Singapore Polytechnic

School of Built Environment

Diploma in Property Development and Facilities Management

Study the effectiveness of Galvanic Protection on reducing scaling at heat exchangers

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Project supervisor: Mr Ng Weng Fai

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Chapter 1

Abstract

This report is to determine the advantages of using Aquabion. We are doing a test on the product called “Aquabion” which reduce encrustations in pipes, premature deterioration of plants, damage to machines and finally to the reduction of performance within the production. Calcium, magnesium and carbonate ions form hard crystalline deposits is the main causes of the reduction of performance. The quantity increases proportionally to the temperature. In addition to the rate of scaling, the oxygen contained in the water increases the corrosion rate of all equipments and machines.

We are to complete the model using water heating coils and carry out testing based on these heating coils. From the testing, it will show whether this product will reduce scaling and corrosion on the water heating coils, thus saving in overall cost.

We will do up an hourly report and progress photographs from the results of the testing. As well as comparison on the difference temperature that affects the rate of scaling. The product will be tested at 50°C initially for around 60 hours and then increase the temperature to 55°C for further 20 hours. Problems that we faced when doing the testing of this product will be included in the report. Also, through this project we find out other ways/products which have the similar way of preventing the coil from scaling and corrode.

Chapter 2

Acknowledgements

First of all, we would like to thank our facilitator, Mr Ng Weng Fai for all the help he gives us, not just heeding us advice on how to improve our report, but also provide us with fruitful information based on his past experiences. Also, the guidance he gave throughout the whole project. Once again, you have our many thanks for all the help we received throughout this whole year for the project.

We would also like to thank the Aquabion supplier, Mr Eng Yong Heng of WinBiz International Pte Ltd for all the useful information he gave us during his visit. With this piece of information and the supply of Aquabion, we are then able to successfully complete this project. We also like to thank for the extra information he gave when we asked for.

We would also like to thank Mr Yap from Nalco, for providing us the necessary information we needed for our project. Without the help from him, we would never able to complete certain part of the project.

We would also like to thank Ms Jessie from Ecolab, for providing us with cost information on their products that we need for the project.

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Chapter 3

a. Project Synopsis

The Final Year Project we are doing is on testing of this product called “Aquabion” which reduce encrustations in pipes, premature deterioration of plants, damage to machines and finally to the reduction of performance within the production. Causes of this is due to calcium, magnesium and carbonate ions form hard crystalline deposits, the quantity of which increases proportionally to the temperature. In addition, the oxygen contained in the water promotes the corrosion of all equipments and machines.

b. Objectives of Project

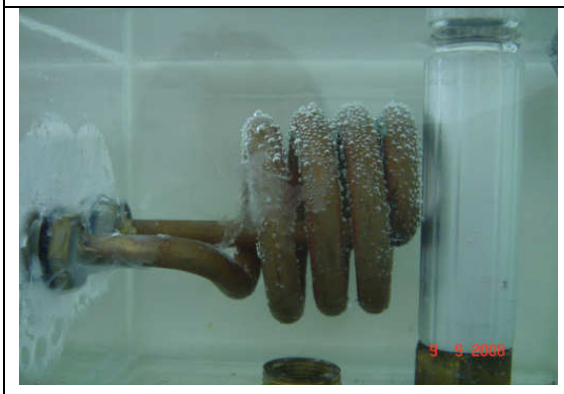
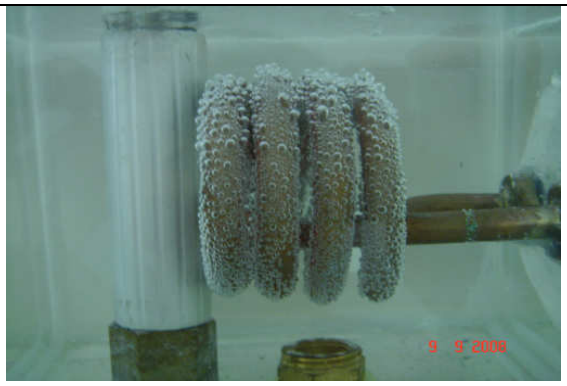
We are to complete the model using water heating coil and carry out testing on the product. From the testing, we will show whether this product will reduce scaling and corrosion on the water heating coil.

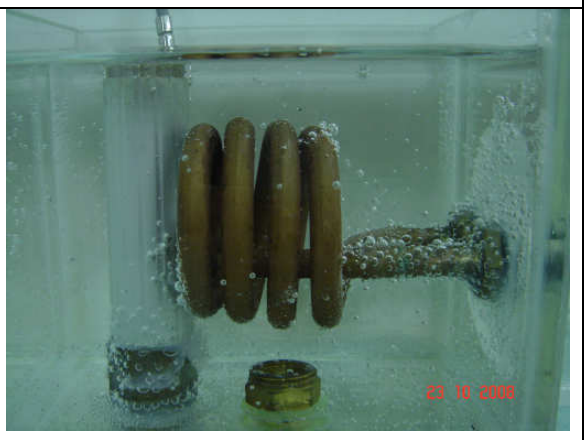
c. Scope of Project

We will do up an hourly report and progress photographs from the results of the testing of the water heating coil. As well as comparison on the difference temperature that affects the rate of scaling. We will be testing the model initially at 50°C and then increase the temperature to 55°C. We also will point out the problems we faced when doing the testing of this product. Also, we find out other products which have the similar way of preventing the coil from scaling but by other means.

Chapter 4

a. Progress Report

Without AquaBion	**With AquaBion**
 Figure 4a.1 – 5th hour	
5th Hour Flow Rate – 0.54 l/minute	5th Hour Flow Rate – 0.60 l/minute
As it is only the 5th hour from the start of running this model, there is no scaling or corrosion form on both of the coil.	
 Figure 4a.2 – 10th hour	
10th Hour Flow Rate – 0.55 l/minute	10th Hour Flow Rate – 0.59 l/minute
After 10 hours of running of the model, there are some slight difference in colour between the coil in without Aquabion and the coil with Aquabion. The coil with Aquabion looks much newer as compared to the coil without Aquabion.	

<table>
<tr><td> 
Figure 4a.3 – 20th hour</td><td>  </td></tr>
<tr><td>20th Hour Flow Rate – 0.53 l/minute</td><td>20th Hour Flow Rate – 0.58 l/minute</td></tr>
<tr><td colspan="2">After 20 hours of running this model, we notice that are some green spots formed on the coil without Aquabion while the coil with Aquabion still look as good as new.</td></tr>
<tr><td> 
Figure 4a.4 – 30th hour</td><td>  </td></tr>
<tr><td>30th Hour Flow Rate – 0.51 l/minute</td><td>30th Hour Flow Rate – 0.55 l/minute</td></tr>
<tr><td colspan="2">After 30 hours of running, the coil without Aquabion, its colour is darken as compare to the coil with Aquabion which look shiny.</td></tr>
</table>

<table>
<tr><td> 

Figure 4a.5 – 40th hour</td><td> 
</td></tr>
<tr><td>40th Hour Flow Rate – 0.54 l/minute</td><td>40th Hour Flow Rate – 0.61 l/minute</td></tr>
<tr><td colspan="2">After 40 hours of running this model, the green spot have grown bigger patch on the surface of the coil which is very obvious as compared to previous photo, while the coil with Aquabion just turned darken in its colour.</td></tr>
<tr><td> 

Figure 4a.6 – 50th hour</td><td> 
</td></tr>
<tr><td>50th Hour Flow Rate – 0.52 l/minute</td><td>50th Hour Flow Rate – 0.57 l/minute</td></tr>
<tr><td colspan="2">There are more green spots appears on the coil without Aquabion now while the coil with Aquabion started to form some green spots.</td></tr>
</table>

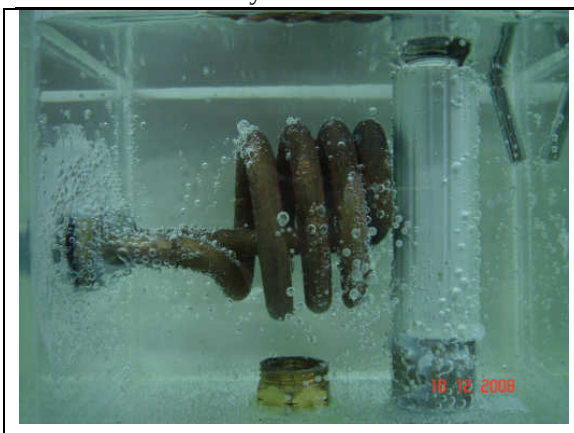
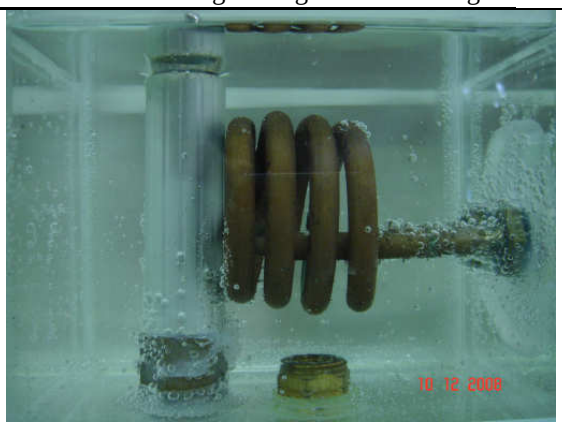


Figure 4a.7 – 60th hour



60th Hour Flow Rate – 0.54 l/minute	60th Hour Flow Rate – 0.55 l/minute

The coil without Aquabion started to corrode and scaling continue to grow. The coil with aquabion still remain with some green spot. The temperature is raise to 55°C.

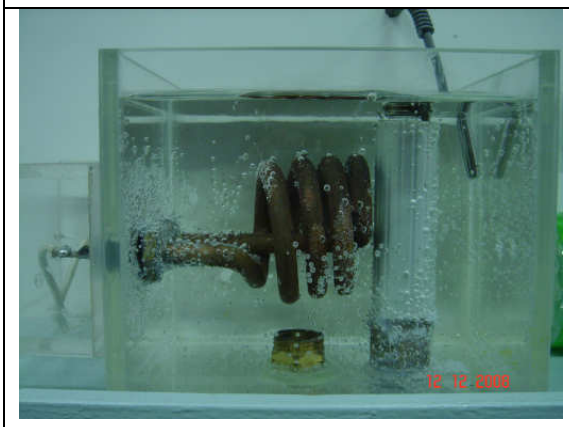
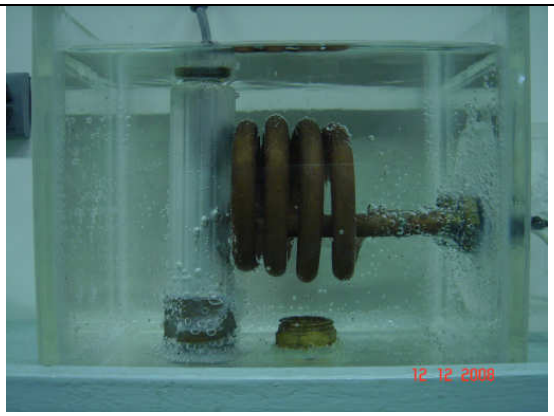


Figure 4a.8 – 70th hour



70th Hour Flow Rate – 0.53 l/minute	70th Hour Flow Rate – 0.56 l/minute

The green spot formed on the coil without Aquabion started to turn into dark brown while the coil with Aquabion started to corrode slightly.

 Figure 4a.9 – 80th hour	
80th Hour Flow Rate – 0.55 l/minute	80th Hour Flow Rate – 0.54 l/minute
As show in the picture, the coil without Aquabion has show signs of scaling and corrosion and the whole coil were darken and dull in colour. While comparing with the coil protected by Aquabion, it is much cleaner, and the whole coil is still brightly coloured.	

b. Literature

Problem inherent to water contaminants

There are five types of cooling water problem encountered in cooling tower system. These are: scale formation, corrosion, organic growth, suspended matter and oil leakage. Different types of treatment have been use with various degrees of success. Treatment such as addition of chemical inhibitors and uses of alloy tubes. Usually it is a more expensive way of solving the problem.

Due to evaporation, salts contained in the water tend to concentrate and cause scale in the system. The scale tendency of water can be controlled by an appropriate blowdown to lower the salts content. Oxygen, carbon dioxide and various chemical used to reduce scale can lead to corrosion.

Corrosion within the tower itself is due to mainly existing of air, humidity and temperature. Scaling and corrosion are related to one another. Corrosion is simply oxidation of metal forming iron oxide by galvanic action. Rate of corrosion is faster at a higher oxygen level. Therefore, increasing pH to decrease corrosion but the pH increased causes scaling

The principal of scaling is formed by calcium carbonate and is formed by the decomposition of calcium bicarbonate. The alkalinity, dissolved and pH determine the scaling characteristics. Decreasing the pH by addition of acid will decrease the scaling with limit. Corrosion is less of a problem in non-recycle water system, where oxygen content is relatively low. Similarly, scaling is less of a problem compare with recycle case. In recycle system, the water is reaerated in cooling water, which makes it more aggressive from a standpoint of corrosion.

