

US EPA ARCHIVE DOCUMENT

APPENDIX 7.4

Optimization of R P Adams Filter

Experimental Design
& Results

Review with Chlorine
Institute

Results of Pilot Work



- Defined operating conditions that reliably predict the level of mercury in 50% caustic after filtration.
- Demonstrated the conditions to consistently achieve 30-40 ppb level after filtration.
- Developed statistical model to predict filter performance.

Design Approach



- Select significant variables
 - Temperature
 - Flux Rate
 - Recycle Rate (Recycle Ratio)
- Utilize Fractional Factorial Design as screening test
- Analyze Variances

Project Organization

- Schedule- August 1998 - January 1999
- Equipment Cost - \$210K
- Equipment
 - Pilot RP Adams (14 ft²)
 - Mercury On-line analyzer
 - Process Control- OMNX

Fractional Factorial Design



- Intended to be used in early stage of investigation as screening
- Main effects > 2-factor interactions > 3 factor interactions
- Designs can be augmented to resolve ambiguities.
- Can directly go to Evolutionary Optimization

Fractional Factorial Design

Variable	-	0	+
1. Temperature, °C	80	90	100
2. Flux Rate,gpm/ft ² min	0.20	0.25	0.30
3. Recycle Rate,ratio	0	0.5	1.0

Constrained Variables	
Pressure Drop, psig	≤ 20
Precoat type	AZO carbon
Precoat amount, lb./ft ²	0.25

<i>Design</i>				
<i>Run</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>Response ppb Mercury</i>
1	80	.20	0	
2	80	.25	.50	
3	80	.30	1.0	
4	90	.20	.50	
5	90	.25	1.0	
6	90	.30	0	
7	100	.20	1.0	
8	100	.25	0	
9	100	.30	.50	

Statistical Inference



- ANOVA (Standard Error)
- Coefficients (Algorithm)
- Contour Plot (Surface Response)
- Echip
 - Echip, Inc. 724 Yorklyn Road, Hoeckessin, DE
 - Tel. (302) 239-5429

Analysis of Variance

ANOVA

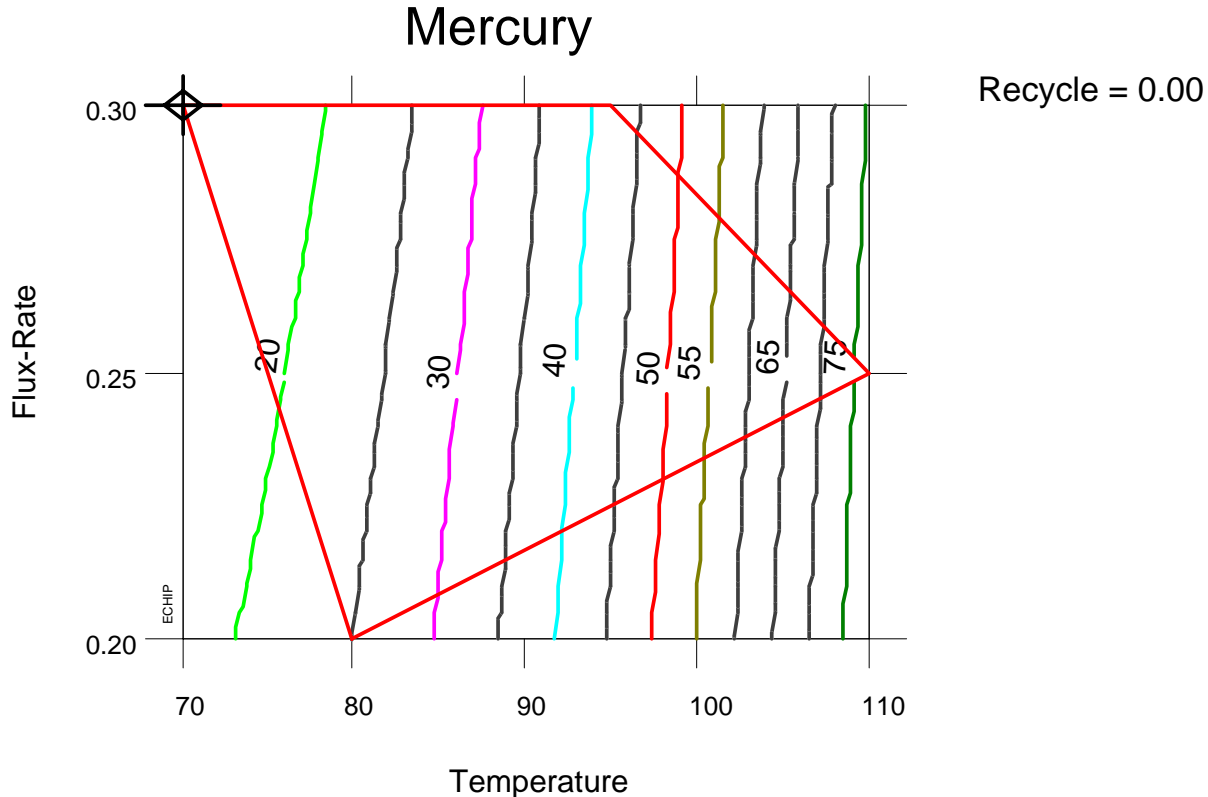
Variable	Mean Squares	Degrees of Freedom	P
Temperature	3257.2	2	0.0001
Flux-Rate	25.258	1	0.6499
Recycle	79.2014	1	.4273
Error	114.6	9	

