Experiment on rust and scale inside water pipes with IOREX

I. **Experiment on corrosion control of water pipes with IOREX**

II. **Experiment on conversion of rust into a magnetite**

III. **Experiment on water softening effect of IOREX**

Experiment Institution : FP INNOVATIONS   Experiment Period : July, 2017 - Feb, 2019

SAVE *Water and energy.*

REDUCE *Environmental impact.*

EXTEND *Operation life of pipe, equipments.*

I.   Experiment on corrosion control of water pipes with IOREX

The loop with the IOREX significantly reduced the corrosion rate of the pipe.
IOREX proved itself to be a strong rust inhibitor.

Materials and Methods

1. Conditions (2 total): steel pipe; with and without IOREX.
2. Flow rate: 0.5 m/sec, Water source: tap water, Temperature: 25 °C ± 2 °C.
3. Test running time: 336 hours.

■ Corrosion Rate by Weight Loss Calculation

Sample	Weight loss (mg)	Corrosion rate (mpy)
CS - IOREX	10.14	1.80
CS - IOREX	10.01	1.77
CS	13.16	2.33
CS	12.68	2.25

The average corrosion rate :
with IOREX 1.79 mpy, without IOREX 2.29 mpy.
→ The result seems to indicate that the corrosion rate was relatively reduced by 21.8% with IOREX.

* Corrosion data from Experiment 1

■ Visual Comparison

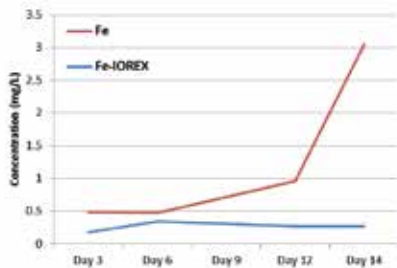Carbon steel pipes after being exposed in the water loops for 336 hours.

IOREX   CONTROL
(inner surface)

IOREX   CONTROL
(surfaces and in the surrounding areas)

Without IOREX system had a lot more deposits (relatively large, dark and round).

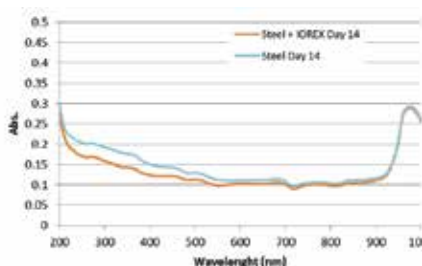### ■ ICP (Inductively Coupled Plasma) Analysis

ICP analysis : The water without the IOREX system had 11 times more dissolved iron ions by the end of the test.
→ The result seems to indicate that IOREX is very efficient in control rusting process.

* ICP Results for Experiment 1

■ UV – Visible Measurements

With IOREX system had lower UV light absorbance after the end of the test.
→ The results seems to indicate that accelerated corrosion is relatively low with IOREX.

* Effect of IOREX on water absorbance values by day during Experiment 1

II.   Experiment on conversion of rust into a magnetite

After installation, IOREX was identified by converting existing rust into magnetite. Therefore, the pipe lifespan is expected to extend more than 2 times.

Materials and Methods

1. Conditions: steel pipe ; with IOREX.
2. Flow rate: 0.5 m/sec, Water source: tap water, Temperature: 25 °C ± 2 °C.
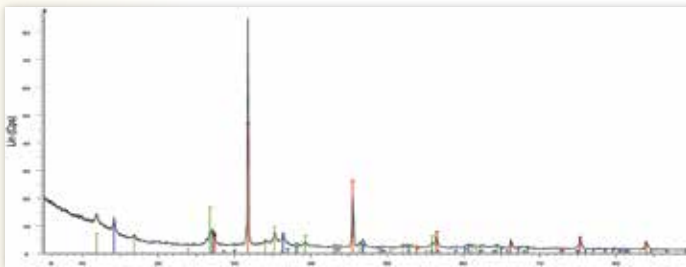3. Test running time: 12 months.

■ Post-Exposure Imaging

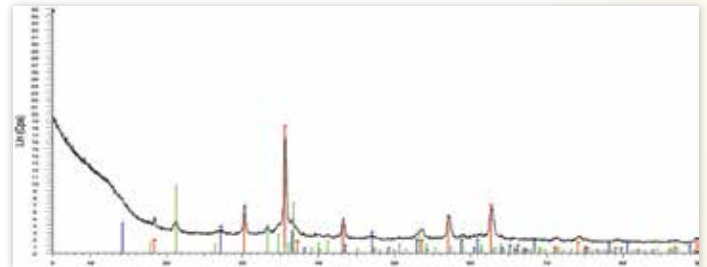(Before)   (After 6 months)   (After 12 months)

Initial rust (red) inside the pipe wall hardens and turns to magnetite (black). This will suppress further formation of corrosion.