The scale formed under moderate temperature is usually due to temporary (bicarbonate) hardness being converted into calcium carbonate, which occurs on heating or increase in alkalinity sufficient to result in calcium carbonate saturation. The solubility of calcium carbonate also affects the corrosion since the alkalinity of dissolved carbon dioxide in the water is greatly reduced as the saturation equilibrium is approached. Ideally, at equilibrium the various form of carbon dioxide are balanced that they cause neither scale nor corrosion.

Pre-treatment of water system

The prevention of scale formation and corrosion is common to all heat transfer equipment, not just cooling towers. The need for protecting metal surfaces against

corrosion in cooling water system is therefore essential to achieve maximum system efficiency and equipment life.

Effective corrosion control programs are essential to reduce the unit downtimes. Such programs must address to not just specific corrosion problems, but anticipate and prevent them as well.

In dealing with metal water cooling systems, today's trend is towards the use of nonchromate-based treatment chemicals. Nonchromate applications rely on less tenacious films for corrosion protection, rather than conventional chromate systems. Pre-treatment conditions must be conducive to the rapid formation of the protective barrier. The conditioning procedure should involve the cleaning and preparation of metal surfaces and the actual application of higher than normal inhibitor concentrations.

There are several procedures that can be employed to clean metal surfaces. Common techniques include hydroblasting, treatment with a mild inhibited acid cleaner or alkaline cleaner and the use of special surfactants during cleansing. The system must be flushed thoroughly after the cleaning stage to minimize undue metal attack by residual concentrations of cleaning chemicals.

Chemical passivation should be started as soon as possible after the cleaning of metal surfaces. Accumulation of new corrosion products can occur if it is not initiated soon after cleaning. It can be achieved by treating the equipment either on or offline.

Online passivation involves elevating the corrosion inhibitor concentration as high as three times normal maintenance levels. At higher concentrations, the rate at which the protective film forms is accelerated. This reduces the degree of initial corrosion on clean but unprotected metal surfaces. The rate at which the corrosion protection takes place depends on the temperature, pH and inhibitor used.

Offline passivation involves treatment of equipment currently out of service. Treatment levels are typically higher; consequently, passivation is completed more quickly. Passivation of nonchromate treatment generally uses either a polyphosphate, zinc, molybdate or other nonchromate-based inhibitor in combination with various surface-active cleaning agents. The passivation solution should be disposed off after the pre-treatment stage, rather than dumped back into the cooling system as it is potential for fouling to exist due to the precipitation of pre-treatment compounds such as zinc or phosphate.

The first methods of cooling tower corrosion control involved adding several hundred parts per million of sodium chromate, as chromate is capable of excellent anodic corrosion control at these dosages. However it is an inefficient and expensive early program of treatment. The advent of synergized zinc chromate-polyphosphate treatments not only made corrosion control more effective, but also lowered its cost. Excellent corrosion control requires only 30-60 ppm (parts per million) of inhibitor, instead of a concentration one to two orders of magnitude higher.

Polyphosphates are also used in cooling systems to attain sufficient corrosion control. Cooling towers are operated in a pH range of 6.0 to 7.5 to provide optimum stability

for the polyphosphate. The feasibility of cooling tower operation at higher pH levels, in which the potential for corrosion is decreased, has increased the popularity of low-chromate programs.

Corrosion Detection

Corrosion detection plays an important role in any corrosion control. Most of the methods employ non-destructive test methods and include: hydrogen evaluation, radiography, dynamic pressure, corrosion probes, stain gauges and eddy current measurements. Of these, the methods employed in cooling tower practice are hydrogen evaluation and corrosion probes.

Hydrogen evaluation is used to detect corrosion in closed systems at low or slightly elevated temperatures in aqueous environments. Sensitive detectors are available to detect the presence of the hydrogen, which is a by-product of the most aqueous corrosion process. This method cannot locate the corrosion but can predict the approximate total corrosion rate.

Corrosion probes detect and measure the amount of corrosion occurring at a given point in a system and can be used to estimate the total amount of corrosion and the types of corrosion. Probes are available for use in a wide variety of temperature and pressure condition.

Chemical treating agent and uses

Chemical and common name	Water treatment use
Inorganic chromate salts	Corrosion control
Inorganic and organic Phosphates and polyphosphates	Scaling and corrosion control
Chromate and phosphate Combination treatment	Corrosion control
Lignin and tannin organic	Scaling and corrosion control
Chlorine and chlorinated phenols	Algae and bacterial slime
Quaternary ammonium copper complexes	Algae and bacterial control
Sulfuric acid	Solubility control

Table 4b.1 - Chemical treating agent and uses

Chapter 5

Discussion

Problems faced in the industry

Scale and corrosion have always been a huge problem for industry increasing their production costs. The calcium, magnesium and carbonate ions form hard crystalline deposits, the quantity of which increases proportionally to the temperature. This leads to encrustations in pipes, premature deterioration of plants, damage to machines and finally to the reduction of performance within the production. In addition, the oxygen contained in the water promotes the corrosion of all equipments and machines by means of oxidation in metals. Which cause an adverse effect on its efficiency in heat transfer, thus replacement have to be made frequently in order not

to waste too much energy for the same amount of efficiency of heat transfer. All these involve cost to the industry which is one of the major factor to them.

Usual solution of the cause

Coolant circulation systems/cooling towers must be chemically treated and cleaned, consuming time and money. Thermostat systems and pipe heat exchangers must be chemically cleaned and/or the plates must be changed on plate heat exchangers. Convectomats develop scale at high temperatures. Vacuum and centrifugal pumps develop scale and suffer from markedly reduced operating lives. Scale and corrosion products build up in piping, causing breakages in the pipes and possible flooding. Shower heads, toilet systems, washing systems, warm water boilers and fittings build up scale which must be regularly maintained or replaced.

Advantage of using Aquabion (AB)

No movable parts, do not require external energy, and is completely free from maintenance during its lifetime. AquaBion works with reliable performance stability in flowing water depending on important water parameters. AquaBion removes nutrients from the circulating water even by reducing the use of hardness stabilisers (phosphates) - causing a reliable reduction in the formation of algae. AquaBion saves on chemical additives and maintenance costs and reduces overall production costs.

What is AquaBion

Figure 5.1 – Aquabion

Zinc Anode

The zinc anode functions as a galvanic element, different cell voltages occur depending on the water parameters. These lead to structural changes in scale the particles carried along the water.

Eddy Body

2 Eddy bodies made of "Nirosta" are placed upstream and downstream, respectively of the zinc anode, which caused the particles carried along to whirl up. By this, the zinc anode is kept free of scale deposits and the desired treatment is increased.

How it works

The AquaBion works upon the galvanic principle of a sacrificial zinc anode, which goes into solution. The galvanic element builds up a potential corresponding to the water parameter. It causes the agglomeration of water constituents around the deposited Zn ion (crystallization particle). The agglomeration of the hardening components also promotes growth of crstals. These results in more particles, which agglomerates with other deposited products. According to the laws of hydrodynamics, these particles offer a larger surface area to attack & are then flushed away with the water. These agglomerates will not adhere to the pipe surfaces.

Problem we faced during setting up of the model

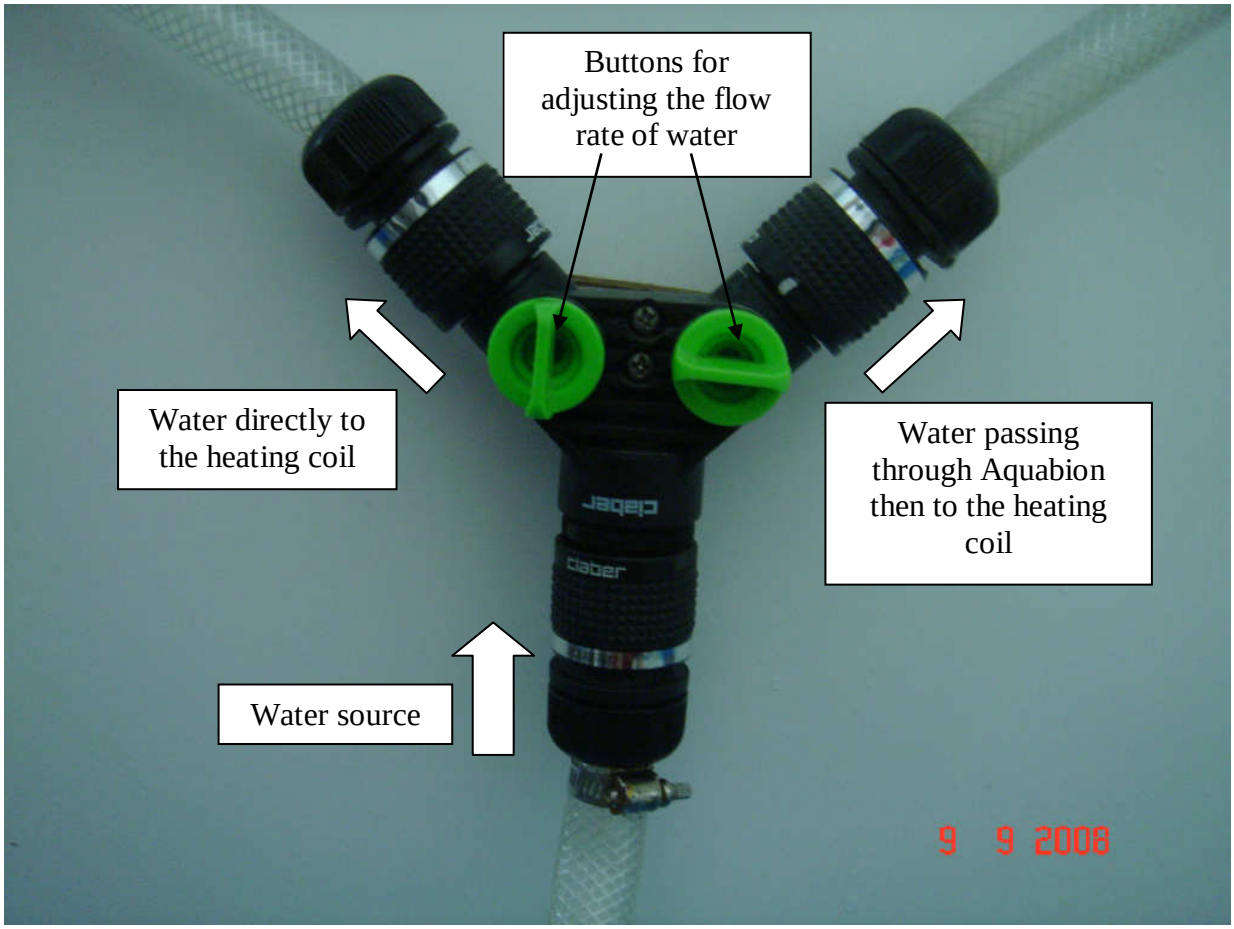


Figure 5.2 – Problem 1

From the main water source the water enters through a tube and then split into two directions by using the Y split junction tube as you can see from the picture above. Left tube goes directly to the heating coil without AquaBion installed while the right tube goes through the AquaBion before reaching the heating coil. In order to get the same flow rate, we have to adjust the two green buttons as shown on the picture. It is not possible to get the same flow rate as the button is very sensitive. Every slightest adjustment results in a major difference in the flow rate. We have to spend at least 10 to 20 min each time in order to get the flow rate as close as possible. We use a stop watch and two 500ml measuring cylinder to time the rate of water every 1 min.

