Evaluation of Debris Bags

Debris Bag Evaluation: Boric Acid Dissolution

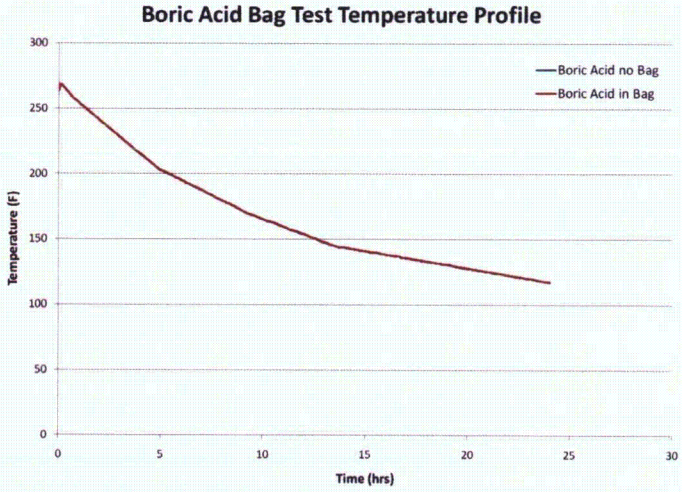
Test Objective:

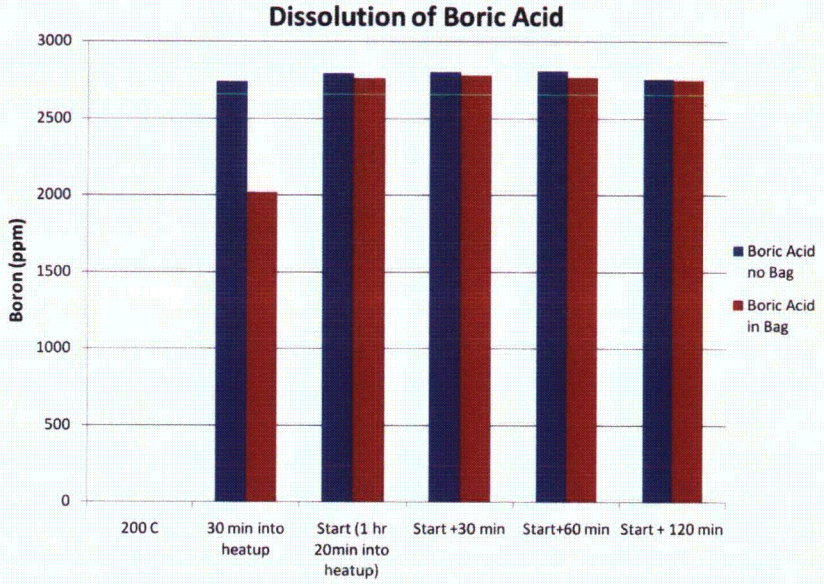
Determine the difference in dissolution rate between boric acid in a filter bag and boric acid added directly to the tank.

- Started with DI water
- Added enough BA to achieve 2700 ppm B
  - Directly to tank in one case and in a filter bag in the other
- Ran temperature profile and sampled periodically to test boron level

Debris Bag Evaluation: BA Dissolution (cont.)

- Relatively fast transport across the filter bag
- 75% dissolved, transported across bag, and circulated in tank within half hour



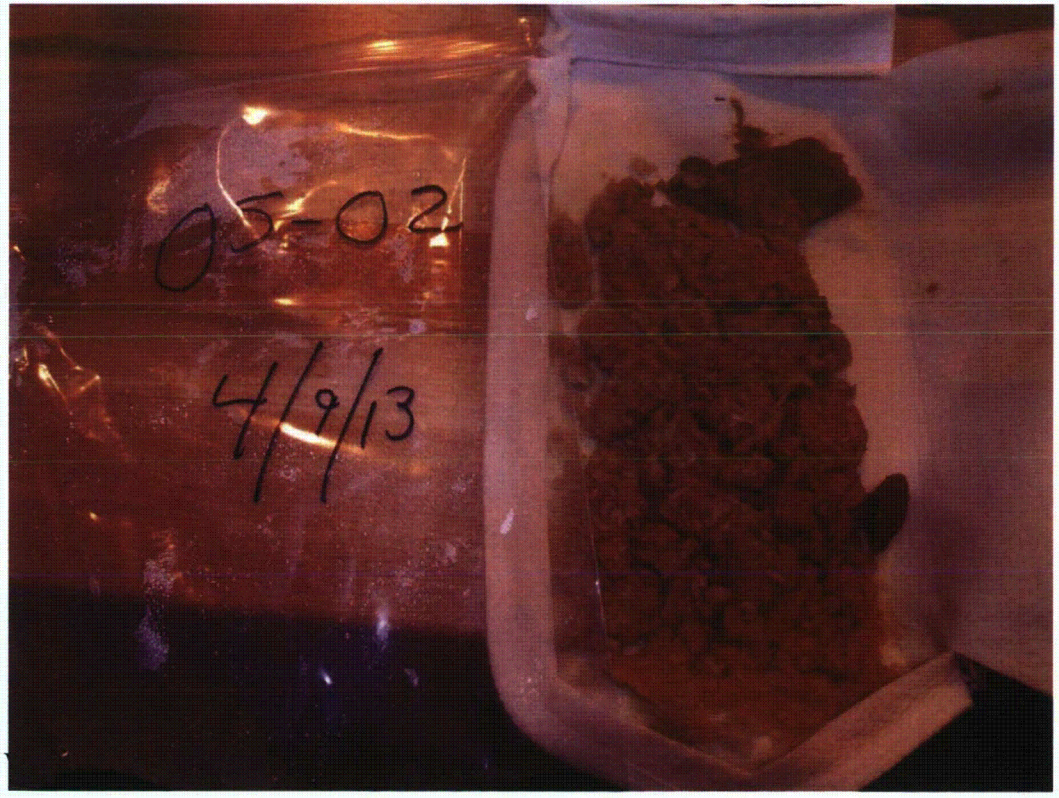


- Slightly lagging dissolution of loose BA addition

Debris Bag Evaluation: Visual Examination (1)

Test Group:	15
Target pH value(s):	8.5
Test Volume (liters):	50
Insulation Material	**Amount per AC (g)**
CalSil	0.00
E-glass	24.61
Silica powder	0.00
Mineral Wool	14.95
Aluminum Silicate	0.00
Concrete	0.001
Interam	0.00

Coupon Material	No. of Coupons	Coupon Width (in)	Coupon Length (in)	Area ft²
Aluminum	1	1	3.11	0.043
Galvanized Steel	2	4	6.49	0.721



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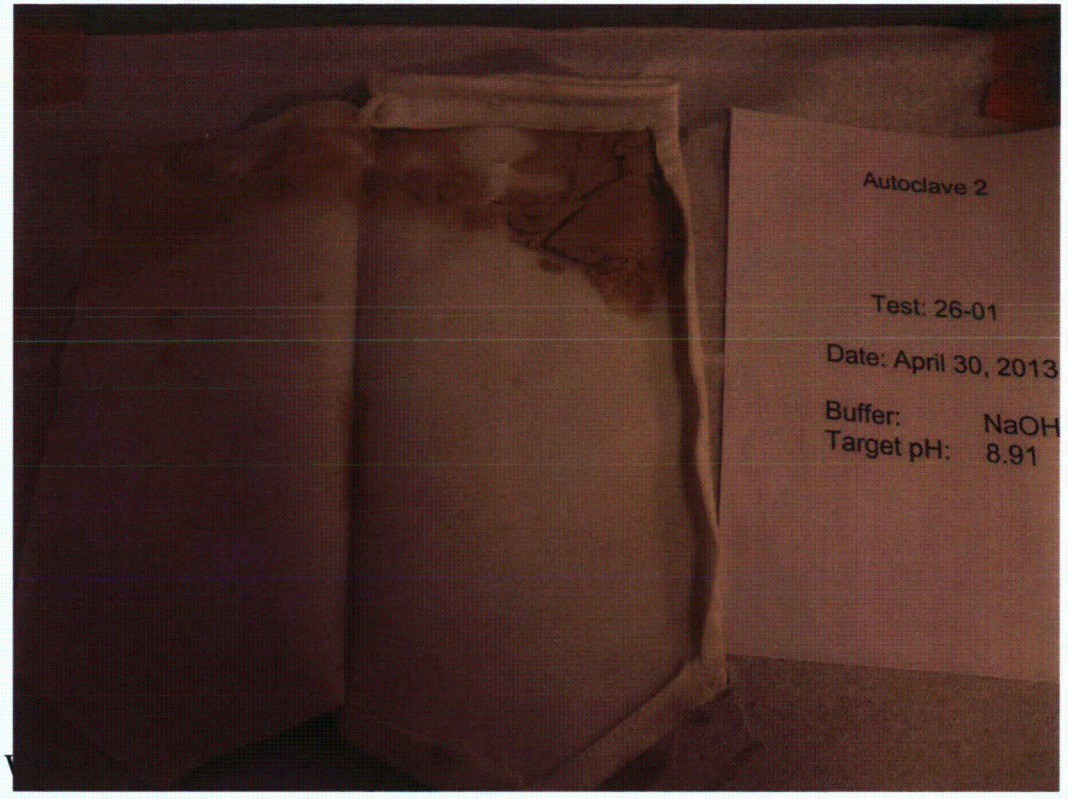
Debris Bag Evaluation: Visual Examination (2)

Test Group:	26
Target pH value(s):	8.91
Test Volume (liters):	50
Insulation Material	**Amount per AC (g)**
CalSil	8.93
E-glass	0.86
Silica powder	0.11
Mineral Wool	0.00
Aluminum Silicate	0.00
Concrete	0.0029
Interam	0.00

Coupon Material	No. of Coupons	Coupon Width (in)	Coupon Length (in)	Area ft²
Aluminum	1	4	5.53	0.307
Galvanized Steel	14	4	8.53	6.634



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Debris Bag Evaluation: Visual Examination (3)

Test Group:	26
Target pH value(s):	8
Test Volume (liters):	50
Insulation Material	**Amount per AC (g)**
CalSil	0.00
E-glass	1.29
Silica powder	1.56
Mineral Wool	4.73
Aluminum Silicate	0.00
Concrete	0.006
Interam	0.00

Coupon Material	No. of Coupons	Coupon Width (in)	Coupon Length (in)	Area ft²
Aluminum	1	2	3.30	0.092
Galvanized Steel	2	4	8.34	0.927

Debris Bag Evaluation: Visual Examination (4)

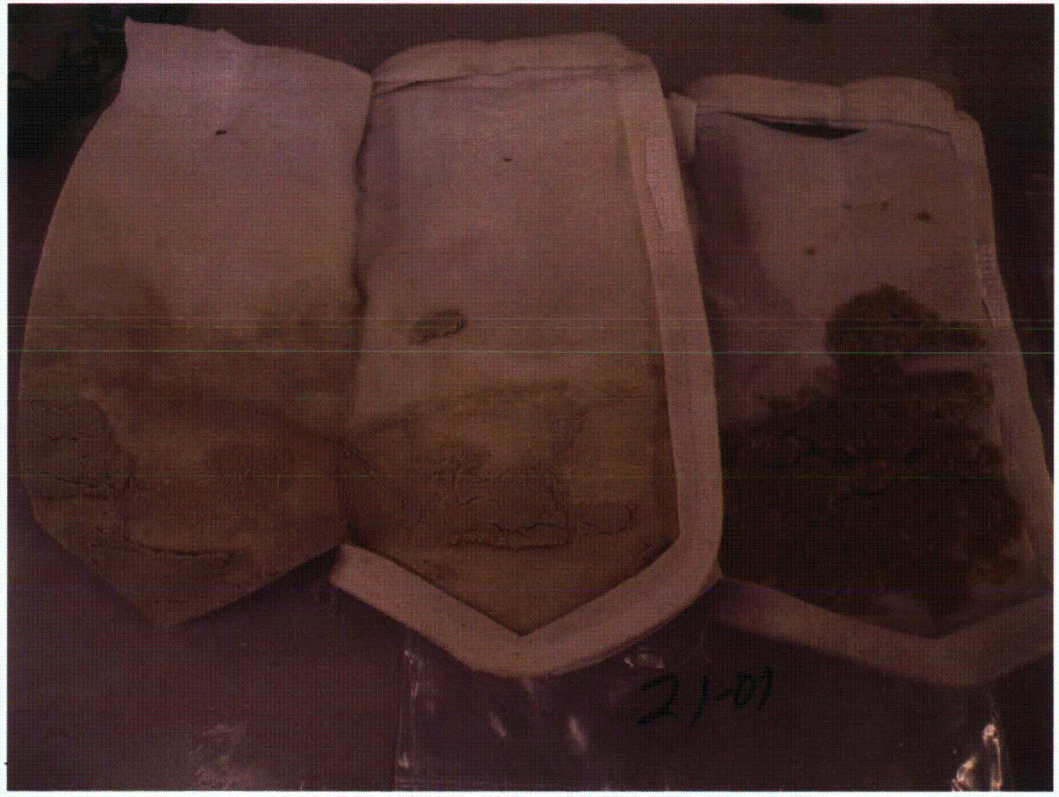
Test Group:	6
Target pH value(s):	10.5
Test Volume (liters):	50
Insulation Material	**Amount per AC (g)**
CalSil	0.00
E-glass	97.48
Silica powder	7.28
Mineral Wool	0.00
Aluminum Silicate	27.84
Concrete	0.0004
Interam	0.00

Coupon Material	No. of Coupons	Coupon Width (in)	Coupon Length (in)	Area ft²
Aluminum	1	1	1.68	0.023
Galvanized Steel	1	3	4.71	0.196

