Corrosion Control Pilot Study – Hodder Pressure Zone

Report Date: August 16, 2017

Prepared By: City of Thunder Bay – Water Authority

Executive Summary

The City of Thunder Bay – Water Authority conducted a Corrosion Control Pilot Study in the Hodder Pressure Zone from January 2015 until January 2017. The purpose of the study was to: 1) confirm lead levels can be reduced at the tap by adjusting the pH of the drinking water with sodium hydroxide; 2) study the effects on disinfection efficiency; 3) confirm sodium levels would remain below 20mg/L in the distribution system; and 4) evaluate operability and maintenance of a sodium hydroxide injection process.

Based on the results from the Corrosion Control Pilot Study in the Hodder Pressure Zone, chemical addition of sodium hydroxide for pH adjustment is a safe and effective method of reducing lead levels at the tap. Additionally, the study showed that there is no indication that disinfection was compromised by adjusting pH to a level that is effective in reducing lead concentrations. Sodium concentrations remained well below the health related standard. In terms of operability and maintenance of a sodium hydroxide injection process, the pilot study assisted in design improvements of a full scale system.

It is recommended that the City of Thunder Bay's Environment Division – Water Authority implements pH adjustment for reducing lead concentrations in residential plumbing for city wide distribution.

Corrosion Control Pilot Study – Hodder Pressure Zone

Study Period: January 2015 – January 2017

Background

The revised City of Thunder Bay's Corrosion Control Plan, approved by the Ministry of Environment and Climate Change in November 2014, included a corrosion control pilot study to measure the effectiveness of corrosion control through chemical addition to reduce lead levels at the tap and evaluate the impact on disinfection prior to a city wide system change. Based on a previous corrosion control study completed in 1996, sodium hydroxide was deemed to be the most effective form of chemical corrosion control for the Bare Point drinking water system. Sodium hydroxide is also included in the Drinking Waterworks Permit #024-021 for corrosion control and therefore was selected for the study in the Hodder pressure zone.

Purpose

The purpose of the Corrosion Control Pilot Study in the Hodder Pressure zone was to: 1) confirm lead levels can be reduced at the tap by adjusting the pH of the drinking water with sodium hydroxide; 2) study the effects on disinfection efficiency; 3) confirm sodium levels would remain below 20mg/L in the distribution system; and 4) evaluate operability and maintenance of a sodium hydroxide injection process.

Why Hodder Pressure Zone Selected

Small pressure zone ~ 764 residences

Combination of old and new homes with lead and copper service connections

Booster pumping station readily available to use as injection site

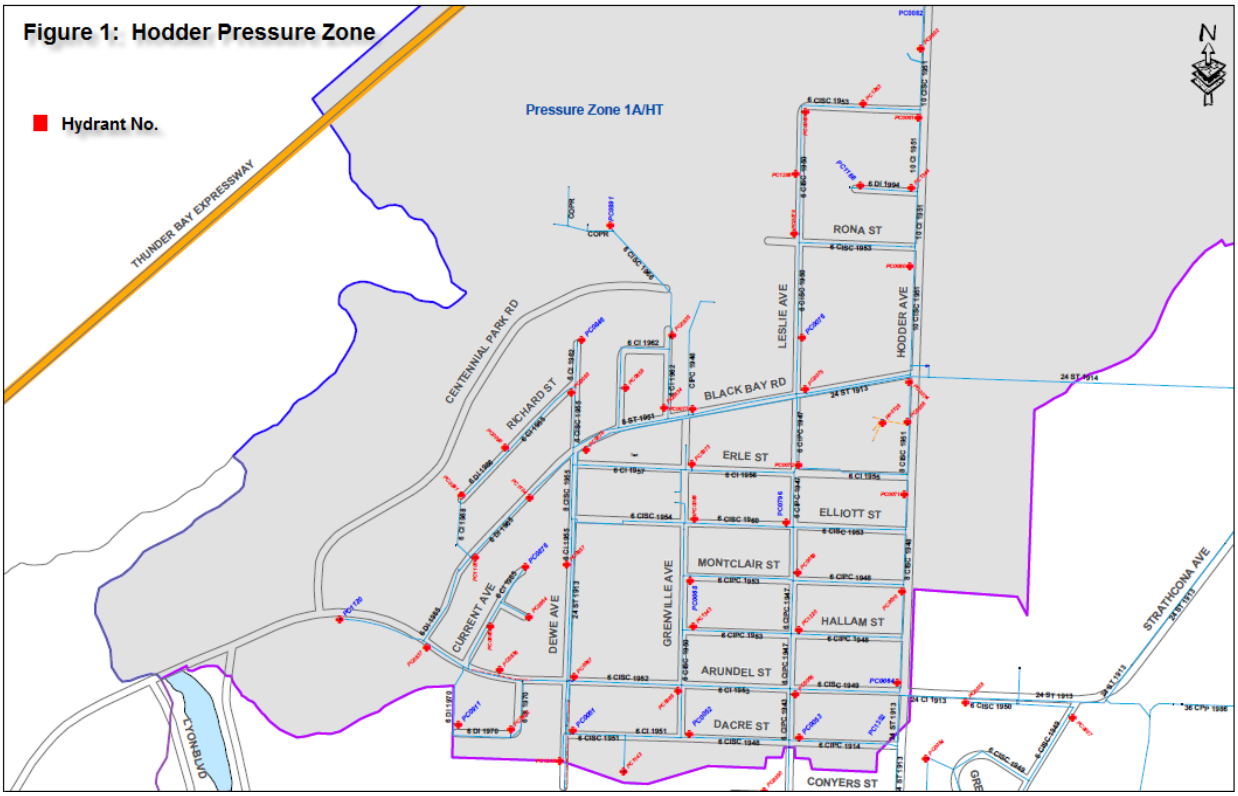
No industrial users within the pressure zone