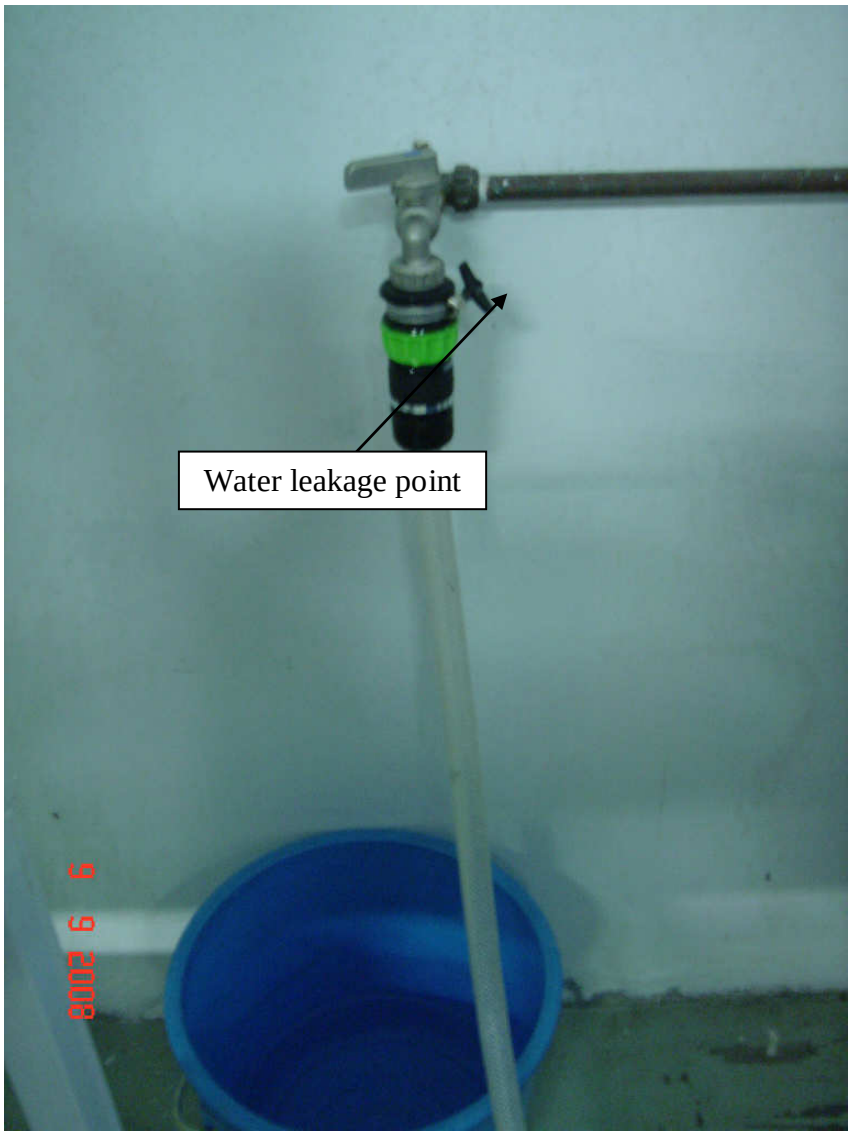


Figure 5.3 – Problem 2

The next problem we faced was from the main water source. No matter how tight we fix the water hose to it, it tends to leak. Because of that, we need to place a pail under water main. The cause of it was due to resistance from the Y split point towards the heating coil as both of the valves are not fully opened, thus, the water usually backflow to the water main and seep out through the gap in the hose and the water main.

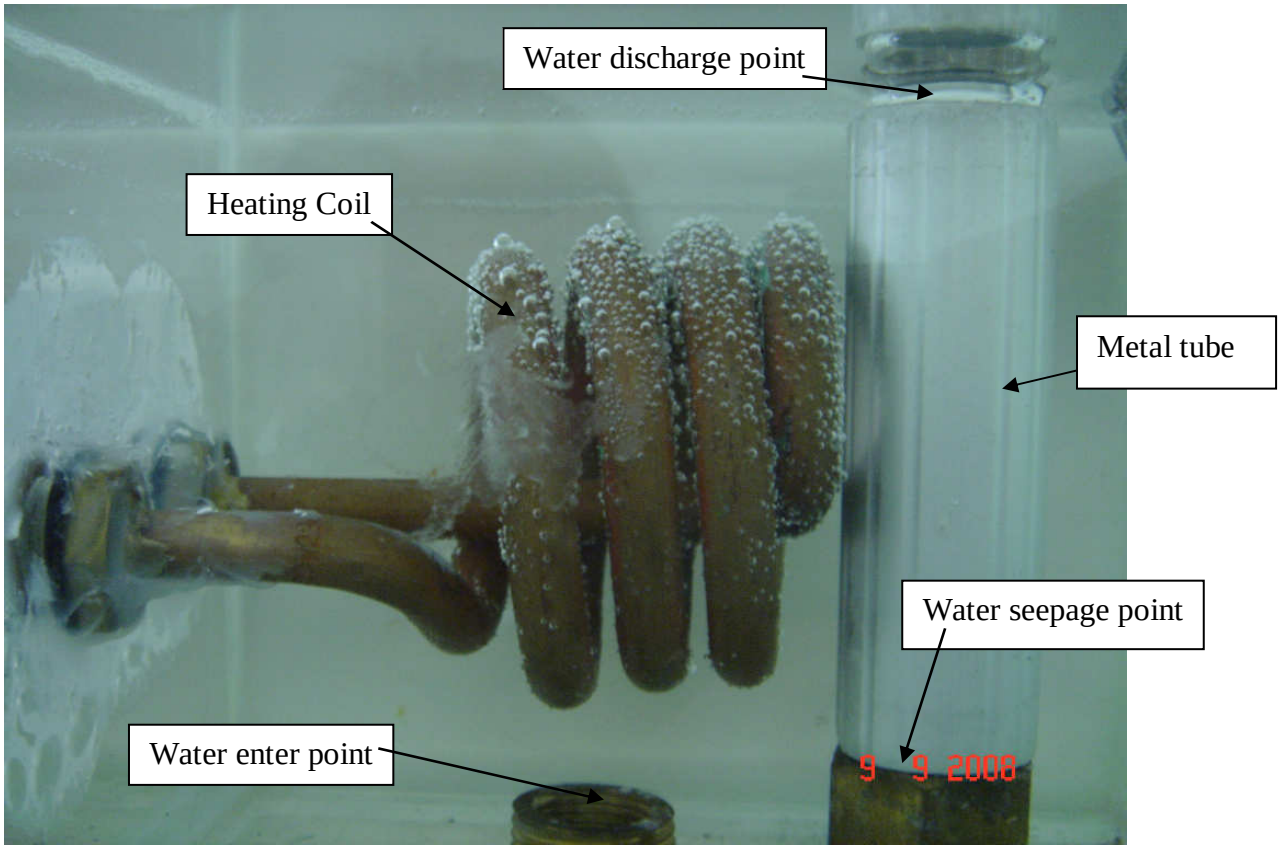


Figure 5.4 – Problem 3

Thirdly, the metal tube in the water container which discharges the water out is not properly secured. Because of it, the water flow rate is also affect by this water that seeped out almost immediately upon entering the container. As such, the water is continuously heated in the water container without being displaced by new water supply due to the convention current. This affects our reading as the water temperature will be kept high temperature as our temperature sensor was placed at

the top of the water container. We had solved this problem by securing the metal tube using silicon sealant.

Chapter 6

Research 1

DHF Anti-corrosion treatment and coating

Polyethylene is for mainly internal corrosion protection of liquid transmission line such as sea water line, drink water line, and chemical solution line. It is done by coating a layer of polyethylene on the coil surface. DHF's polyethylene coating pipe is stable against corrosion. Coating is done so as to protect the pipe outside surface from corrosion.

Figure 6.1 – DHF Anti-corrosion treatment and coating

Research 2

Siemens Water technology

Scale and corrosion are usually made up of solids and sediments that collect on or in the distribution system piping and storage reservoirs. It consist of corrosion such as manganese oxides, aluminium hydroxide, and calcium carbonate, as well as solids that carry over from water treatment plants.

Scale and corrosion deposits serve as sites for adsorption or co-precipitation and mineral growth for certain contaminants, such as arsenic, radium, and vanadium. So any changes in water chemistry or any physical disturbances to distribution system materials can result in the re-release of the contaminants into our water supply, sometimes in elevated amounts. When this happens, dangerous contaminant levels can end up at our taps.

Siemens Water Technologies offers a number of products that help municipal water plants control scale and corrosion: Pumps, Filters, Feeders and Chemical Addition Systems.

Siemens also provides treatment systems and analytical testing to document the efficacy of treatment prior to installation. We also provide parts and service on all of our equipment, as well as equipment which may have been provided by other manufacturers.

Research 3

InspectAPedia

When a heating boiler uses a coil that does not required water tank to produce domestic hot water, a third single-function control may be installed for that purpose. In this photo a Honeywell limit control switch is being used to monitor hot water temperature at the tankless coil which is in turn mounted on a steam boiler of an older home in Portland, Maine. The black-handled mixing valve in the lower right of this photo.

Cold water from the building is entering the coil via the bottom pipe and hot water, heated by the coil is leaving at the upper part of the coil, where it turns downwards to enter the left side of the mixing valve.

Additional cold water is allows to enter the bottom of the mixing valve, and tempered (non-scalding) hot water then leaves at the right side of the mixing valve in this photo.

In this picture of a more traditional single-function heating boiler limit control, the limit switch is being used on a coil, and in the enlarged version of the photo you'll see that the temperature limit on the control is set to about 140 degF. Below we show a sketch that explains how an anti-scald valve or tempering valve actually works.

Figure 6.2 – InspectAPedia

Research 4

Suprion-scale-prevention

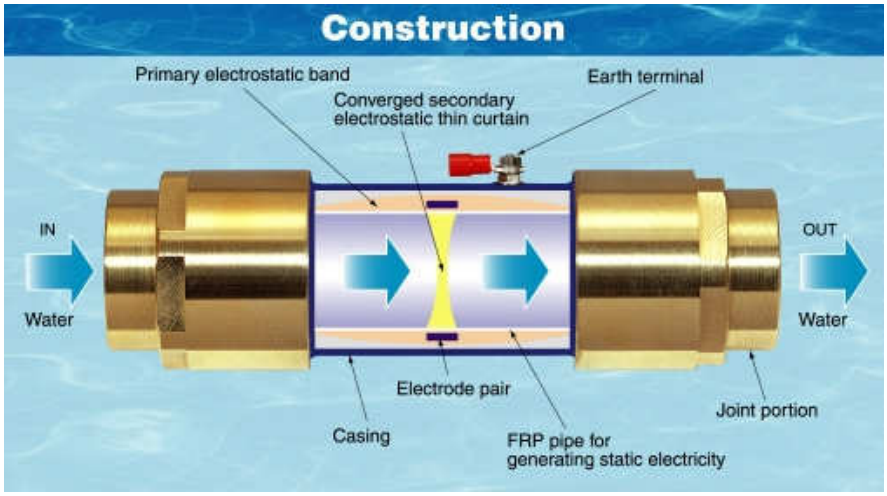


Figure 6.3 – Suprion-scale-prevention

Plastic pipe (Epoxy FRP)

The plastic pipe is smooth inside, and so does not impede the flow of water. However, there is enough friction to generate static electricity. The Epoxy FRP has excellent resistance to corrosion and pressure, and no harmful substances leach into the water.

Electrodes

The Suprion contain two electrodes, one carbon, and the other aluminium. The Suprion's electrodes are outside the plastic pipe, and do not come into contact with the water. This prevents corrosion of the electrodes, a significant problem with other devices.

Casing

The metal casing completely encloses the electrodes and the plastic pipe, creating an impermeable seal.

Joints

Suprion devices designed for smaller pipes up to 40mm (1½"), are fitted with screw or olive couplings. The larger Suprion models from 50mm (2") to 450mm (18"), are flanged and supplied with the corresponding welding flanges.

Earth terminal

When a Suprion is connected to metal pipework at one or both ends, it does not need to be grounded to earth. For installations where both ends are connected to plastic pipe, a Class 3 Earth Terminal is provided. The earth terminal is located towards the downstream end, aiding correct installation if the flow arrow label is missing or illegible.

Research 5

Aquaflow

Suprion is a directional device indicated by the “IN”, “OUT” and arrow markings on the identification plate. Optimum performance can be guaranteed when the Suprion unit is installed with proper orientation and specialist.

Suprion units have an earth terminal located toward the “OUT” end of the device (if for any reason the directional markings on the identification plate are obscured, the terminal can be used as a directional guide). This terminal have to be properly earthed (grounded) when the Suprion unit is installed in a plastic or non-earthed pipeline. The earth terminal can be left unconnected if the pipeline is metal and earthed.

For best results the Suprion unit must be installed in the feed line, as close as possible to the system to be protected.

Operating Advantages, Features and Benefits: "Fit and forget", operator foolproof, self energising, no power supply is required, no magnets is required, no filters is required, does not required any chemicals, no sacrificial electrodes is required, maintenance free thus no addition cost, uninterrupted water flow, not restricted by TDS or Conductivity, not dependent on pressure or flow rate, no release of metals ions into water supply, wide range of sizes, three models specifically designed for "point-of-use" electrical appliances, si model specifically designed for prevention and removal of Silica, WRAS approved for potable applications, ATEX certification, five years warranty, optimum ten year operation with potable water supplies.

Research 6

Water and waste water international

Figure 6.4 – Water and waste water international

Housetron catalytically preventing scaling in houses, flats, condominiums

Scaling caused by limescale in the home can be a real problem and nuisance.

The Housetron catalytic scale prevention system not only saves energy, but also prevents scaling round taps and faucets, in shower heads and on baths. Less washing powder usage and better lather have also been reported. The Housetron is installed on the inlet to the home to be protected. Baths and sanitary ware are easier to clean as well.