Debris Bag Evaluation: Visual Examination (5)

Test Group:	21
Target pH value(s):	7.5
Test Volume (liters):	50
Insulation Material	**Amount per AC (g)**
CalSil	10.52
E-glass	14.19
Silica powder	0.00
Mineral Wool	0.00
Aluminum Silicate	0.00
Concrete	0.002
Interam	0.00

Coupon Material	No. of Coupons	Coupon Width (in)	Coupon Length (in)	Area ft²
Aluminum	1	2	4.40	0.122
Galvanized Steel	2	4	6.98	0.776



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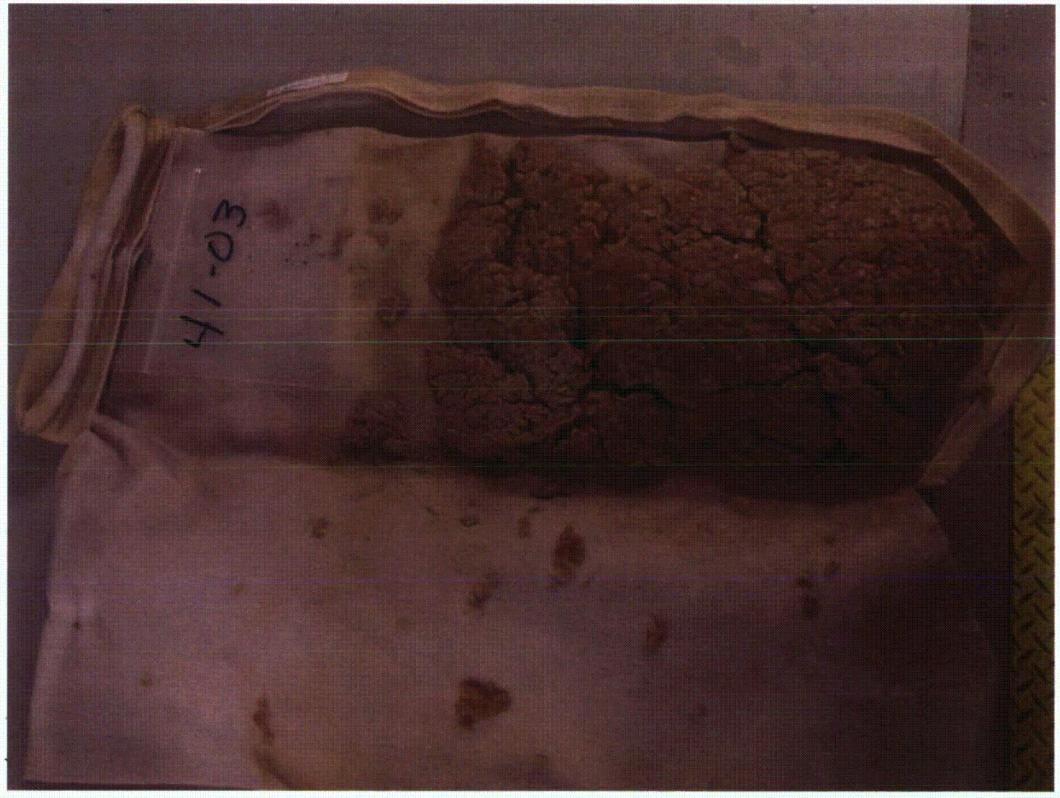
Debris Bag Evaluation: Visual Examination (6)

Test Group:	41
Target pH value(s):	9
Test Volume (liters):	50
Insulation Material	**Amount per AC (g)**
CalSil	2.87
E-glass	124.11
Silica powder	0.37
Mineral Wool	0.00
Aluminum Silicate	0.00
Concrete	0.0016
Interam	0.00

Coupon Material	No. of Coupons	Coupon Width (in)	Coupon Length (in)	Area ft²
Aluminum	1	2	7.24	0.201
Galvanized Steel	2	2	4.74	0.263



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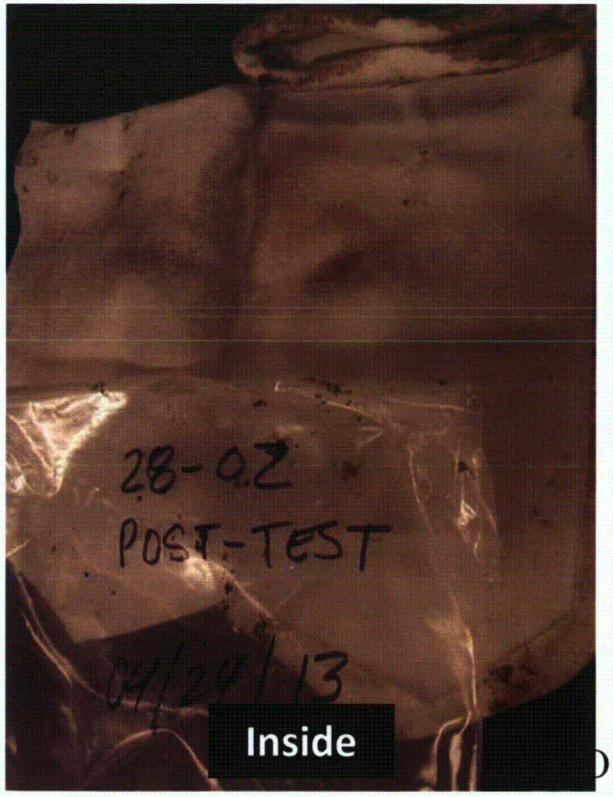
Debris Bag Evaluation: Visual Examination (7)

Test Group:	28
Target pH value(s):	10.5
Test Volume (liters):	50
Insulation Material	**Amount per AC (g)**
CalSil	0.00
E-glass	0.00
Silica powder	0.00
Mineral Wool	0.00
Aluminum Silicate	0.00
Concrete	0.0136
Interam	0.00

Coupon Material	No. of Coupons	Coupon Width (in)	Coupon Length (in)	Area ft²
Aluminum	3	4	6.76	1.127
Galvanized Steel	1	4	7.38	0.410



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Evaluation of Effect of Bag on Chemistry- IBOB Study

- Group 21 was run with a new aluminum area to reflect current conditions for the associated plant
- Samples were not cooled to simulate the RHR before filtering (No RHR at the plant)
- Run with and without bag.

IBOB 1 and IBOB 2 Conditions

Previous Test Group:	21
Repeats:	In-bag and out-of-bag
Target pH value(s):	7.5
Min. sump vol. (ft^3):	31293
Test Volume (liters):	50
Test Boron (ppm)	2700
Test Buffer	NaTB

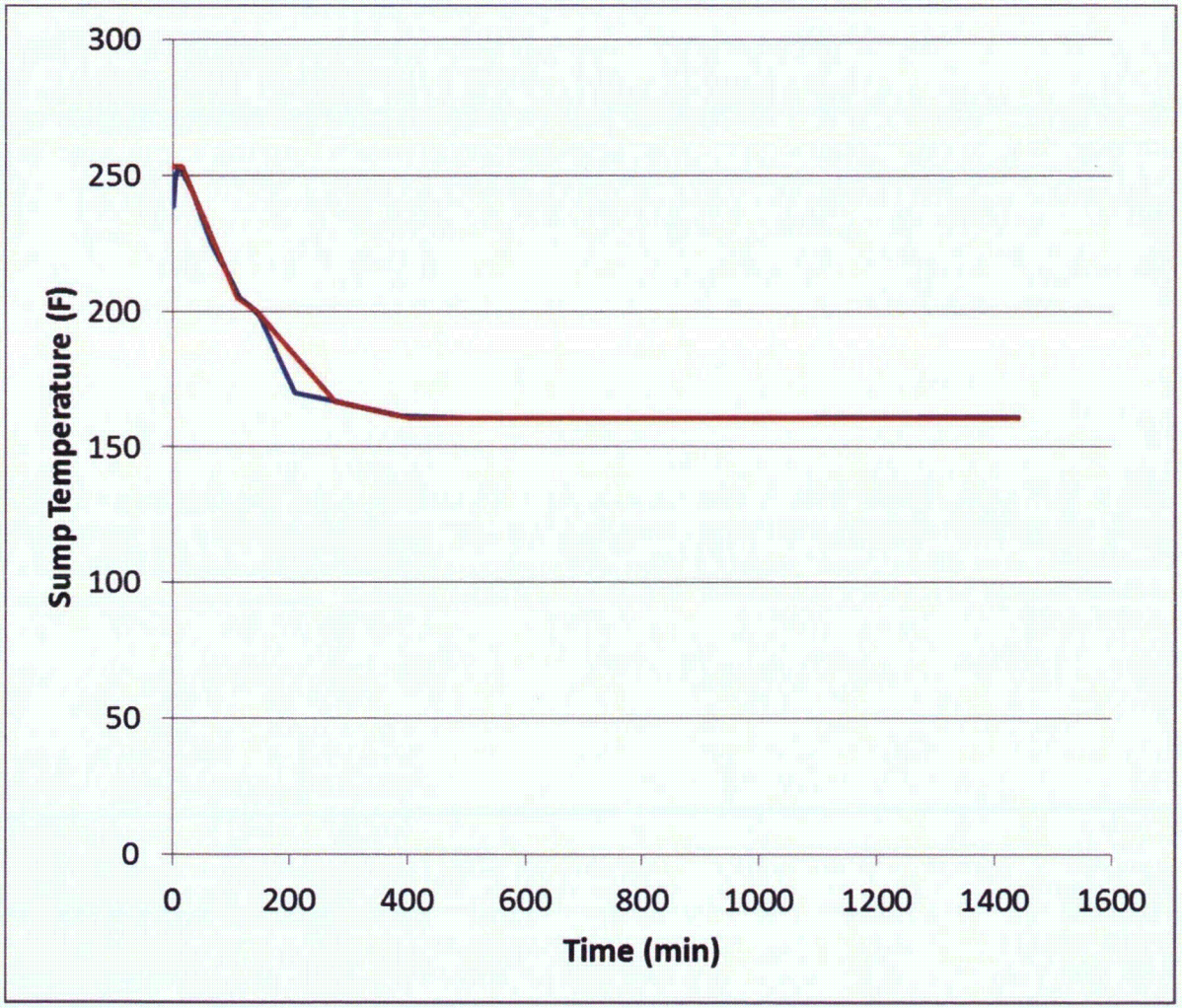
IBOB 1 and IBOB 2 Conditions continued

Coupon Material	Value [ft²]	Target per Autoclave [ft²]	No. of Coupons	Coupon Width [in]	Coupon Length [in]	Area [ft²]
Aluminum	924.1	0.052	1	2	1.88	0.052
Galvanized Steel	13736	0.775	2	4	6.98	0.776

IBOB 1 and IBOB 2 Conditions continued

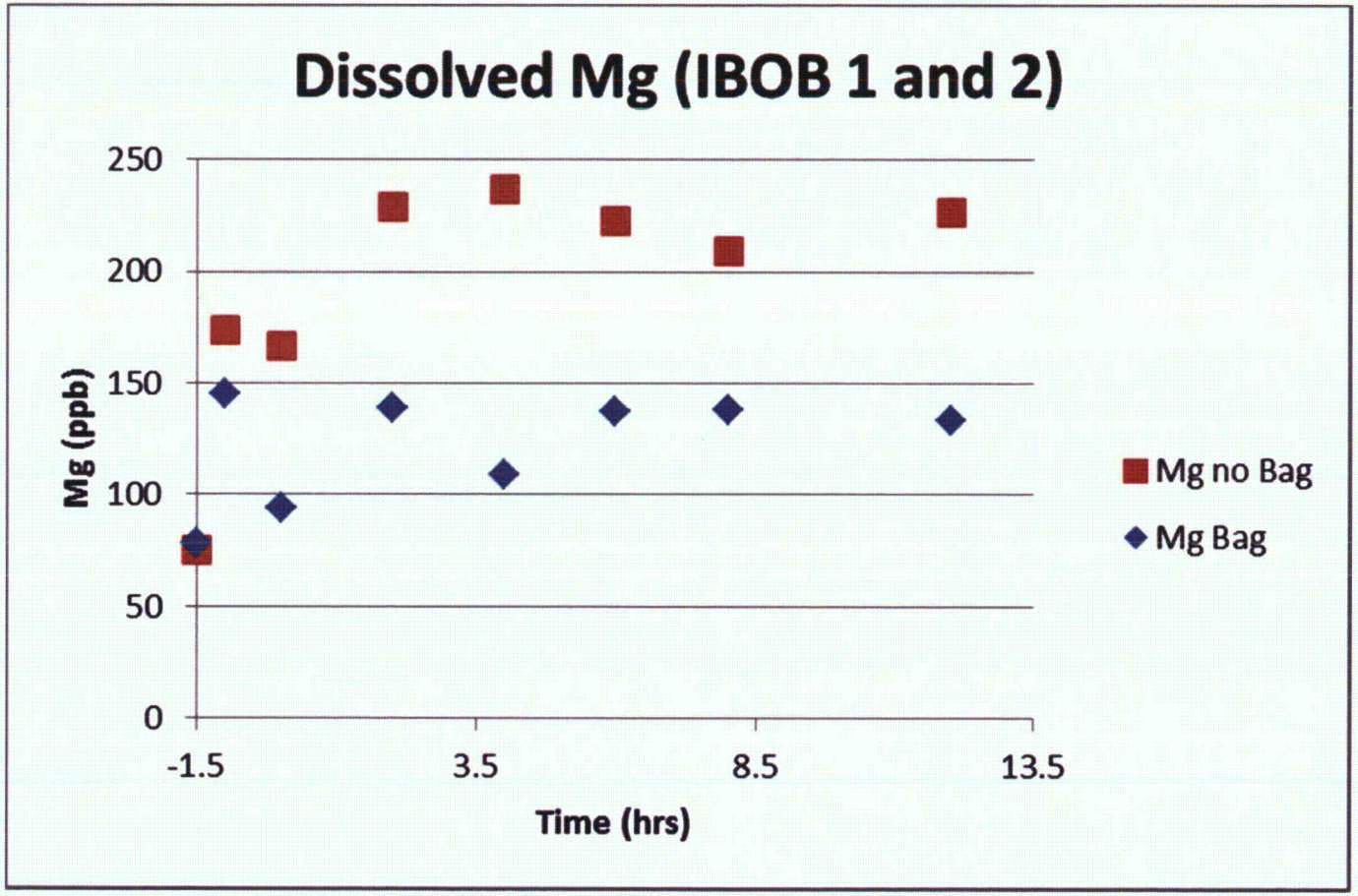
Insulation Material	Value [ft^3]	Density or Specific Surface Area [lbm/ft^3]	Amount per Autoclave [g]
Cal-Sil	28.39	14.5	10.52
E-glass	138.8	4	14.19
Silica powder	0	16	0.00
Mineral Wool	0	10	0.00
Aluminum Silicate	0	12	0.00
Concrete	3450	99.4 [ft^2/g]	0.002
Interam	0	60	0.00

