4.0 EXPERIMENTAL RESULTS

4.1 Recirculation Test Results

4.1.1 Test Operation and Sequence

4.1.1.1 Description

Preparation of recirculation test began with the heating of 264 gallons of de-mineralized water to 149°F in preparation tank.
Upon reaching the desired temperature, chemicals were added and dissolved using agitator and filled up to 317 gallons with the water. Those chemicals were boric acid, NaTB, NaOH, $LiOH.H_2O$ and HCl.
Setting of metal coupons, concrete and fiber glass in test tank was performed on August 10, 2008.
The next morning, 264 gallons of the test solution in the preparation tank was transported to the test tank and the circulation pump began to operate in recirculation and latent debris(concrete particulates) were put into the tank.
The test started with initiation of spray operation on August 11, 2008 and it ended on September 11, 2008. Recirculation flow was set in 52.8gpm and the spray flow was set in 6.9gpm.

4.1.1.2 Process Control

Process control consisted of monitoring of recirculation solution temperature, recirculation flow rate and spray flow rate. Temperature and flow rate were controlled to the desired values.

Recirculation Flow Rate :
The average of recirculation flow rate was 53.0 gpm including spray flow rate. The flow rate had a standard deviation of( )gpm with range of 49.7 - 55.7 gpm and average spray flow rate was 6.5 gpm.

Temperature :
The test average test solution temperature was 149.2 °F with range of 142.7 °F - 156.7 °F.

4.1.2 Metallic and Concrete Coupons

4.1.2.1 Coupon Racks

The total of 89 metal coupons, 1 concrete coupon and NUKON™ were contained in the test tank.

Metal coupons consisted of aluminum, copper, carbon steel and galvanized steel. Those coupons and concrete in the test tank were located in six coupon racks with numbering configuration shown in Figure 4.1-1, Figure 4.1-2. NUKON™ was located on #1 coupon rack in submerged.

Coupons numbering

example : 1-**GZ**-**2**-**10**-**8**

GZ : kind of material

GZ ; galvanized steel(Z), AL ; aluminum(A), Conc ; concrete(CN),
CS ; carbon steel(F), CU ; copper(C)

