4.2 Autoclave Test Results

4.2.1 Test Operation and Sequence

4.2.1.1 Description

Preparation of autoclave test began with placing coupon rack into test vessel and 1.85 gallons of test solution was filled in the vessel. The test stared at beginning of heating for test solution.
Tests of standard condition (A-2, A-5) were stared at September 10, 2008 and it ended at September 14, 2008 during 100Hours.
Tests of alkaline condition (A-3, A-6) was stared at September 18, 2008 and it ended at September 22 during 100Hours and tests of acidic condition (A-7, A-8) was stared at September 29, 2008 and it ended at September 30 during 24Hours.
Test solution samples were taken every 24Hours during test period and every 4Hours until 12 Hours.

4.2.1.2 Process Control

Process control consisted of monitoring of solution temperature. Temperature was controlled to the desired values.
Tests with temperature constant condition (A-2, A-3, A-7) were controlled with constant of 149 °F. Tests with temperature transient condition (A-5, A-6, A-8) was heated up to284 °F in 2Hours and kept 1Hours and decreased down to 149 °F within 100Hours(Figure 4.2-1 – Figure 4.2-4).Temperature of standard condition (A-2) was controlled at range of 147.0°F to 152.1 °F. Temperature was controlled at range of 145.9 °F to 152.6 °F for acidic condition (A-7) and at range of 147.9 °F to 150.6 °F for alkaline condition.