IBOB 1 and IBOB 2 Conditions continued

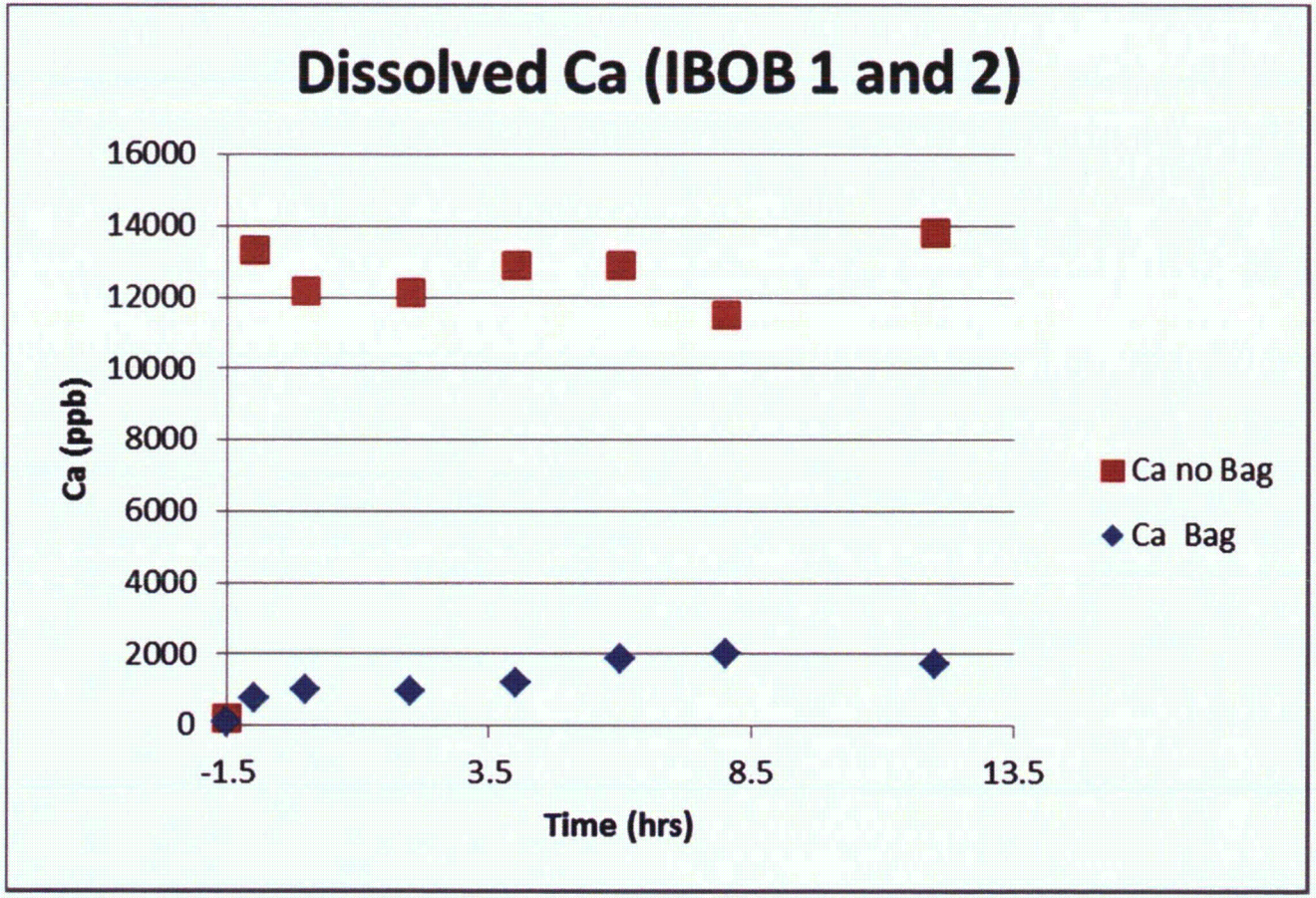


Blue- Plant
Red- Controller

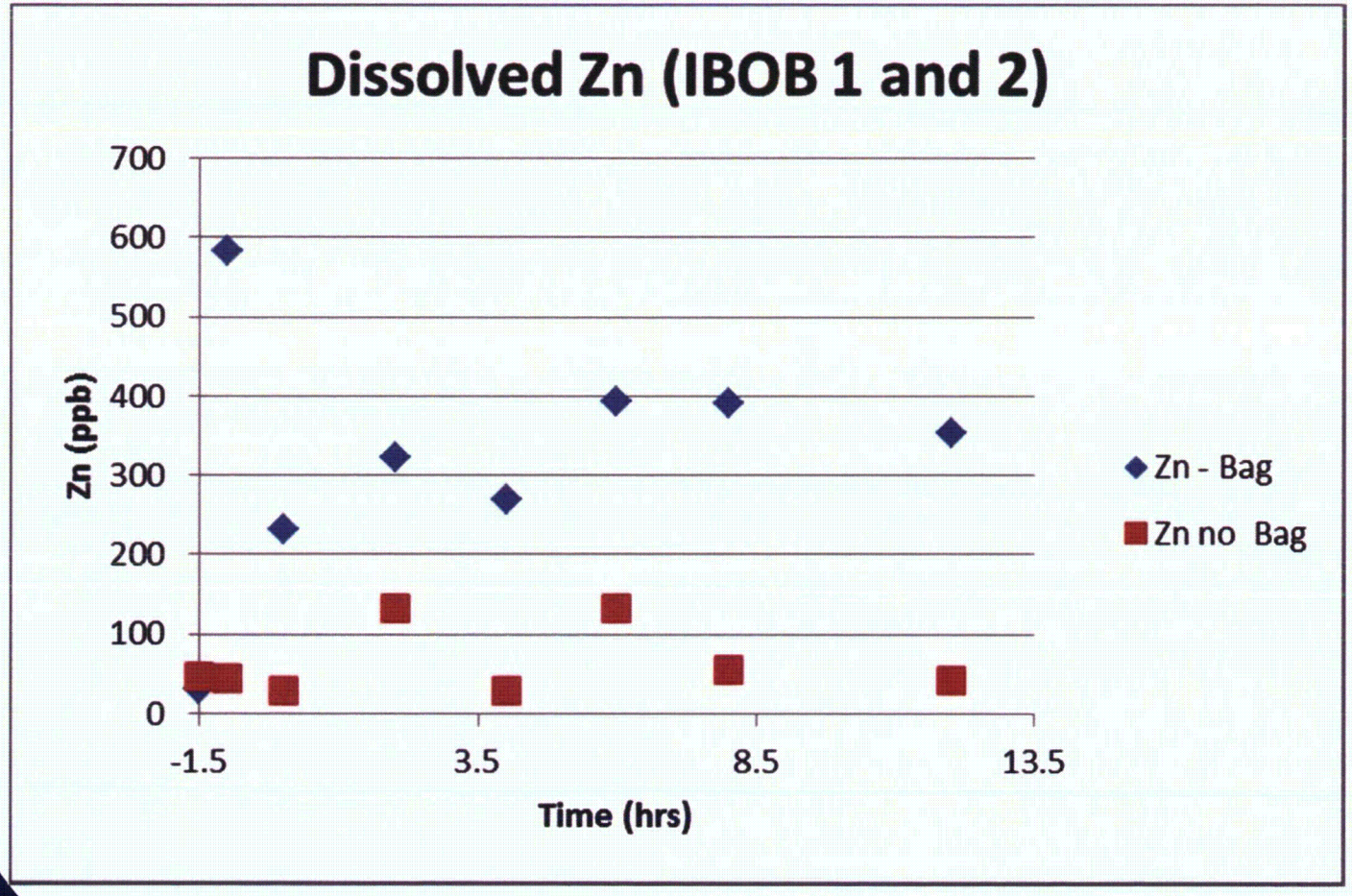
IBOB 1 and IBOB 2 Results- Mg



IBOB 1 and IBOB 2 Results- Ca

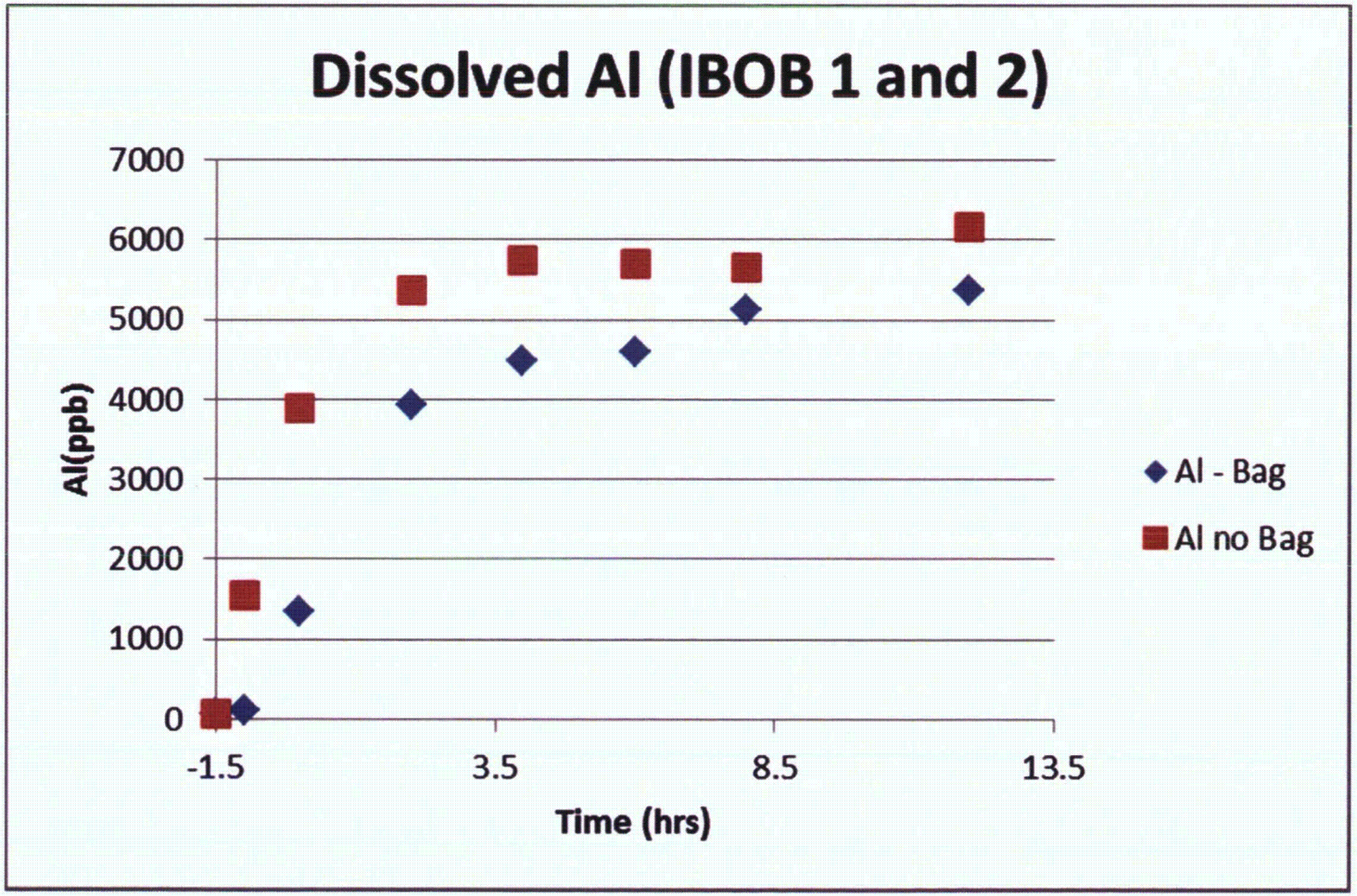


IBOB 1 and IBOB 2 Results- Zn



Dispersing the debris reduced galvanized corrosion

IBOB 1 and IBOB 2 Results - Al



Summary of Debris Bag Investigation

- Boric acid test proves that transport across the bag occurs rapidly
  - Should minimize the chance of dissolved species becoming concentrated in the bag
- Visual examination of the bags and debris
  - No precipitation noted on the insides of the bags or on the debris
  - Some bags contained a lot of debris, which may have inhibited flow

Summary of Debris Bag Investigation Continued

- CalSil dissolve much more quickly when fully dispersed
  - Increased Ca available for precipitation
- Metallic coupon corrosion changed by dissolved powdered debris
  - Galvanized corrosion greatly decreased
  - Aluminum corrosion increased a small amount

