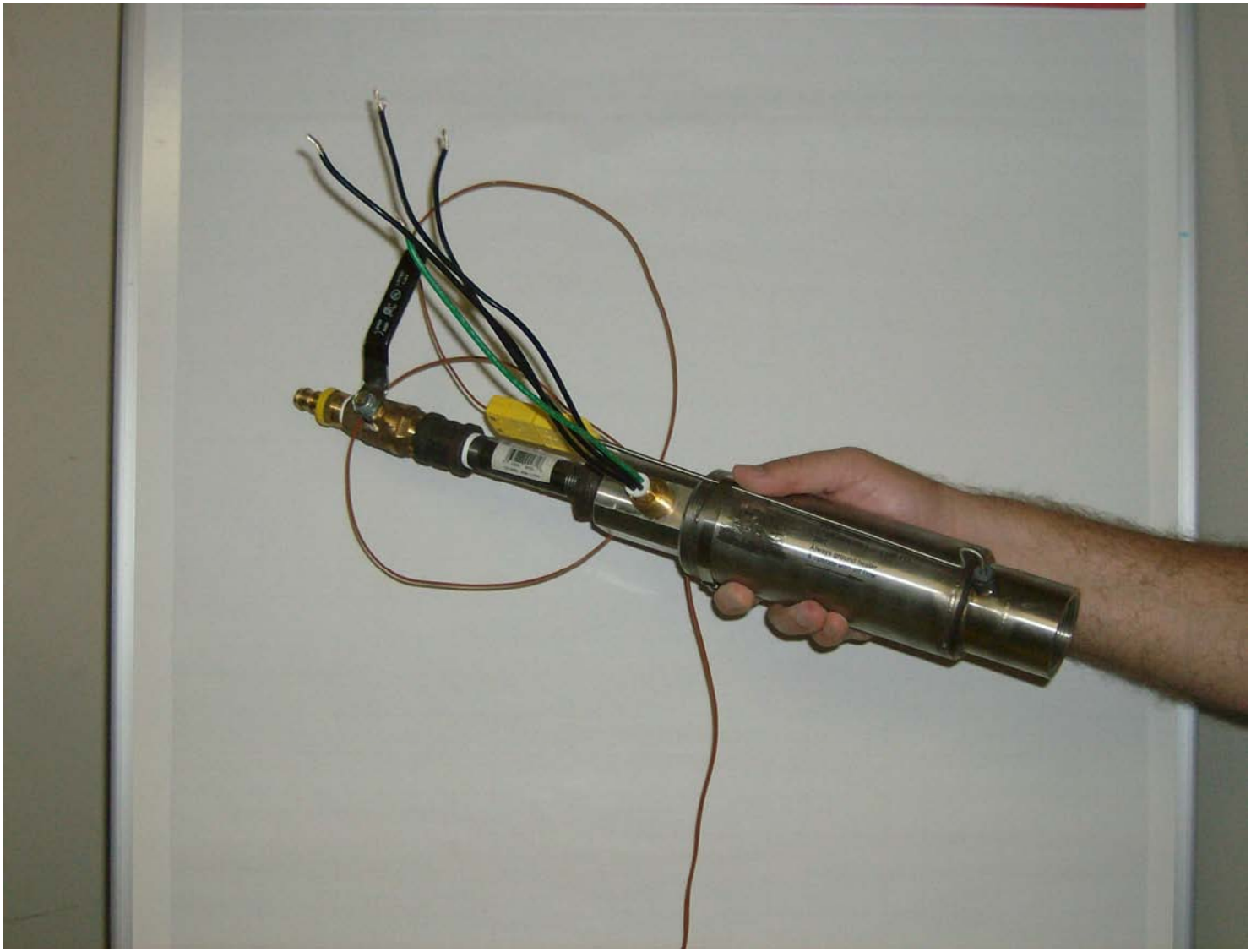

Diffusion Coefficient Change with Pressure
Diffusion Coefficient Adjustment
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-10
0
10
20
30
40
50
60
70
80
90
100
Pressure (psig)
What is the MODERN Silicate Range?
A.
B.
C.

Water

Equilibrium Water Vapor Pressure Change with Temperature



New Generation Heating Technology



Smart Core Box

The first SCB used embedded data acquisition to help make sodium silicate CO^2 cores

