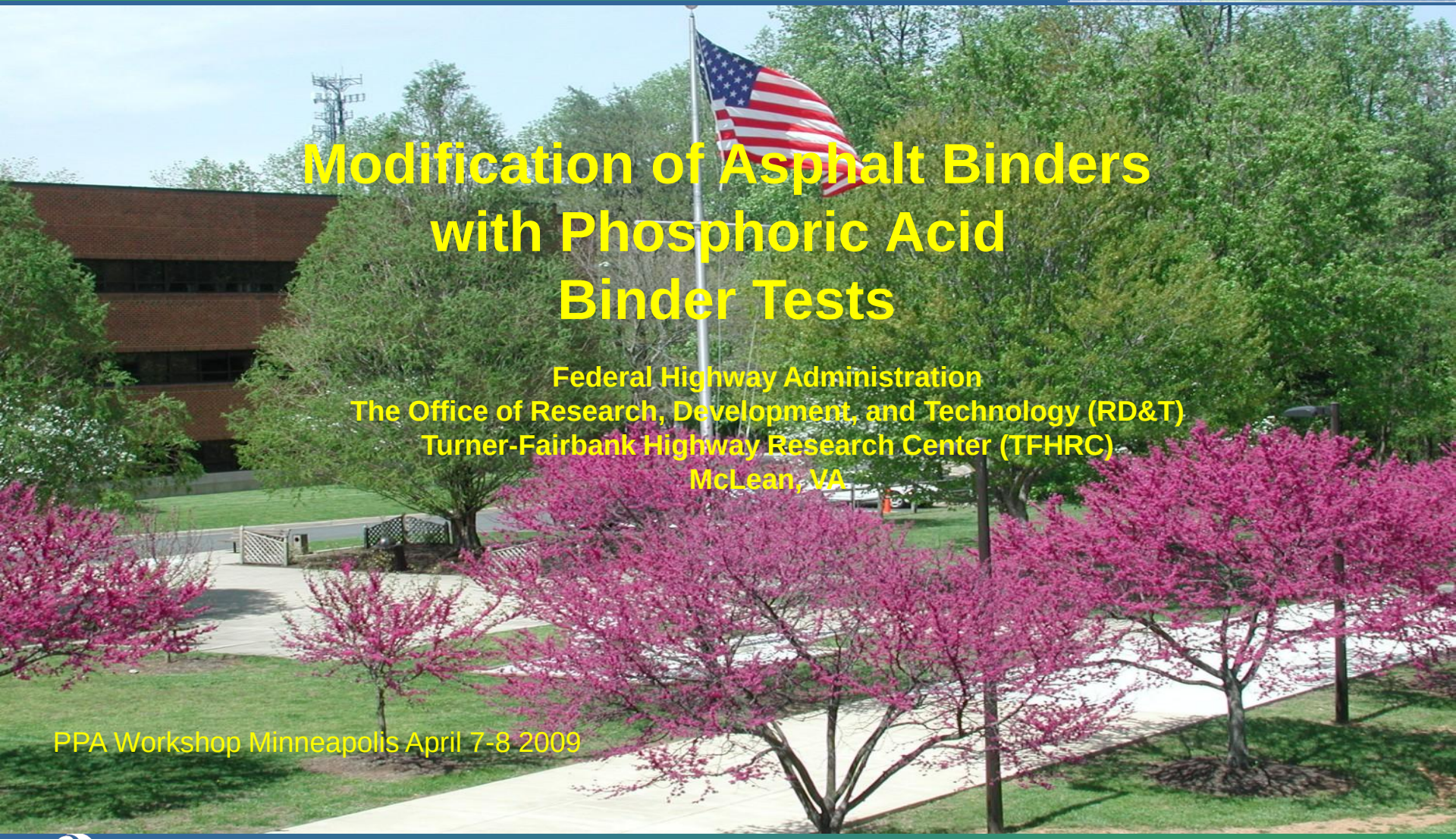
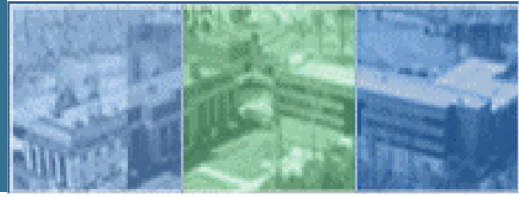


Modification of Asphalt Binders with Phosphoric Acid Binder Tests

Federal Highway Administration
The Office of Research, Development, and Technology (RD&T)
Turner-Fairbank Highway Research Center (TFHRC)
McLean, VA

