




ICP-OES

Inductively Coupled Plasma-Optical Emission Spectrometry



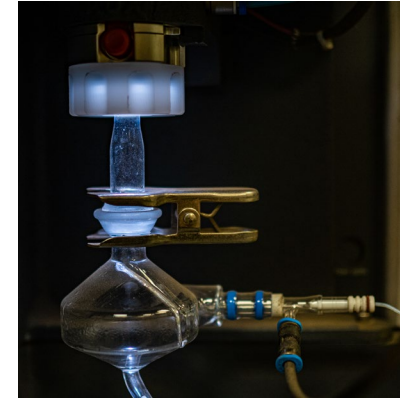
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- Hello, I'm Joel Siegel the lab director for Liberty Oilfield Services.

- ICP-OES stands for Inductively Coupled Plasma - Optical Emission Spectrometry
- An ICP-OES is a type of spectrometer
- We use our ICP-OES as the primary tool to test for a variety of elements in oilfield waters
 - It allows for simultaneous identification
 - The technique is mainly used to test for metals in liquid samples

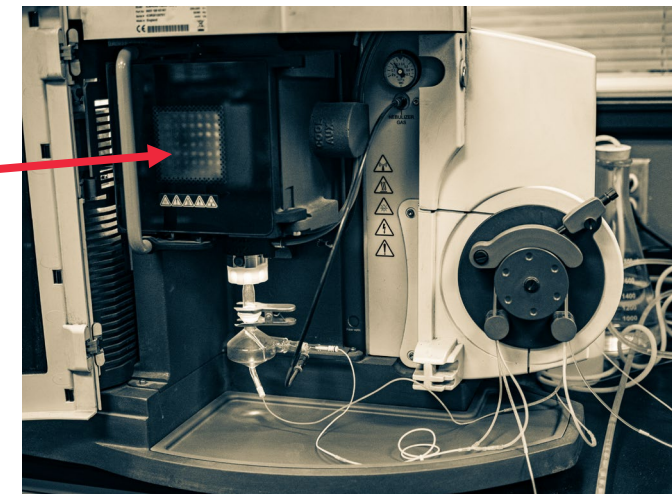


Image of our ICP-OES in Williston. We have a total of 3 units across the country

- As the name suggests, the ICP-OES consists of two defining components
 - The ICP part stands for Inductively Coupled Plasma
 - Plasma is used as the “source”
 - Plasma is a state of matter that is formed at very high temperatures.
 - Sample is first turned into an aerosol
 - Then gets injected into the plasma torch
 - The plasma torch ionizes or break the sample down to its individual ions or atoms
 - The wavelength of this light is related to the type of element and its intensity is related to the element’s concentration.



nebulizer & spray chamber = sample aerosol



ICP-OES opened to display torch that sits above the spray chamber

- OES is the Optical Emission Spectrometry
 - Optical Emission refers to this light created from the atoms returning to their lower energy state.
 - Each element generates a unique emission spectra.
 - The light is then split by a diffraction grating
 - The wavelengths and intensities of these spectrum are then measured by the detector



The grooves of a CD can be used as a diffraction grating

WHAT DO WE TYPICALLY TEST WITH OUR ICP-OES?

- Test pretty much any type of water
- We generally test oilfield waters related to hydraulic fracturing
 - Such as frac source waters
 - Flowback waters and production waters
- Current methods allows for quantification of 21 separate elements in produced waters.
 - Al, Ba, B, Ca, Cl, Co, Fe, Pb, Li, Mg, Mn, Mo, Ni, K, P, Si, Na, Sr, S, V, Zn
 - Customizable

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
			58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
			90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

HOW DO WE UTILIZE THE DATA FROM OUR ICP-OES?

- Predict the likelihood of downhole scaling from frac operations
 - To do this, we combine the ICP-OES with titrations
 - Full water analysis
- Water analysis is entered into scale software
 - The blending of waters can be simulated at various temperatures and pressures

GEOCHEMICAL SIMULATION GRAPHS

Example:

You select a produced water as your frac source water.

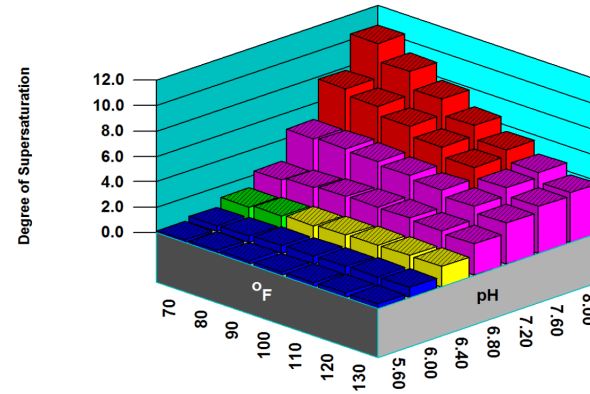
The water analysis of your frac source water and formation water enables:

- Simulation of potential scaling issues
 - As frac water mixes with formation water
 - As this mixture flows back up hole
 - Accounting for pressure drops, temperature variations and mix ratios

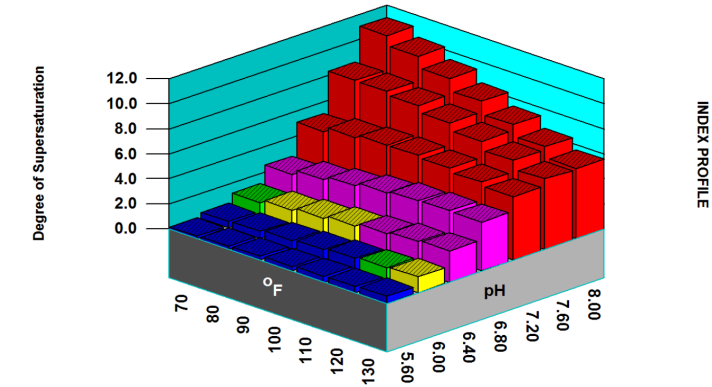
Predict minimum inhibition concentration necessary

Cost performance comparisons

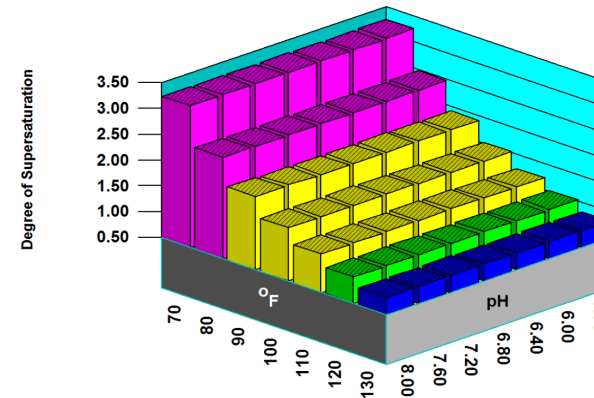
Calcite Saturation Level



Siderite Saturation Level



Barite Saturation Level



CONCLUSION

- ICP-OES is a useful tool
 - Saves time
 - Aids in predicting scaling tendencies of water
 - Scale inhibitor selection
- For more information, please visit Libertyfrac.com



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