2 : number of coupon rack

10 : location number in the coupon rack from north side of test apparatus

8 : number in each material

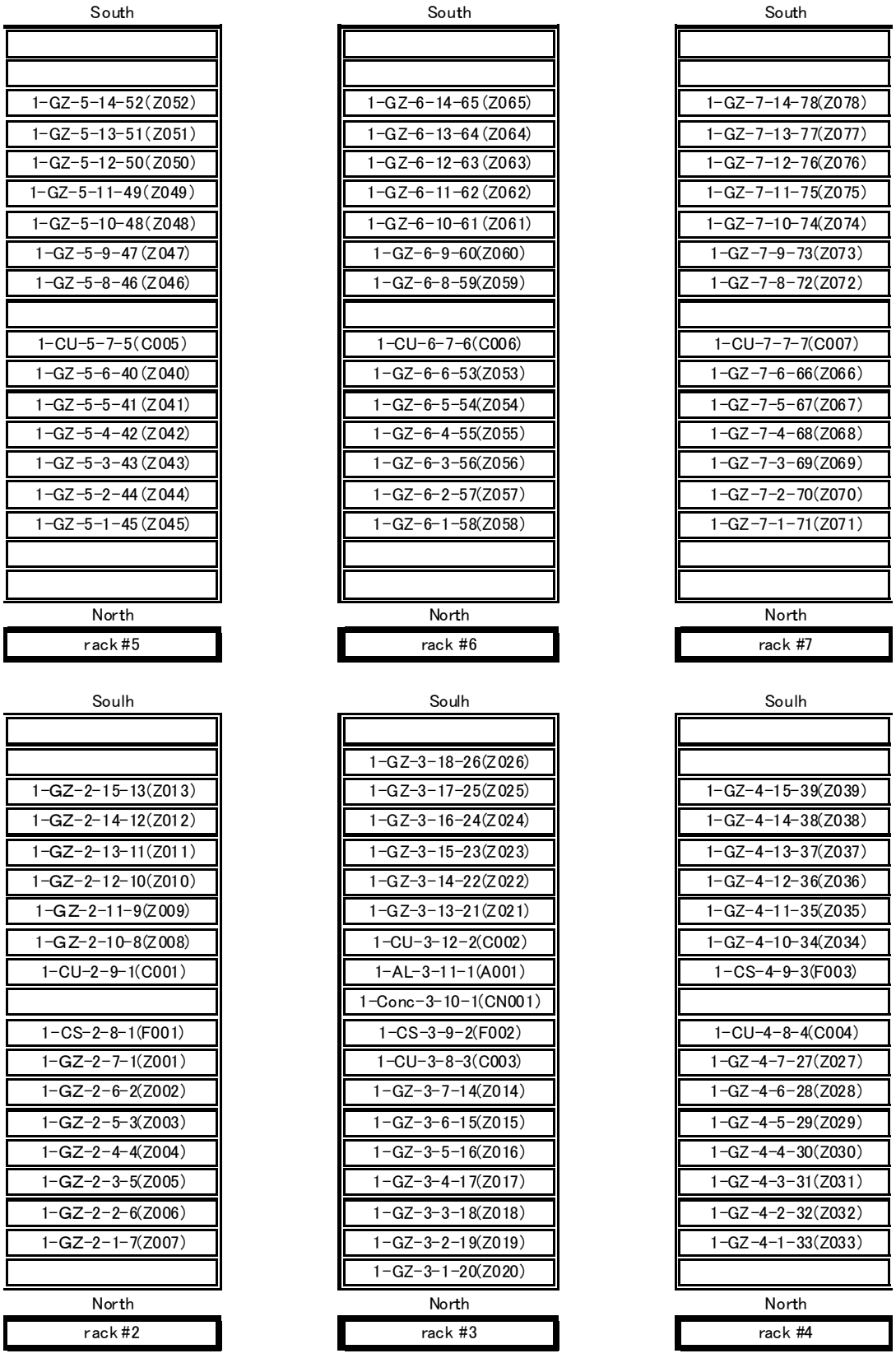


Figure 4.1-1 The Position of Metal and Concrete Coupons in Each Coupon Racks

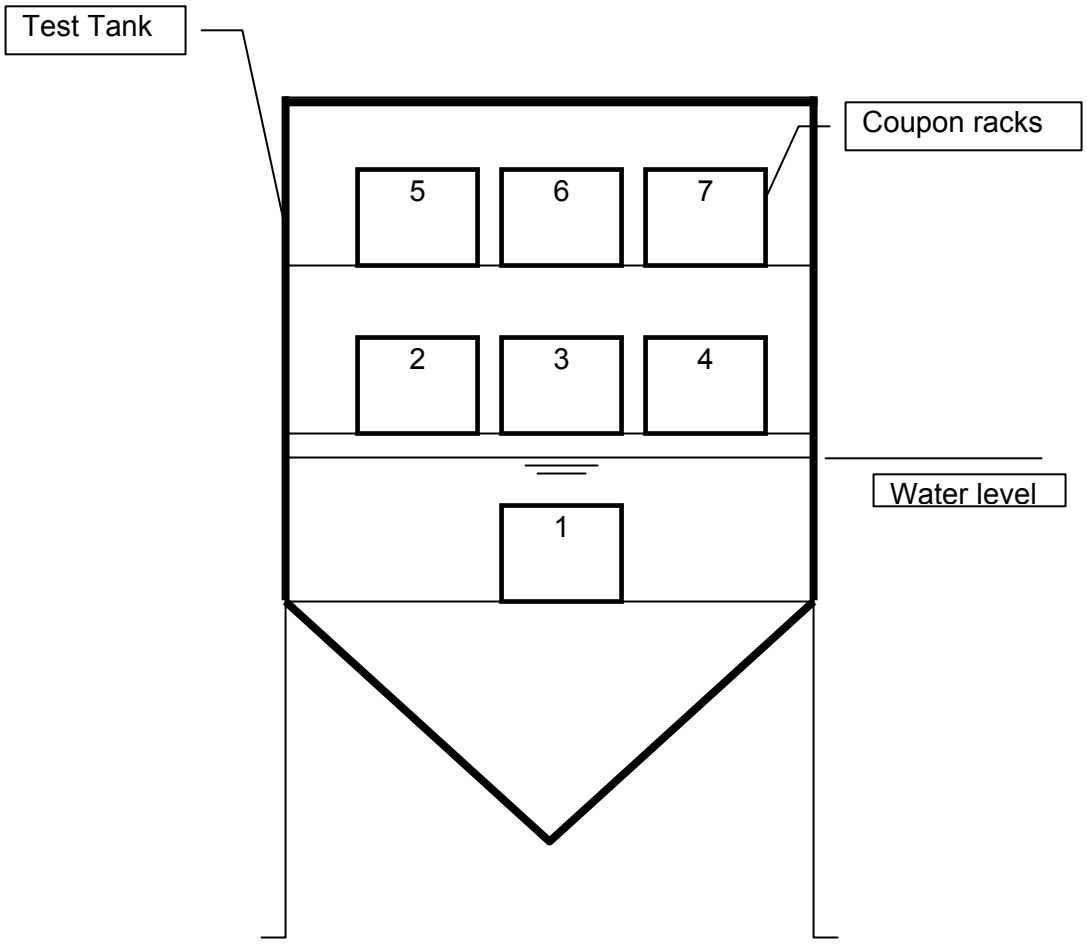


Figure 4.1-2 The Position of the Coupon Racks in a Test Tank: View from Control Box Side of the Tank

4.1.2.2 Coupon Photographs

All of the coupons were weighted before and after test, photographed, and inventoried.
NUKON™ fiber was located in stainless steel mesh holder fixed on #1 coupon rack, as shown in Figure 4.1-3.
Photograph of each coupon racks with coupons before test are shown in Figure 4.1-4 and Figure 4.1-5.
Photograph of coupon racks (#2, #3, #4) with coupons after test are shown in Figure 4.1-6.