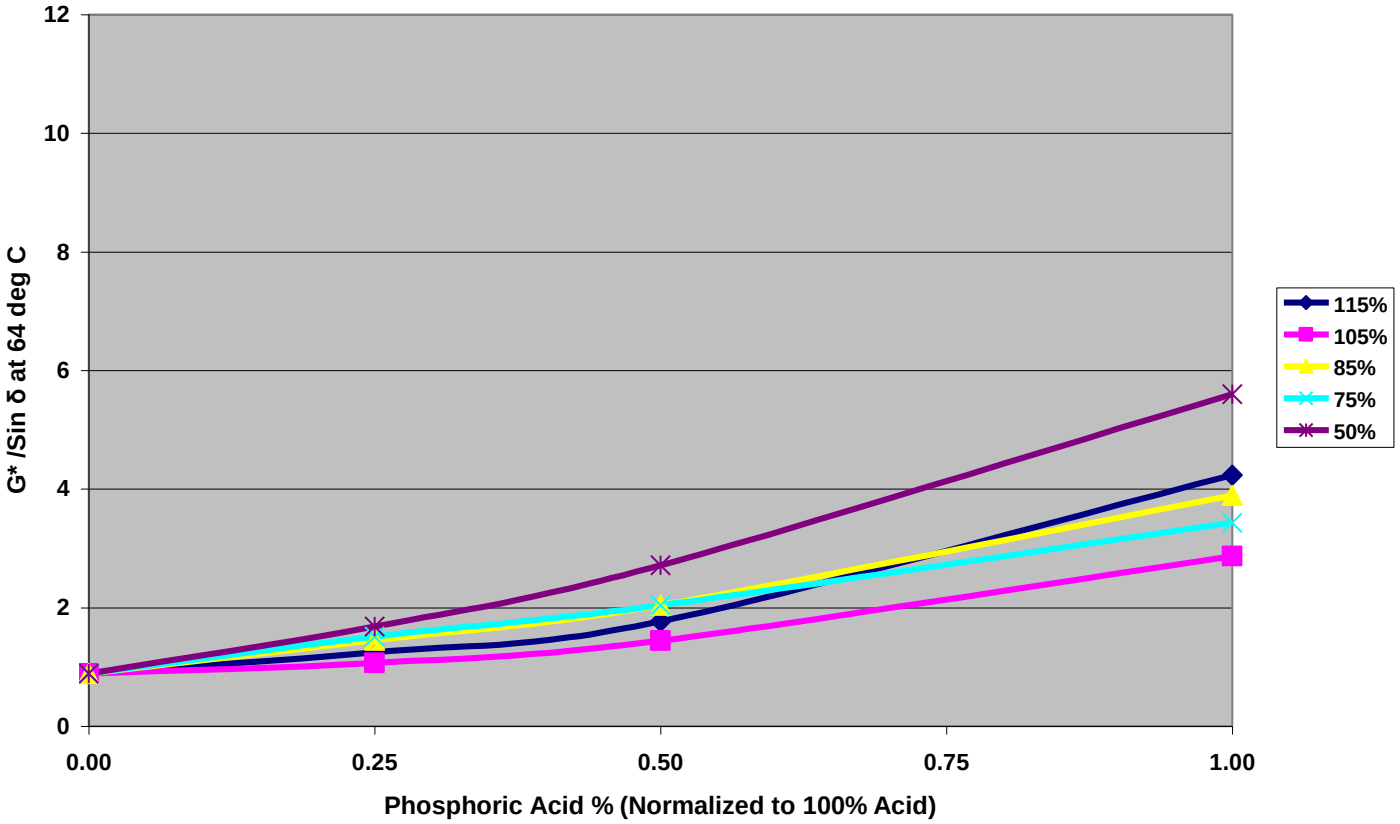
PPA Workshop Minneapolis April 7-8 2009



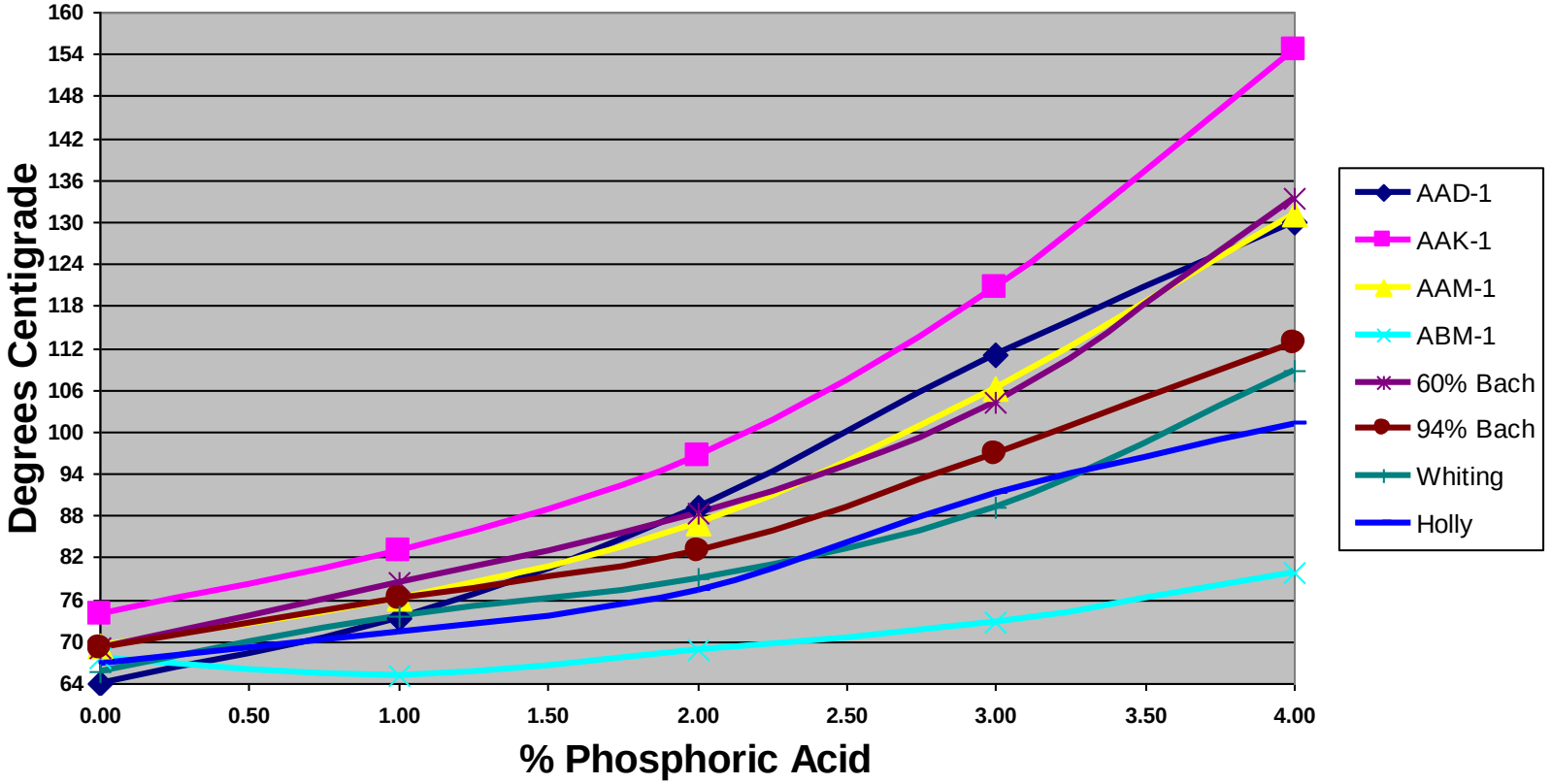
Preconceptions and Concerns about Polyphosphoric Acid

- Grade of Acid - Any grade can be used
- Type of Asphalt – Stiffening Effect is Asphalt Dependent
- Moisture Resistance was not found to be an issue at low acid levels <0.75%

Effect of Acid Grade - AAD-1

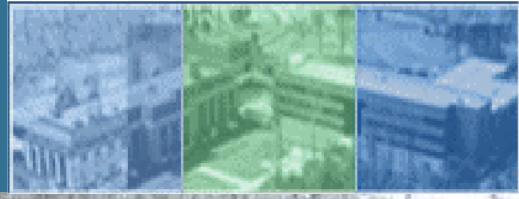


Effect of 115% PPA Acid Modification on Original PG Grade



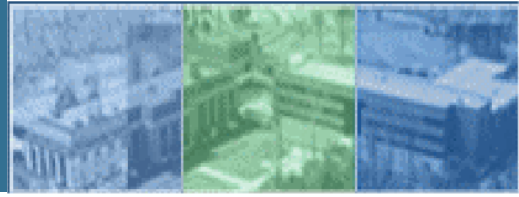
How Much PPA to Increase one PG Grade?