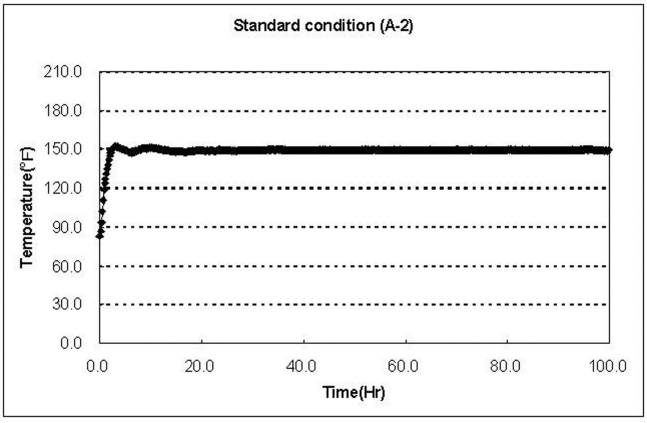

Figure 4.2-1 Operating Temperature of Standard condition(A-2)test

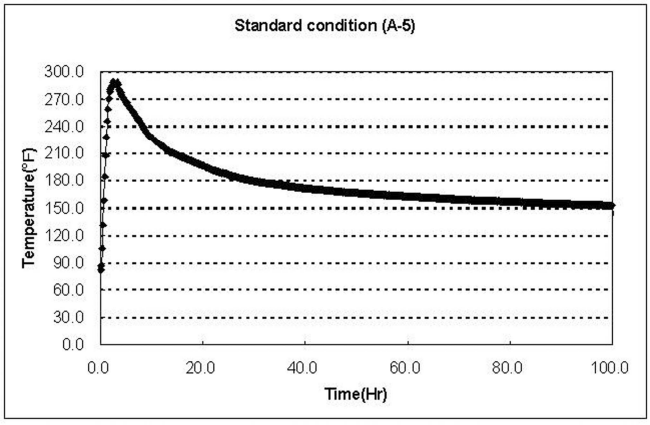

Figure 4.2-2 Operating Temperature of Standard condition(A-5)test

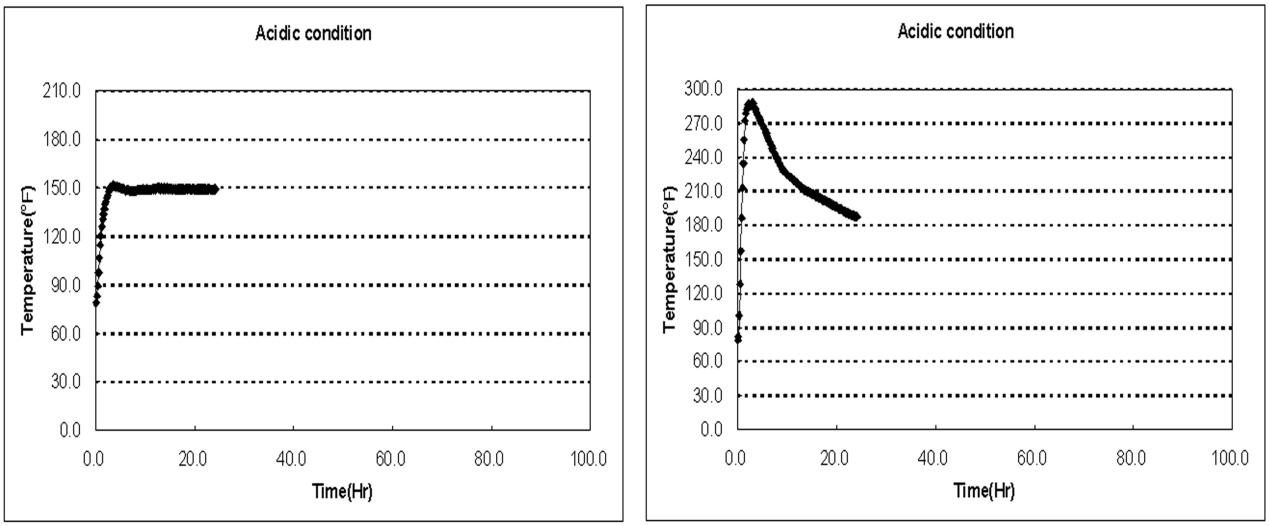

Figure 4.2-3 Operating Temperature of Acidic condition(A-7,A-8)test

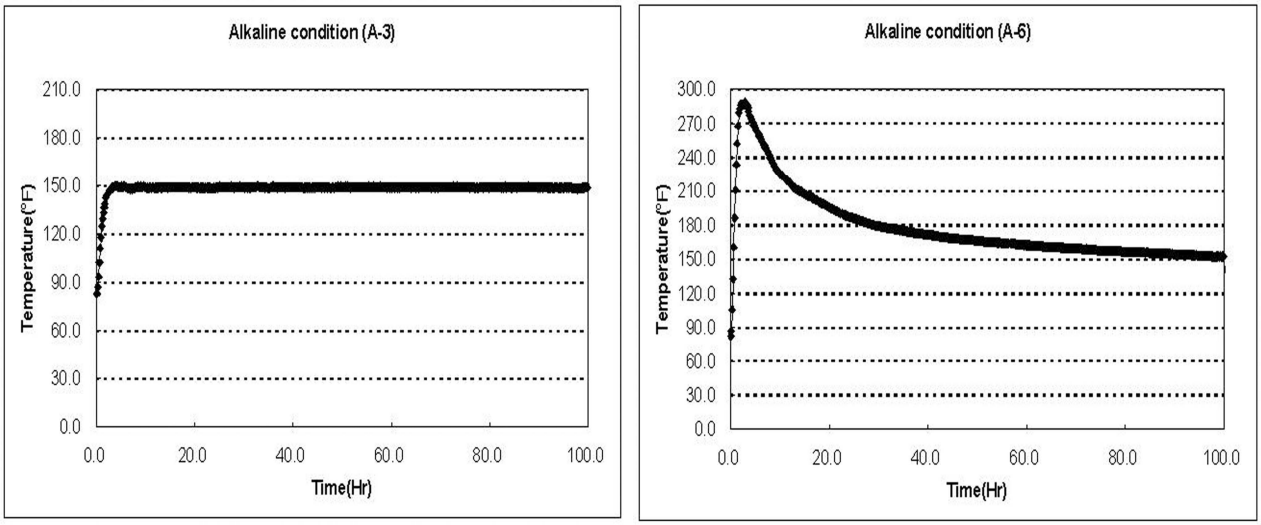

Figure 4.2-4 Operating Temperature of Alkaline condition(A-3,A-6)test

4.2.2 Metallic and Concrete Coupons

4.2.2.1 Coupon Racks

The total of 14 metal coupons, 1 concrete coupon and NUKON was contained in test vessel. Metal coupons consist of aluminum, copper, carbon steel and galvanized steel. Those coupons and NUKON in test tank were located in a coupon racks with numbering configuration shown in Figure 4.2-5. NUKON was contained inside stainless steel fine mesh holder.