Sodium hydroxide in drinking water is safe to consume

It is an approved corrosion inhibitor as listed in NSF/ANSI Standard 60-2013: Drinking Water Treatment Chemicals – Health Effects

Overview of Study

Prior to the addition of the corrosion control chemical, sodium hydroxide, pre-addition baseline data was collected for twelve months from January 2015 to January 2016 in the Hodder pressure zone (Figure 1). Water samples were collected from the distribution system and participating private residences and tested for lead, alkalinity, pH, chlorine residual, iron, sodium, total coliform, E.coli, heterotrophic plate count (HPC), colour and turbidity.



The Hodder pressure zone was isolated from the rest of the City's drinking water system prior to chemical addition for the purpose of this study.

Bench scale tests were conducted at the City's laboratory and revealed that for optimum pH adjustment, 7 to 12 mg/L of sodium hydroxide would be required to be added to the drinking water. To adjust the pH of the drinking water in the Hodder pressure zone a temporary sodium hydroxide injection system was installed at the Hodder pumping station. The addition of sodium hydroxide for pH adjustment commenced on January 29, 2016. The sodium hydroxide was introduced incrementally to the system at the Hodder pumping station until the target pH of 9.5 was reached. Injection of sodium hydroxide ceased on January 17, 2017. The pH of the drinking water in the Hodder pressure zone returned to pre-addition levels by February 3, 2017 and the zone was then reopened to the City's drinking water system.