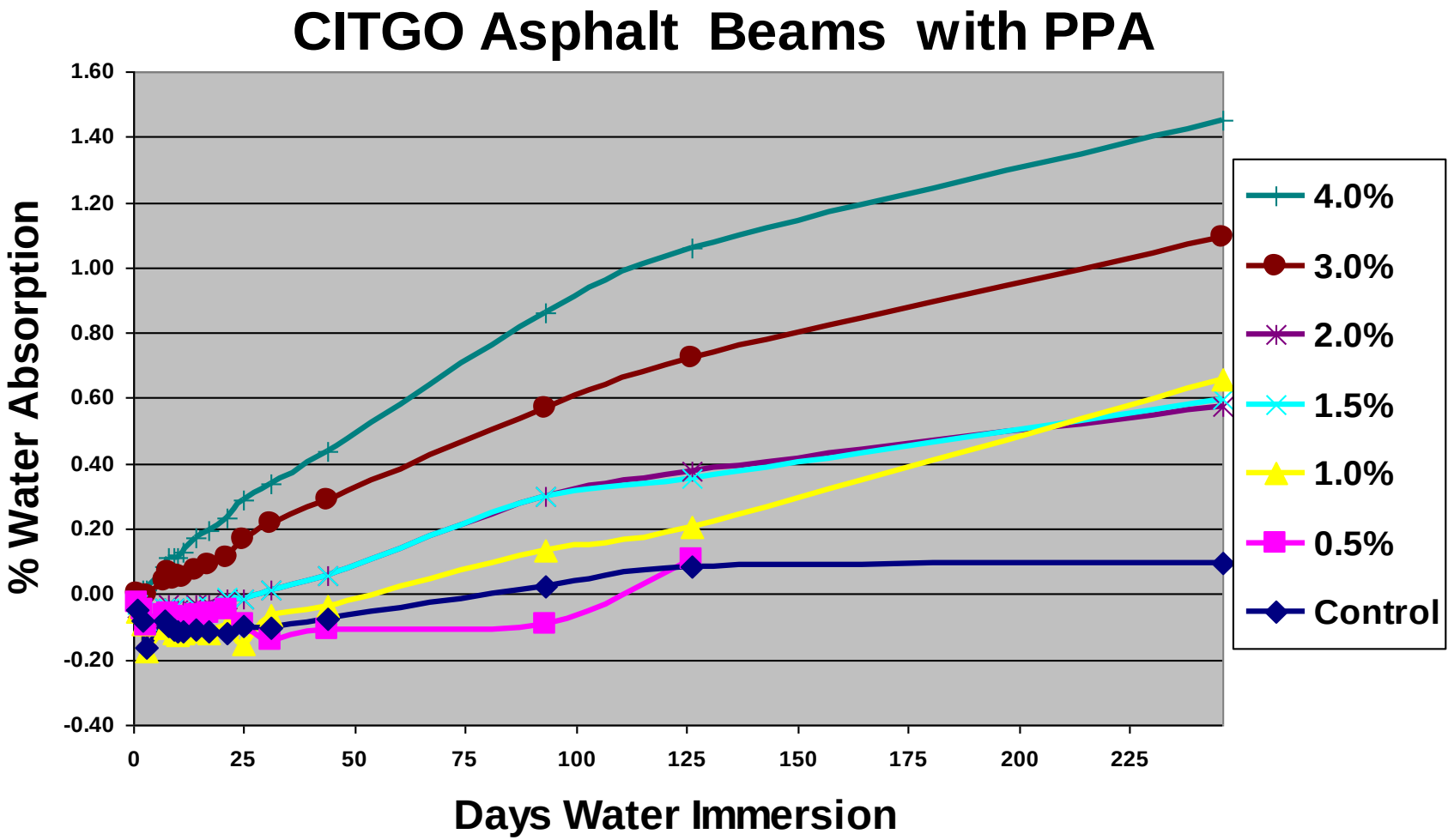
	PG-70	PG-76	PG-82
AAK-1	0	0.25%	0.9%
60% Bachequero	0.1%	0.75%	-
94% Bachequero	0.1%	1.0%	-
AAM-1	0.1%	1.0%	-
Whiting	0.5%	1.5%	-
AAD-1	0.7%	1.2%	-
Holly	0.7%	1.8%	-
ABM-1	2.4%	3.4%	-