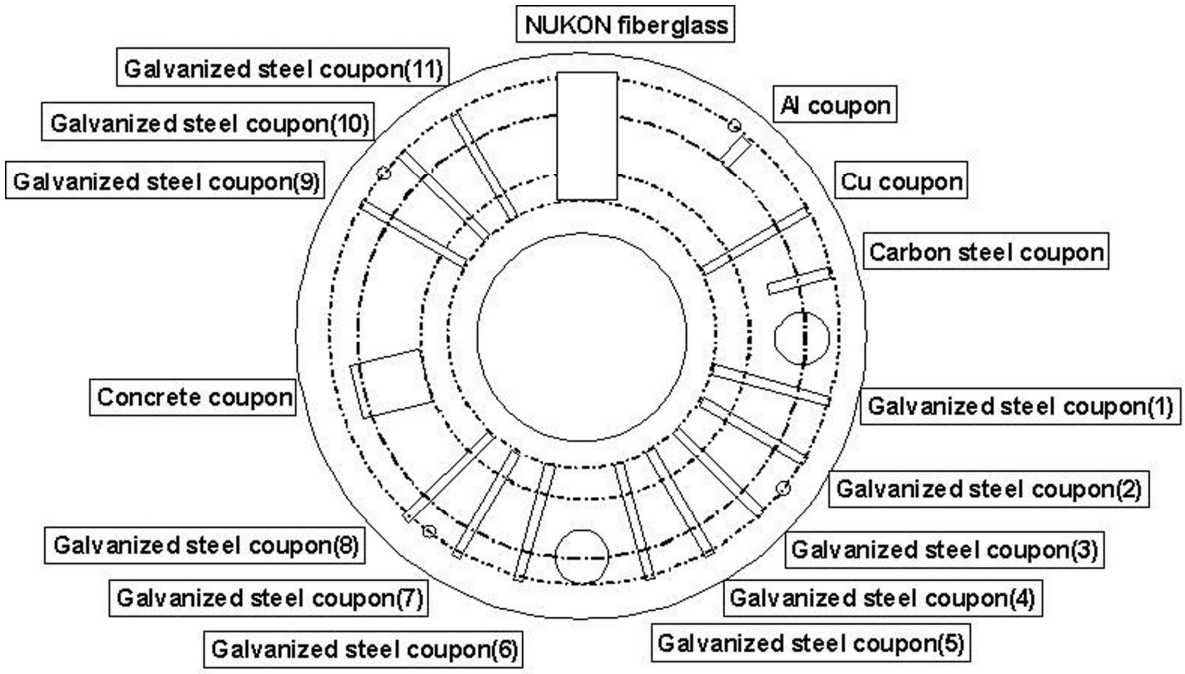

Figure 4.2-5 Arrangement of test coupon

4.2.2.2 Coupon Photographs

All of the coupons were weighted before and after test, photographed, and inventoried. Typical photographs of coupon before and after standard condition test (A-5) are shown in Figure 4.2-6 – Figure 4.2-8.
Table 4.2-1shows surface appearance of coupons after standard condition test (A-5).

Table 4.2-1 Observation Results of Coupon Surface after test

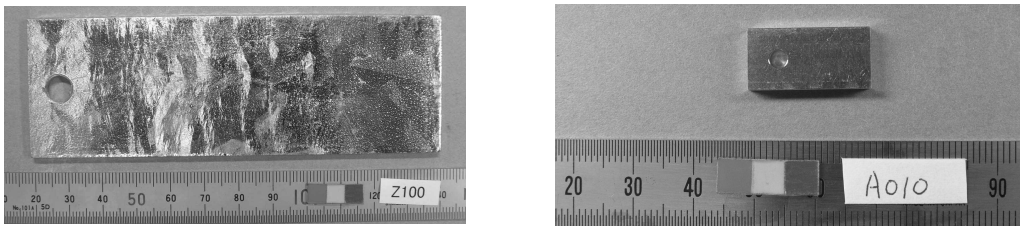

Figure 4.2-6 Galvanized steel (left) , Aluminum(right) of Standard condition (284°F transient A5) (Upper : before test , Lower : after test)