Research 7

CALCLEAR

The CALCLEAR water conditioning technology works by changing the mineral crystals in water into tiny particles, thereby offering a treatment that is both prevention and cure for most of the scaling and corrosion problems caused by water in industry, agriculture and in the home.

The CALCLEAR system is unique in combining:

An effective de-scaling and scale prevention system (without the use of chemicals).

An economical supply of softened water (without salt or backflushing).

A water supply with proven growth and health benefits.

"The CALCLEAR system is the most cost effective, environmentally friendly water treatment process available. It is the future of water treatment

Figure 6.5 – Calclear

Research 8

Nalco

Nalco's boiler internal treatment programs eliminate scale on heat transfer surfaces and/or inhibit boiler corrosion. NexGuard® is Nalco's premier internal boiler treatment technology for eliminating boiler scale. NexGuard is an innovative program that combines the most advanced boiler internal treatment chemistry with new TRASAR® Technology plus state-of-the-art diagnostic, monitoring, feed, and control equipment. NexGuard eliminates boiler scale to support higher levels of safety and efficiency, reduced downtime for boiler repair and cleaning, and extended equipment life.

Research 9

EcoLab

Ecolab keeps water-related systems clean by offering unique products and advanced chemical delivery systems to meet the water treatment needs of our customers. It eliminate scaling and corrosion on heating surface. Ecolab's advanced water treatment technology for boilers and cooling water combines state-of-the-art dispensing equipment and unique product technology, which improves safety and reduces waste. Ecolab specialists analyze and maximize the total efficiency of an operation by looking at all cost factors. By balancing these variables, Ecolab keeps systems operating at peak efficiency, and prevents hard-earned dollars from going down the drain through maintenance by mean of clearing.

Chapter 7

Cost implication

Aquabion comes in various sizes to accommodate different pipe size. It ranges from about $1000 to $3000. The life span of the Aquabion is estimated to last up to 5 years base on the hardness of the water. On average, the majority of the size they use cost about $1000.

Initial cost estimated at	$1000
Operating cost	$0
Maintenance cost (Labour at $25/ Month)	$1500
Total cost for 5 Year	$2500
Average monthly cost ($2500/ 60 months)	$41.67

For chemical application, they are usually supply in Volume. For example, Nalco Pte Ltd supplies the chemical in pail of about 25kg. Each kg cost about $15. In total for 25 kg it will cost $325. Based on the volume of the model which we have, it is estimated to last about 1 year. This does not include labour to clean and application.

Initial cost estimated at	$325
Operation cost	$0
Reapplication of chemical (e.g. specialise labour)	$80
Maintenance cost (Labour at $25/ Month)	$300
Total cost for 1 year	$705
Average monthly cost ($705/12 month)	$58.75

Ecolab Pte Ltd supplies the chemical in Litres. Each Litres cost about $9.50. In total for 25 L it will cost $237.50. Based on the volume of the model which we have, it is estimated to last about 1 year. These do not include labour to clean and application.

Initial cost estimated at	$237.50
Operation cost	$0
Reapplication of chemical (e.g specialise labour)	$80
Maintenance cost (Labour at $25/ Month)	$300
Total cost for 1 year	$617.50
Average monthly cost ($617.50/12month)	$51.46

Chapter 8

Compare with other form of method

Chemical application

Usually the common method in Singapore industries is by mean of chemical application. It is done by introducing chemical into the water system. The chemical is then circulating in the system. It is only applicable to recycled water system. After a certain time, it is necessary to reapply the chemical into the system. Before application, cleaning work has carried out to clean the boiler coil. It usually involves manual brushing and scrubbing of the coil to remove the scales formed which means extra labour is needed. Protection to the coil are then need to be carry out immediately to prevent oxidation of the metal boiler coil. If the protection does not carry out immediately, it will cause the clean coil to expose to all the oxygen or other chemical which will cause a reaction to the coil which maybe affects the coil even before protection to the coil is carried out. Thus the protection to the coil would

mean to be of an useless application as the coil had already been affected by the reaction of the oxygen or other chemical that changes the coil which means dropping efficiency of heat transfer in boiler.

Aquabion

With the latest technology from Germany, they come out with a product called Aquabion. It is a device that is connected to the water pipe system to the boiler. It is usually connected at the water inlet point of the pipe system as this device treats the water to prevent scaling of the piping system and the boiler coil itself. It allow water to pass through the pipe with spiral action through the mechanical technology of Aquabion that make sure all the water will be treated before they leave the device. There is no requirement of any magnetic wave or power connection. It can be used in both residential and industries. It only requires to replace it once every 5 year. No extra labours require to carry out clearing of the coil. It can use for treating water for drinking. This device can be incorporated in both recycle water system and once through water system. Available in various sizes to accommodate the consumer needs.

Chapter 9

What makes our product better?

The AquaBion, its flanges and all non-visible materials are carefully selected materials in line with the very latest technology. After many years of experience and long-term tests with the most extreme water parameters and different systems, it has been shown that the galvanic process principle of the new AquaBion system, depending on the conditions of the plant in question, plus the quality of the water can

guarantee a long-term success. In addition, the Aquabion is cost-effective and far more environmentally friendly, because the outflow is not polluted with chemicals and can be reused as industrial water.

- 5 year

  Aquabion can last for as long as 5 year. Only the first time install and worry-free throughout the lifecycle

- 1 time payment

  As the product can last for 5 year, it only required a 1 time payment for every 5 year

- No operation and other cost throughout the lifecycle

  Throughout this 5 year, there is no need to worry about other cost such as daily operation or other cost. As Aquabion do not need to change any internal spare parts.

- Easy and install.

  Aquabion do not need any screwing of parts or gluing to the water pipe

- Come in various standard size

  Aquabion come in different sizes in order to suit for all size of pipes and requirement that will fit for different industries' pipes.

- Cheaper

  As shown in the cost implication, after simple calculation, it is much cheaper to use Aquabion as compare to other product in the market.

- Last longer

  Some commonly use of protection is via introduction of chemical into the water system. Usually after certain time, the effect of the chemical will wear off and require heavier dosage. But Aquabion do not required any re-application; it can last for 5 year before replacing the whole thing as the zinc anode is used up.

- No chemical require thus saving in cost

  No chemical required therefore saving in overall cost and cost for labour for reapplication.

- Latest Germany technology

  Materials are carefully selected materials in line with the very latest technology. Therefore it last much longer

- Reliable performance stability in flowing water

  The internal design is designed so that the water flow in spiral action ensuring all water passes through the zinc anode

Chapter 10

Conclusion

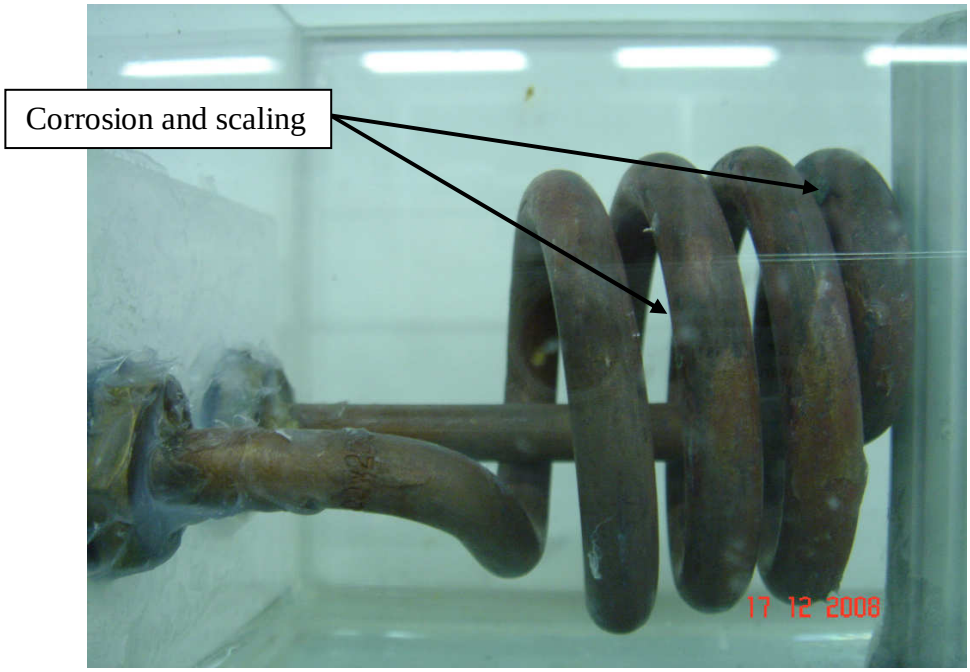


Figure 10.1 – Without Aquabion

After 80th hours of running, the coil is much more obvious. Corrosion and scaling can be seem much more clearer. About 30% of the coil is corroded.

Figure 10.2 – With Aquabion

As compared with the coil not protected by AquaBion, this coil corroded for about 10% at the 80th hours of testing.

Chapter 11

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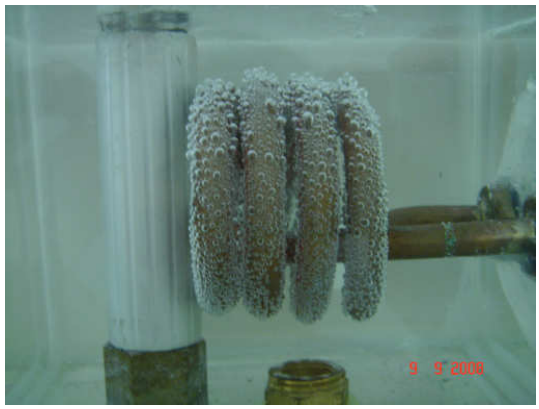
Chapter 12

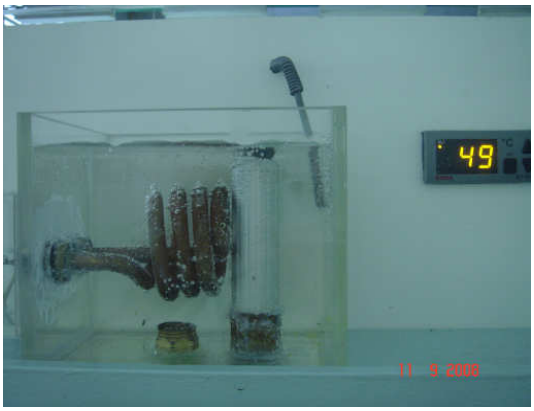
Appendix

1st Hour

2nd Hour



3rd Hour



4th Hour

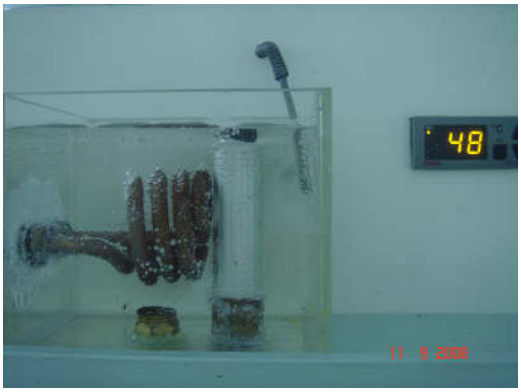


Figure 12.1 – 1st – 4th hour

5th Hour

6th Hour

7th Hour

8th Hour

Figure 12.2 – 5th – 8th hour

9th Hour

10th Hour

11th Hour

12th Hour

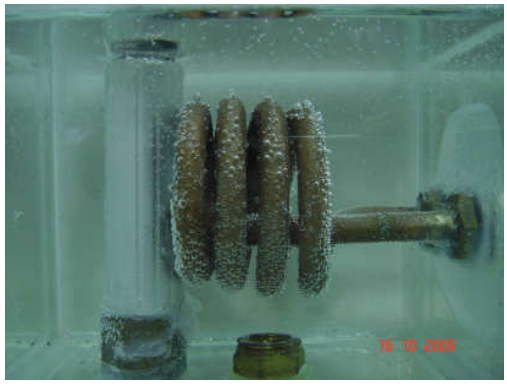
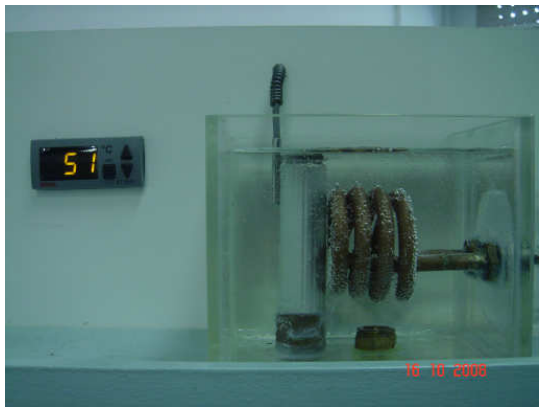
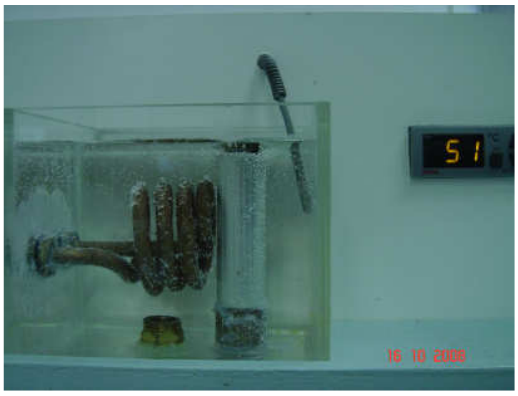
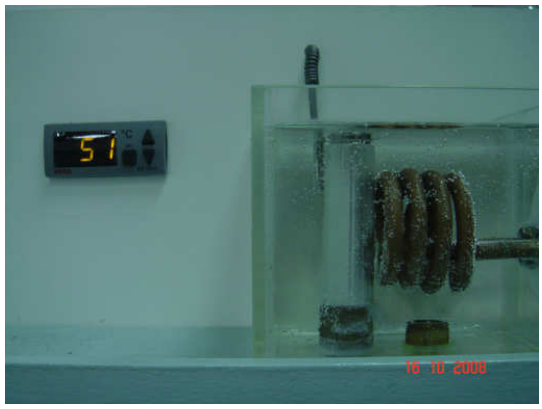