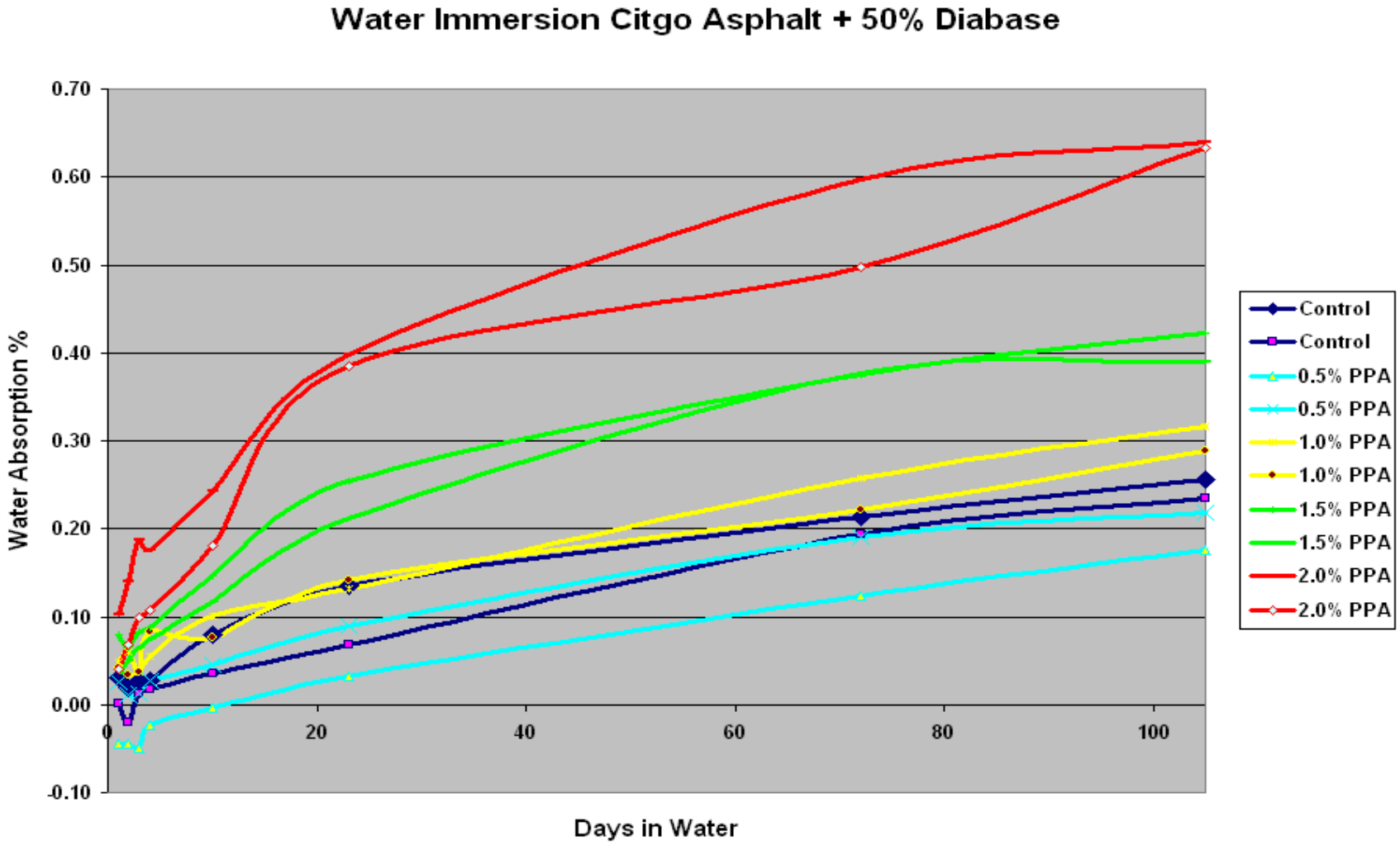


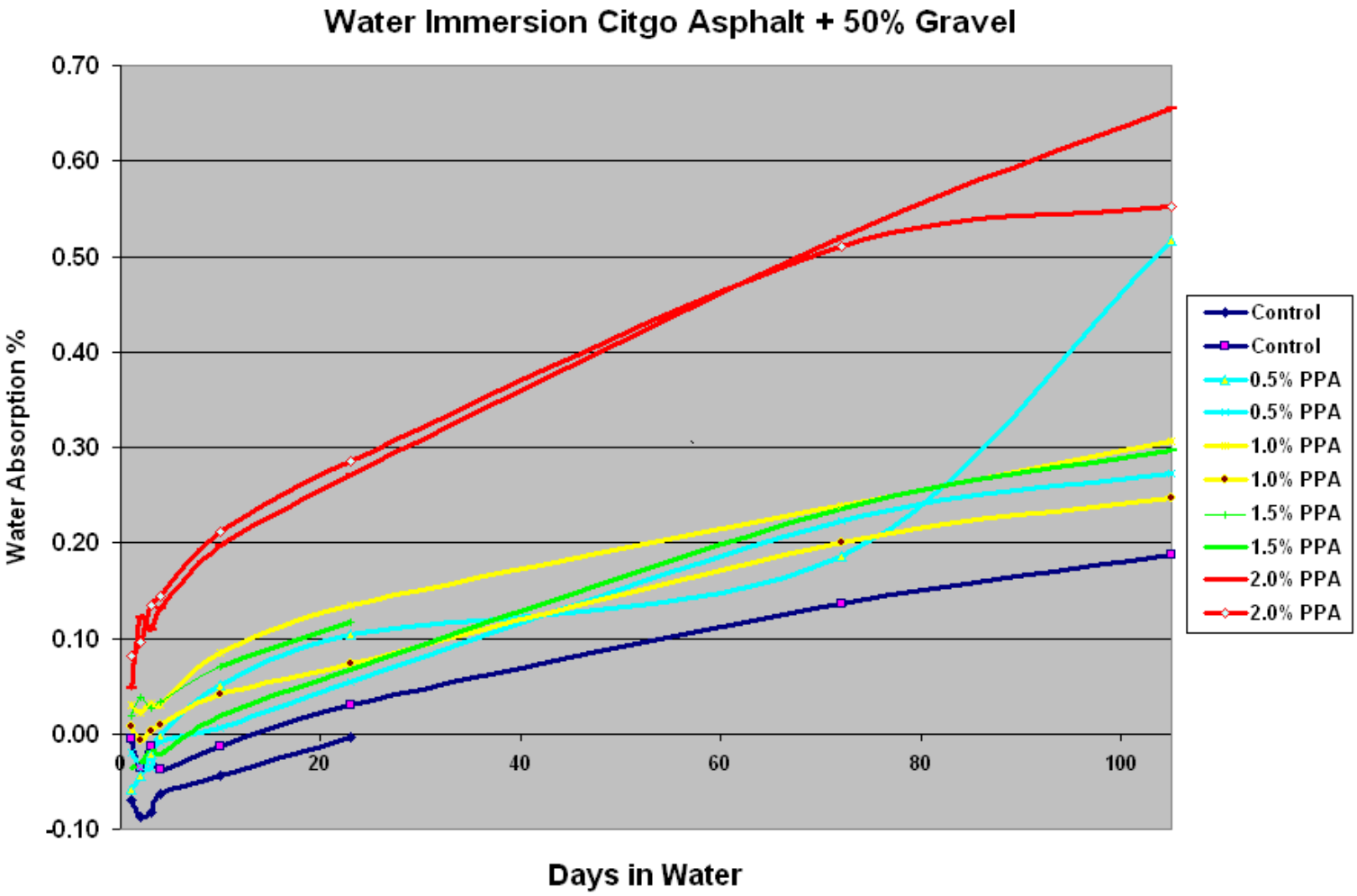
Moisture Sensitivity

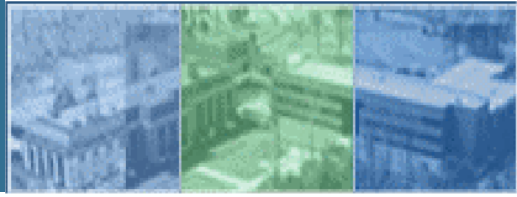
Does adding a hydrophilic material like phosphoric acid impart moisture sensitivity to the binder?

