# Black Belt Project:  Reducing Mercury in Wastewater

**ABC* Materials Company**
**Chemicals Business Group**

(*All Names Changed for Anonymity)

Date Submitted:  December 15, 2004
Black Belt Certification Candidate:   Roger D.
Project Champion:  Jim P.

Team Members

| **Name** | **Area Represented** |
|---|---|
| Paul A. | Operations |
| Tom C. | E&I Maintenance |
| Randy D. | Technical/Best Practices |
| Abe D. | Technical/Lab |
| Ed F. | Plant Services |
| Chris M. | Technical/Engineering |
| Mark S. | Technical/Engineering |
| Dave H. - ad hoc | R&D/Process Chemistry |
| Tom P. - ad hoc | Technical/Mercury Balance |

<u>Summary of Six Sigma Tools Used</u>

Project Charter
Process Mapping
Cause & Effect Matrix FMEA
Gage R&R
MSA
Capability Analysis
Screening DOE
Optimization DOE
Response Surface Analysis
ANOVA
Tests for Equal Variances
Box-Cox Transformations
Control Plan

## Executive Summary

In December of 2000, the State DNR promulgated new effluent mercury limits based on the joint US/Canadian Great Lakes Initiative (GLI). The mercury control technology employed by the plant at that time was not capable of meeting these standards.

A Pareto study identified treated process wastewater as the principle source (67%) of mercury in the plant effluent.

A benchmarking survey of other producers indicated that our operations were already an industry leader in removing mercury from process wastewater. Thus, transfer of control technology from other mercury cell operators was not an option for addressing this issue.

In February of 2001, a Black Belt project was chartered to achieve compliance with the new effluent mercury standards by reducing the mercury content of treated process wastewater. The deadline for meeting the new standards was February 1, 2002.

The project team used the full Six Sigma Roadmap including Baseline Capability; Y and x MSA's ; process stabilization; mapping; C&E Matrix; FMEA; graphical analysis; multi-vari analysis; DOE's and a comprehensive control plan to improve the plant's wastewater treatment capability.

As a result of this effort, compliance with the new GLI-based standards was achieved prior to the February 1, 2002 deadline. An overall reduction of 74% in median mercury concentration of treated wastewater was realized, and the standard deviation of this key output variable was reduced by 84.3%. In addition, several follow-up projects were identified for future performance improvements.

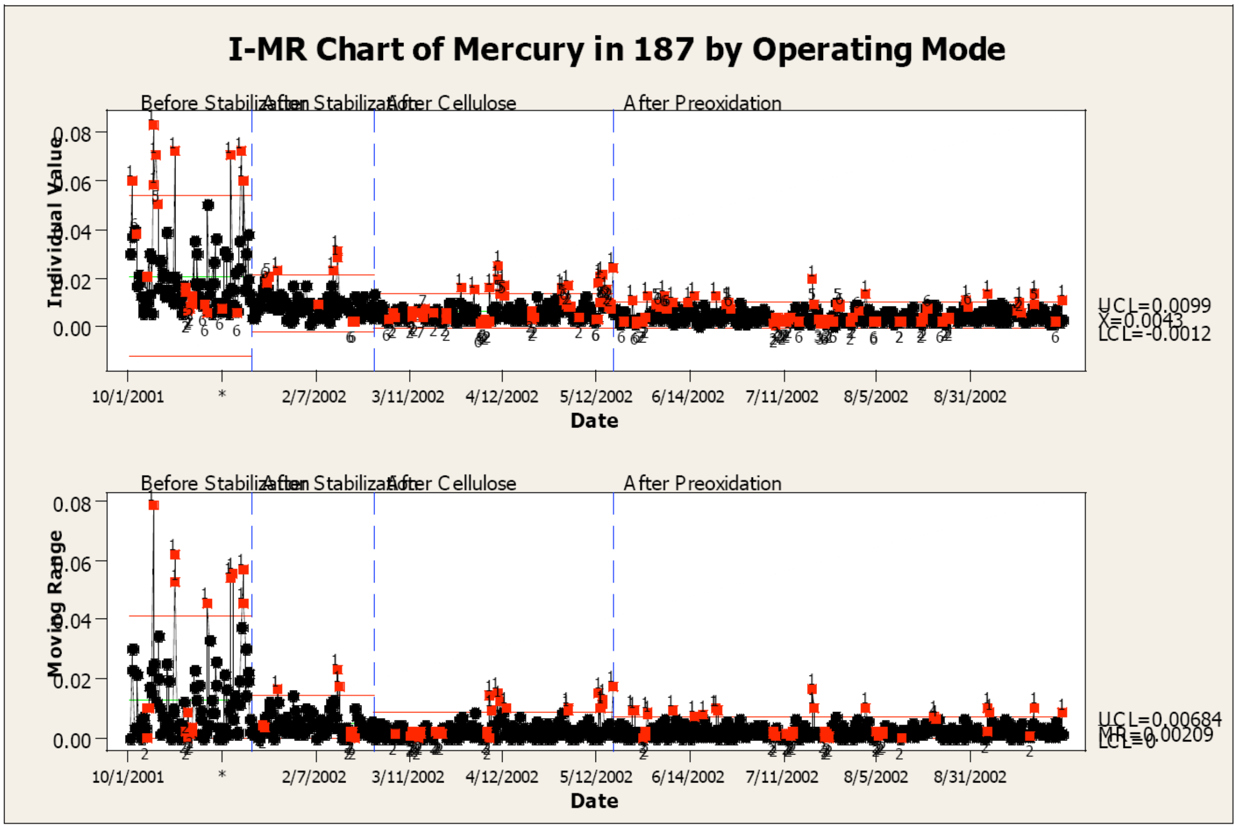
The optimized process has been documented in revised operating instructions and in the plant process control book. Log sheets were also modified to ensure that operator emphasis was directed toward control of key input variables. Operators were field and classroom trained in these procedures by team members. Sign-off sheets were used to document this training. Also, control charts for key parameters were established to ensure long-term compliance with team recommendations.

