Nicor Gas | Energy Efficiency Program

Emerging Technology Program

#1085: Chemical Descaling of Boilers

Final Pilot Assessment Report

Updated February 3, 2023

Technical Contacts

Ram Dharmarajan
Engineer
rdharmarajan@gti.energy

Hardik Shah
Senior Engineer/Program Manager
hshah@gti.energy

GTI Energy
1700 South Mount Prospect Road
Des Plaines, IL 60018

Nicor Gas Contact

Mark Szczygiel
Supervisor, Planning & Regulatory Energy Efficiency
mszczygi@southernco.com
630.388.2738

Nicor Gas Company
1844 Ferry Road
Naperville, IL 60563

Table of Contents

List of Tables

Legal Notice

This report was prepared by Gas Technology Institute (GTI) for Nicor Gas Company (Nicor Gas). Any use of or reliance on this report and/or any information contained in this report by any party is at that party's sole risk. Neither GTI nor Nicor Gas, or any person acting on behalf of either of them:

a) Makes any warranty or representation, express or implied with respect to the ownership, accuracy, completeness, or usefulness of the information contained in this report. Inasmuch as this work is experimental in nature, the technical information, results, or conclusions cannot be predicted. Conclusions and analysis of the results by GTI represent GTI's opinion based on inferences from measurements and empirical relationships, which inferences and assumptions are not infallible, and with respect to which competent specialists may differ.

b) Assumes any liability with respect to the use of, reliance on, or for any and all damages resulting from the use of or reliance on this work and/or any information, apparatus, method, or processes disclosed in this report.

The results within this report relate only to the items tested.

Executive Summary

Introduction

As part of the Nicor Gas Energy Efficiency Program, the Emerging Technology Program (ETP) assesses new technologies that can realize natural gas savings for the 2.3 million Nicor Gas customers in northern Illinois. Gas Technology Institute (GTI) provides program implementation for the Nicor Gas ETP. This report summarizes the findings of field evaluations for descaling steam boiler systems with a chemical descaler and the potential for this technology to provide energy efficiency savings to Nicor Gas commercial and industrial customers.

Background

Even with careful and precise water treatment in a boiler system, mineral scales are formed over time due to the high pressure and heat. The mineral scale is typically calcium, carbon, iron, and silica particle deposits that form on the boiler tubes. Scale creates a problem because it typically possesses a thermal conductivity, an order of magnitude less than the corresponding value for bare steel. Even thin layers of scale serve as an effective insulator and inhibit heat transfer. The result is overheating of boiler tube metal, tube failures, and less efficient operation of the boiler system.

Descaling a boiler system will improve efficiency by removing mineral scale buildup on boiler tubes. Descaling is done either through mechanical or chemical cleaning techniques. Mechanical descaling usually involves using a nozzle, wire brush, and vacuum hose to clean the tubes. It is done by inserting a nozzle into the full length of the boiler tube and activating a circular wire brush. A vacuum hose then draws loosened scale out of the tube. There are several limitations to mechanical cleaning, one of them being that firetube boilers cannot be mechanically cleaned. Depending on the size of the boiler, it can take up to a week to mechanically clean the tubes and hard to reach areas are off limits. This results in significant labor costs and the boiler must remain offline for a considerable time.

In contrast, chemical cleaning can be done either continuously by treating the boiler feedwater, or periodically by flushing the boiler on an annual/biannual basis depending on the degree of scaling. Some of the commonly encountered limitations with chemical cleaning are that the chemicals are hazardous, require neutralizing agents, specialized personnel, and constant supervision.

Potential Savings from Descaler

Potential savings from descaling boilers include:

1. Improved heat transfer between the burner, boiler surface, and water
2. Extended equipment life due to reduction in overheating and tube failures

3. Fuel savings due to increased combustion efficiency assuming constant steam production before and after descaling

NSF/ANSI 60 Certification[1]

This standard establishes the minimum health effect requirements for chemicals, chemical contaminants, and impurities that are directly added to drinking water from drinking water treatment chemicals. It also contains health effect requirements for other chemical products that are directly added to water but are not intended to be present in the finished water. Per the certification, tested chemical is designed to be used off-line and flushed out prior to using the system for drinking water. The effluent water should be monitored to ensure that all traces of the product have been removed before placing the boiler back into service. Tested chemical descaler can be safely handled by personnel, and there are no transportation or handling restrictions even at 100% concentration.

Field Demonstration

This Nicor Gas ETP pilot field study targeted four steam boilers to evaluate the effectiveness of the chemical descaling procedure. The sites selected for field testing were two middle schools in Downers Grove, Illinois. There were four firetube boilers—two in each school. To evaluate performance and energy savings potential, the baseline combustion efficiencies of all the boilers were captured prior to descaling. Baseline data were collected in the 2018/19 heating season with the boilers running at a high firing rate using a handheld combustion emissions analyzer. The combustion efficiencies of the boilers were also captured after descaling in the 2019/20 heating season.

Results

Combustion efficiencies pre- and post-descaling were compared to calculate the fuel savings for the system. One of the boilers was not operational during the retrofit measurements and so has been omitted from the calculations. The thickness of the scale was estimated using a combination of a borescope and by physically scraping the scales and measuring them. Natural gas savings ranged from 4.4% to 6.4% across systems (Table 1).

[1]Listing accessed October 16, 2021: https://info.nsf.org/Certified/PwsChemicals/

Table 1 – Fuel Savings by Boiler at Field Demonstration Sites

	Estimated Scale Thickness (inches)	Combustion Efficiency Pre-Descaling	Combustion Efficiency Post-Descaling	Fuel Savings (% of Total Use)
Boiler #1	0.04	79.2	82.9	**4.4%**
Boiler #2	0.05	73.58	78.8	**6.4%**
Boiler #3	0.04	74.1	77.7	**4.7%**
Boiler #4	N/A due to being non-operational during retrofit			

There is good agreement between the realized fuel savings from the pilot and analytical savings from a previously published study.[2] Because the dataset at the pilot sites was limited with respect to scale thickness variability, the energy savings were subsequently tiered using a combination of the field results and the analytical study. Fuel savings ranged from 1.6% to 6.2% of total annual use depending on the degree of scaling (Table 2).

Table 2 – Summary of Fuel Savings

Scale Thickness (inches)	Low Pressure (≤15 psig) Applications[3] Fuel Savings %	High Pressure (>15 psig) Applications Fuel Savings %
Low (≤1/64)	1%	1.6%
Normal (≥1/32 & ≤ 3/64)	2.5%	3.9%
High (≥1/16)	3.9%	6.2%

Implications for Energy Efficiency Programs

This technology offers a cost-effective process to restore boiler tubes to optimum efficiency. The normalized cost of the entire process based on the pilot demonstration was $378/MMBtu/hour per boiler. Because this is a non-toxic, non-hazardous process, it can be undertaken by facility personnel, reducing labor costs and time compared to alternatives.

It is crucial to note the distinction between this measure and a routine, annual boiler tune-up, which involves minimal downtime and is a relatively non-invasive process with tasks like vacuum cleaning, resetting burners, adjusting O_2 ratio, and oiling mechanical parts. A descaling process will involve a longer downtime of 1-2 days and is highly invasive.

[2] 'Clean Firetube Boiler Waterside Heat Transfer Surfaces', U.S. Department of Energy, April 2012, https://www.energy.gov/sites/prod/files/2014/05/f16/steam7_surfaces.pdf

[3] Low pressure systems here are defined as steam boiler systems operating at and below 15 psig. High pressure systems are steam boiler systems operating above 15 psig.