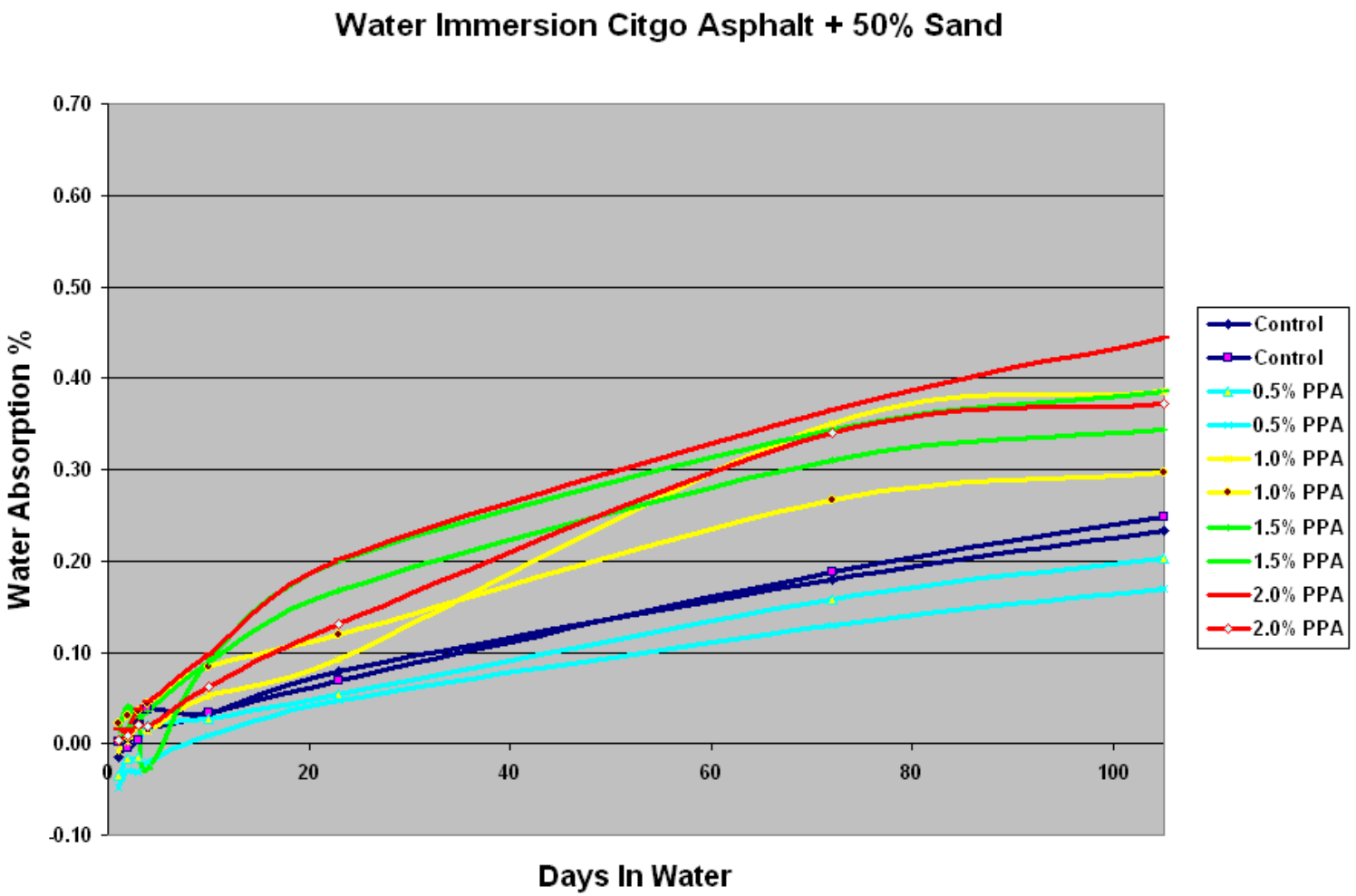



CITGO Asphalt Beams with PPA
% Water Absorption
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
0
25
50
75
100
125
150
175
200
225
Days Water Immersion
4.0%
3.0%
2.0%
1.5%
1.0%
0.5%
Control