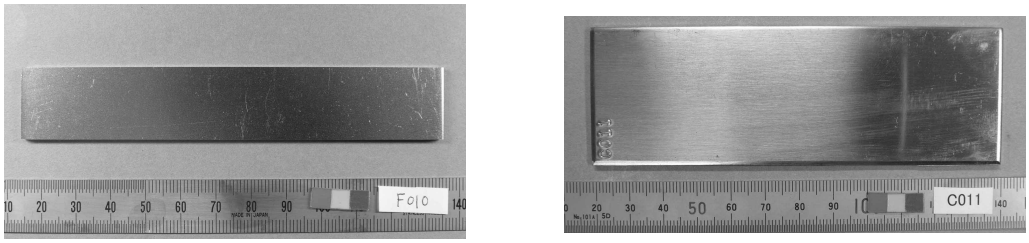

Figure 4.2-7 Carbon Steel(left),Copper(right) of Standard condition (284°F transient A5) (Upper : before test , Lower : after test)

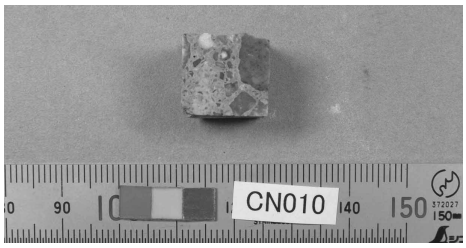

Figure 4.2-8 Concrete of Standard condition(284°F transient A5) (Upper : before test , Lower : after test)

4.2.2.3 Weight Measurements

All coupons were weighted before and after test and after de-scaling with plastic brush. Measurements of coupon weights were taken on calibrated scale. Weight differentials of coupon for over 0.11 lbm were within[ ]lbm and the differentials of coupon for less than 0.11 lbm was within[ ] lbm.
Table 4.2-2 shows average weight of a coupon before and after test, after de-scaling in standard condition (A-5).
Average weight of 11 galvanized steel was gained[ ] lbm.
Weight loss of a coupon were[ ] lbm for aluminum[ ] lbm for concrete, [ ]lbm for carbon steel[ ] lbm for copper.

Table 4.2-2 Average Weight for Each Coupon in Autoclave Test of Standard Condition(A-5)

4.2.2.4 Deposition Analysis

Deposition on coupons was analyzed using EDS method. Table 4.2-3 shows EDS analysis results of standard condition (A-5).

Table 4.2-3 Elemental Composition of Deposition on Coupon Surface(EDS Analysis) (Transient temperature test (A-5))

4.2.3 NUKON™ Fiberglass Samples

NUKON fiberglass insulation was heat treated for 24 Hours with 600 °F and then was shredded by NUKON manufacturer.
NUKON of 7.7×10^{-4} lbm was enclosed in stainless steel fine mesh holder placed in test vessel.

Figure 4.2-9 shows SEM image of NUKON after the standard condition test (A-5).