Figure 4.1-3 The NUKON™ Fiber Glass Holder Made of Stainless Steel Mesh with Sample on Coupon Rack #1

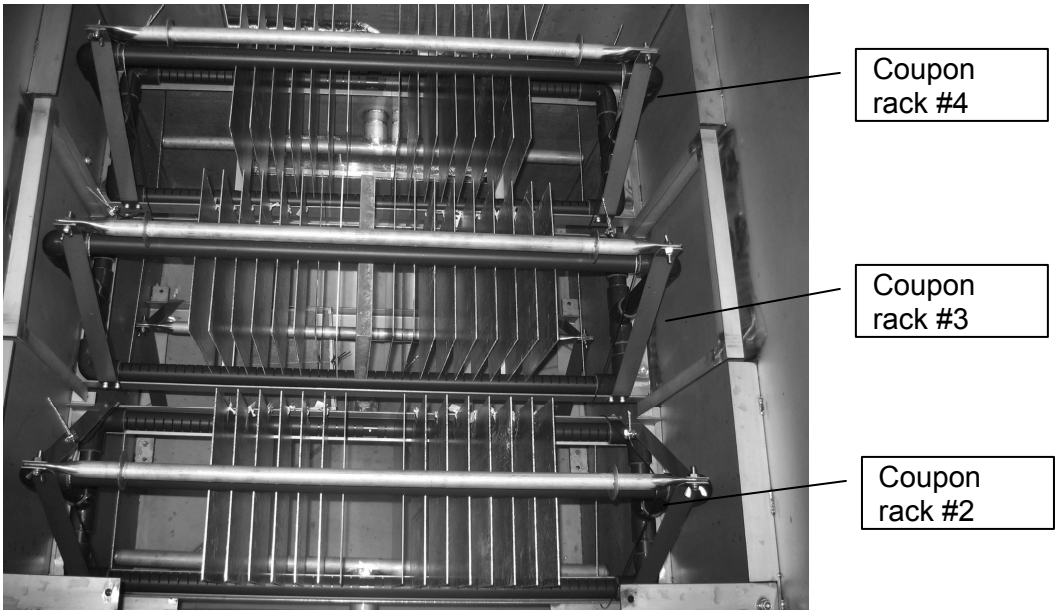


Figure 4.1-4 Coupon Racks #2,#3,#4 in Test Tank

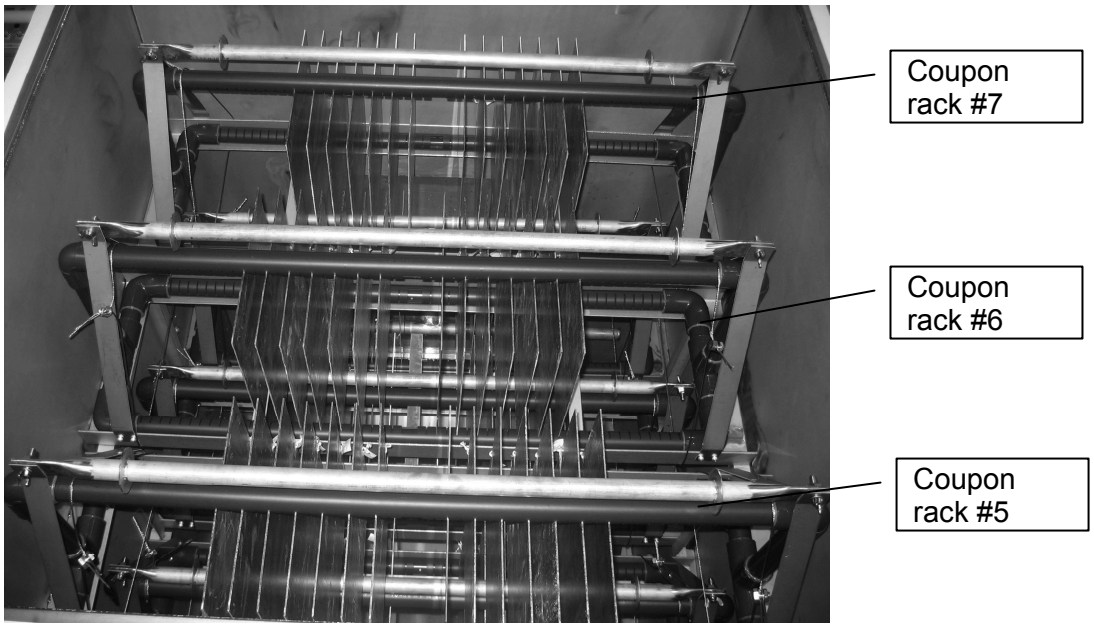


Figure 4.1-5 Coupon Racks #5,#6,#7 in Test Tank

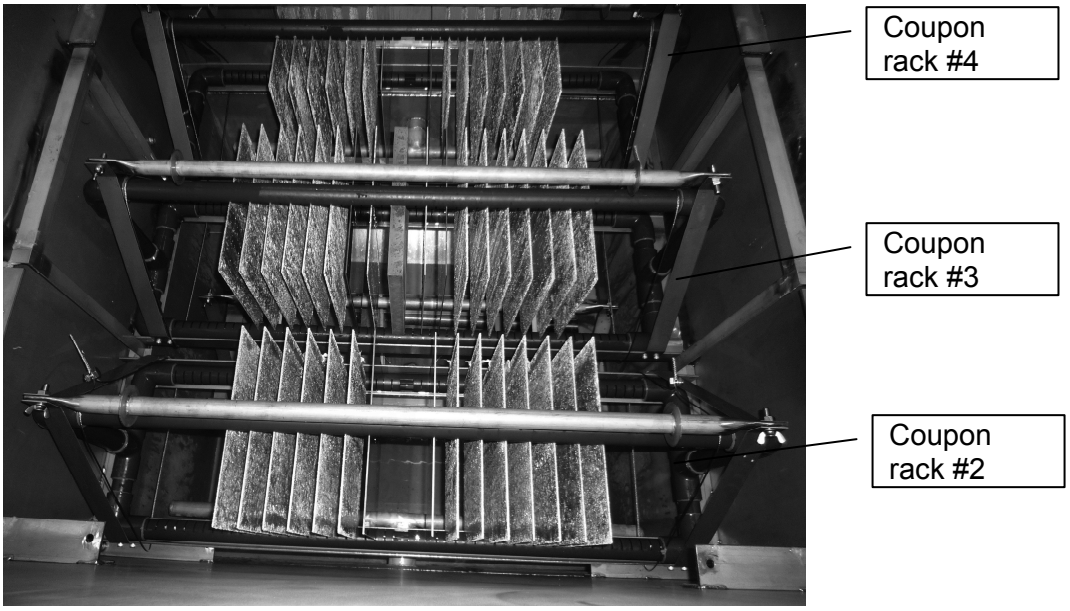
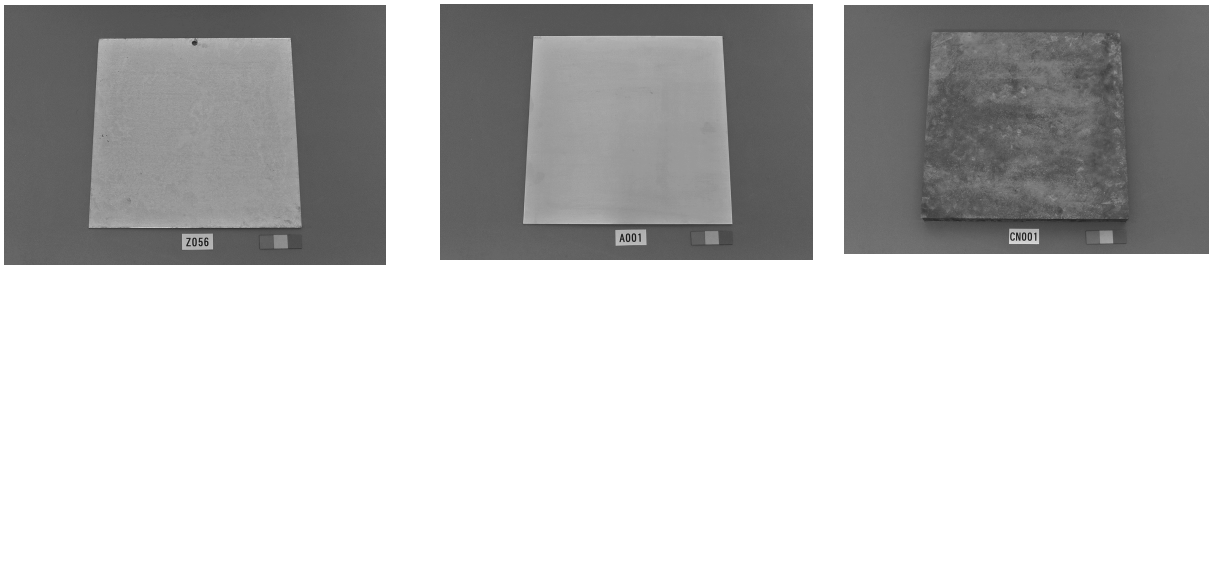


Figure 4.1-6 Coupon Racks #2,#3,#4 after Test

Typical photographs of coupon before and after test are shown in Figure 4.1-7.
Table 4.1-1 shows surface appearance of coupons after test.

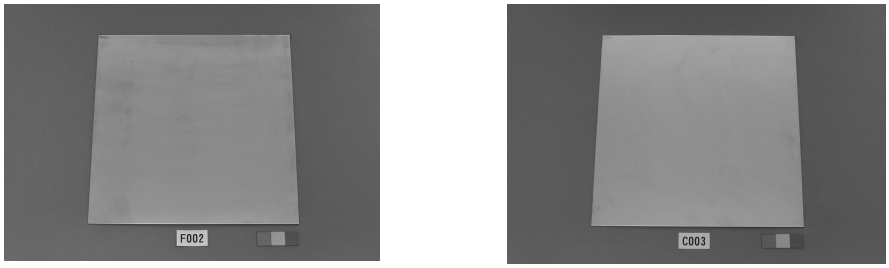
Table 4.1-1 Observation Results of Coupon Surface after Test



Galvanized Steel (1-GZ-6-3-56)

Aluminum (1-AL-3-11-1)

Concrete (1-Conc-3-10-1)



Carbon Steel (1-CS-3-9-2)

Copper (1-CU-3-8-3)

Figure 4.1-7 Coupons before and after Recirculation Test (Upper (before test), Lower (after test))

4.1.2.3 Weight Measurements

All coupons were weighted before test, after test and after de-scaling with plastic brush. Measurements of coupon weights were taken on calibrated scale. Weight differentials of coupon are within [ ] lbm and the differentials of deposition on coupon are within [ ] lbm.

Table 4.1-2 shows average weight of a coupon for each material before and after test, after de-scaling, and deposition on coupon.

Average weight of 78 galvanized steel before test was 3.9121 lbm. Some of the steel were weight gained and some of the steel were weight lost. Average weight loss of 78 steel was [ ] lbm and average weight of deposition for a coupon was [ ] lbm.
Weight of one aluminum before test was 1.3715 lbm and weight loss after test was [ ] lbm.
Deposition weight was [ ] lbm.
Weight loss of a concrete after test was [ ] lbm and deposition weight was [ ] lbm.
Average weight change of 3 carbon steel was not significantly observed [ ] and average deposition weight was [ ] lbm.
Average weight change of 7 copper was gained of [ ] lbm and average weight of deposition was [ ] lbm.