Out-of-Bag Drain Time Testing

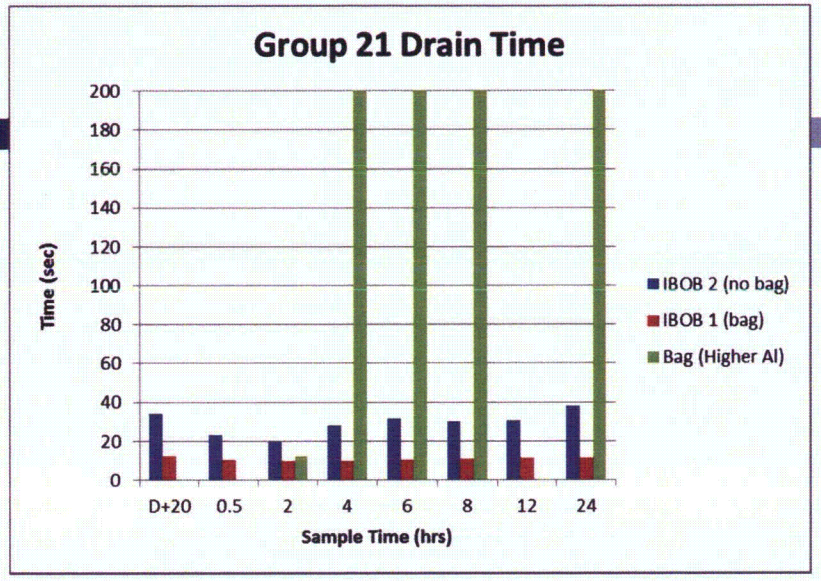
Evaluation of Effect of Bag on Drain Time

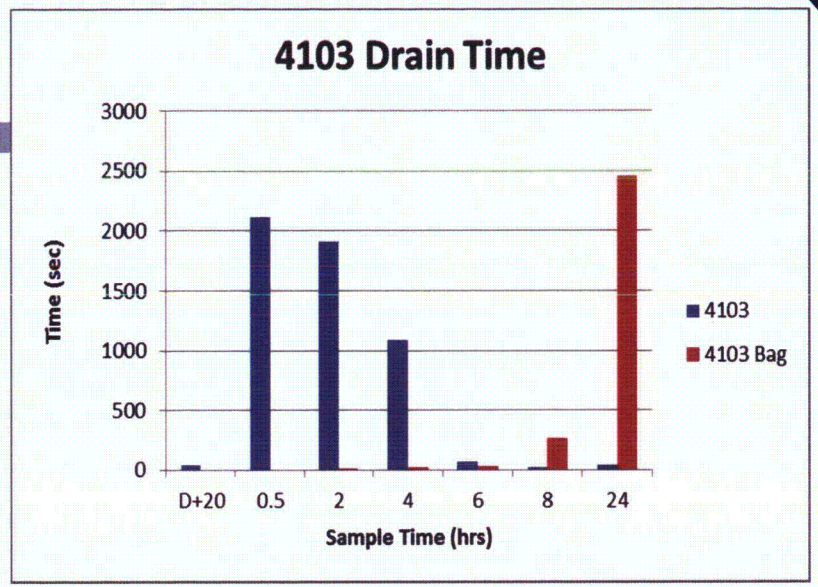
- Since the previous investigation showed that the bag had a significant effect, autoclave testing was repeated with loose debris dispersed in the autoclaves. Only drain times have been measured to date.
- The presence of chemical products that create high head loss on a filter bed should still be reflected in long drain times.

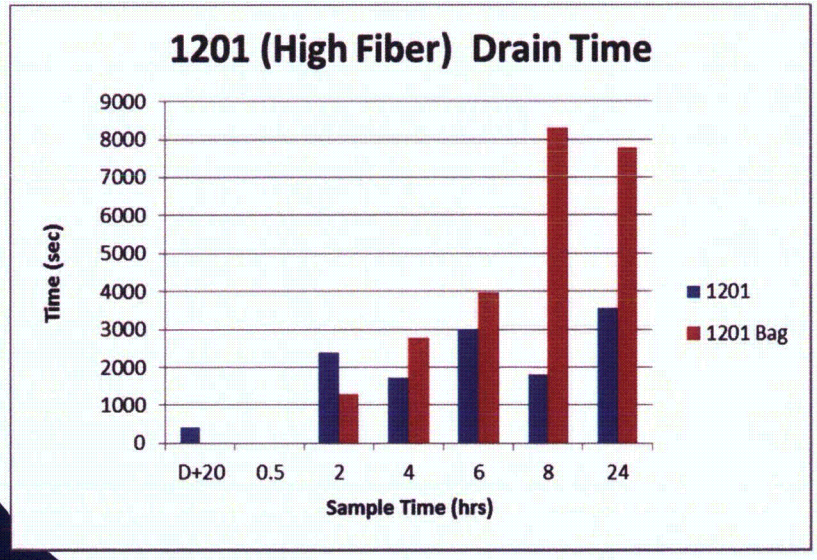
Evaluation of Effect of Bag on Drain Time

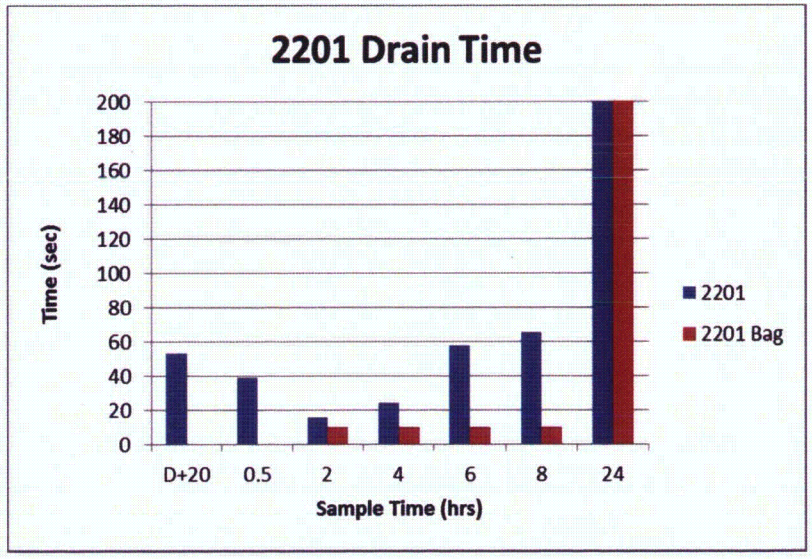
- The results for 3 groups clearly changed
  - Two got worse
- There were borderline changes for 5 groups

Comparison of Drain Times

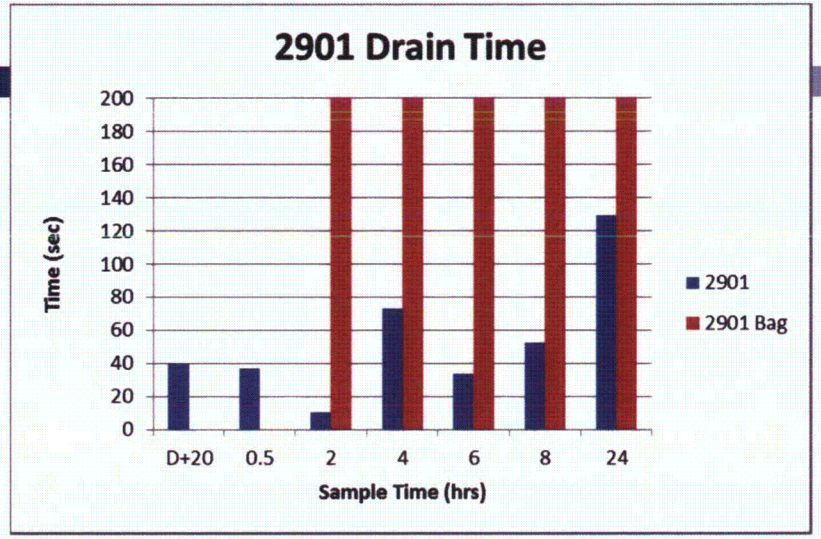


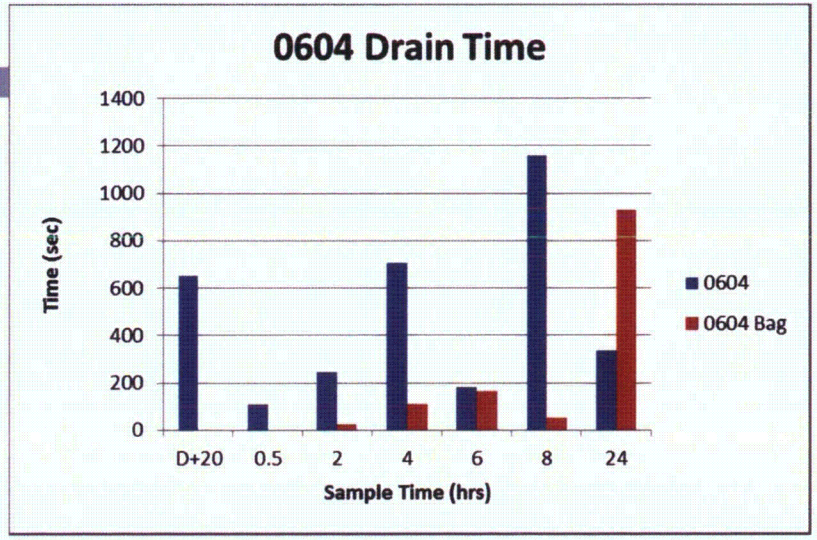


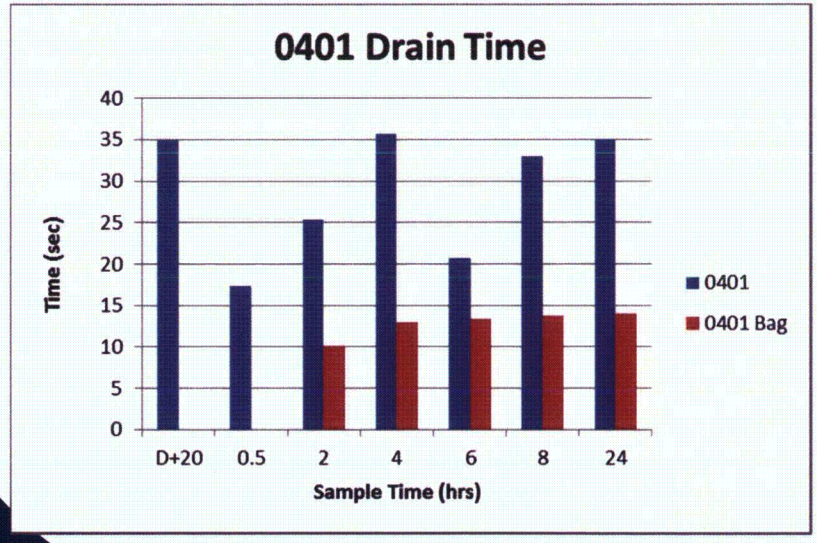


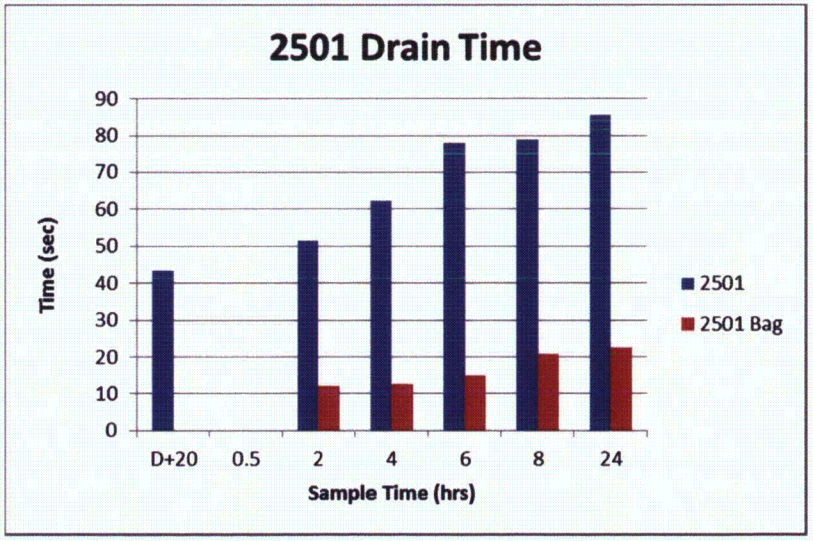


Comparison of Drain Times, cont.