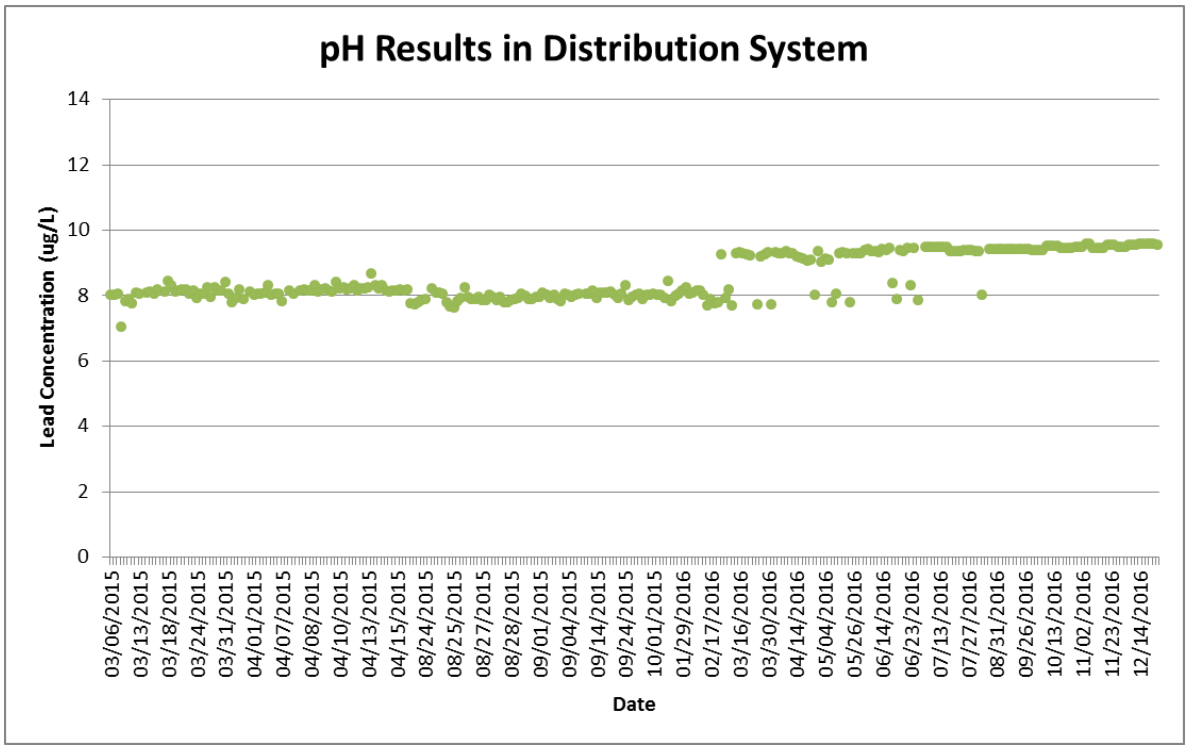
Concurrent with the addition of sodium hydroxide, data collection commenced in the distribution system and in participating private residences. Post-addition data collection consisted of the same testing parameters as the pre-addition baseline data.

Data was collected from thirty-six private residences and fifteen designated distribution hydrants.

Study Results & Discussion

pH Adjustment

The pH results in the distribution system from early 2015 until the end of December 2016 are displayed in Graph 1 below. It clearly shows the increase in pH after the addition of sodium hydroxide.



Graph 1: pH Results in Distribution System – pre and post-addition

In Table 1, the additional residential plumbing water quality parameters measured pre and post-addition are listed. When comparing the results, no significant changes were recorded or observed.

Table 1: Additional Residential Plumbing Water Quality Parameters – Pre & Post Addition

Parameter	Pre Addition		Post Addition	
	Average	Minimum to Maximum	Average	Minimum to Maximum
Alkalinity, mg/L as CaCO3	46.7	45.3 – 48.7	54.14	49.5 – 59.4
Turbidity, NTU	0.33	0.1 – 2.41	0.24	0.10 – 0.93
Color, TCU	2.5	<2.0 – 2.5	2.68	<2.0 – 3.4
Total Coliform (presence/absence)	Absent*	Absent	Absent	Absent
E. Coli (presence/absence)	Absent	Absent	Absent	Absent
Chlorine Residual (mg/L)	1.09	0.71 – 1.29	0.81	0.25 – 1.31