Coefficients

Variable	Coefficients	Standard Deviation	P
Constant	39.0267		
Temperature	1.5047	.256839	.0001
Flux-Rate	-36.6366	78.0385	.6499
Recycle	3.65373	4.39505	.4273
Temperature ²	.0287338	.0194628	.1740

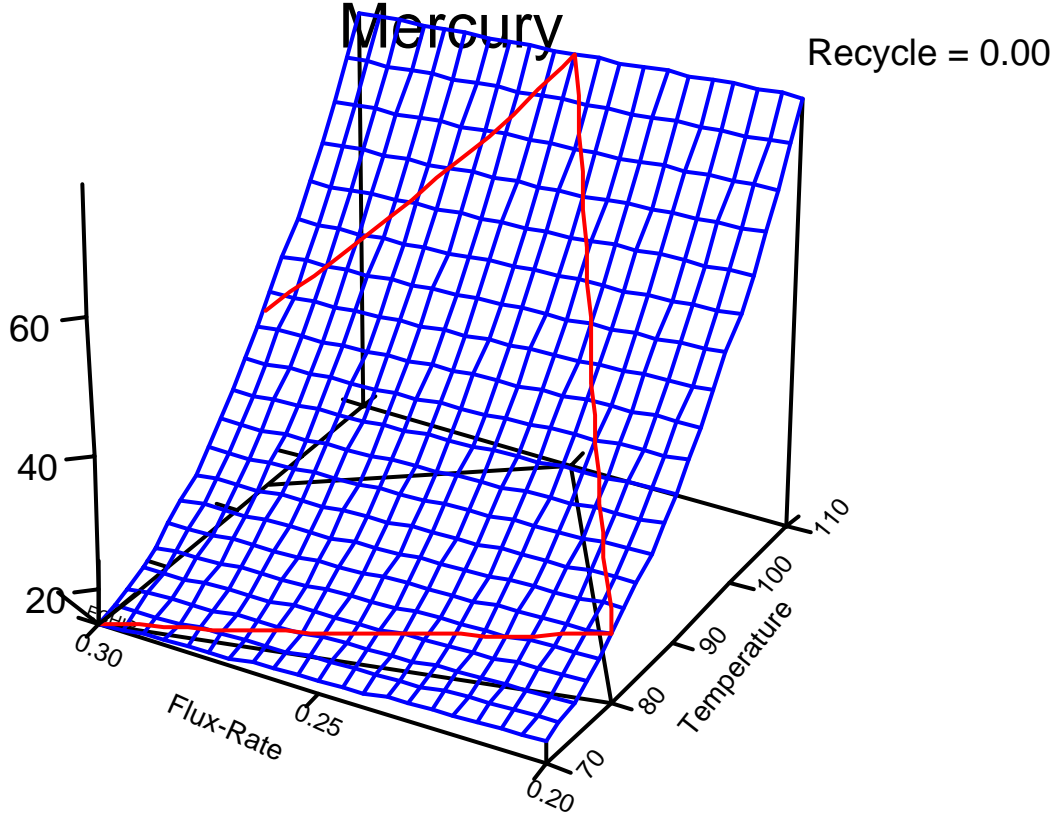
N TRIALS = 14
N terms = 5
R Squared = 0.982

Contour Plot



Temperat= 70.00	Flux-Rat=0.3000	
Value	Low Limit	High Limit
14.94	-16.57	46.46

Contour Plot



Results of Predictive Model

Prediction Values at 95% Confidence

Temperature	Flux Rate	Recycle	C-Hull	Mercury	Limits
70	.30	0	Inside	15	(-16,46)
80	.30	0	Inside	21	(-5,47)
90	.30	0	Inside	33	(6,61)
100	.30	0	Outside	51	(23,79)
110	.30	0	Outside	75	(46,104)
120	.30	0	Outside	104	(65,143)