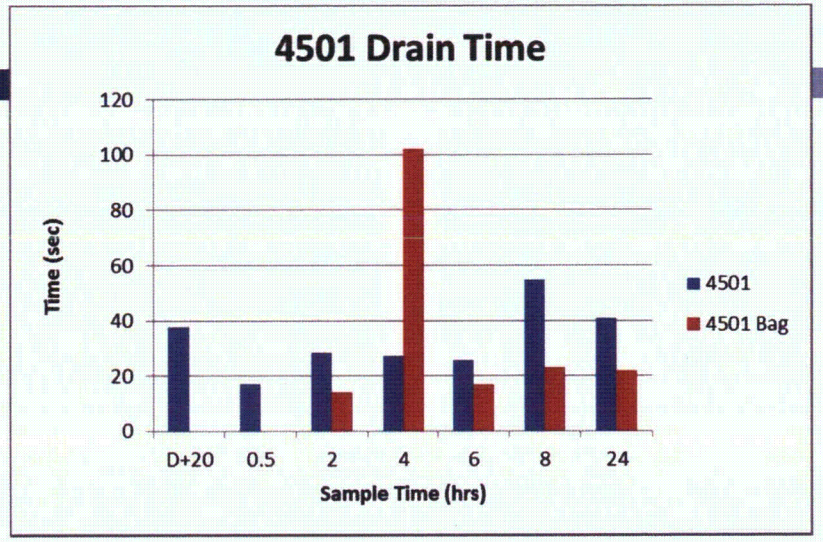


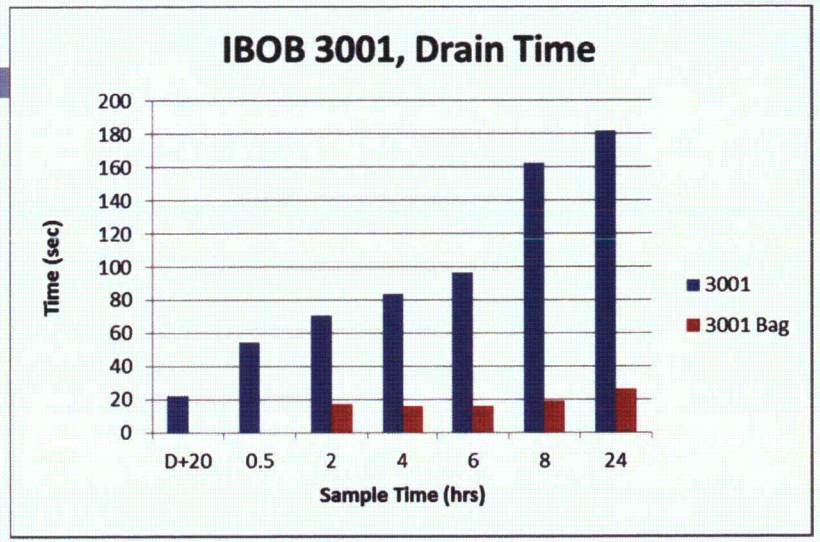


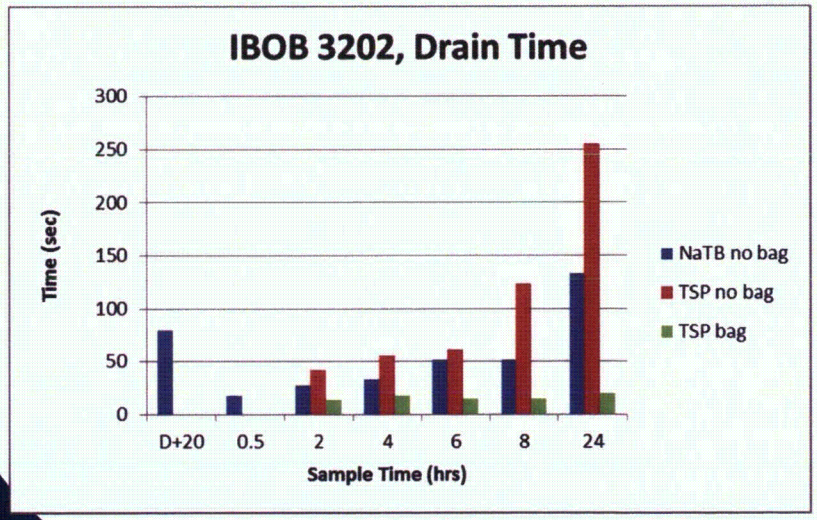


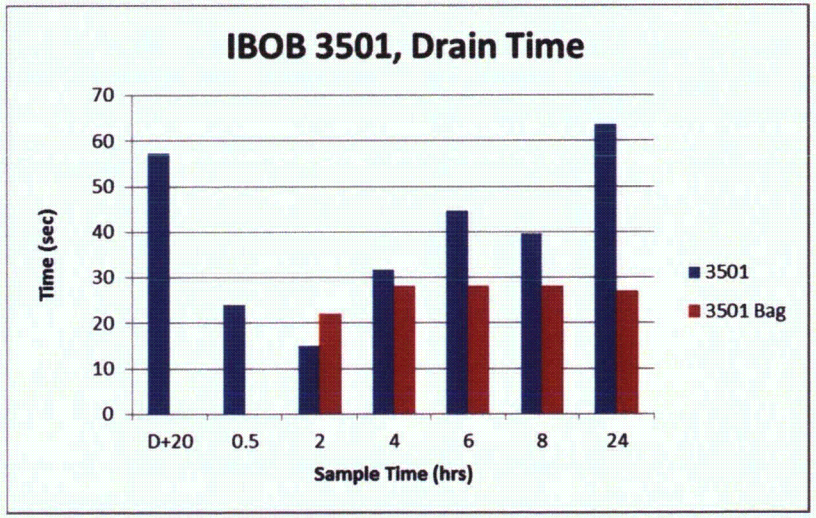


Comparison of Drain Times, cont.

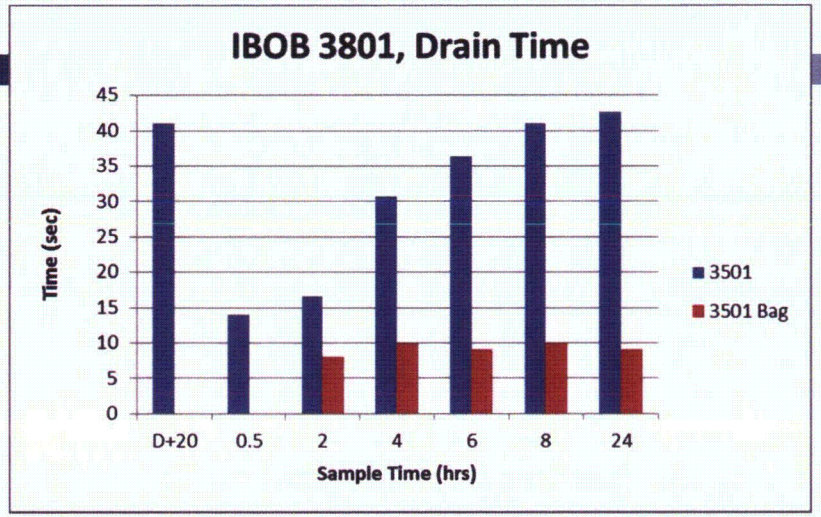


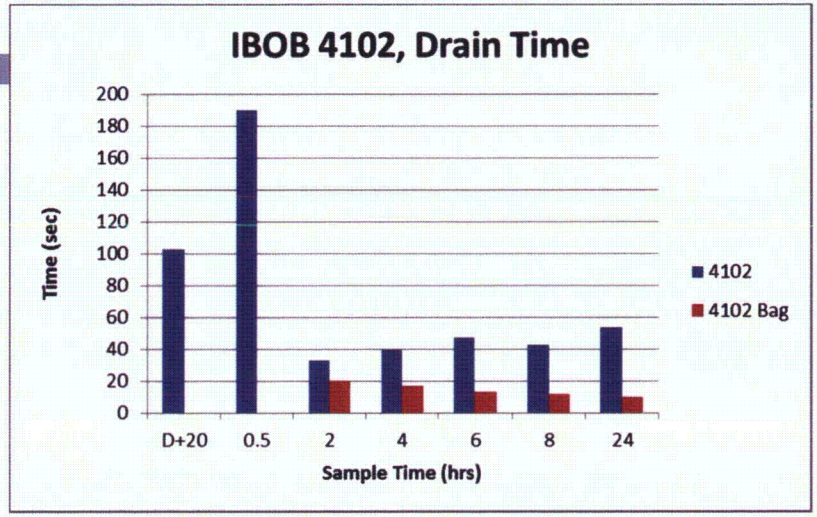


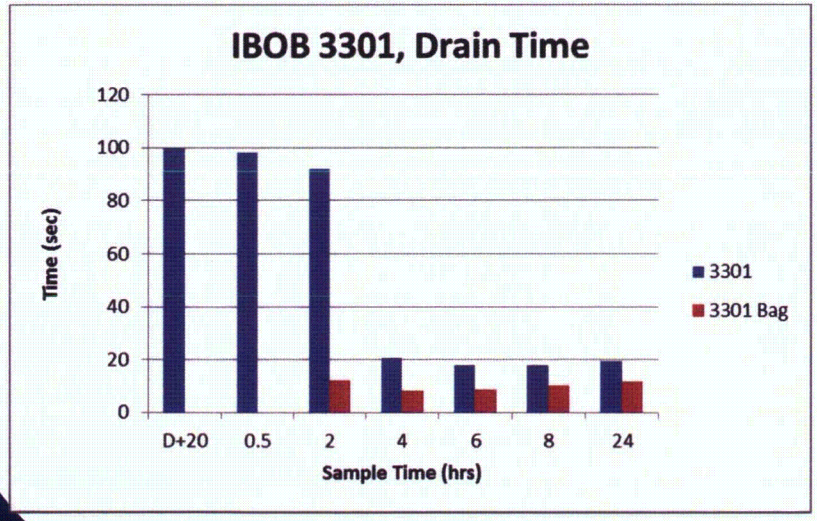


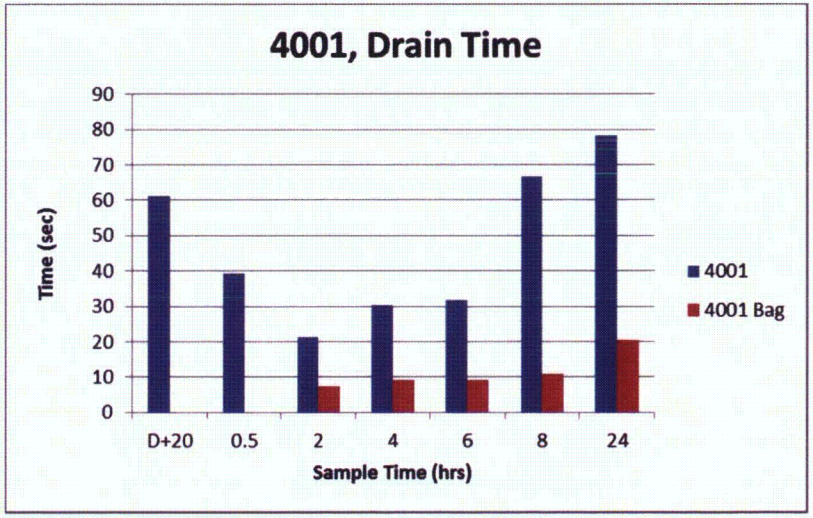


Comparison of Drain Times, cont.