**One TC result was present in pre-addition data collection*

Lead Concentrations

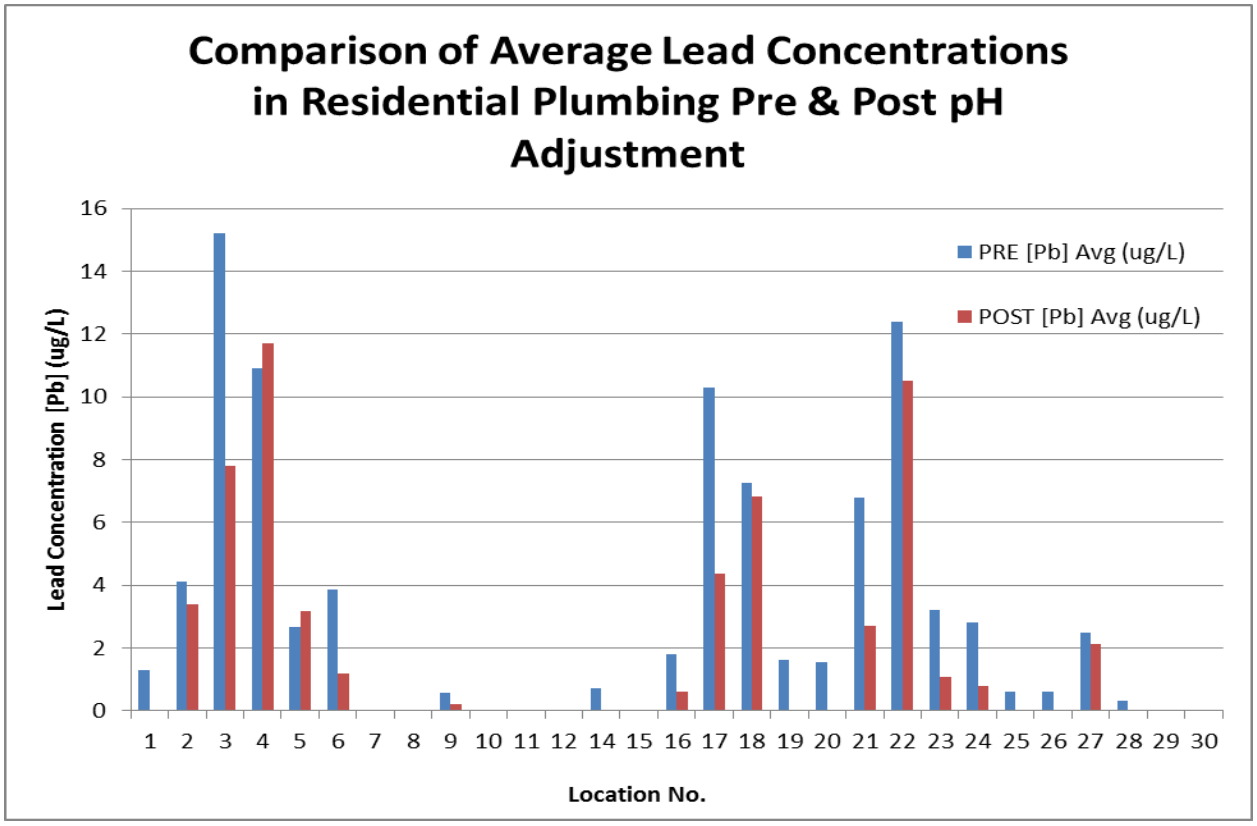
This section includes the lead concentration results pre and post-addition of sodium hydroxide in the distribution system and residential plumbing, as well as the percent lead reduction at each of the residential locations included in the study.

The average lead concentrations from pre and post-addition of sodium hydroxide in the distribution system displayed in Table 2 are well below the provincial standard of 10ug/L.

