

# Optimization of Oil Stabilization Process

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## Executive Summary

Oil stabilization is a critical downstream process that ensures the safe handling and transportation of crude oil by reducing the concentration of volatile components, particularly hydrogen sulfide (H<sub>2</sub>S). Maintaining H<sub>2</sub>S levels within a targeted range is essential for operational safety, regulatory compliance, and economic efficiency.

This paper presents a case study on the application of Lean Six Sigma methodology to optimize the H<sub>2</sub>S content in the crude oil stabilization process. The study aimed to reduce variability in H<sub>2</sub>S levels and maintain them within defined specification limits with a tolerance of  $\pm 5$  ppm. The study focused on two key stabilizers within the process, with recommendations for replication across all units.

The successful implementation of data-driven improvements led to significant operational benefits, including reduced steam consumption, increased crude yield, and enhanced process control.

## 1. Introduction

Oil stabilization involves the removal of light hydrocarbons and sour gases such as H<sub>2</sub>S from crude oil. This is typically achieved through heat and steam injection in stabilization columns. The goal is to meet safety and quality standards while minimizing energy consumption and maximizing crude oil recovery.

However, in many facilities, H<sub>2</sub>S levels in the stabilized crude oil vary significantly, leading to:

- Increased safety risks during transportation
- Overuse of steam and energy in over-stabilization
- Lost revenue due to suboptimal crude recovery.

To address these challenges, a Lean Six Sigma study was initiated to analyze, improve, and control the stabilization process, focusing on H<sub>2</sub>S content consistency.

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## 2. Project Objectives

The primary objective of the study was to: - Stabilize H<sub>2</sub>S levels in crude oil to meet the defined specification limits with a tolerance of  $\pm 5$  ppm by reducing the variability in the stabilization process.

Secondary goals included: Achieve operational cost savings and increased crude yield, enhancing operator training and process awareness, improving instrumentation and control strategies, developing a robust maintenance and monitoring framework

### 3. Methodology: Lean Six Sigma DMAIC Framework

The study followed the Define-Measure-Analyze-Improve-Control (DMAIC) framework to systematically address the stabilization process challenges.

#### Define Phase

- **Scope:** Two stabilization columns were selected for in-depth analysis and process optimization.
- **CTQ (Critical to Quality):** Maintain H<sub>2</sub>S content in crude oil within the specification limits.
- **Stakeholders:** Process engineers, operators, maintenance staff, and control systems specialists.

#### Measure Phase

- Baseline data showed a high level of variation in H<sub>2</sub>S levels
- Key metrics included:
  - H<sub>2</sub>S concentration
  - Steam consumption
  - Crude oil yield

#### Analyze Phase

Root cause analysis identified several contributing factors to H<sub>2</sub>S variability:

Cause	Root Cause
Steam Quality	Malfunctioning air filtration in control valves
Sampling Procedures	Inconsistent operator training
Feed Flow Rate	Control valve malfunctions
Steam Injection Amount	Operator inexperience
Feed Temperature	Weather-related fluctuations

Regression and ANOVA analysis confirmed the statistical significance of these causes on H<sub>2</sub>S levels.

## Improve Phase

Targeted solutions were implemented to address the root causes:

1. **Control Valve Optimization:**
  - Streamlined preventive maintenance (PM) for air filtration systems
  - Improved valve tuning procedures post-maintenance
2. **Operator Training:**
  - Conducted training sessions on sampling and analysis procedures
  - Introduced “quick reference” aids (e.g., sticky notes on control consoles)
3. **Process Automation:**
  - Installed soft sensors for real-time H<sub>2</sub>S monitoring
  - Began development of an Advanced Process Control (APC) system
4. **System Integration:**
  - Automated steam injection control logic to reduce manual intervention

## Control Phase

- Developed monitoring dashboards and control charts to ensure sustained performance
- Established a feedback loop between operations and engineering for continuous improvement
- Scheduled periodic reviews of the PM and control strategies

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## 4. Results and Benefits

### 4.1 Process Performance Improvement

- H<sub>2</sub>S levels in crude oil were consistently meeting the specification limits post implementation

### 4.2 Economic Impact

- Improved stabilization led to annual financial savings of \$2.85 million

### 4.3 Operational and Safety Benefits

- Reduced safety risks due to consistent H<sub>2</sub>S levels
- Enhanced process understanding and operator engagement
- Lower maintenance costs via optimized PM schedules

## 5. Key Learnings and Challenges

### Key Learnings

- Lean Six Sigma provides a structured approach to process optimization.
- Cross-functional collaboration is essential for identifying and addressing root causes.
- Real-time monitoring and automation significantly reduce process variability.

### Challenges

- Initial resistance to change from operational teams
  - Time constraints in balancing study work with routine duties
  - Ensuring consistent data collection across all process units
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## 6. Recommendations for Broader Implementation

To replicate the success across additional stabilization units:

1. **Scale Automation:** Deploy APC and soft sensors across all columns to reduce manual intervention.
  2. **Standardize Training:** Implement ongoing training programs and reference tools for operators.
  3. **Enhance Maintenance Protocols:** Regularly review and update PM procedures for valves and instrumentation.
  4. **Establish Performance Metrics:** Use dashboards and control charts for continuous process tracking.
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## 7. Conclusion

The application of Lean Six Sigma to the oil stabilization process demonstrated that data-driven methodologies can yield substantial operational and financial benefits. By focusing on key process variables and engaging stakeholders across functions, the study successfully optimized H<sub>2</sub>S control, reduced costs, and improved crude oil yield.

This case study serves as a template for other facilities aiming to achieve similar improvements in stabilization and downstream processing through systematic process analysis and improvement.

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## Appendix: Glossary

- **H<sub>2</sub>S (Hydrogen Sulfide):** A toxic, flammable gas found in crude oil; must be removed for safe handling and transport.
- **Stabilization:** A process that removes volatile components from crude oil.
- **Lean Six Sigma:** A methodology combining Lean (waste reduction) and Six Sigma (variability reduction) for process improvement.
- **Soft Sensor:** A software-based inferential model that estimates hard-to-measure variables using easily measured process data.
- **APC (Advanced Process Control):** Automation system that uses models to optimize process variables in real time.

## References

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- API Standards



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