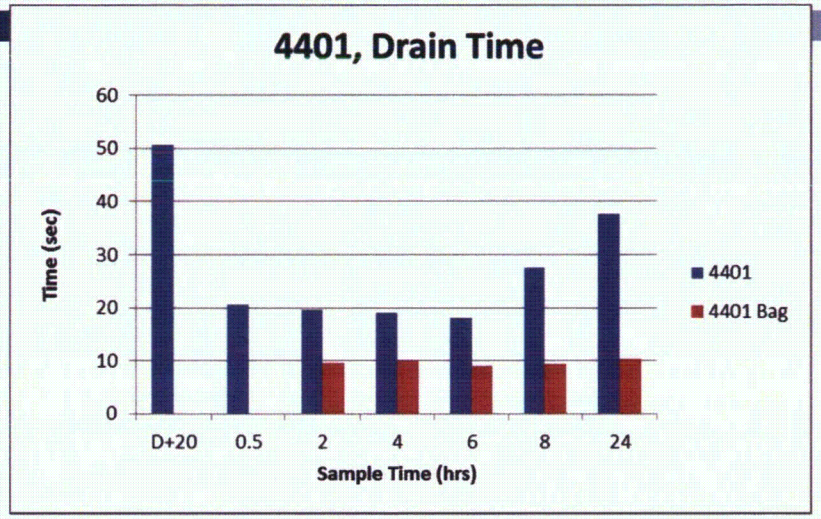


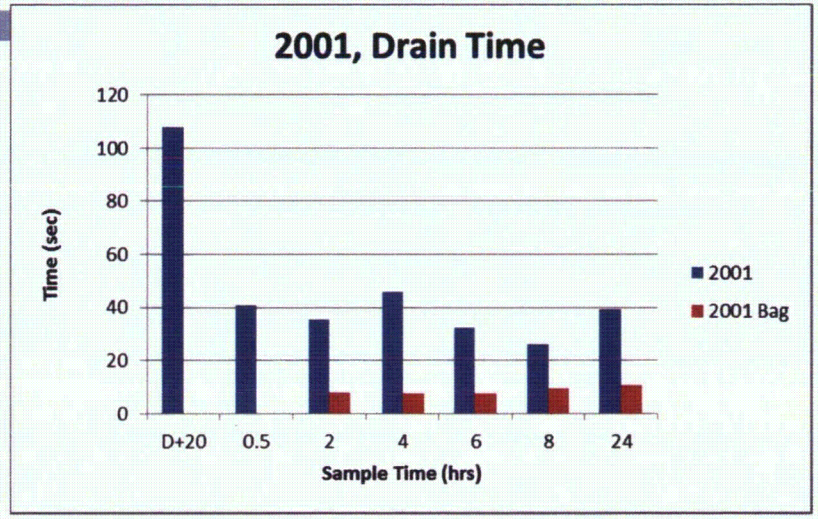


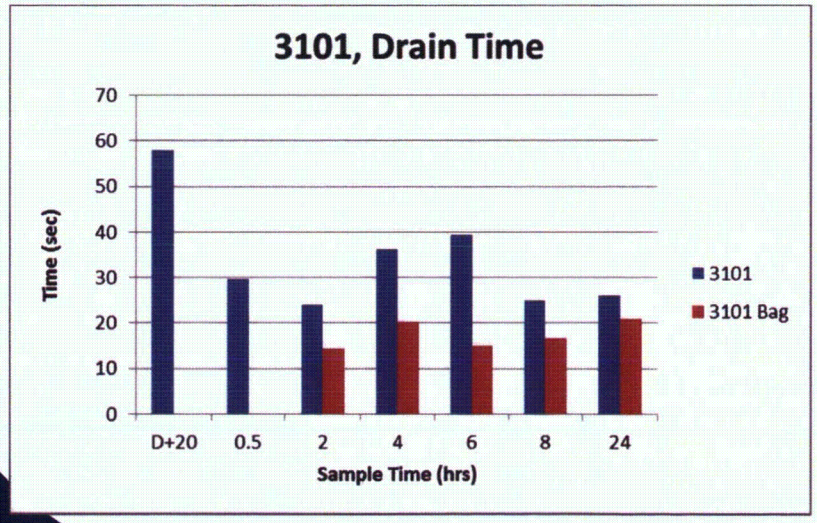


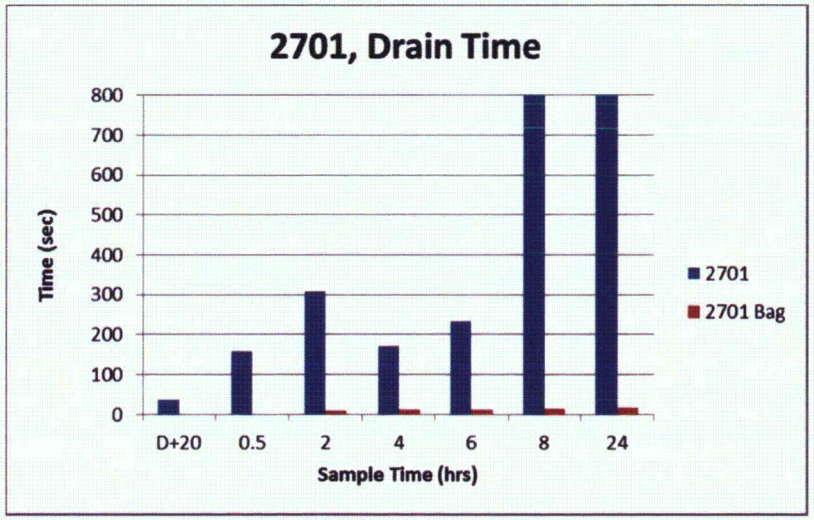


Comparison of Drain Times, cont.

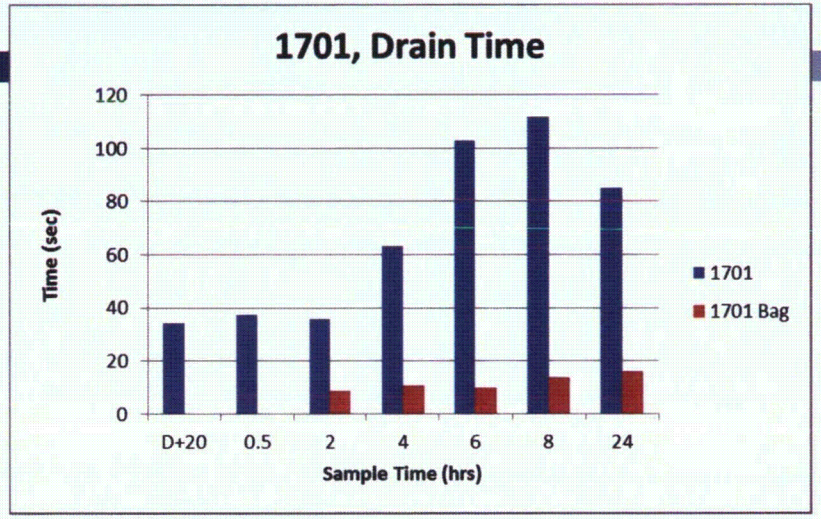


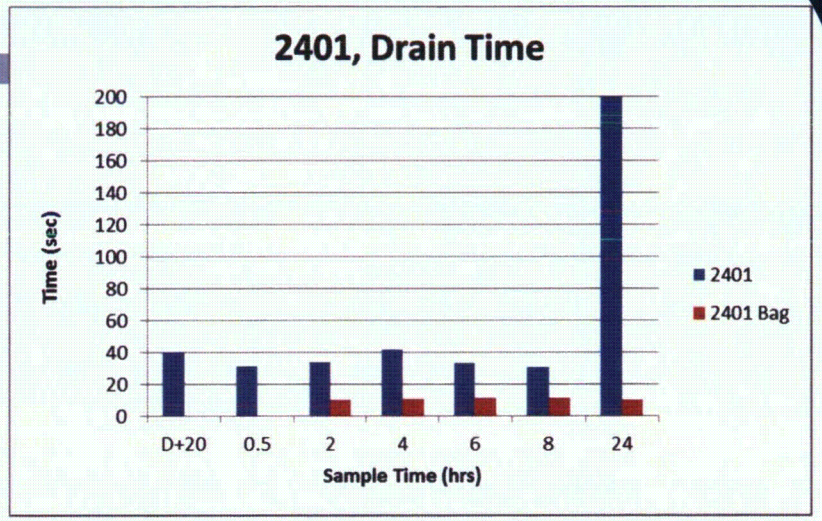


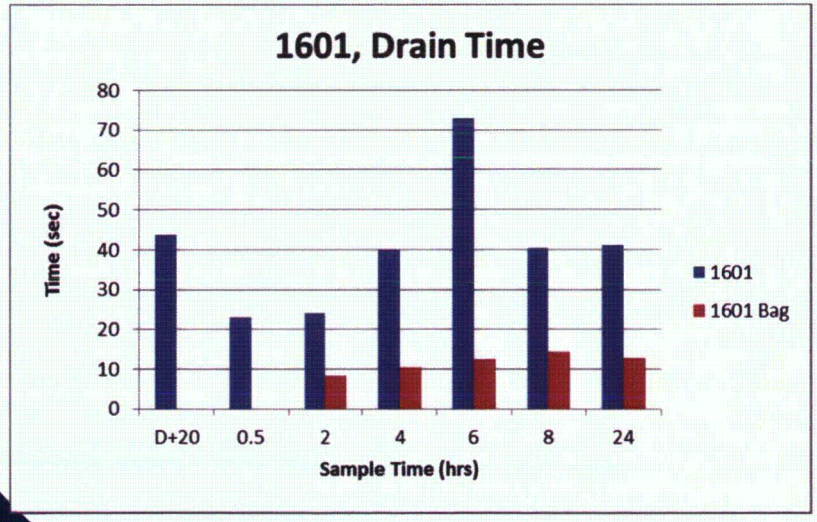


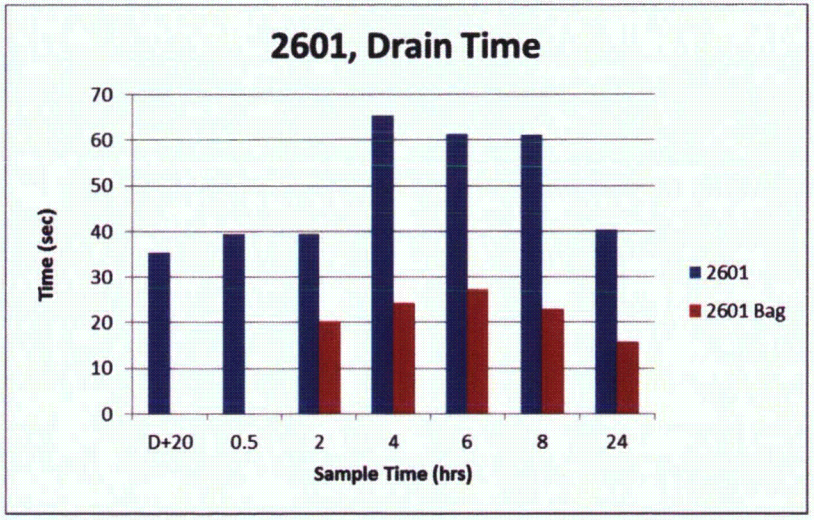


Comparison of Drain Times, cont.

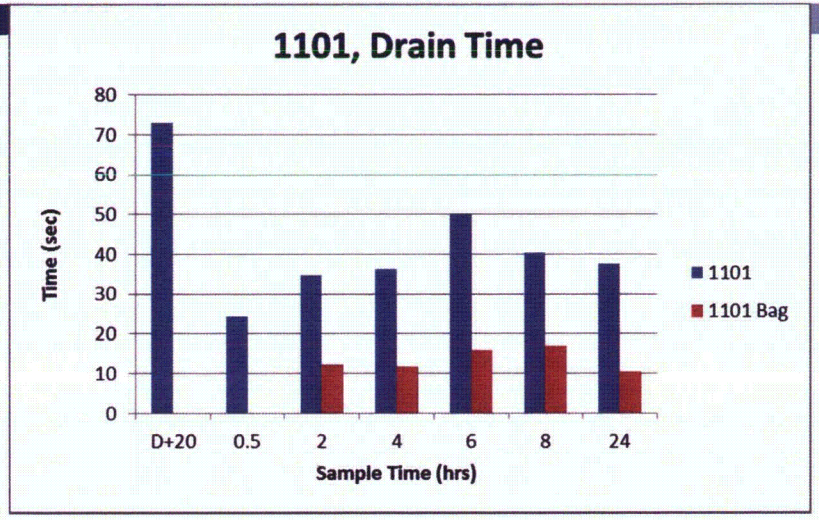


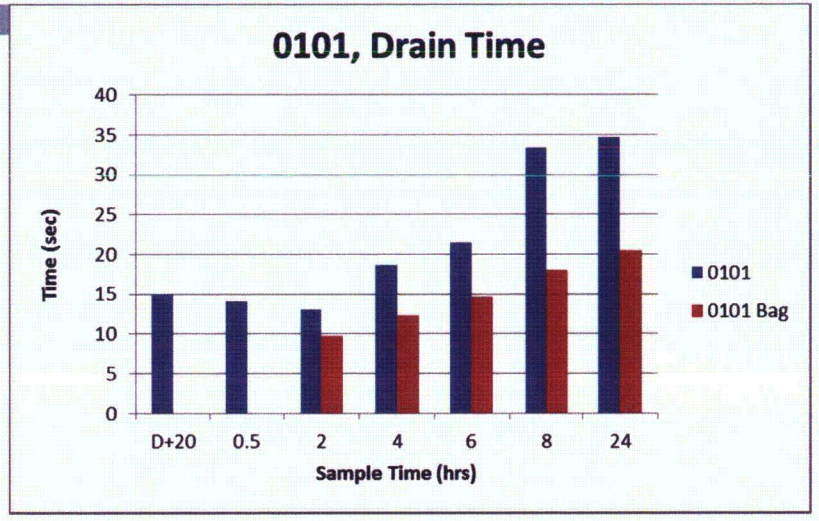


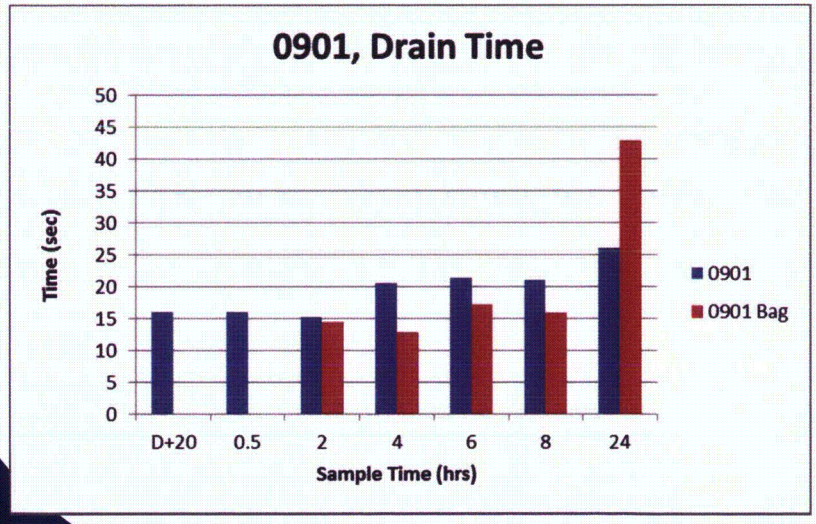


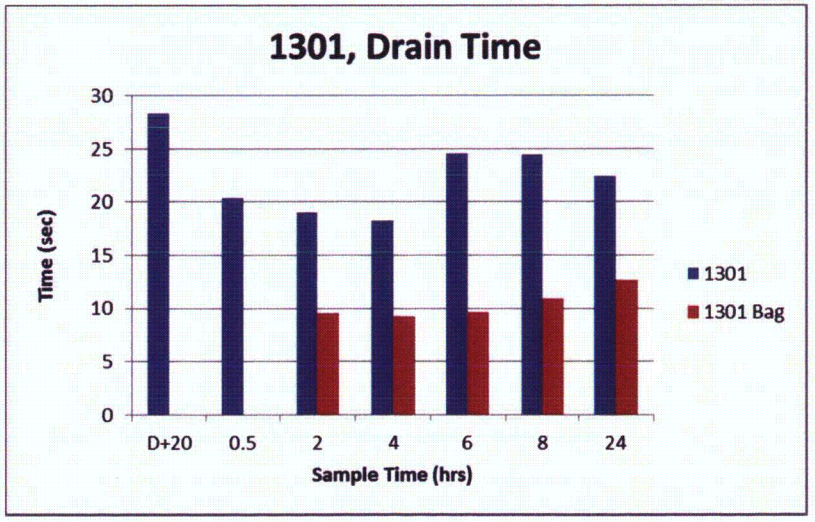


Comparison of Drain Times, cont.