Table 4.1-2 Average Weight for Each Coupon in Recirculation Test

[ ]

4.1.2.4 Deposition Analysis

Deposition on coupons was analyzed using EDS (Energy Dispersive Spectroscopy).
Table 4.1-3 shows EDS analysis results.

Table 4.1-3 Elemental Composition of Deposition on Coupon Surface(EDS Analysis)

4.1.3 NUKON™ Fiberglass Samples

NUKON™ fiberglass insulation was heat treated for 24 Hours at 600 °F and then was shredded by NUKON™ manufacturer.
NUKON™ of 0.110 lbm was enclosed in stainless steel fine mesh holder placed on #1 coupon rack in the tank.
Weight measurement:
Weight of NUKON™ in mesh holder was decreased to [ ] lbm after test, because part of fiberglass was flowed out to recirculation solution during test.
SEM observation:
Figure 4.1-8 and Figure 4.1-9 shows SEM image of NUKON™ before and after test.

[ ]

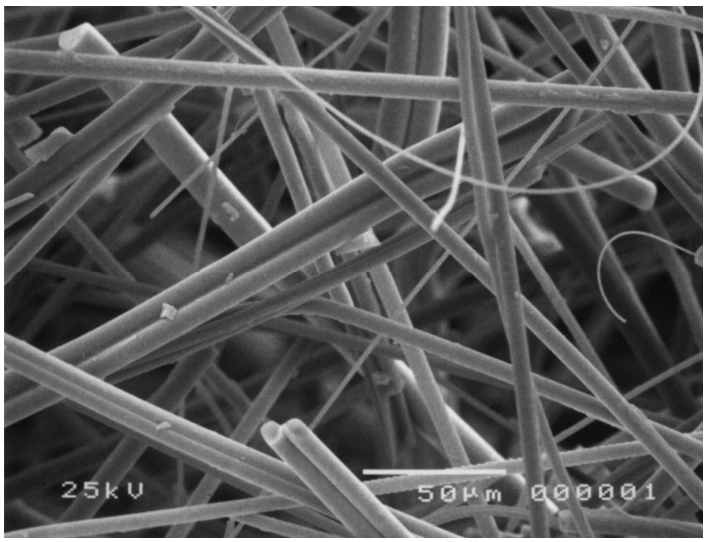


Figure 4.1-8 SEM Image of NUKON™ Fiberglass before Test

[ ]

Figure 4.1-9 SEM image of NUKON™ fiberglass after Recirculation Test

EDS analysis:

Table 4.1-4 shows EDS analysis results of before and after NUKON™ fiberglass.

Table 4.1-4 Elemental Composition of NUKON™ Fiberglass before test and of Deposition on the Fiberglass after Test (EDS Analysis)

4.1.4 Concrete Particles Samples

Concrete particles sample was prepared by crushing of concrete plate and 0.110 lbm of the particles less than 70 μm size was used in test.

SEM observation:

Figure 4.1-10 shows concrete particles sample before test.

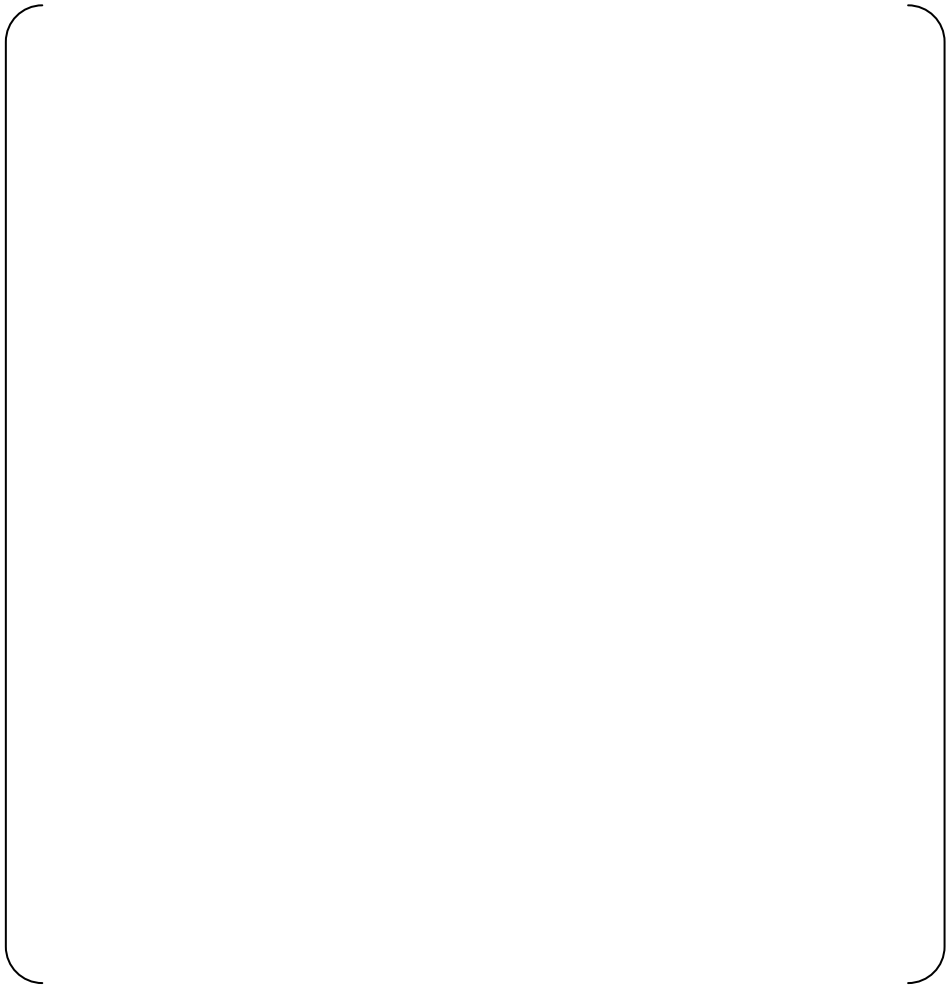


Figure 4.1-10 SEM image for before test of Powdery Concrete Samples

EDS analysis:

Table4.1-5 Elemental composition of powdery concrete (EDS Analysis)

4.1.5 Solution Chemistry

4.1.5.1 Chemical Concentration

Chemical concentrations in recirculation solution such as Al, Ca, Cu, Fe, Ni, Si, Mg, Zn were daily analyzed using ICP(Inductively Coupled Plasma) method duration the test.
Analysis results of chemical concentration are shown in Figure 4.1-11 - Figure 4.1-18.

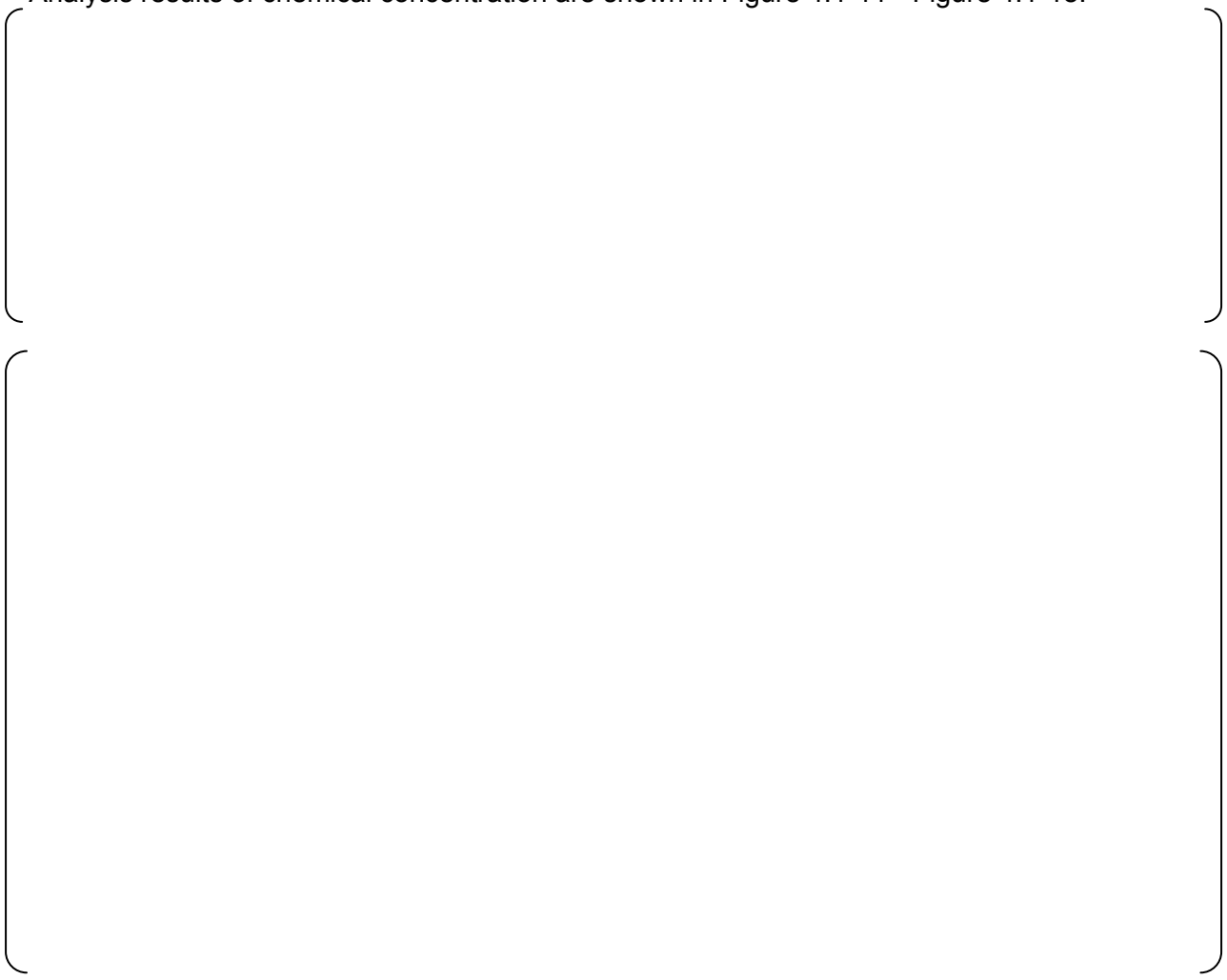


Figure 4.1-11 Aluminum concentration in Recirculation test

Figure 4.1-12 Calcium concentration in Recirculation test

Figure 4.1-13 Copper concentration in Recirculation test

Figure 4.1-14 Iron concentration in Recirculation test

Figure 4.1-15 Nickel concentration in Recirculation test

Figure 4.1-16 Silicon concentration in Recirculation test

Figure 4.1-17 Magnesium concentration in Recirculation test

Figure 4.1-18 Zinc concentration in Recirculation test

4.1.5.2 Turbidity

Figure 4.1-19 shows turbidity of test solution during test.