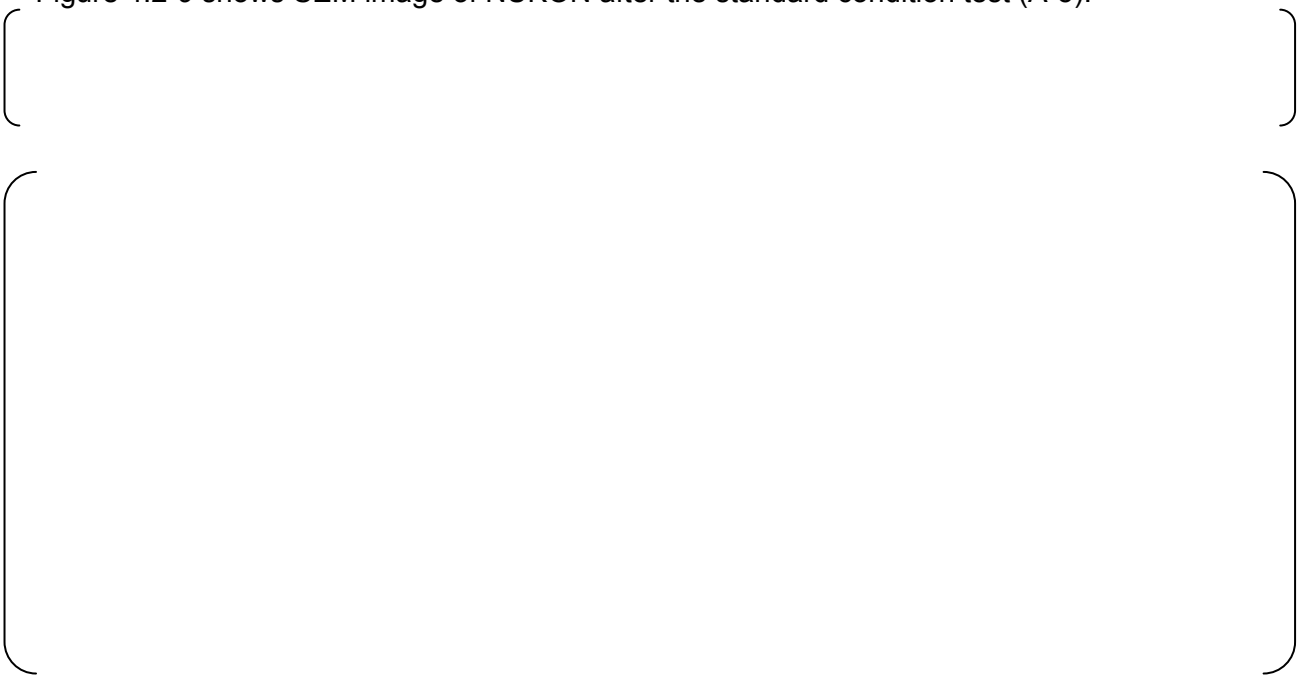

Figure 4.2-9 SEM image of Fiber glass for a Standard condition(284°F transient.A5)

Table 4.2-4 Elemental Composition of deposition on NUKON™ Fiberglass after Test (A-5) (EDS Analysis)

4.2.4 Concrete Particles Sample

Concrete particles sample was prepared by crushing of concrete plate and 7.7×10^{-4} lbm of the particles less than 70 μm size was used in test.

4.2.5 Solution Chemistry

4.2.5.1 Chemical concentration

Chemical concentrations in recirculation solution such as Al, Ca, Cu, Fe, Ni, Si, Mg, Zn were analyzed using ICP method duration test.
Analysis results of temperature transition tests(A-5, A-6, A-8) show in Figure 4.2-10 - Figure 4.2-13.