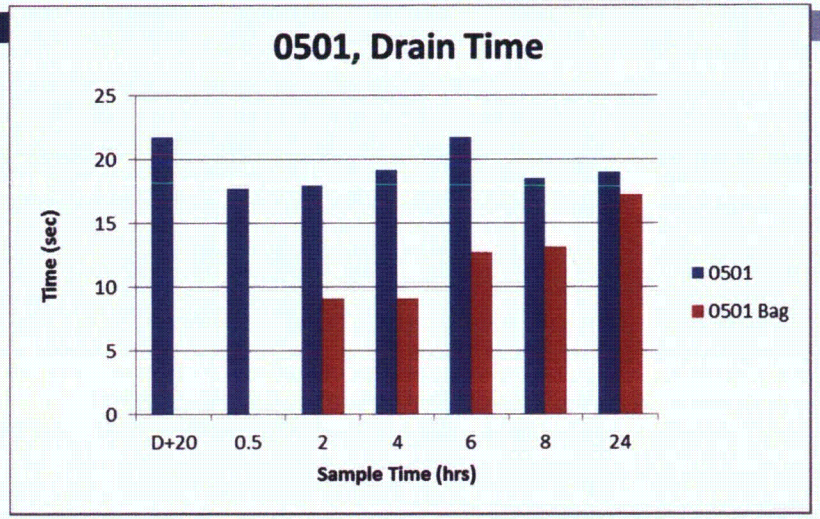


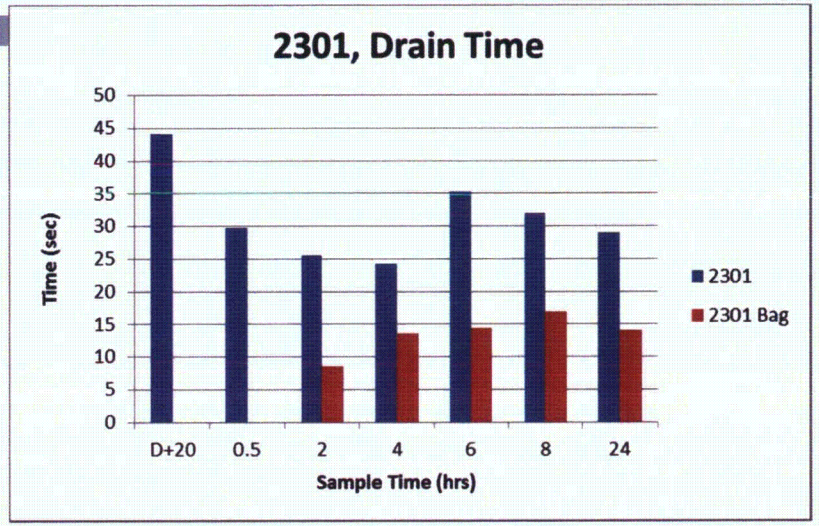


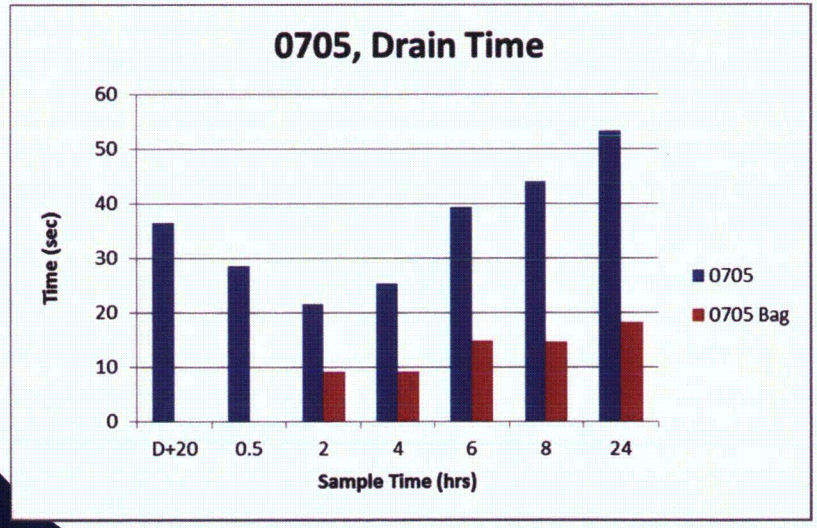


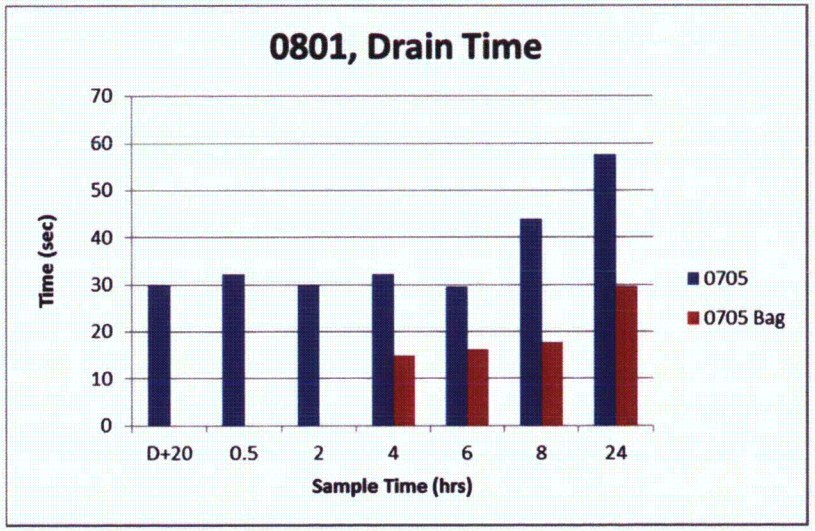


Comparison of Drain Times, cont.

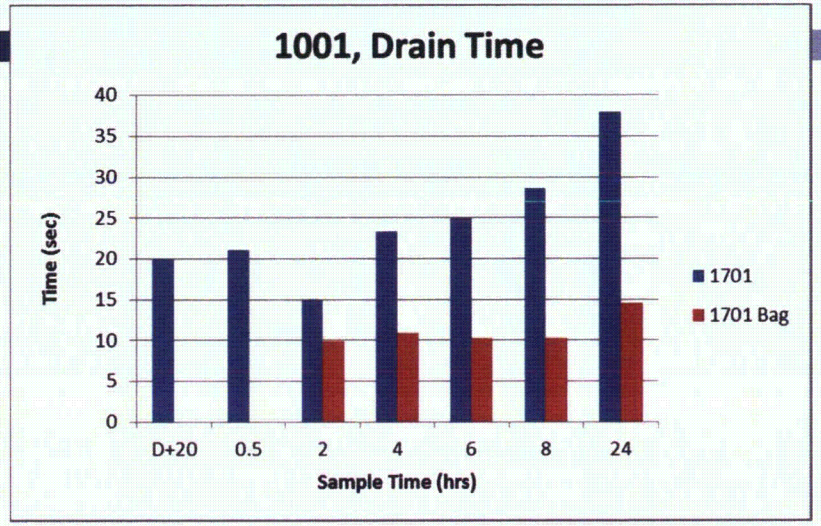


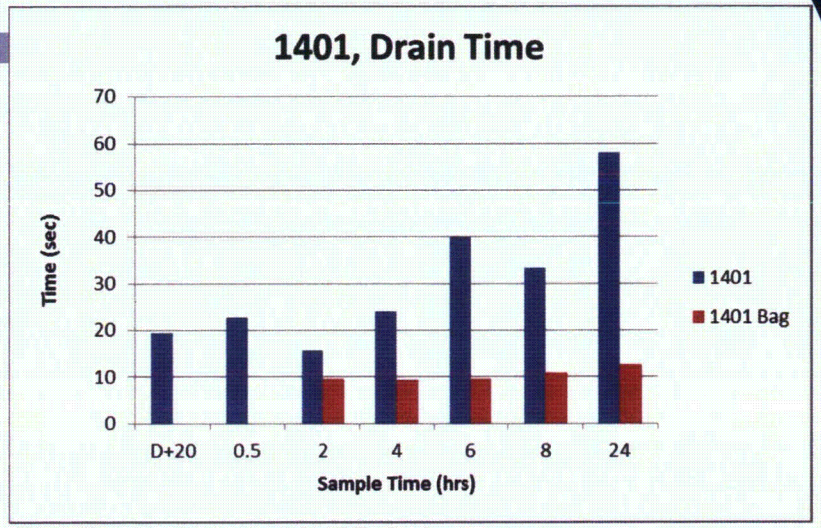


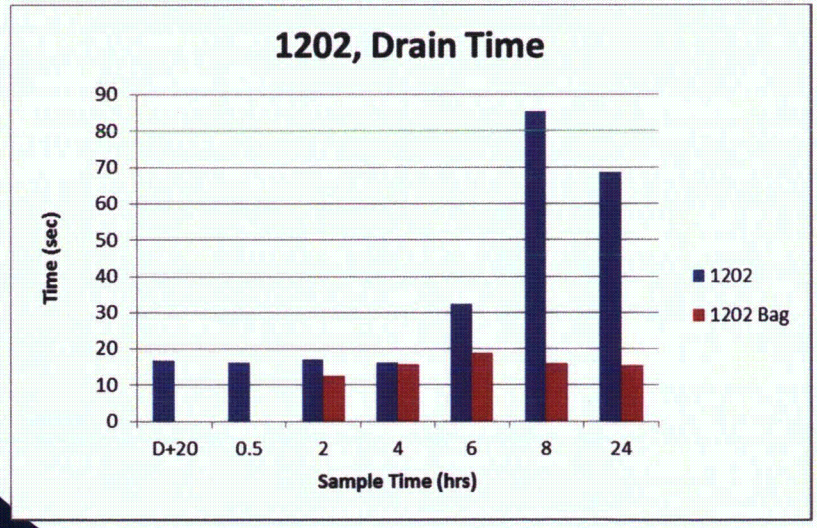


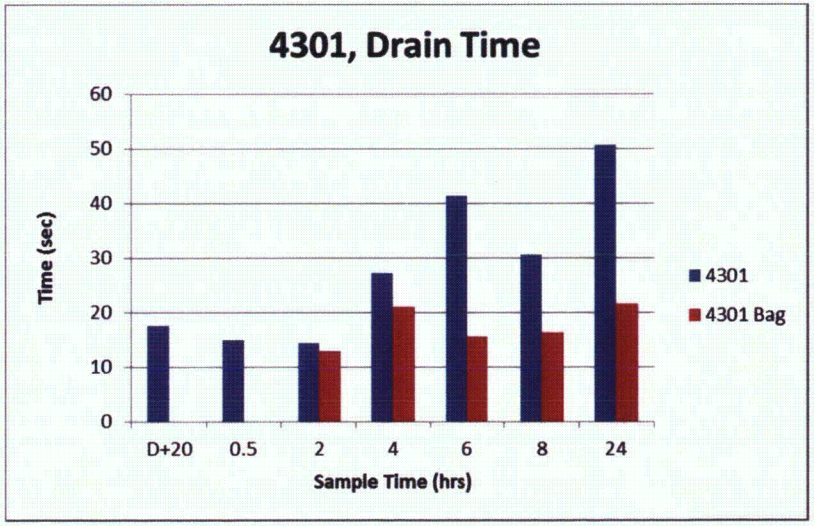


Comparison of Drain Times, cont.