Figure 12.3 – 9th – 12th hour

13th Hour

14th Hour

15th Hour


16th Hour

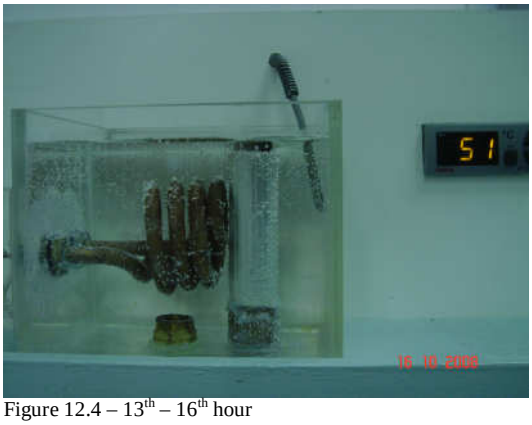
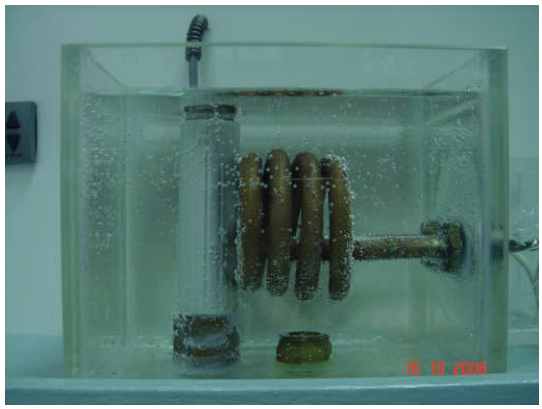
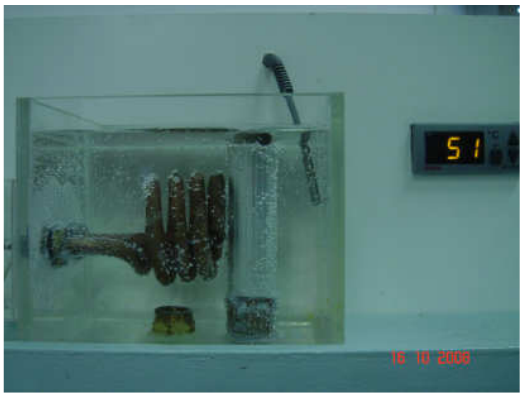
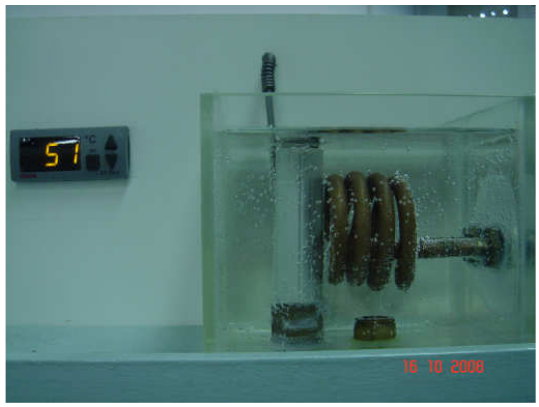



Figure 12.4 – 13th – 16th hour

17th Hour

18th Hour

19th Hour


20th Hour

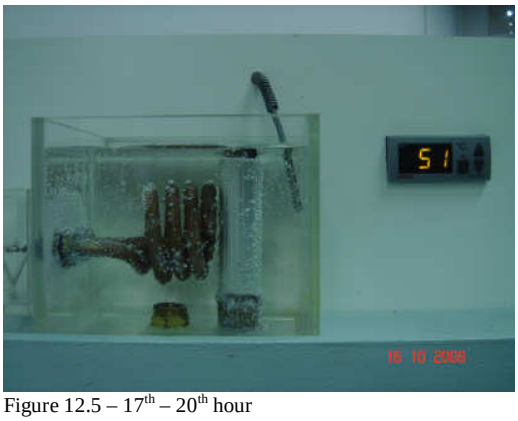
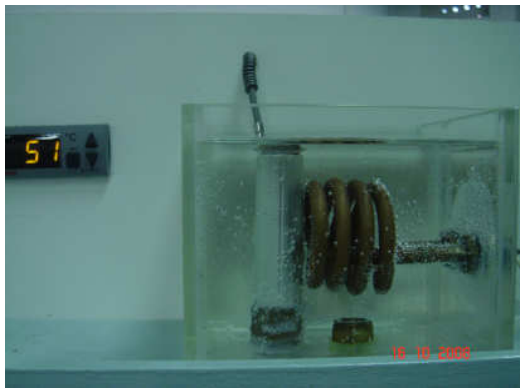


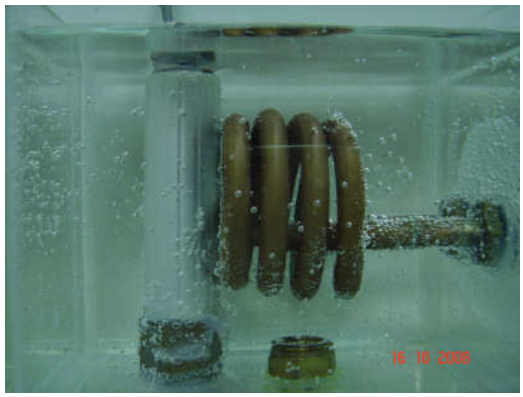

Figure 12.5 – 17th – 20th hour

21st Hour

22nd Hour



23rd Hour



24th Hour

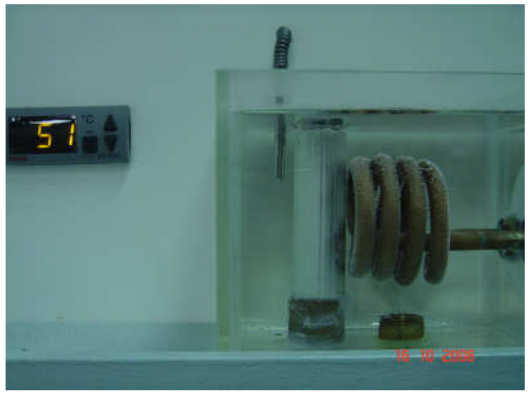
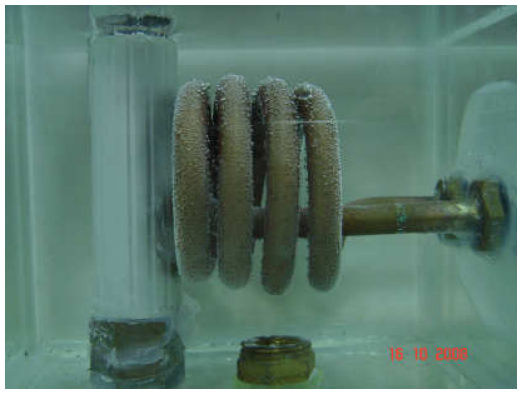


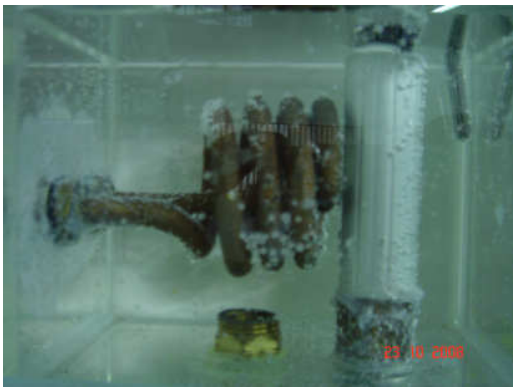
Figure 12.6 – 21st – 24th hour

25th Hour



26th Hour

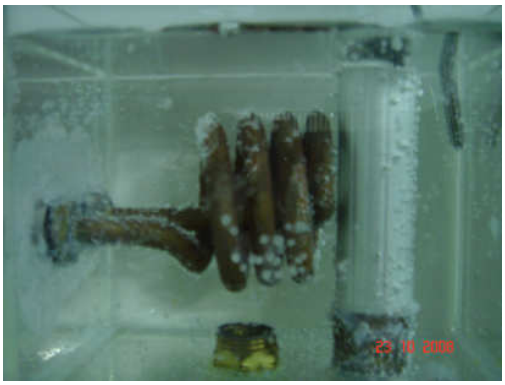
27th Hour



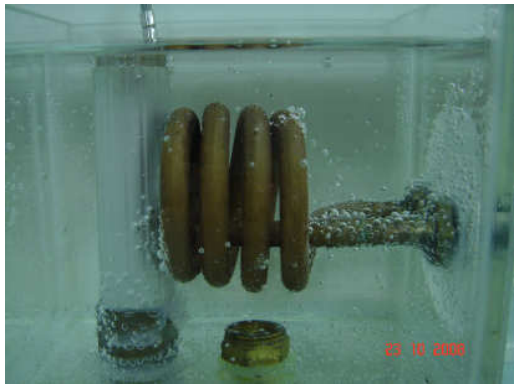
28th Hour

Figure 12.7 – 25th – 28th hour

29th Hour



30th Hour



31st Hour

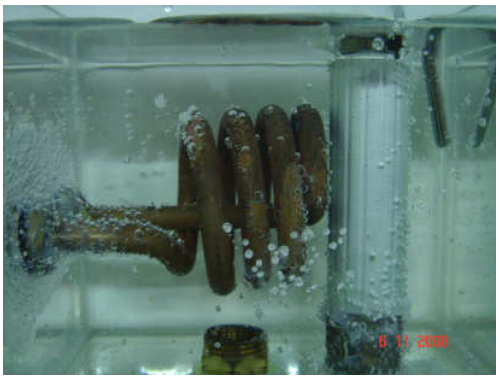
32nd Hour

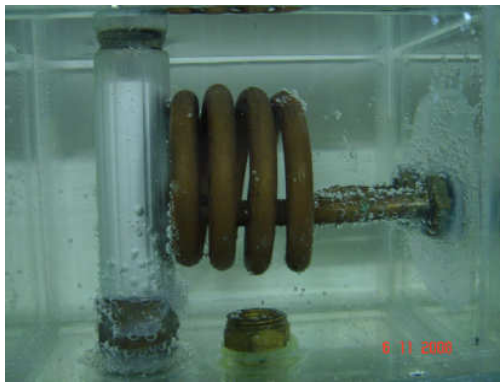
Figure 12.8 – 29th – 32nd hour

33rd Hour

34th Hour

35th Hour





36th Hour

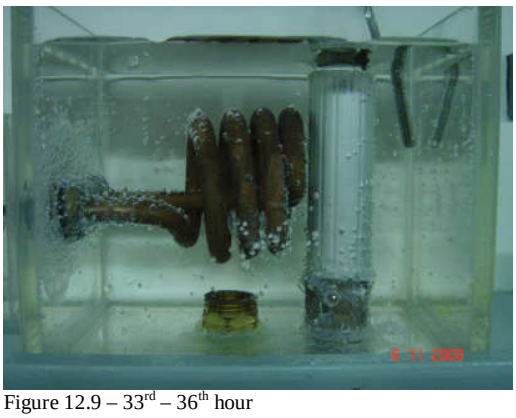
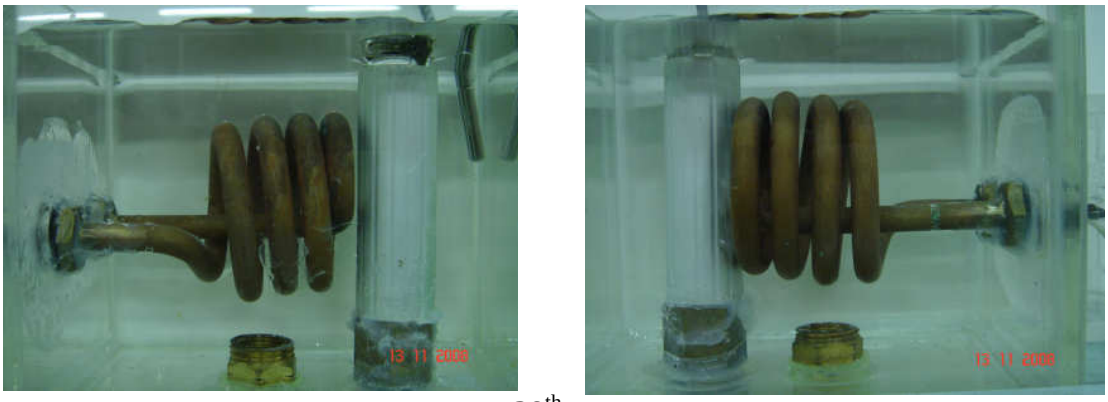