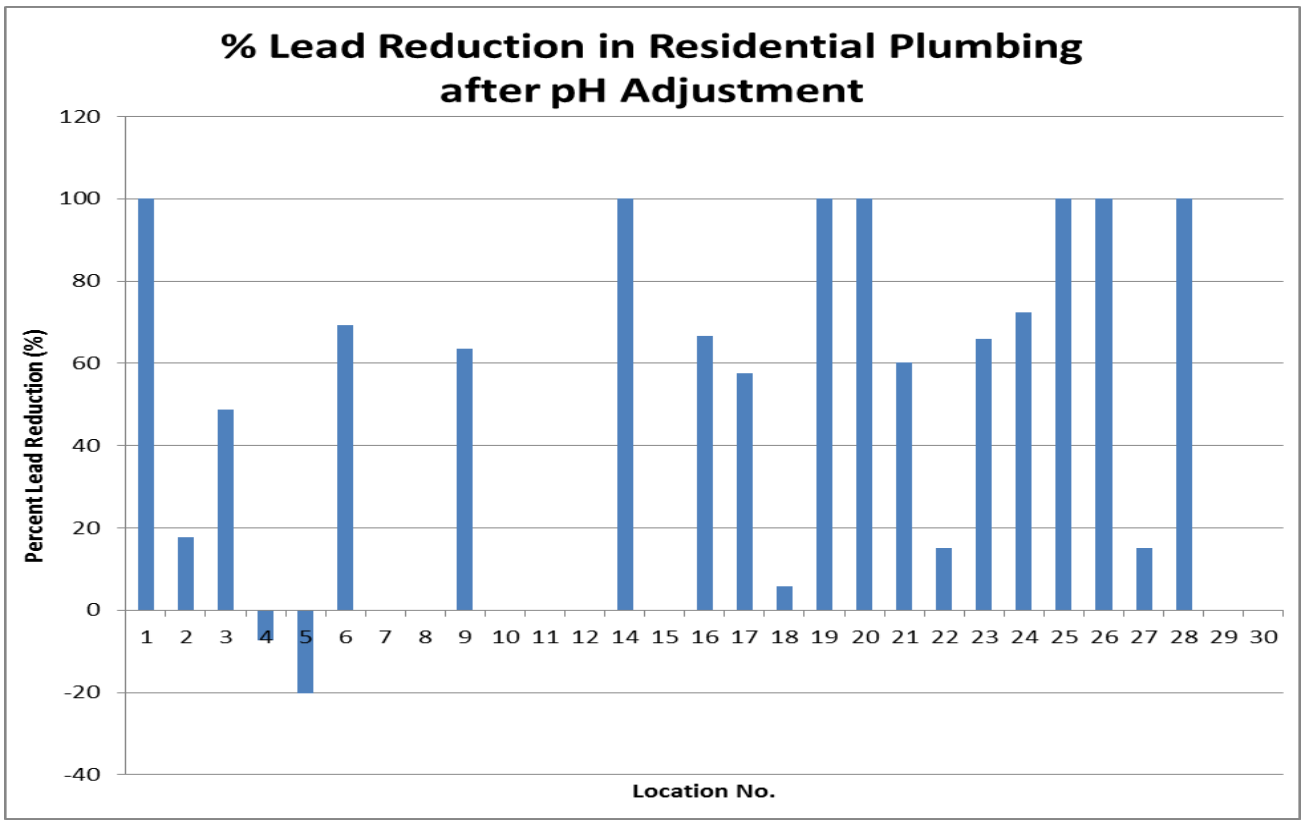
Table 2: Lead Concentrations in Distribution System – Pre & Post Addition Results

Location		# of Samples	Average pH	Average Lead Concentration (ug/L)	Minimum to Maximum Lead Concentration (ug/L)
Distribution System	**Pre Addition**	44	8.07	1.44	0 – 28.2
	Post Addition	191	9.40	0.26	0 – 16.6

The lead concentrations from pre and post-addition of sodium hydroxide in residential plumbing are displayed in Graph 2. Each Location No. represents a single residence that participated in the pre and post-addition sampling of the study. Data from Location No. 13 was determined to be an outlier and was not included on the graphs. Graph 3 depicts the percent reduction in lead concentrations after pH adjustment at each of the locations. In order to isolate the Hodder pressure zone prior to the addition of sodium hydroxide a bypass located at the zone perimeter was closed. The closure of this bypass created a dead end. A hydrant was installed at this location to accommodate weekly flushing of the zone with the goal of maintaining optimal water quality. Two locations, No. 4 and 5 experienced an increase in lead concentrations at the tap post-addition. Residences along this street did experience discoloured water during the study due to increased valve operation for the purpose of flushing within the pressure zone.



Graph 2: Comparison of Average Lead Concentrations in Residential Plumbing Pre & Post pH Adjustment



Graph 3: Percent Lead Reduction in Residential Plumbing after pH Adjustment

Effects on Disinfection

Chlorine is utilized to maintain a persistent disinfectant residual in distribution systems (water pipes) and to protect drinking water from microbiological re-contamination, reduce bacterial regrowth, control biofilm formation and serve as an indicator of distribution system integrity.

Microbiological testing for Total Coliform (TC) and Escherichia Coli (E.Coli) were collected in conjunction with lead testing. The presence of TC and E.Coli in drinking water is considered an adverse water quality incident and is reportable to the Ministry of Environment and Climate Change and Ministry of Health. There were no confirmed adverse test results for TC or E.Coli observed in the Hodder pressure zone in both distribution and residential plumbing.

Heterotrophic plate count (HPC) is used as an indicator of background bacteriological growth. The HPC test (also known as Standard Plate Count) can be used to measure the overall bacteriological quality of drinking water in public, semi-public and private water systems.