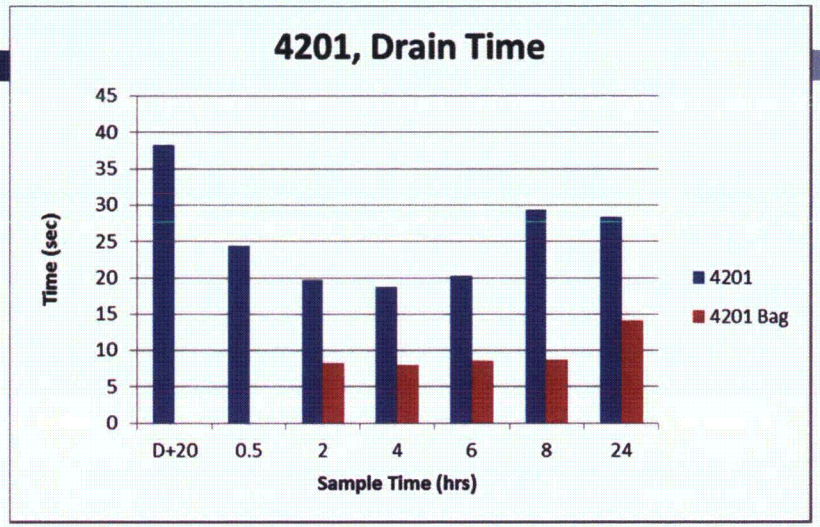


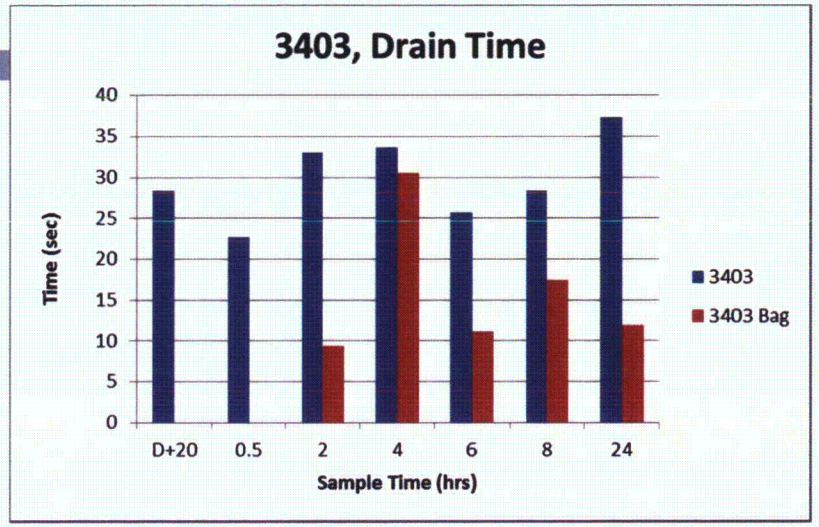


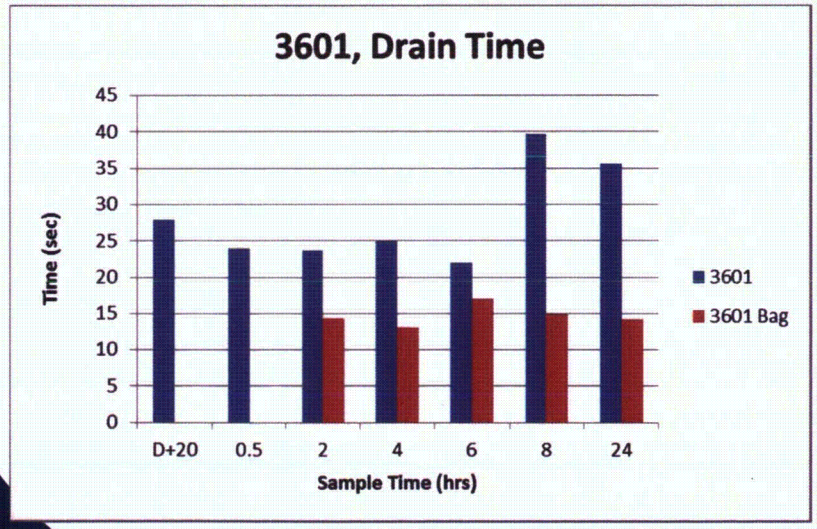


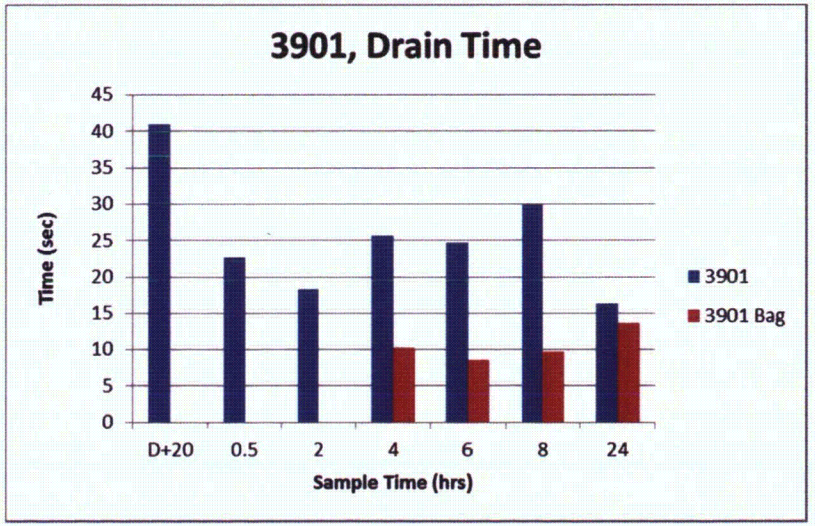


Effect of Bag on Drain Time, cont.

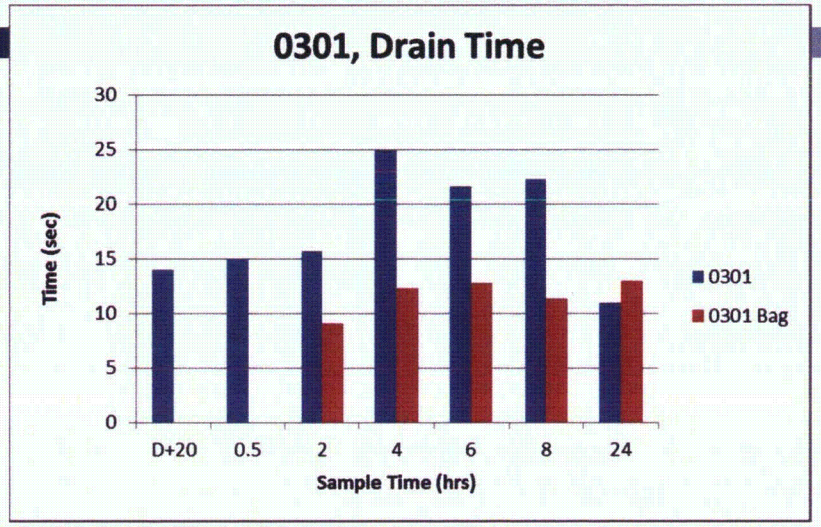


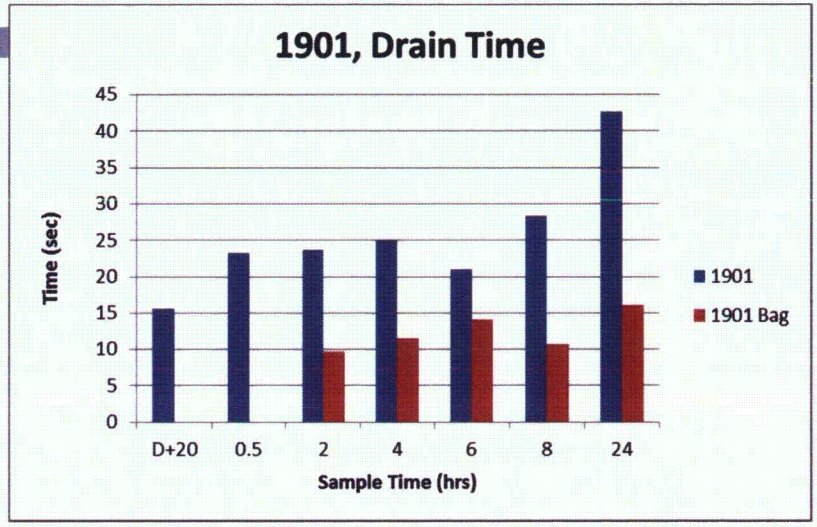


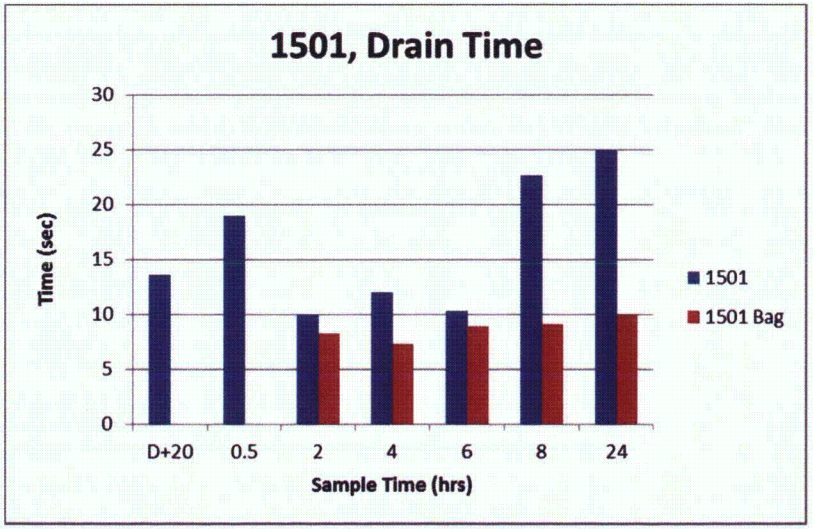




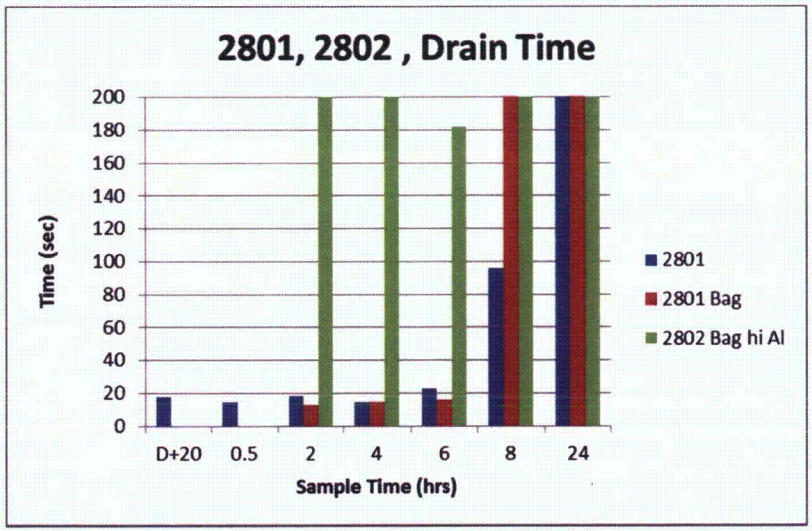
Comparison of Drain Times, cont.

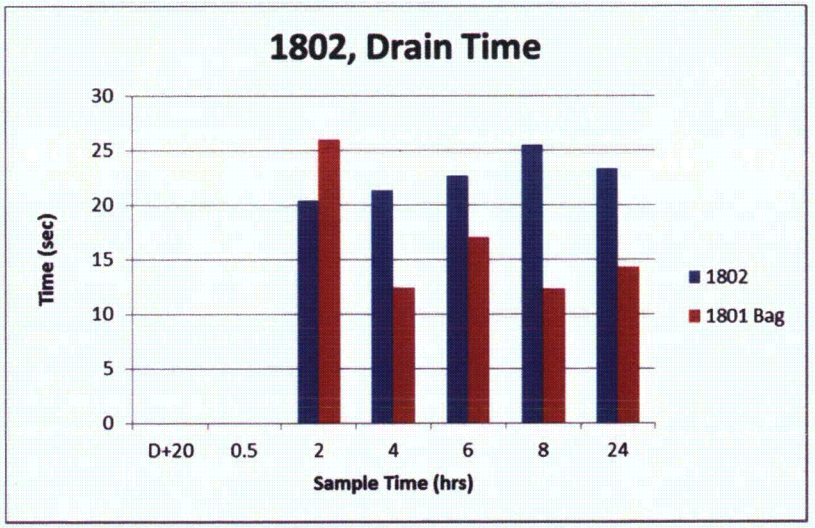






Comparison of Drain Times, cont.





Summary of Chemical Effects at 6 and 24 Hrs, In-Bag and Out-of-Bag

Group	6 Hr Chemical Product	24 Hr Chemical Product
24	None	AlOOH
2	None	None
4	None	None
28	AlOOH	AlOOH
27	AlOOH	AlOOH
17	?	?
43	None	None
8	None	None
5	None	None
15	None	None
48	None	None
16	None	None
31	None	None
32	None	?
11	None	None
23	None	None
36	None	None
10	None	None
1	None	None
26	None	None
13	None	None
20	None	None

Group	6 Hr Chemical Product	24 Hr Chemical Product
14	None	None
35	None	None
6	?	AlOOH + NAS
9	None	None
19	None	None
41	?	?
40	None	None
12	None	None
7	None	None
18	None	None
3	None	None
21	None	None
38	None	None
29	AlOOH	AlOOH
34	None	None
37	None	None
25	None	None
30	None	?
33	None	None
22	None	AlOOH
39	None	None
42	None	None
44	None	None
39	None	None

Path Forward

Motivation for Change in Direction

- Uncertainty based on IBOB results
- With no containment of loose debris, large scale integrated head loss testing with representative flows would be very difficult
  - Settling rates similar for Microtherm and AlOOH
  - If a scaled sump screen strainer was used to get the right distribution of particles, fibers, and possible chemical products, the test could not be generic.
  - Few plants fit into Category 2 or 3, and focus has shifted to avoiding chemical effects.
  - Need a way to deal with changing plant conditions and debris
- Since original approach would be too difficult, and number of plants that we think have early chemical effects are so few, an alternative analytical approach is desired
  - Also becomes a tool for future plant evaluations when plant changes are made

Resolution Path

- Develop a model (empirical or semi-empirical) to predict the time for chemical product formation (specifically for Al) using plant specific data
  - Will develop an approach comparable to WCAP-16530, but for the short term (<24 hrs), to include recent autoclave test data
  - New data will be generated to refine predictions and to bound the model
  - The model will estimate uncertainties in the predicted time of precipitation
  - Early precipitation will be predicted using a thermodynamic solubility approach and will be an input into the initiation of significant chemical effects

Resolution Path

- A modeling team has been created with representation from Alion, Westinghouse, and NWT
- Project managed by AREVA
- Two face-to-face meetings have been held as well as frequent teleconferences
- Further needs for autoclave testing and ICP analysis of out-of-bag tests are being discussed

Preliminary Evaluation Process

- A process to evaluate chemical effects timing will be developed based on buffer and input conditions
- The model will be used to get an initial prediction of early precipitation, if any
- Autoclave testing results and other available data will be utilized in conjunction with precipitation predictions to determine if early chemical effects are expected

Initial Assessment

- Independent review of IB autoclave data
  - In many cases, predicted Al precipitation matches test results
  - In some cases, Al precipitation predicted but drain times unaffected
  - In some cases, Al precipitation not predicted but drain times increased significantly
- Evaluating additional data and testing needs
  - ICP for some portion of OB tests
  - Success cases for early chemical effects
  - New set of autoclave tests to fill in data points, perform repeats, etc.
  - Potentially, review particulate sizes
- Evaluating appropriate thermodynamic equilibrium code to use for the model

Schedule

Schedule

- Testing to support the path forward is planned for March and April.
- Model development is ongoing and will be completed in May.
  - **Status call with NRC in late April timeframe**
- WCAP-17788-NP, Volume 5 (Chemical Effects) and Volume 1 (Summary) to be submitted in June.

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