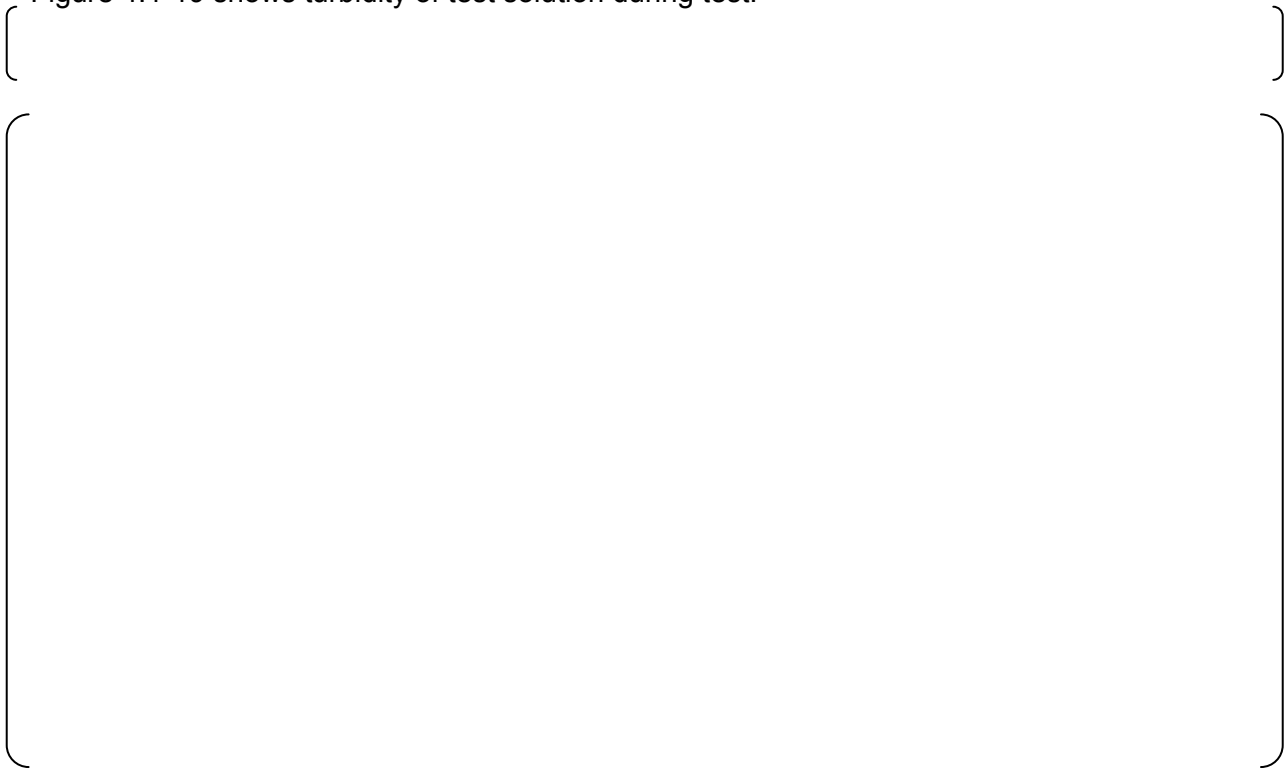


Figure 4.1-19 Turbidity in Recirculation test

4.1.5.3 Total Suspended Solids

Figure 4.1-20 shows total suspended solids concentration of test solution.

Figure 4.1-20 Total Suspended Solids in Recirculation test

4.1.5.4 pH

Figure 4.1-21 shows pH measurement results in test solution.

