

# Silica Control

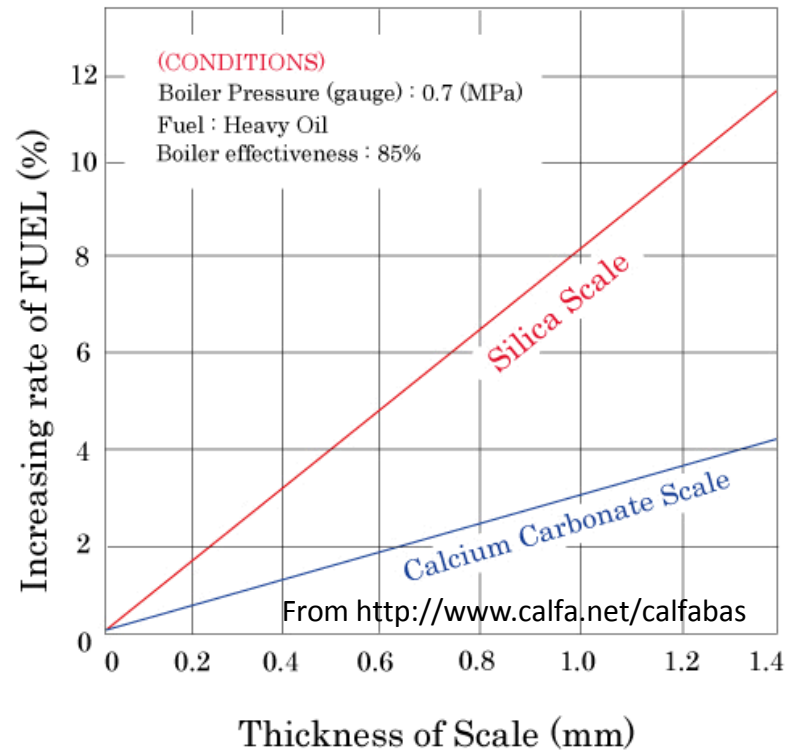
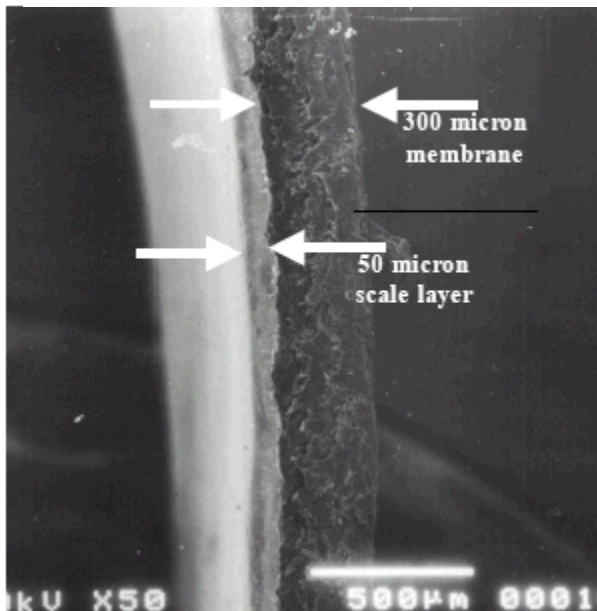
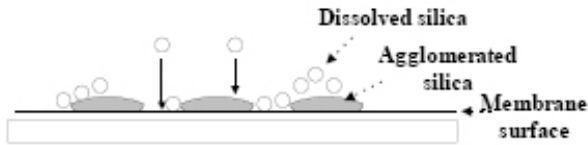
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## Silica on Boilers

Thermal Conductivity (kcal/m hr ft<sup>2</sup> C)<sup>SAND2011-0045C</sup>

<b>Steel</b>	<b>15</b>
CaSO <sub>4</sub>	1 - 2
CaCO <sub>3</sub>	0.5 - 1
<b>Silica</b>	<b>0.2 - 0.5</b>

## Silica on Membranes



Acknowledgements: Many thanks to The National Energy Technology Laboratory for support.