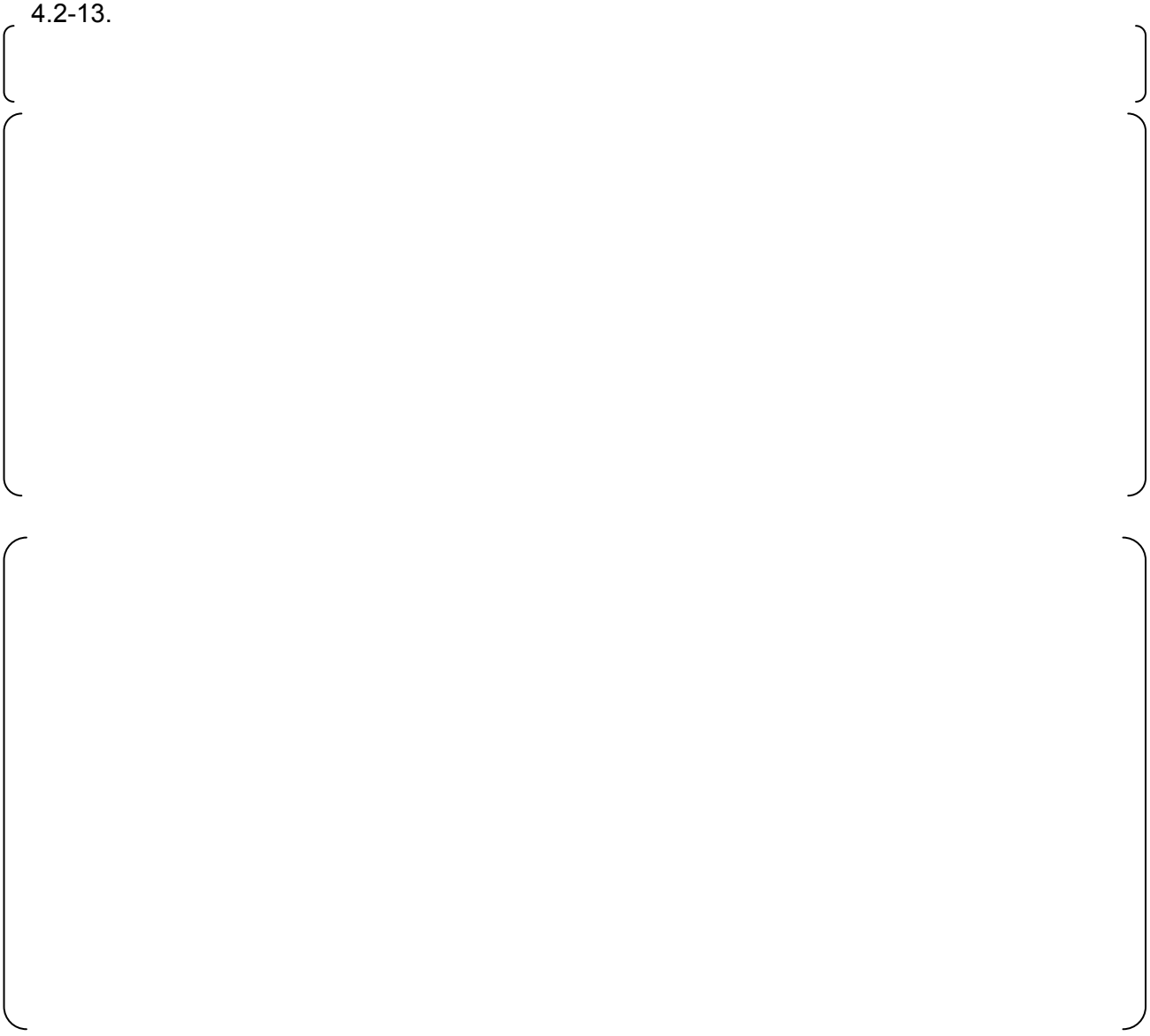

Figure 4.2-10 Aluminum(left) and Calcium (right) concentration (284°F transient)

Figure 4.2-11 Copper(left) and Iron(right) concentration (284°F transient)

Figure 4.2-12 Nickel(left) and Silicon(right) concentration (284°F transient)

Figure 4.2-13 Magnesium(left) and Zinc(right) concentration (284°F transient)

4.2.5.2 pH

Figure 4.2-14 shows pH measurement results for transient condition (A-5, A-6, A-8).