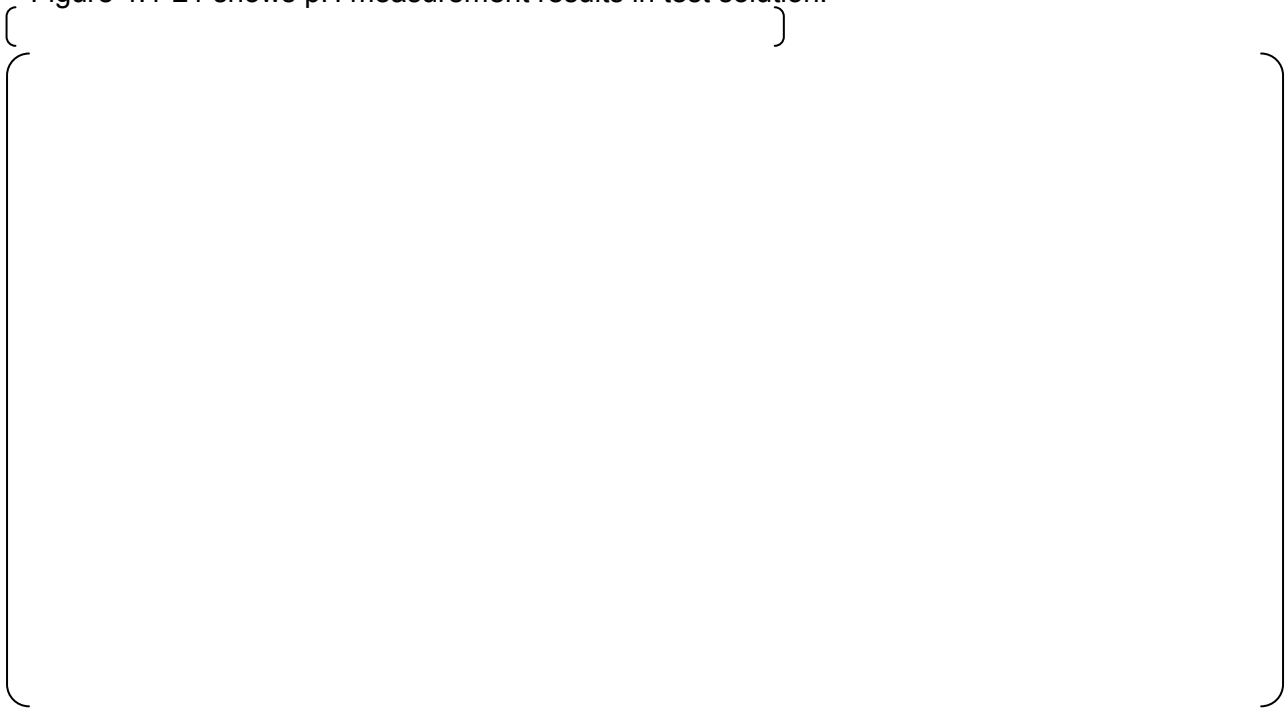


Figure 4.1-21 pH in Recirculation test

4.1.5.5 Viscosity

Figure 4.1-22 shows viscosity measurement results of test solution.

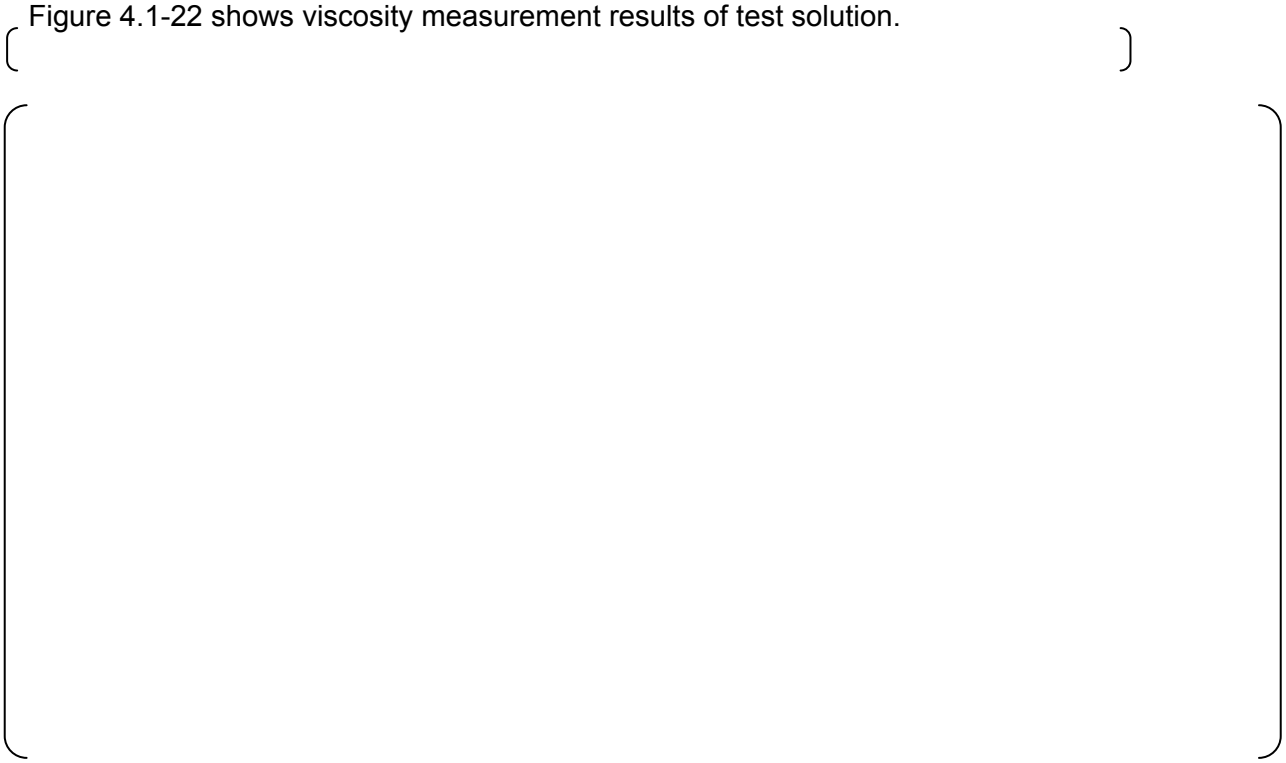


Figure 4.1-22 Viscosity in Recirculation test

4.1.6 Precipitated Solids

The test solution was hot discharged at 149 °F from test loop after the test finished and precipitated solid inside the tank was collected.

Table 4.1-6 shows weight measurement results of collected solids in the tank.

Table 4.1-7 shows EDS analysis results of collected solids on screen mesh and coupon racks.

Figure 4.1-23 Internal View of Test Tank after test
(Side Wall (left) , Tank screen on bottom (right))

Figure 4.1-24 Precipitated Solids in Test Tank after test
(Side Wall (left) , Tank screen on bottom (right))

Figure 4.1-25 SEM image of Precipitated Solids on Test Tank Screen after recirculation test

Table 4.1-6 The amount of sediments in a test tank

Table 4.1-7 Elemental Composition of Precipitated Solids in Test Tank (EDS Analysis)