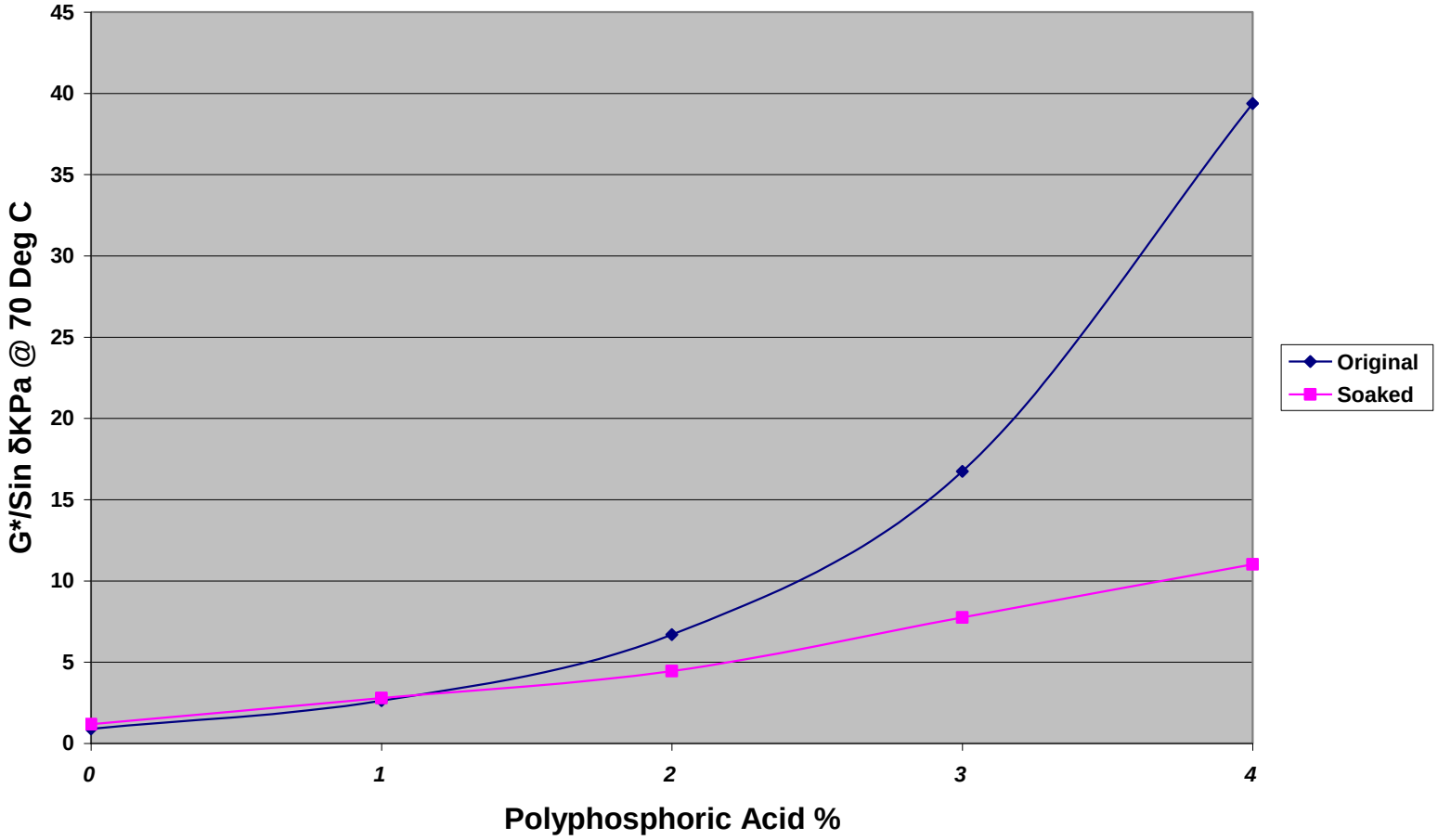

Water Immersion Citgo Asphalt + 50% Diabase
Water Absorption %
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
0
20
40
60
80
100
Days in Water
Control
Control
0.5% PPA
0.5% PPA
1.0% PPA
1.0% PPA
1.5% PPA
1.5% PPA
2.0% PPA
2.0% PPA

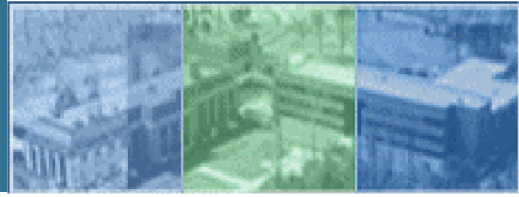

Water Immersion Citgo Asphalt + 50% Gravel
Water Absorption %
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
0
20
40
60
80
100
Days in Water
Control
Control
0.5% PPA
0.5% PPA
1.0% PPA
1.0% PPA
1.5% PPA
1.5% PPA
2.0% PPA
2.0% PPA




Water Immersion Citgo Asphalt + 50% Sand
Water Absorption %
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
0
20
40
60
80
100
Days In Water
Control
Control
0.5% PPA
0.5% PPA
1.0% PPA
1.0% PPA
1.5% PPA
1.5% PPA
2.0% PPA
2.0% PPA

Effect of 245 Days 44 degF Water Soaking Citgo Asphalt

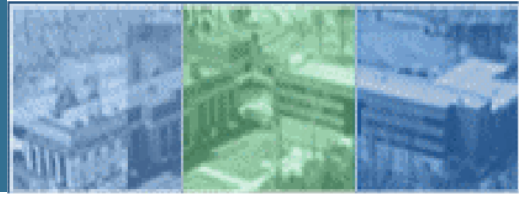




Does the Binder Contain Phosphoric Acid?