## The Problem

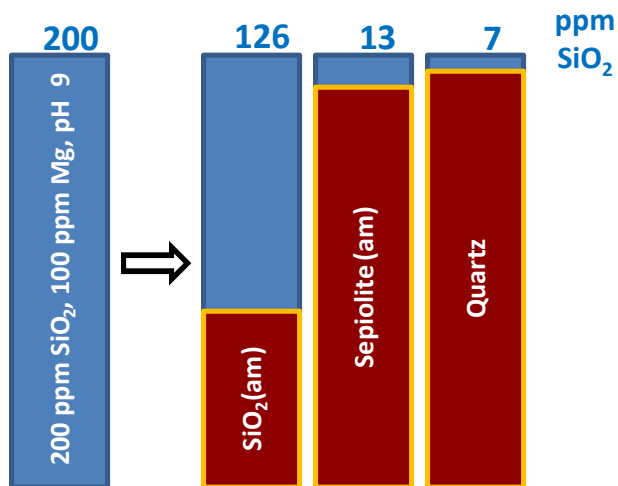
“Without testing it is impossible to know the exact silica solubility in production waters. Tables of silica solubility as a function of temperature or pH exist only for pure water. In the presence of other anions, cations, or dissolved solids the silica solubility is unpredictable” (from Pedenaud et al., SPE Production and Operations, Feb. 2006.)

## The Waters

	Los Alamos tapwater	El Paso Desal conc.	Cooling Tower	Wairakei geothermal	Ohnuma geothermal	SAGD
SiO <sub>2</sub> <sup>aq</sup>	88	148	123	560	521	239
Na <sup>+</sup>	14	2674	152	1190	384	1050
Ca <sup>2+</sup>	13	589	163	2	13	8
Mg <sup>2+</sup>	4	153	27	18	0.6	1
Cl <sup>-</sup>	4	4699	105	2100	540	1435
SO <sub>4</sub> <sup>2-</sup>	3	1039	139	32	199	*
HCO <sub>3</sub> <sup>-</sup>	90	412	374	13	*	316
T	25°C	24°C		90-100°C	97°C	
pH	7.8-8.2	8.0	8.9	7.9	7.3	

LANL – Wohlberg, C., V. P. Worland, et al. (1999). The management of silica in Los Alamos National Laboratory tap water. Los Alamos, NM, Los Alamos National Laboratory. I. **El Paso** - Tarquin, T. (2009). High tech methods to reduce concentrate volumes prior to disposal. *Draft Final Report to Texas Water Development Board*, University of Texas at El Paso. **Cooling Tower** – 1/14/2010 analyses from SNL/CINT cooling tower water. **Wairakei** - Rothbaum, H. P., B. H. Anderton, et al. (1979). "Effect of silica polymerisation and pH on geothermal scaling." *Geothermics* 8: 1-20. **Ohnuma** - Kato, K., A. Ueda, et al. (2003). "Silica recovery from Sumikawa and Ohnuma geothermal brines (Japan) by addition of CaO and cationic precipitants in a newly developed seed circulation device." *Geothermics* 32: 239-273. **SAGD** – average of 5 de-oiled produced waters, Portelance, S. N. (2000). *Waste Water Treatment Options for a SAGD oil production facility*; IWC 07-26. International Water Conference, Pittsburgh, PA.