Optimization of R P Adams Filter



Equipment Configuration
& Reliability
Review with Chlorine
Institute

Equipment Design



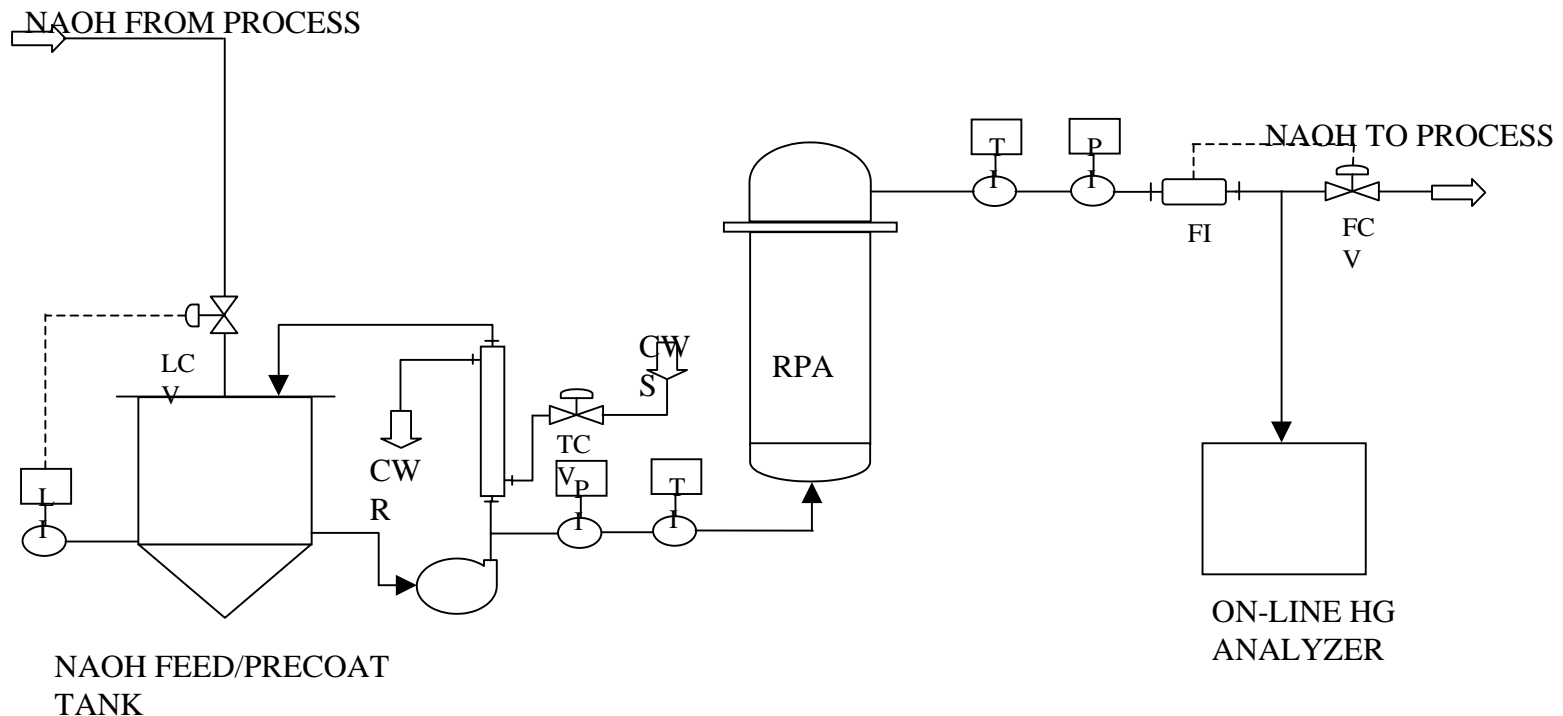
- Test Platform-RP Adams Unit
 - Nickel Lined/Carbon Steel Shell
 - Elements-C-200 Porocarbon Tubes
 - Four Elements in unit-14 ft²
- Filtration Media-Norit AZO
- Mercury On-Line Unit-P S Analytical
- Control via OMNX Software Package

Equipment Reliability



- Up-time for RP Adams @ 100%
- On-line Analyzer
 - Unit requires routine maintenance
 - Unit requires attention to details of operation

Equipment Configuration



FLOW DIAGRAM - RPA FILTER