On a yearly average the City of Thunder Bay collects approximately 1600 microbiological samples within the entire distribution system. It is a requirement under Ministry regulations to test 25% of

these microbiological samples for HPC. In 2016, more than 1700 microbiological samples were collected in the entire distribution system with more than 25% of the samples tested for HPC. The HPC test results ranged from 0-1240CFU (Colony Forming Units), with four instances exceeding 100CFU and one instance exceeding 500CFU. Excluding these 5 instances in 2016 the typical HPC count found in the City of Thunder Bay's distribution system is 0-58CFU.

There is no regulatory requirement to take action based on HPC results. However, as a best practice and in accordance with American Water Works Association (AWWA) standards, flushing should commence if the HPC result exceeds 500CFU and should continue until the HPC result is below the 500CFU threshold. The City of Thunder Bay exceeds this practice and takes action to flush and resample in the distribution system when an HPC result is greater than 100CFU.

In this study, HPC results over 100CFU were used to indicate if the increase in pH would increase the bacteriological growth. In Table 3, Heterotrophic Plate Count Results in Distribution System and Residential Plumbing show that no significant effects were observed in both distribution and residential plumbing within the study area. All HPC results remained below 100CFU.

Table 3: Heterotrophic Plate Count Results in Distribution System and Residential Plumbing

Location		# of Samples	Average pH	Average Chlorine Residual (mg/L)	Average HPC (CFU)	Minimum to Maximum HPC (CFU)
Distribution System	Pre Addition	44	8.07	1.10	0	0 – 1
	Post Addition	191	9.40	0.83	1	0 – 27
Residential Plumbing	Pre Addition	37	7.95	1.09	0	0 – 20
	Post Addition	88	9.37	0.81	2	0 – 48

Sodium Levels

In this study, sodium levels were monitored since it is a health related parameter in the drinking water standards. The health related standard for sodium is 20 mg/L. Sodium concentrations in Distribution System and Residential Plumbing Pre and Post-Addition are shown in Table 4. They illustrate that the combined natural and added sodium concentrations are well below the standard in both distribution and residential plumbing.

Table 4: Sodium Concentrations in Distribution System and Residential Plumbing

Location		# of Samples	Average pH	Average Sodium Concentrations (mg/L)	Minimum to Maximum Sodium Concentrations (mg/L)
Distribution System	Pre Addition	44	8.07	3.09	2.85 – 3.41
	Post Addition	191	9.40	7.29	4.31 – 8.71
Residential Plumbing	Pre Addition	37	7.95	3.14	2.89 – 3.52
	Post Addition	88	9.37	7.11	4.25 – 8.38

Consumer Inquiries

Residents in the Hodder pressure zone were encouraged to contact the City with any water quality inquiries or concerns. Twenty one consumer inquiries were received and addressed throughout the study. See Table 5 for summary of inquiries from residents in the Hodder pressure zone throughout the study period.

Table 5: Summary of Consumer Inquiries/Concerns

Consumer Inquiry/Concern	Number of Inquiries
Water Quality	2
Taste / Odour	6
Colour	5
Request Information on Service Material Type (lead, copper, etc.)	2
Request Lead Testing	4
Corrosion Control Plan Inquiry	2
Total	21

Operation and Maintenance

During the pilot study, it was identified through the operation and maintenance of the temporary injection system that equipment and programming changes would be required before implementing city wide pH adjustment. Building temperature was a concern at the start of the study when the ambient temperature was too low, causing issues for the sodium hydroxide injection process. Once this problem was identified, the temperature was monitored closely during cold periods. Also, when the injection system was brought on line, it was identified immediately that the pH/chlorine analyzers in place at the Hodder pumping station could not accurately measure free chlorine residual at a pH greater than 8.5. The injection of sodium hydroxide was stopped until an adequate analyzer could be installed. An equipment vendor was able to supply a new analyzer that was capable of reading the free chlorine under the higher pH conditions. Once this analyzer was installed the pilot study resumed. These new pH/chlorine analyzers will be required throughout the distribution system to measure the higher pH level in the drinking water before a city wide change.

Conclusion

Based on the results from the Corrosion Control Pilot Study in the Hodder Pressure Zone, chemical addition of sodium hydroxide for pH adjustment is a safe and effective method of reducing lead levels at the tap. Additionally, the study showed that there is no indication that disinfection was compromised by adjusting pH to a level that is effective in reducing lead concentrations. Sodium concentrations remained well below the health related standard. In terms of operability and maintenance of a sodium hydroxide injection process, the pilot study assisted in design improvements of a full scale system.

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