## The Solids



## Existing Solutions

**Solid forming reactions**

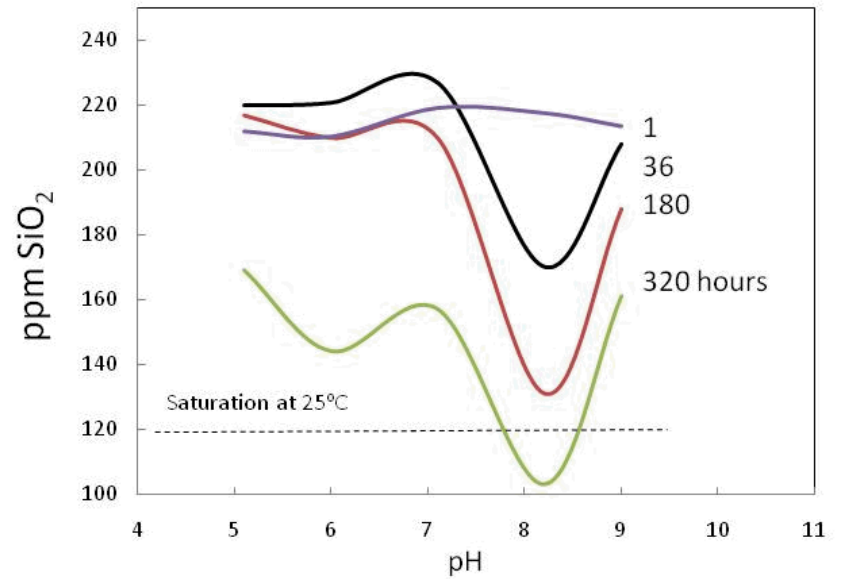
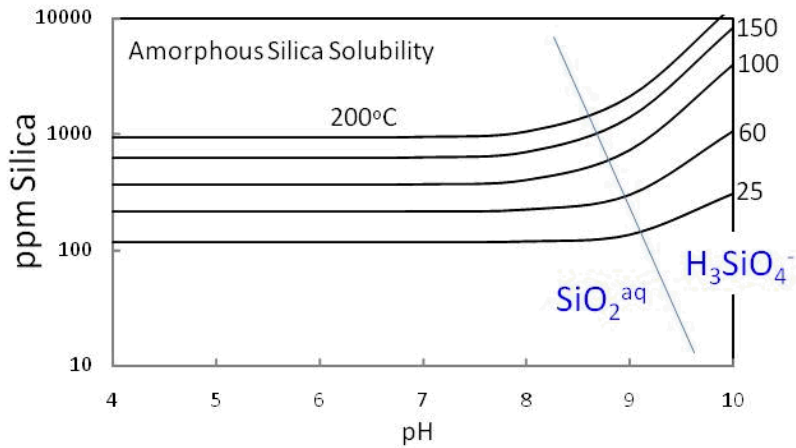
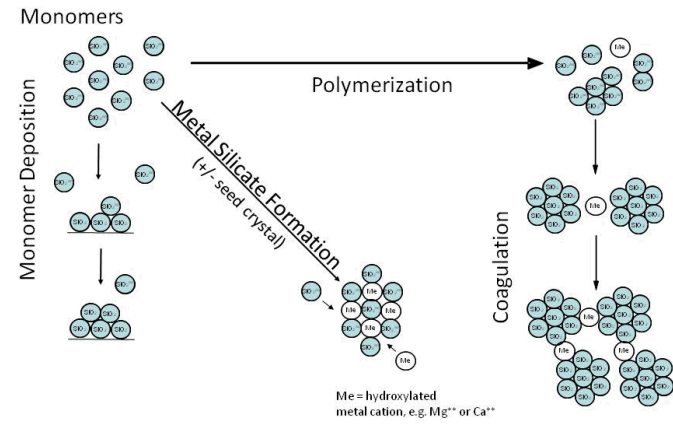
Silica Control Method	Targeted Chemical Process			
	Monomer Deposition	Polymerization	Coagulation	Metal:Silicate Formation
Ion exchange			decreases	decreases
+ Acid		decreases	decreases	decreases
+ Anti-scalant	decreases?	decreases?	decreases	decreases
Mixing	decreases	decreases	decreases	
Magnets		decreases?		
+ Seeds	increases			can increase
+ Coagulant			increases	can increase
WLS	decreases	decreases	increases	increases
Ageing	decreases	increases	increases	

make silicate solids

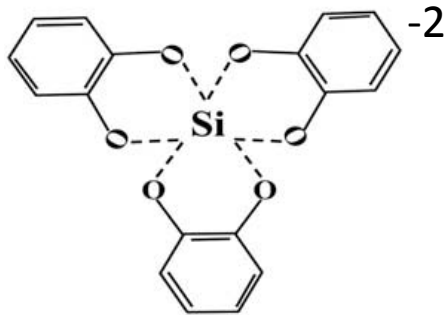
keep silica dissolved

# Silica Control Knobs

pH CHANGE – EASY  
 METALS – CHEAP TO NOT CHEAP  
 COMPLEXING AGENT - ?  
 SEEDS - ?

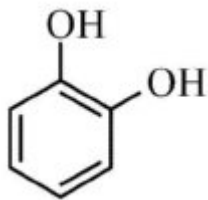


**Silica Control Knobs**  
 pH CHANGE – EASY  
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Source: Jha, R. K., T. Jha, et al. (2008). "Carrier-microencapsulation using Si-catechol complex for suppressing pyrite floatability." *Minerals Engineering* **21**: 889-893.

catechol-silica complex,  
 a "direct lever"?



catechol

Two Alternatives



elbow grease