All this is produced using

modern

Low Emission Binder

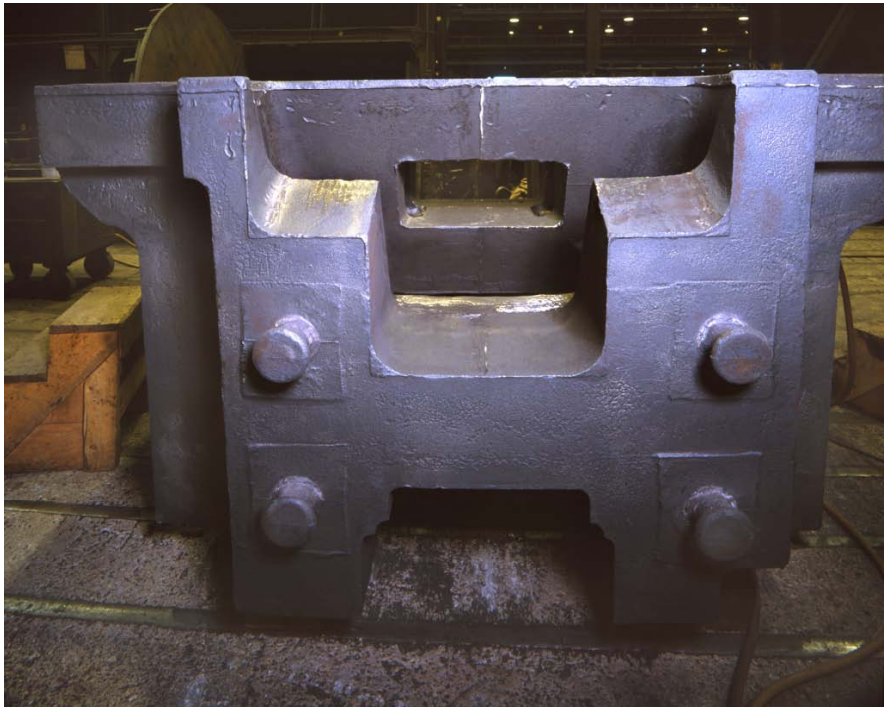
at

high

production rates

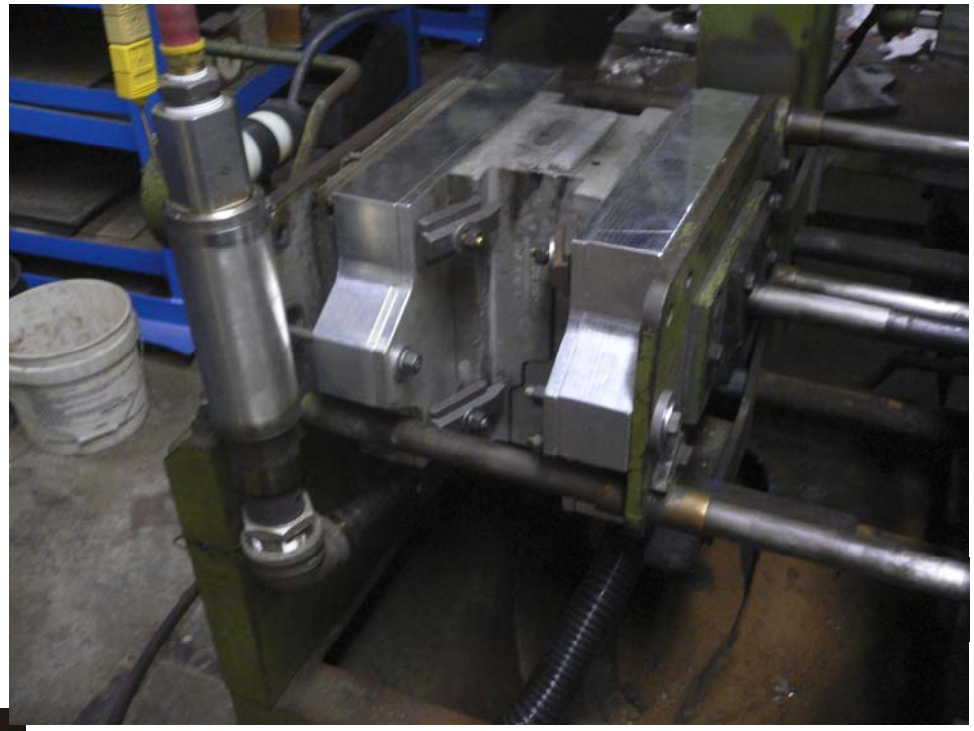
and

probably at slightly lower production rates



Smart Core Box
+
Low Emission Binders

No Catalyzing “Chemical” Used



CO2 “Optional”

A glimpse of the future ?

Goals for the “Smart Core Box” and “Smart Molding” programs:

- Real time quality monitoring and control feedback for core and mold making
- Automate and stabilize solvent/water removal
- Document quality benefits that go beyond the environmental benefits
- Build tooling properly designed for the thermal, vacuum, pressure and other sensors required for stabilizing process variables
- Provide information to foundries and design engineers that will give them the confidence to specify and produce thinner walled and stronger castings
- Expand platform for additional developments already past the proof of concept stage

Structured Innovation

- **Techniques for reducing core gas should be integrated into advanced molten metal gating, metal pouring/pumping and related work being done by others**
- **Environmentally acceptable innovations in all phases of metal processing are needed**
- **We've demonstrated that synergistic, multi-faceted foundry improvements are possible with positive environmental outcomes**
- **Combining efforts = additional energy reductions and environmental benefits**


Questions?