Figure 12.9 – 33rd – 36th hour

37th Hour



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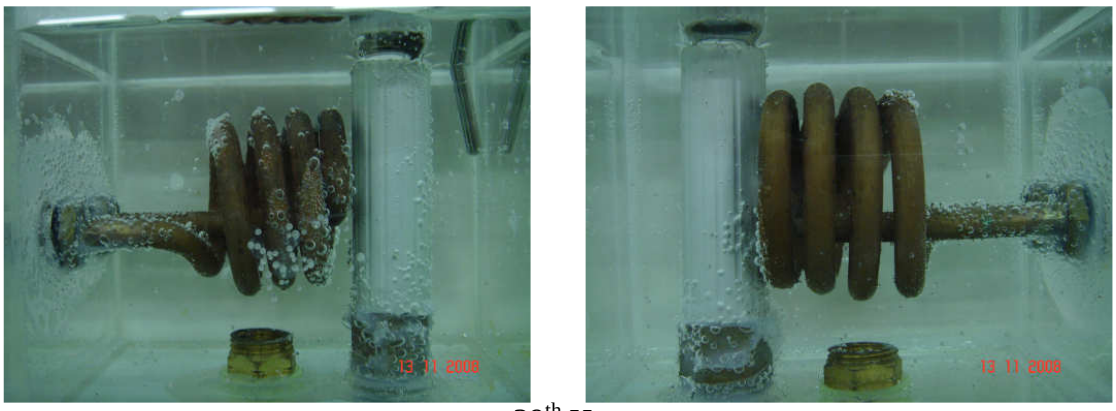

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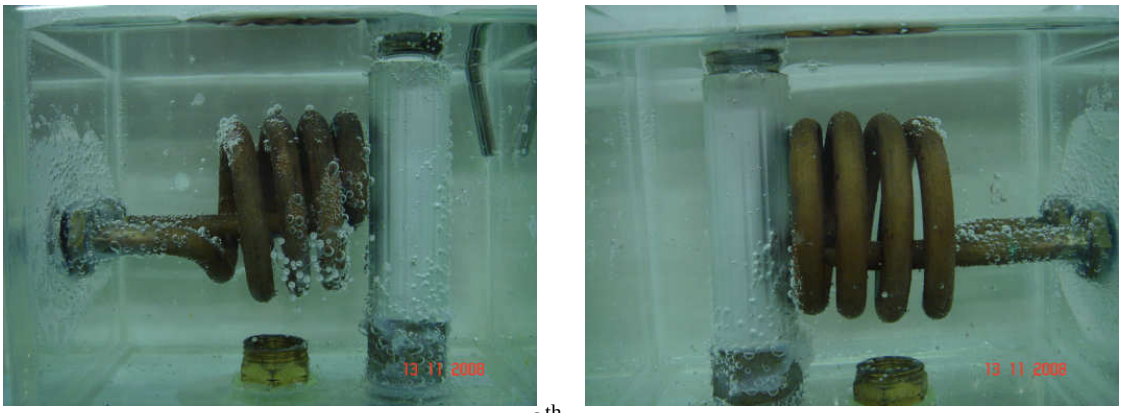


40th Hour

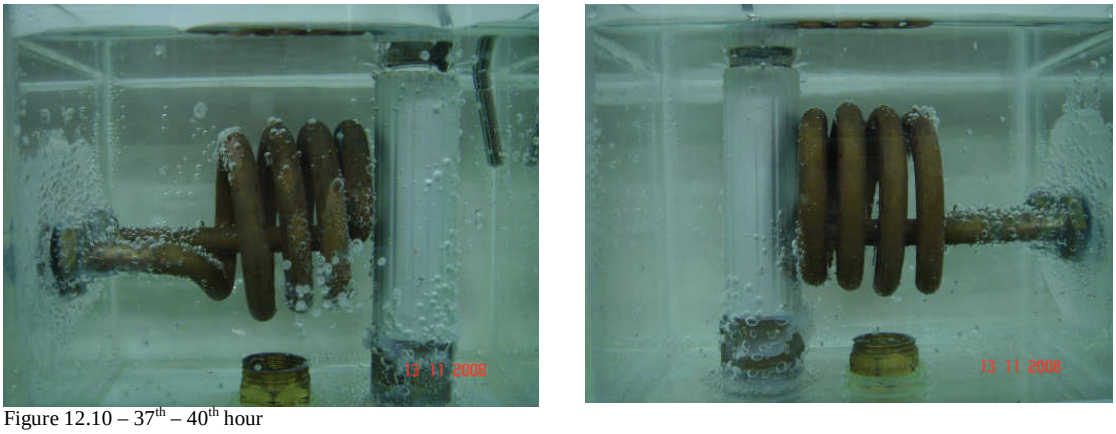
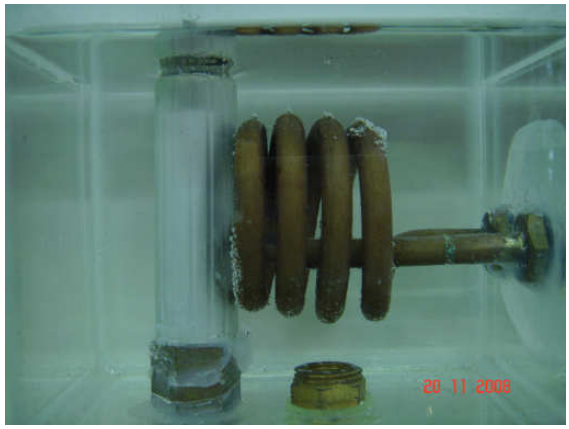


Figure 12.10 – 37th – 40th hour

41st Hour

42nd Hour

43rd Hour



44th Hour

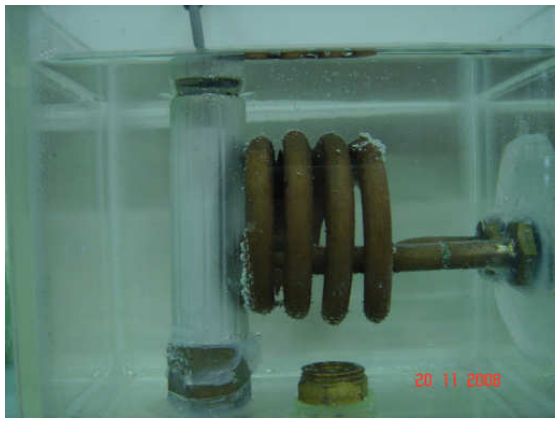
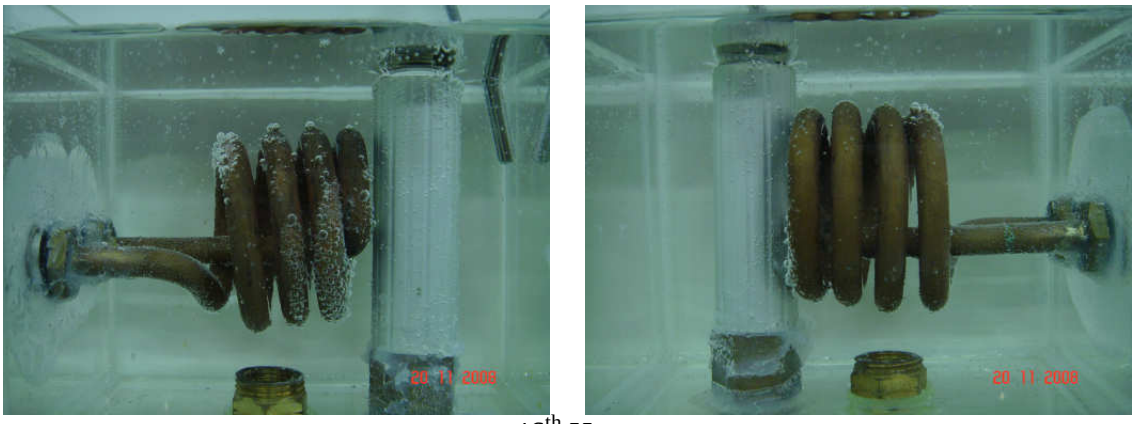


Figure 12.11 – 41st – 44th hour

45th Hour



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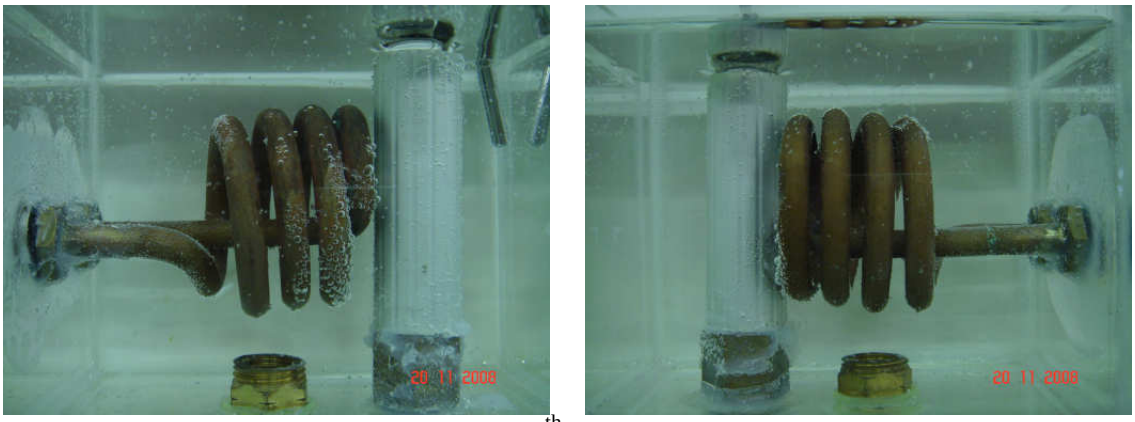
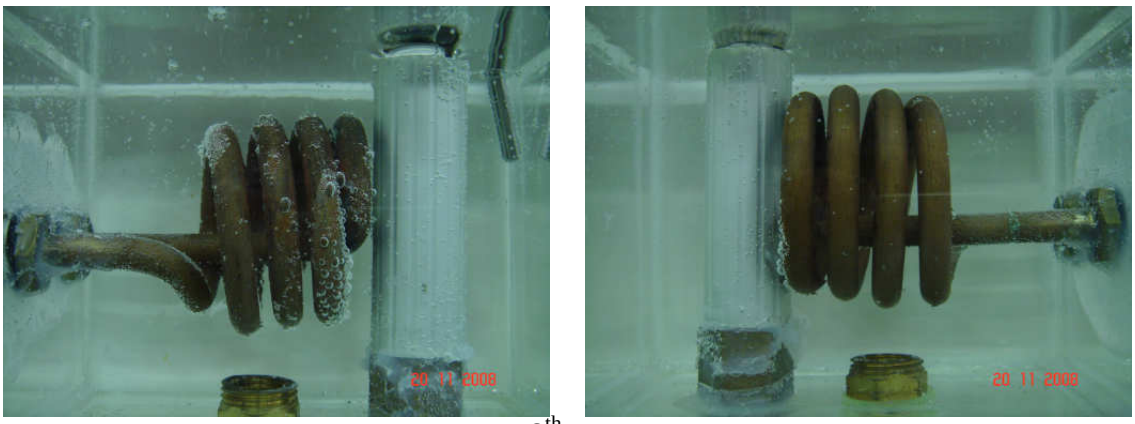


