



Joint Munitions Command

**ENVIRONMENT, ENERGY SECURITY &
SUSTAINABILITY (E2S2)**

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10009 - Improve Environmental Management Systems by Auditing with Lean Six Sigma

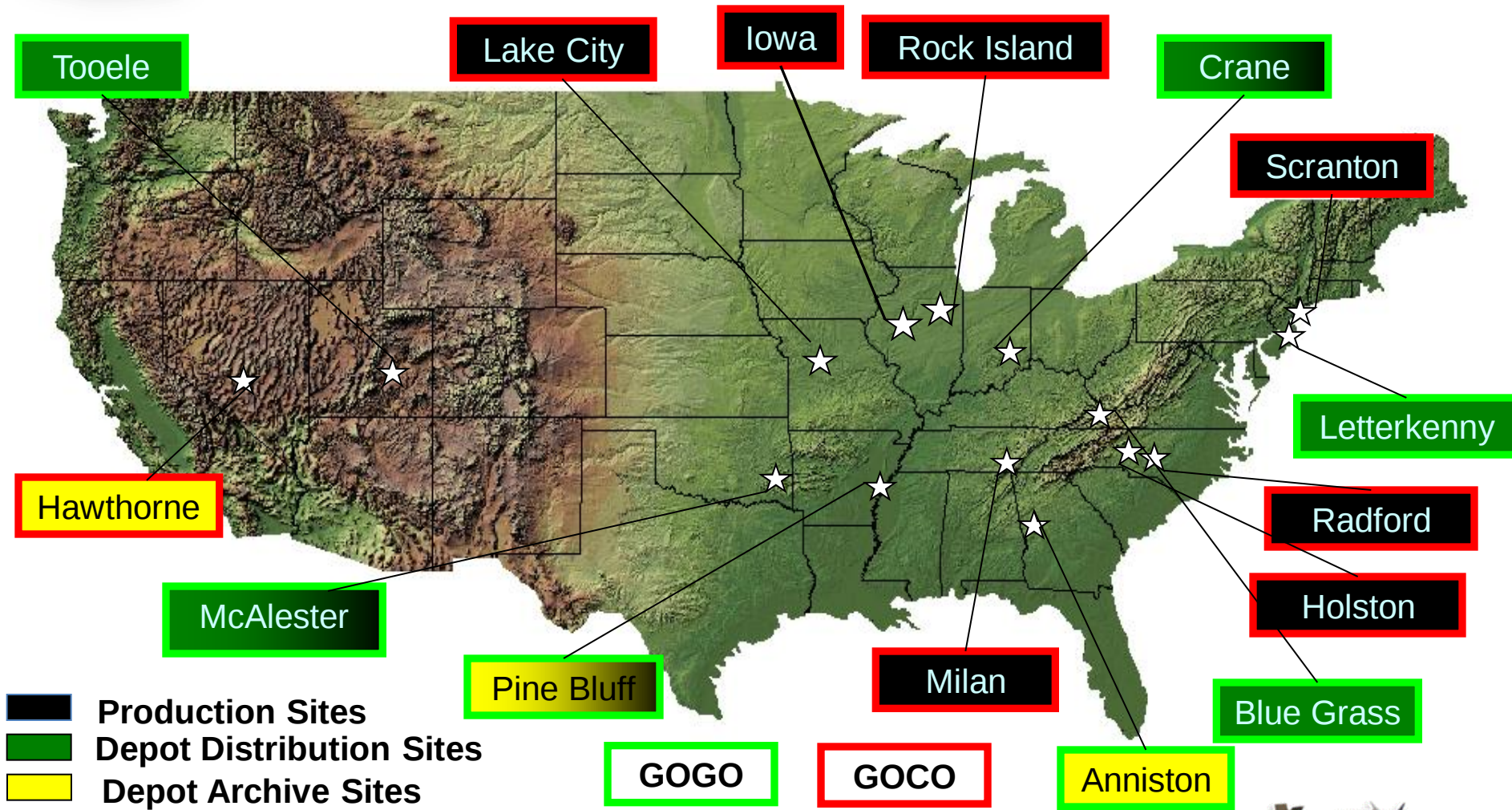
*U.S. Army Joint Munitions Command (JMC)
AMSJM-ISM
1 Rock Island Arsenal
Rock Island, IL 61299*

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Organic Ammunition Industrial Base (Government-owned) (Post-BRAC)



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Lean Six Sigma EMS Auditing Improvement Project Summary

- **Focus of project**
 - Improve Quality of EMS Audit by...
 - Including environmental regulatory identification w/
 - ISO 14001 nonconformance citation
- **Project Scope:** All JMC installations
- ***Where are we feeling the pain?***
 - Under-reported total environmental liabilities causing...
 - Notice of Violation (NOV) Potential
- Management audit observations categorizing...
 - Improved liability prioritization

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Problem/ Goal Statement

Problem: JMC Environmental Management System (EMS) ISO 14001 management conformance audit observations do not always include environmental regulatory standards that would have improved relational connection to potential Notices of Violation.