■ X-Ray Differentiation (XRD)

**XRD Peak Analysis**

Before installation

After 367 days

XRD D-Spacing Values

D-space value	Standard Magnetite	Before Installation	After 12 months
2.9589	27.7	51.2	43.4
2.5233	100.0	100.0	100.0
2.0920	33.8	47.8	30.7
1.6105	28.4	41.8	33.4
1.4791	47.3	48.2	40.9

Before the start of the XRD test, the deposit was composed mainly of rust. However, the values presented in table confirm that the deposit is a good match with the magnetite after 12 months

■ SEM Analysis

Crystal Structure
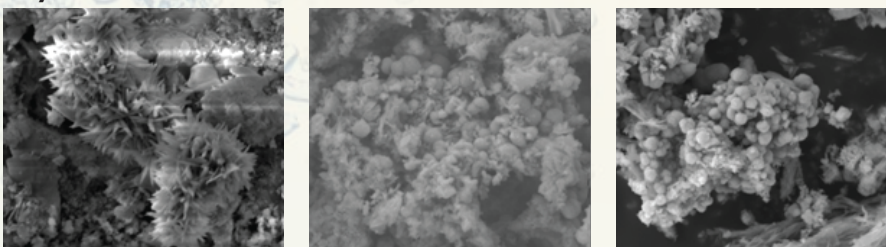
Before Installation   After 6 months   After 12 months

The deposit collected at the beginning of test before installation consists of hematite which has brittle and needle shaped structure. However, the deposit's crystal structure, after IOREX has been installed, clearly shows the black coloured magnetite (Fe_3O_4) with strong, solid and stabilized structure which is characteristic of magnetite.

III. Experiment on water softening effect of IOREX

The experiment has shown the water drained through the IOREX is 2.81 times softer than the water without IOREX. Therefore, IOREX is highly effective in inhibiting scale formation.

Materials and Methods

1. Measure the critical micelle concentration (CMC) using sodium dodecyl sulfate (SDS) as surfactant.
2. 100 ppm of CaCl2 was added to the test waster to simulate moderate hardness conditions.
3. The conductivity was measured 1, 2 and 4 hours after the addition of SDS into the water loops.
4. The temperature was controlled at 25 °C ± 2 °C, and the water flow set a 0.5 m/s.
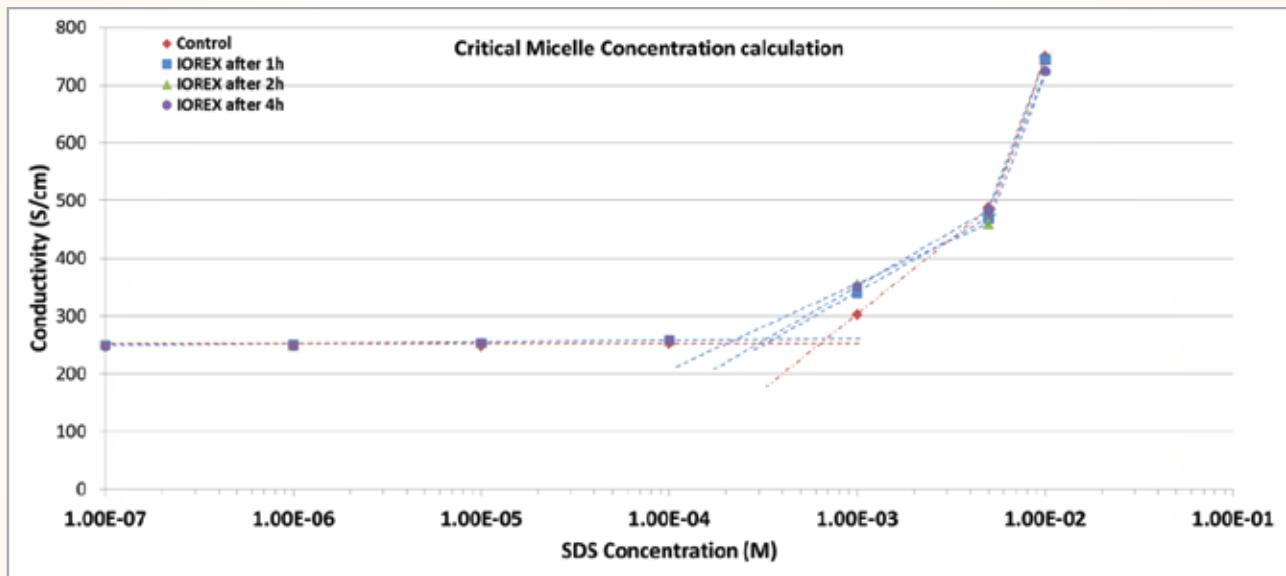
* CMC Calculation for the control loop and the loop with the IOREX filter.

Figure shows the change in conductivity with SDS concentration in water. The CMC was calculated by extrapolating the trend of the initial plateau, when conductivity values remain stable, and t he second region of the graph when the first sudden increase in conductivity was measured.

	1st CMC With IOREX	1st CMC control	Difference
Surfactant Concentration	2.2 x10-4 M	6.22 x10-4 M	2.81 times

* Effect of IOREX on water softening as estimated by CMC

Table shows the effect of IOREX on water softening. The loop without the IOREX system needed 2.81 times more SDS to reach the CMC.