47th Hour



48th Hour

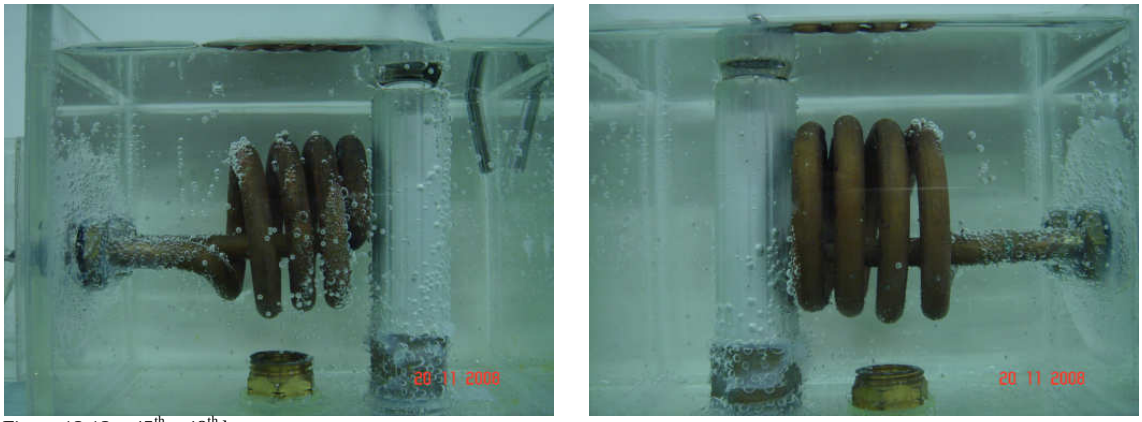
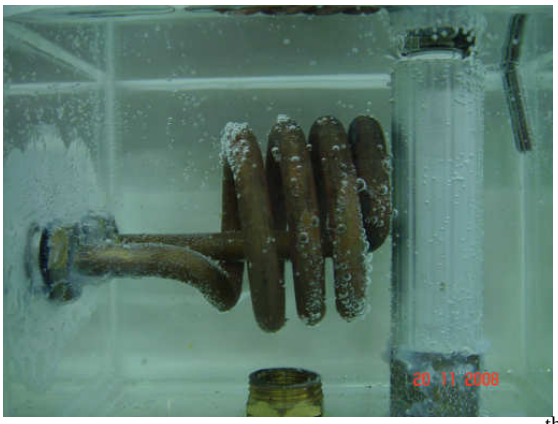
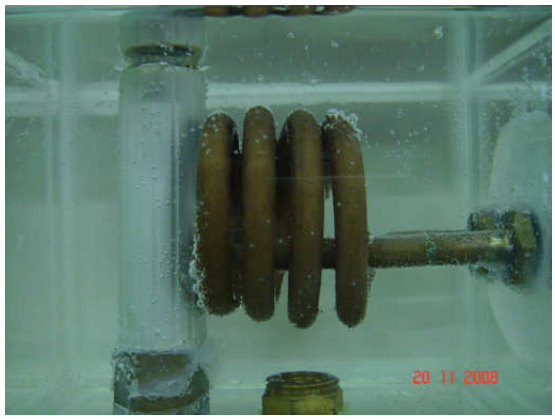


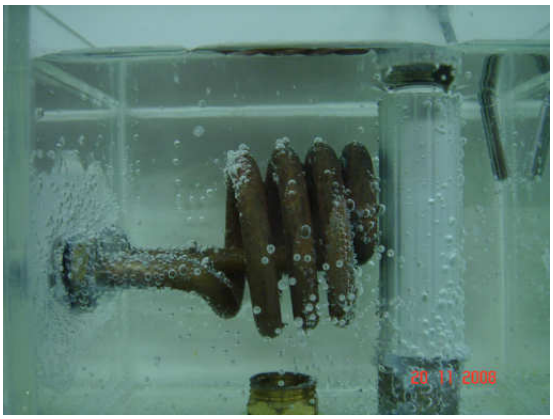
Figure 12.12 – 45th – 48th hour

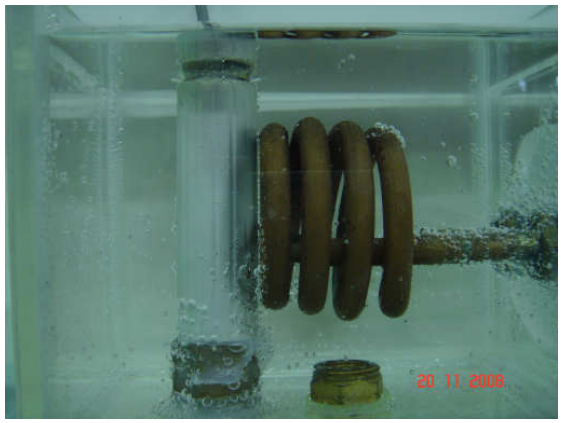
49th Hour





50th Hour



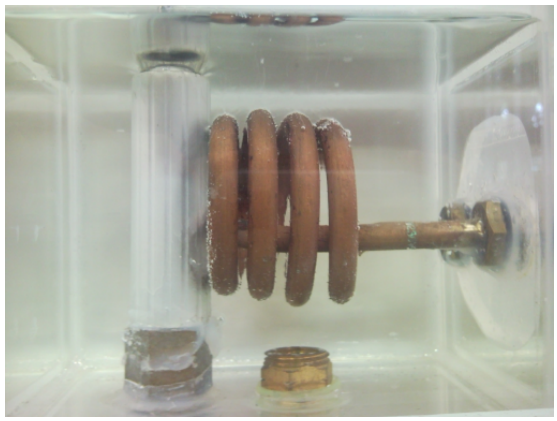


51st Hour

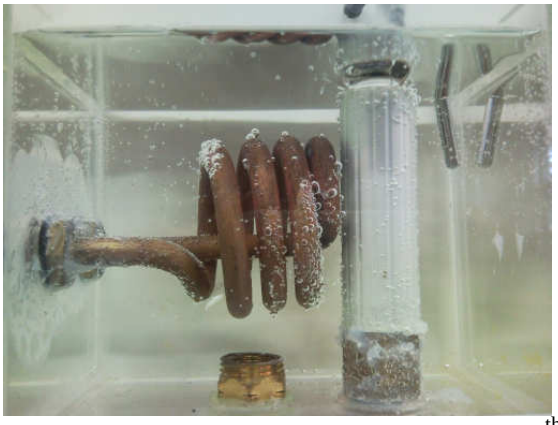
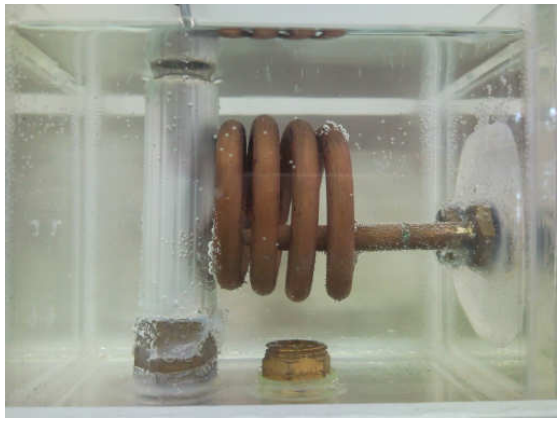
52nd Hour

Figure 12.13 – 49th – 52nd hour

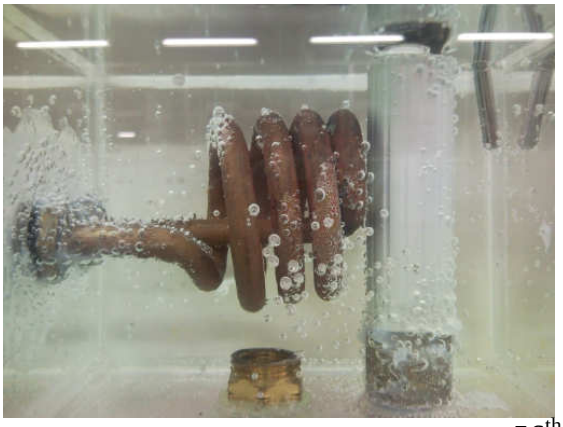
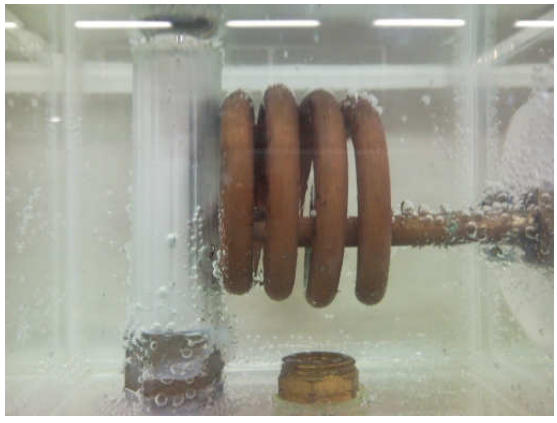
53rd Hour

54th Hour

55th Hour

56th Hour

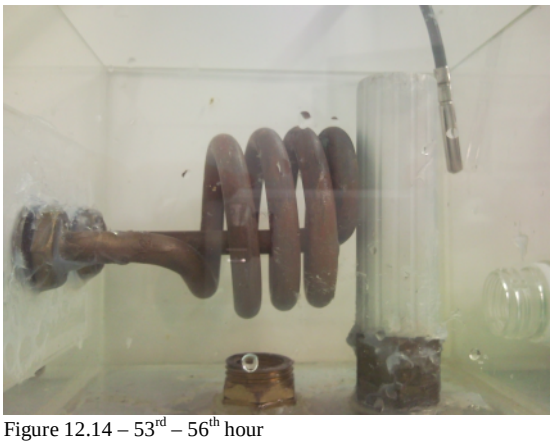
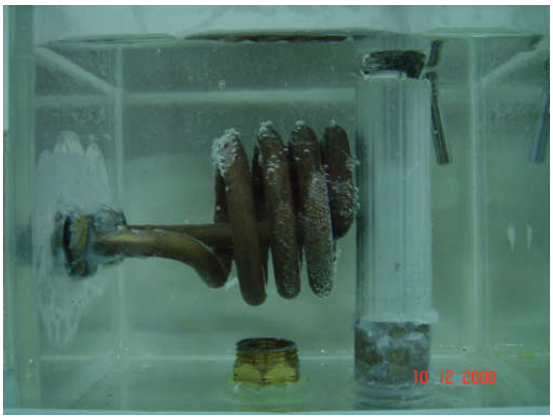
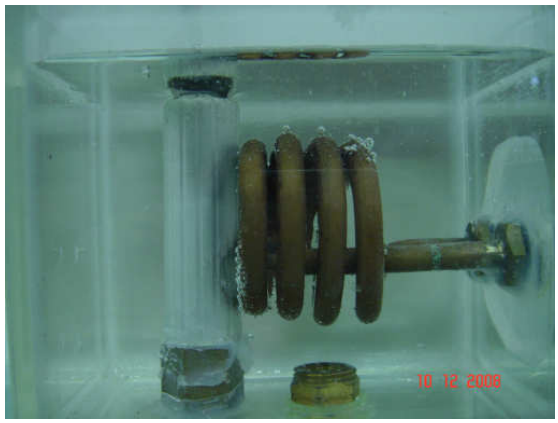
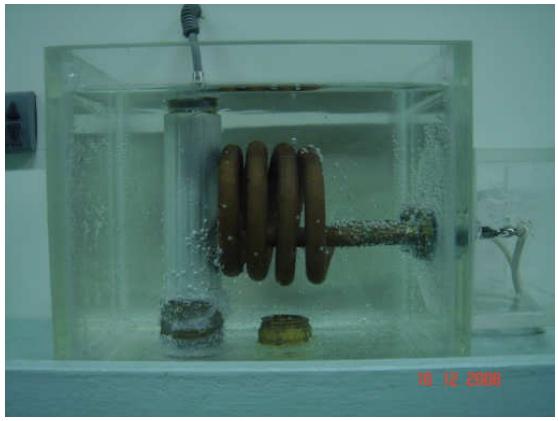