Goals:

Metric #1: Fifty percent (50%) of audit observations must cite environmental regulatory standard , “best management practice” or cite as a safety/IH/P2

Metric # 2: Increase Sigma Quality Level (SQL) significantly

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Improve Phase Summary

Solution Selection

Using Nominal Group
Technique

We determined the
following solutions (three
voted best cited in red):



- 1. Audit findings w/
compliance regulation cited
(best)**
2. Improve SOW
- 3. Audit follow-up**
4. Provide adequate auditor
training
5. Improve communication
- 6. Provide compliance
protocols on computers**
7. Provide additional
compliance personnel
8. Ensure compliance
auditor certification

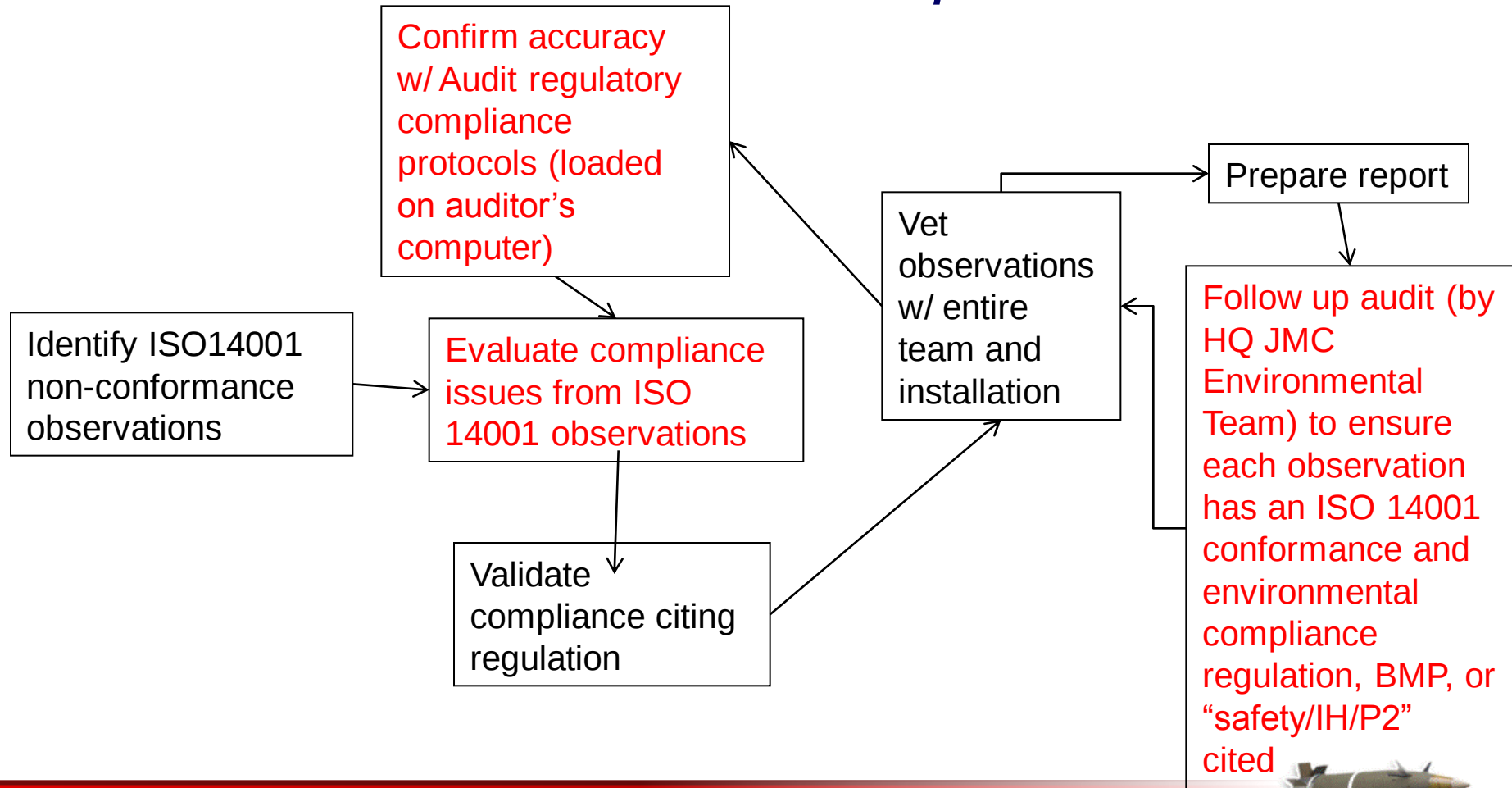
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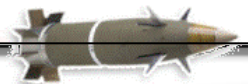


Improve Phase Summary (cont.)