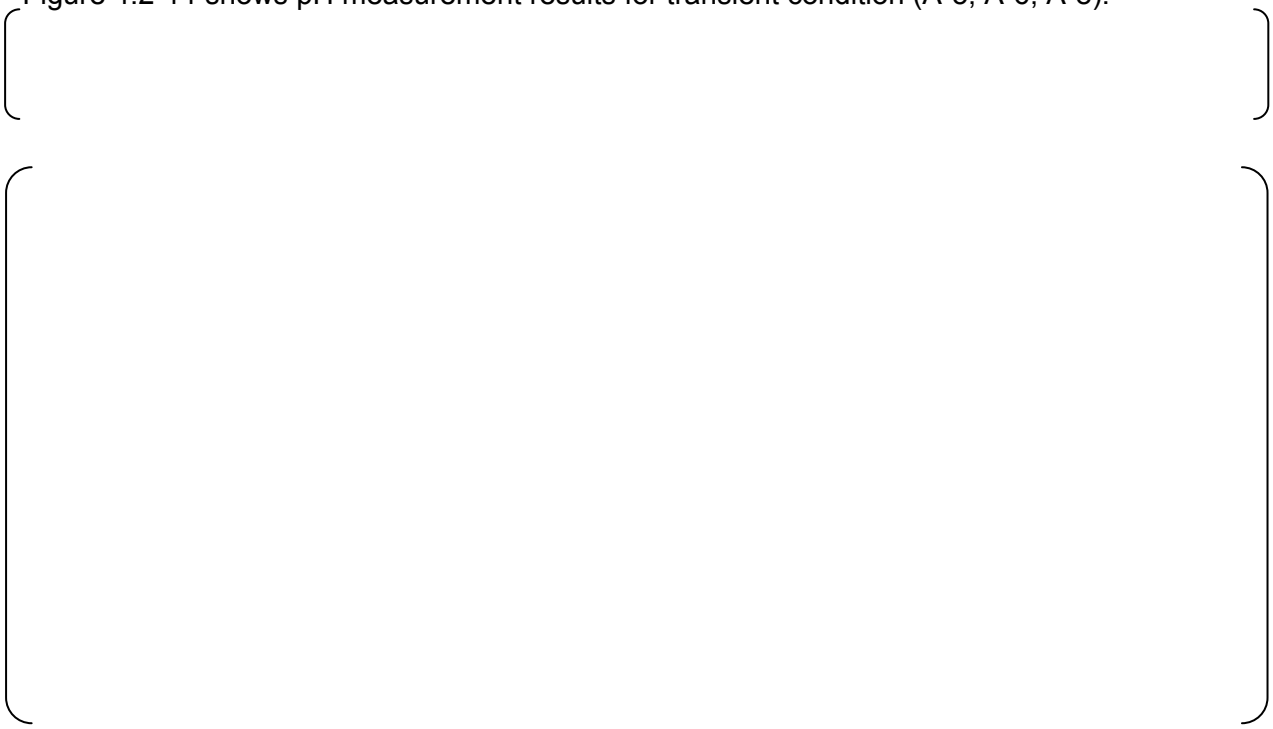

Figure 4.2-14 pH (284°F transient.A5)

4.2.5.3 Viscosity

Table 4.2-5 shows viscosity measurement results in standard condition (A-5).

Table 4.2-5 Viscosity

4.2.6 Precipitated Solids

Table 4.2-6 shows EDS analysis results of precipitated solids in standard condition test (A-5).

Table 4.2-6 Elemental Composition of Precipitated Solid in Test Tank(EDS Analysis) (Transient temperature test (A-5))

The deposition on coupon rack and on surface of tank was collected by cloth wiping.
SEM image of the deposits for standard condition test (A-5) were shown in Figure 4.2-15.

Figure 4.2-15 SEM image of deposit on the Coupon rack(left), Inside surface of Autoclave(right) for a Standard condition(284°F transient.A5)

4.3 Summary of Test Results

The chemical effects tests were performed to obtain experimental data on corrosion products in long term recirculation test in a post-LOCA environment and in short term test for temperature transient condition in a post-LOCA.

Chemical concentration of corrosion products in long term recirculation test was shown as follows.

Maximum chemical concentration of corrosion products with temperature transient (284 °F) condition in short term autoclave test was Ca : 20 mg/L, Si : 8 mg/L, Zn : 4 mg/L, Al : 20 mg/L, and Cu, Fe, Ni, Mg : < 1 mg/L in standard condition.
And maximum concentration with temperature transient (284 °F) condition in acidic and alkaline condition was shown as follows.

5.0 CONCLUSION

The chemical effects tests were performed to obtain experimental data under simulated plant conditions on the corrosion products that may form in a post-LOCA environment.
MHI has performed the chemical effects tests conducted in the program to simulate the chemical environment present inside the US-APWR containment recirculation water after a LOCA referring to ICET (The Integrated Chemical Effects Test) experiment (Ref.3).

30days recirculation test under long term cooling and 100Hours test under short term temperature transient condition in post-LOCA were conducted in this experiment.
Test materials in this experiment were simulated ratio of surface area to circulation water volume in US-APWR and chemical concentration of test solution was also simulated with it in US-APWR during post-LOCA condition.

Recirculation test chemistry was controlled with constant pH value range of 7.7 – 7.8.
Chemical concentration in recirculation solution was daily measured, and Ca, Si showed tendency of concentration increasing with time. Zn concentration increased in initial period of test and did not significantly change during test. Al and other elements were not significantly detected in recirculation solution.
Experimental data of corrosion products was obtained using chemical effects test facility.

The experimental data will be used to the long-term reactor core cooling evaluation and sump strainer performance evaluation in post-LOCA of US-APWR.

6.0 REFERENCES

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4. US-APWR Sump Debris Chemical Effects Test Plan, MUAP-08006-NP (R1), 2008
5. US-APWR Sump Strainer Performance, MUAP-08001-P (R6), May 2012, Figure 3-14
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