Test for Phosphate in Asphalt

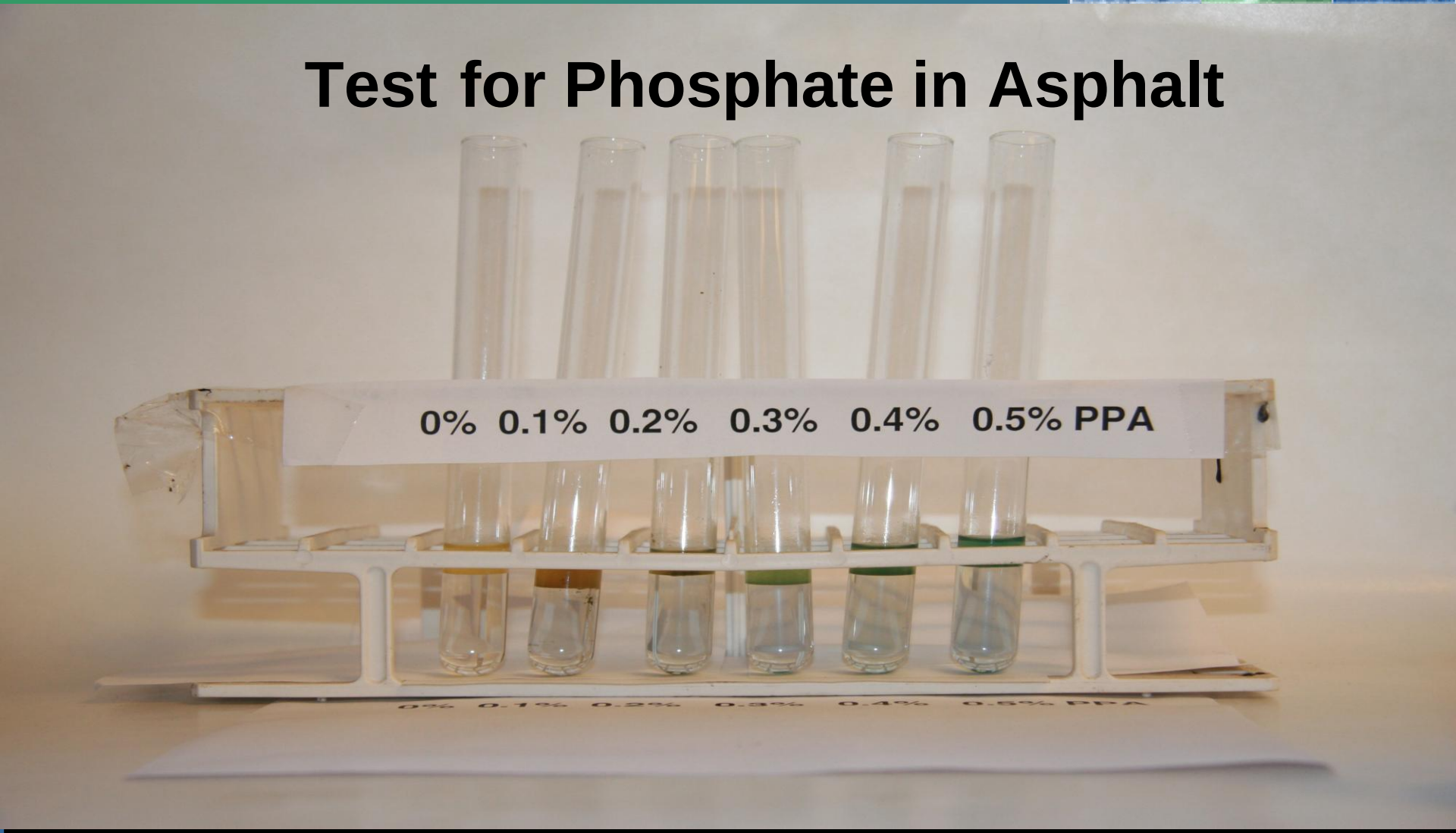
- No special equipment or expertise needed
- Requires a few inexpensive chemicals
- Test is rapid and simple
- A blue color is developed after 5 minutes
- Test can detect 0.1% PPA in asphalt
- Details available on TFHRC Website: http://www.tfhrc.gov/

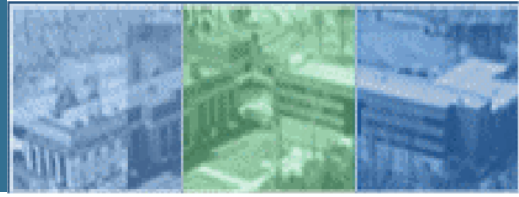


Test for Phosphate in Asphalt

- Quantities are not critical
- Put 1 gram of hot asphalt into a 1oz can
- Add 1ml of n-butanol and swirl/stir in the can
- Add 2mls water
- Add 1 ml of ascorbic acid/ammonium molybdate solution
- A blue color is developed in the water phase within a few minutes.

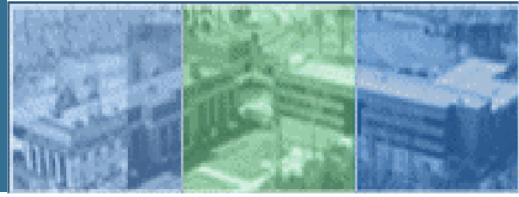
Test for Phosphate in Asphalt





X-Ray Fluorescence Spectrometry

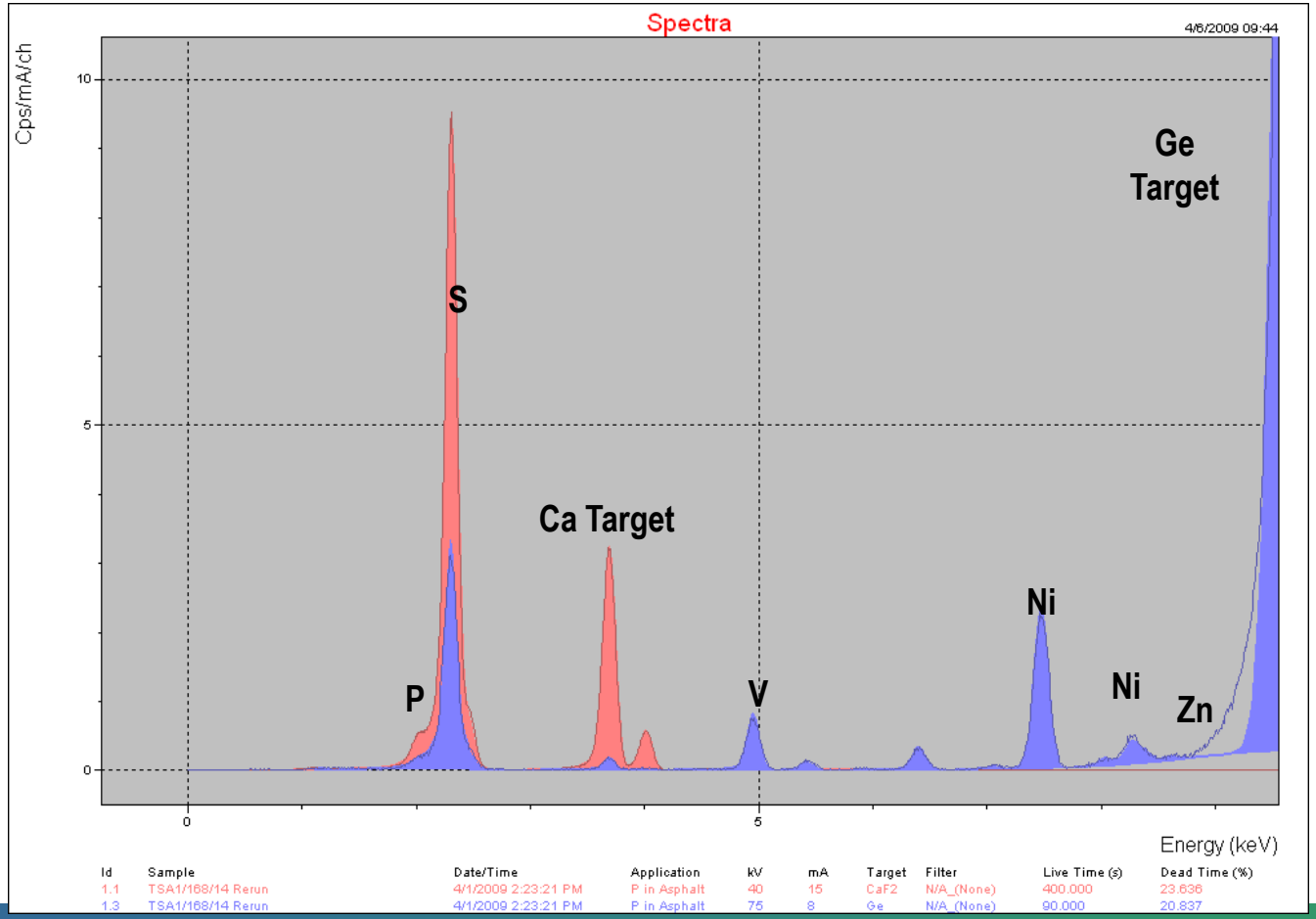
- Quantitative test has been developed by Mathy Technology & Engineering Services Inc.
- Beware – Just because the binder contains Phosphorous it does not mean it has been modified with phosphoric acid.