“To-Be” Process Map



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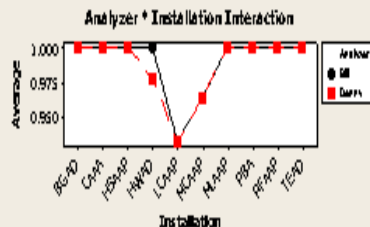
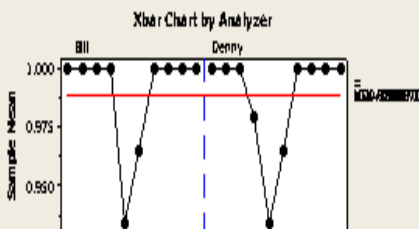
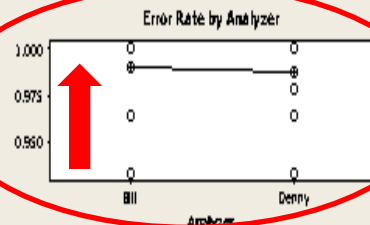
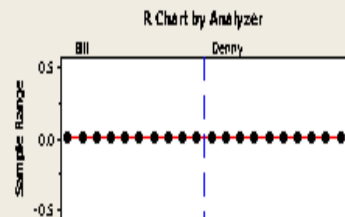
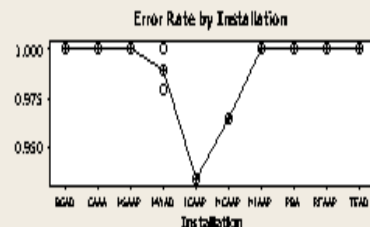
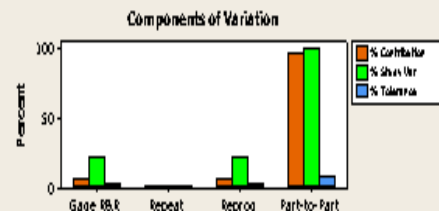
MSA Control Charts Baseline vs. Improved

Gage R&R (ANOVA) for Error Rate

Gage name:
Date of study:

Reported by:
Tolerance:
Misc:

Baseline

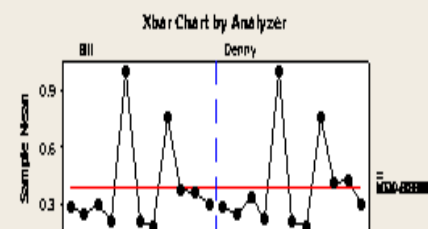
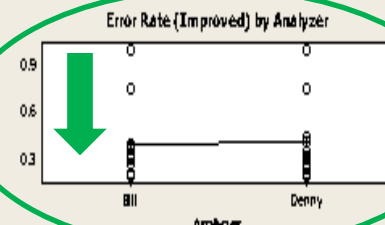
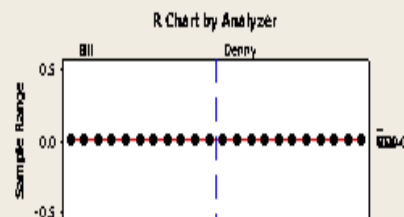
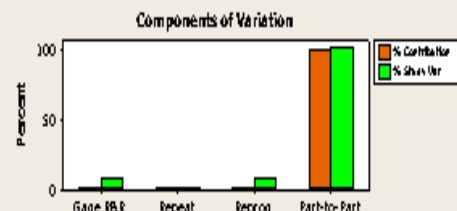


Gage R&R (ANOVA) for Error Rate (Improved)

Gage name:
Date of study:

Reported by:
Tolerance:
Misc:

Improved



- Visual reduction in both average and variation

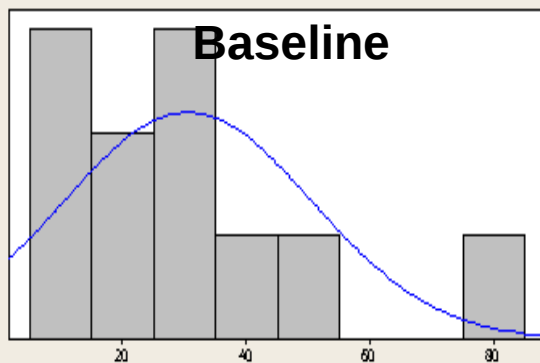
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Summary Statistics

Baseline vs. Improved

Summary for No Compliance Citations



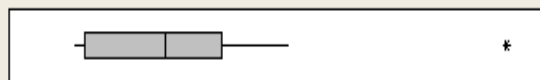
Anderson-Darling Normality Test

A-Squared 0.75
P-Value 0.036

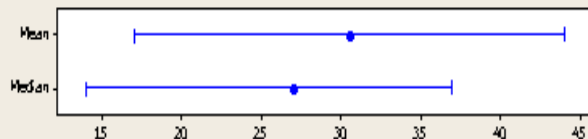
Mean 30.545
StDev 20.037
Variance 401.473
Skewness 1.88249
Kurtosis 4.21219
N 11

Minimum 12.000
1st Quartile 14.000
Median 27.000
3rd Quartile 36.000
Maximum 82.000

95% Confidence Interval for Mean
17.085 44.006
95% Confidence Interval for Median
14.000 36.904
95% Confidence Interval for StDev
14.000 35.163



95% Confidence Intervals



Summary for No Compliance Citations



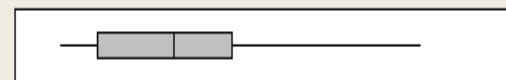
Anderson-Darling Normality Test

A-Squared 0.65
P-Value 0.066

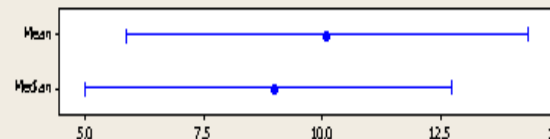
Mean 10.091
StDev 6.316
Variance 39.891
Skewness 1.10614
Kurtosis 0.27472
N 11

Minimum 3.000
1st Quartile 5.000
Median 9.000
3rd Quartile 12.000
Maximum 22.000

95% Confidence Interval for Mean
5.848 14.334
95% Confidence Interval for Median
5.000 12.740
95% Confidence Interval for StDev
4.413 11.084



95% Confidence Intervals



The Lean Six Sigma challenge is to shift the mean and/ or reduce variation. Our baseline mean (30.5) and standard deviation (20.0) shifted to mean 10.1 and standard deviation 6.3 with variance from 401.5 to 39.9 showing improvement.

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Summary Statistics Baseline vs. Improved

Installation	Reg Stated	Attempts	Defects	Good	Installation	Reg Stated	Safety	P2	IH	BMP	Strict EMS	Attempts	Defects (EMS only)	Good
HSAAP	0	24	24	0	HSAAP	3	4	2	0	8	7	24	7	17
LCAAP	1	15	14	1	LCAAP	4	7	0	0	1	3	15	3	12
MCAAP	1	28	27	1	MCAAP	12	5	1	0	5	5	28	5	23
PBA	0	32	32	0	PBA	7	13	0	0	0	12	32	12	20
HWAD	0	47	47	0	HWAD	16	7	1	0	12	9	45	9	36
CAAA	0	36	36	0	CAAA	14	7	1	0	5	9	36	9	27
IAAAP	0	12	12	0	IAAAP	0	0	0	0	0	12	12	12	0
RFAAP	0	14	14	0	RFAAP	5	2	0	0	2	5	14	5	9
TEAD	0	20	20	0	TEAD	2	6	0	0	6	6	20	6	14
MLAAP	0	28	28	0	MLAAP	6	0	0	0	1	21	28	21	7
BGAD	0	82	82	0	BGAD	20	23	4	0	9	22	78	22	56
Totals	2	338	336	2	Totals	89	74	9	0	49	111	332	111	221

The Sigma Quality Level (SQL) for our baseline was $336/338 \times 1,000,000 = 994,083$ DPMO, SQL < 0.1. The SQL after process improvements was $111/332 \times 1,000,000 = 334,337$ DPMO, SQL > 1.9; showing improvement.