The financial impact of this project is $3.5MM/year cost avoidance. This is the annual capital charge associated with converting this particular plant to membrane technology. A technology change would have been the only available alternate to project success (aside from facility closure).

Key Process Insights

- Stabilizing the process through implementation of consistent operating instructions and capable measurement systems had the largest impact on process performance compared to other parts of the Roadmap
- Expert knowledge was missing in one major process step pre-coat filtration). Acquiring and applying expertise in this area resulted in a statistically significant improvement in wastewater mercury results.

- An incapable measurement system for a key input variable was responsible for setting incorrect, non-optimal levels for this variable. A new, capable measurement system allowed input levels to be properly set and controlled, resulting in improved process performance.
- A process step was added to deal with a form of mercury that was previously untreatable.
- An improved main Y (mercury in wastewater) gage will be needed for further improvements in short-term median and standard deviation. However, outliers can be studied and addressed with the current main Y measurement system, if management so desires.




**Descriptive Statistics: Mercury in 187 by Operating Mode**

| Variable | Operating Mode | N | | Mean | SE Mean | StDev. | Minimum |
|---|---|---|---|---|---|---|---|
| Hg in 187 | | | | | | | |
| | Before Stabilization[1] | 109 | 0 | 0.02067 | 0.00161 | 0.01684 | 0.00500 |
| | After Stabilization[2] | 109 | 0 | 0.00909 | 0.00049 | 0.00514 | 0.00100 |
| | After Cellulose[3] | 212 | 0 | 0.00624 | 0.00028 | 0.00409 | 0.00060 |
| | After Preoxidation[4] | 400 | 0 | 0.00433 | 0.00013 | 0.00264 | 0.00030 |

| Variable | Operating Mode | Q1 | Median | Q3 | Maximum |
|---|---|---|---|---|---|
| Hg in 187 | | | | | |
| | Before Stabilization[1] | 0.01000 | 0.01500 | 0.02650 | 0.08300 |
| | After Stabilization[2] | 0.00590 | 0.00800 | 0.011000 | 0.03100 |
| | After Cellulose[3] | 0.00400 | 0.00500 | 0.007450 | 0.02500 |
| | After Preoxidation[4] | 0.00240 | 0.00386 | 0.005975 | 0.01900 |

[1] Baseline
[2] Results of Measure Phase
[3] Results of Analyze Phase
[4] Results of Improve and Control Phases