Engine Oil Additives

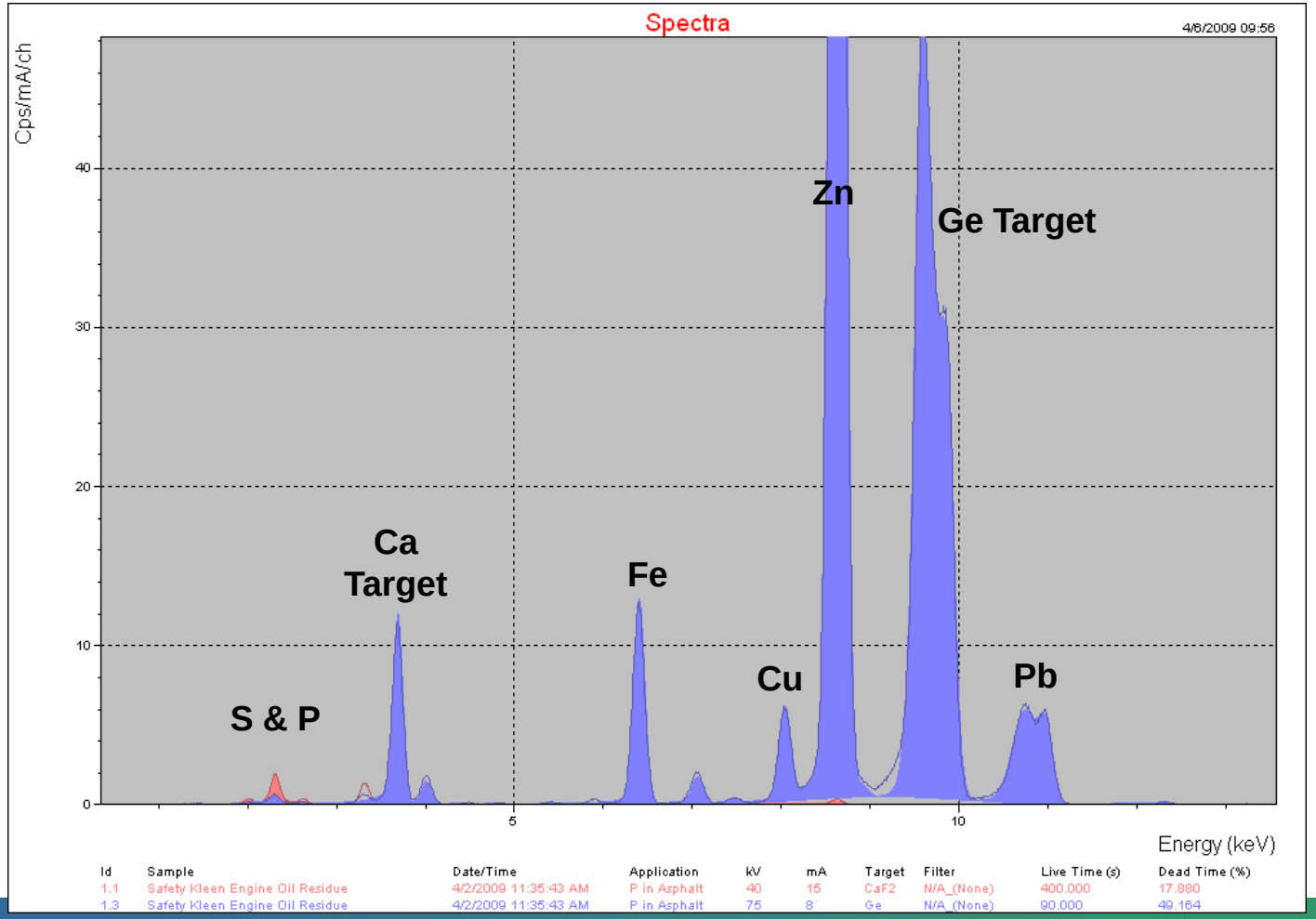
- There are many oil additives used
- Zincdioctyldithiophosphate - a heat stabilizer
- $C_{32}H_{68}P_2ZnS_4O_4$
- Contains 8% Phosphorous, 8.5% Zinc

Asphalt Containing 1% Phosphoric Acid



Id	Sample	Date/Time	Application	kV	mA	Target	Filter	Live Time (s)	Dead Time (%)
1.1	TSA1/168/14 Rerun	4/1/2009 2:23:21 PM	P in Asphalt	40	15	CaF2	N/A_(None)	400.000	23.636
1.3	TSA1/168/14 Rerun	4/1/2009 2:23:21 PM	P in Asphalt	75	8	Ge	N/A_(None)	90.000	20.837

Engine Oil Residue



Conclusions

- Any grade of Phosphoric Acid can be used
- Stiffening effect is asphalt dependent
- Binder (Citgo 64-28) showed water sensitivity at modification levels above about 0.75%
- Water sensitivity increased with increasing levels of modification
- Presence of phosphorous does not necessarily mean the asphalt was modified with Phosphoric Acid


Thank You