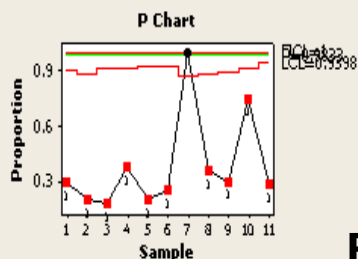
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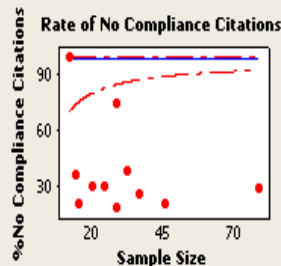
Process Capability Baseline vs. Improved

Binomial Process Capability Analysis of No Compliance Citations

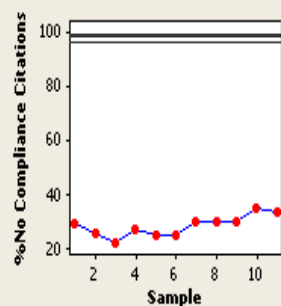


Baseline

Tests performed with unequal sample sizes

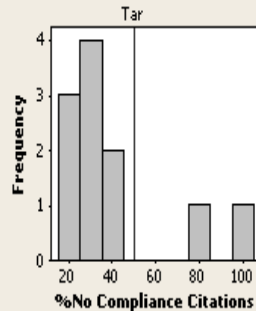


Cumulative % No Compliance Citations

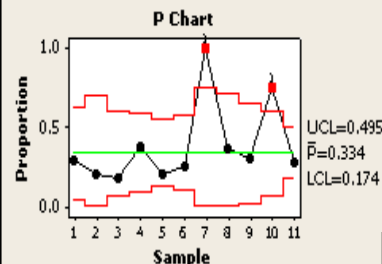


Summary Stats (95.0% confidence)	
% No Compliance Citations:	98.33
Lower CI:	96.29
Upper CI:	99.42
Target:	50.00
PPM Def:	983300
Lower CI:	962949
Upper CI:	994153
Process Z:	-2.1272
Lower CI:	-2.5212
Upper CI:	-1.7860

Histogram

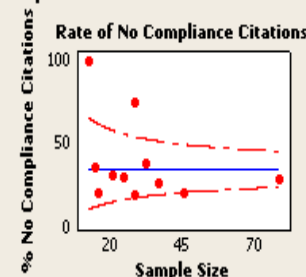


Binomial Process Capability Analysis of No Compliance Citations

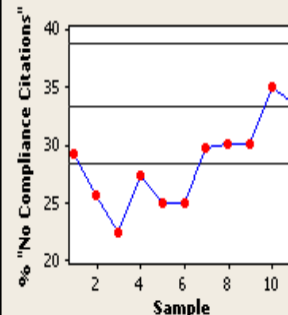


Improved

Tests performed with unequal sample sizes

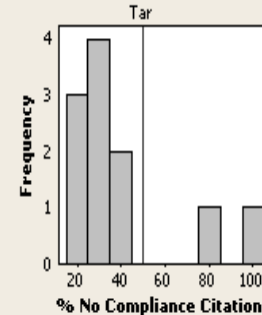


Cumulative % No Compliance Citations



Summary Stats (95.0% confidence)	
% No Compliance Citations:	33.43
Lower CI:	28.38
Upper CI:	38.79
Target:	50.00
PPM Def:	334337
Lower CI:	283765
Upper CI:	387897
Process Z:	0.4280
Lower CI:	0.2848
Upper CI:	0.5717

Histogram



Met customer goal for < 50% no compliance citations (actual ~33% no compliance citations) through improvements to observations. Two-thirds (2/3) of audit observations now classified and validated to environmental compliance standards, identified as safety/ industrial hygiene, pollution prevention, or BMPs.

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Business Impact

Type III: More frequent up-to-date information on environmental compliance requirements providing:

- Better awareness,
- Funding visibility and prioritization, and
- Fix environmental problems prior to regulatory detection as an NOV.
- The SQL for the process was increased from < 0.1 to > 1.9 SQL.

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Lessons Learned

1. Difficult to pinpoint only one applicable regulation for an audit observation.
2. Safety and industrial hygiene observations should mention the appropriate regulatory exception
3. The ISO 14001 areas of legal requirements, operational control, and document control have the highest frequency regulatory noncompliance.
4. Always more appropriate to follow a regulatory compliance audit with an ISO 14001 audit, so the efficiency and effectiveness of an installation's Environmental Management System can be properly evaluated.
5. Always some "defectives" (no compliance citations) during an ISO 14001 audit since some ISO 14001 non-conformances under the ISO 14001 standard have no regulatory compliance parallel or standard.
6. Auditing environmental professionals must be well versed in both the ISO 14001 standard and environmental regulatory standards and have experience and education in performing environmental auditing.

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