Figure 12.14 – 53rd – 56th hour

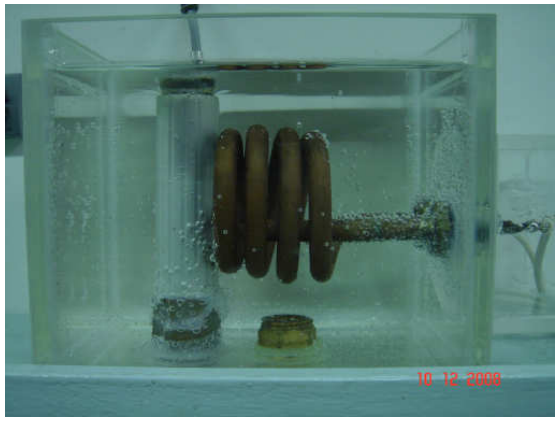
57th Hour

58th Hour

59th Hour

60th Hour

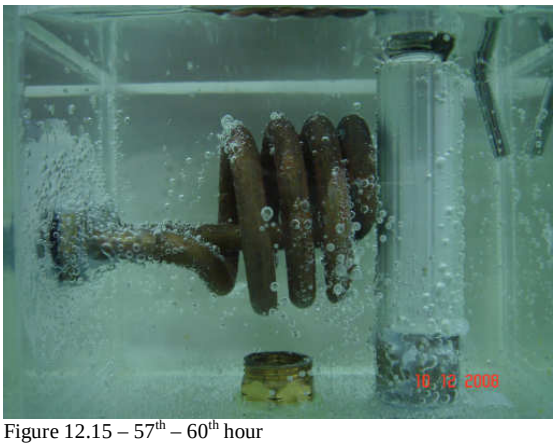
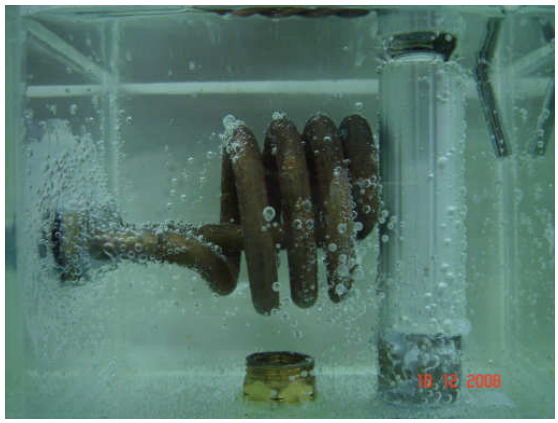
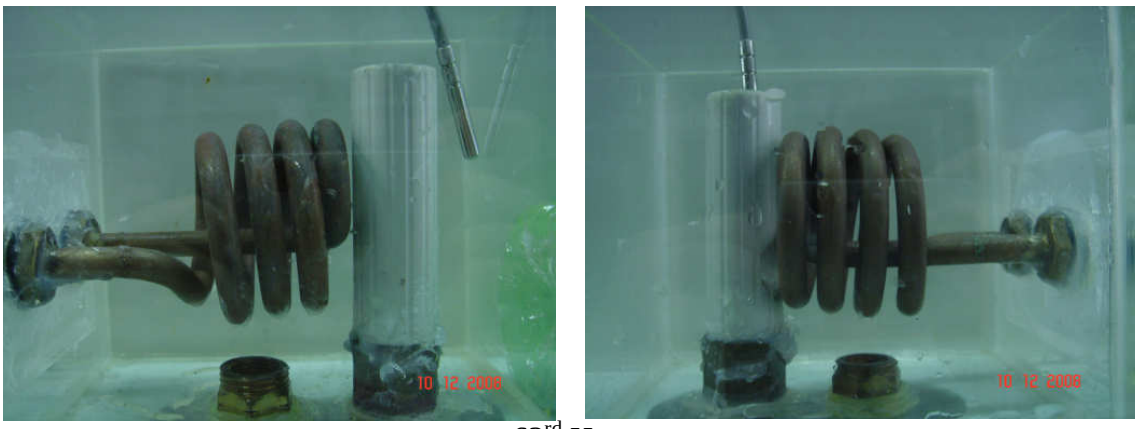



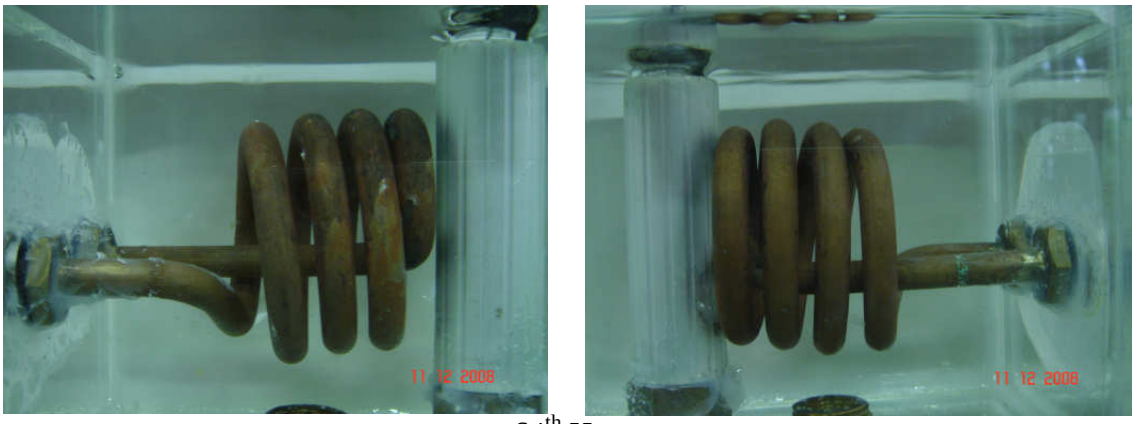
Figure 12.15 – 57th – 60th hour

61st Hour

62nd Hour



63rd Hour



64th Hour

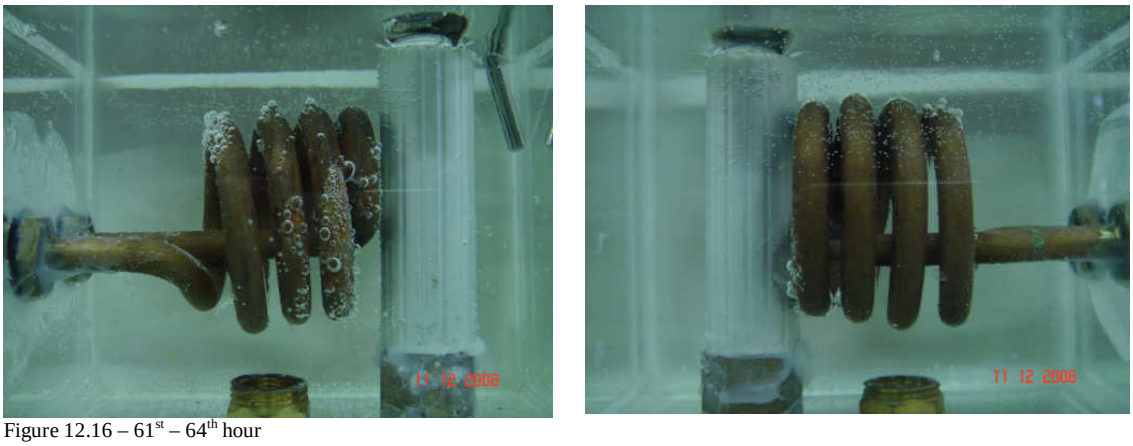
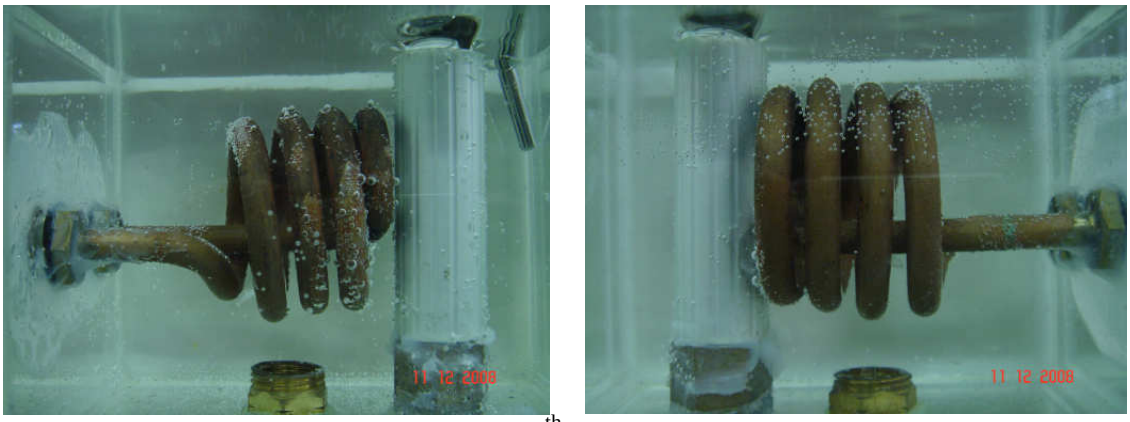
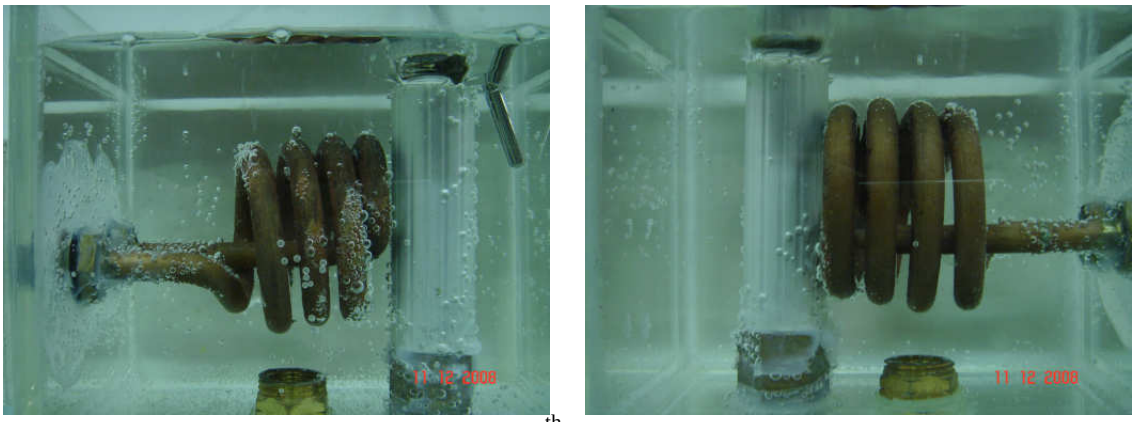


Figure 12.16 – 61st – 64th hour

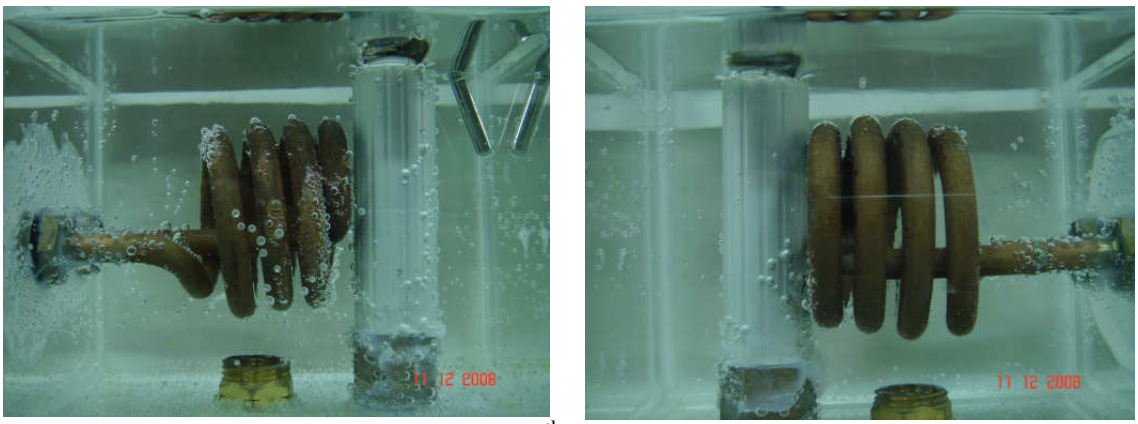
65th Hour



66th Hour



67th Hour



68th Hour

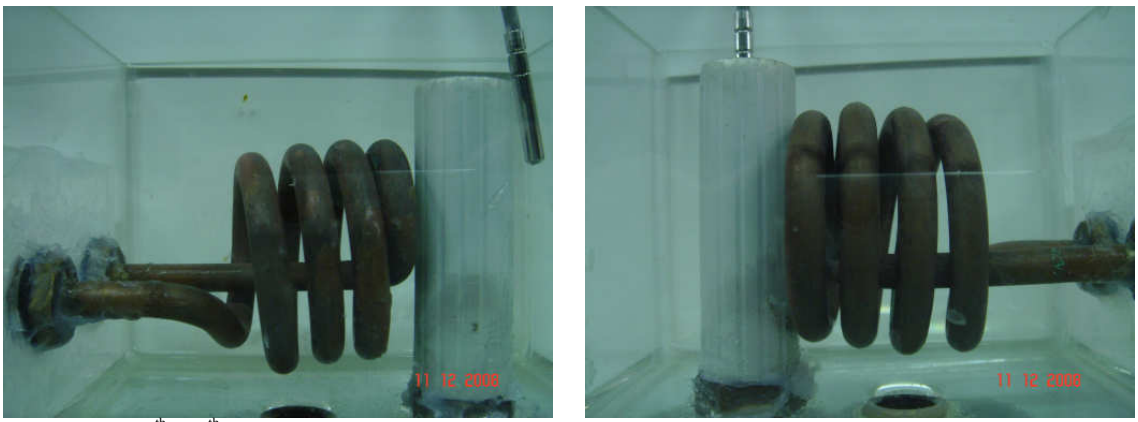
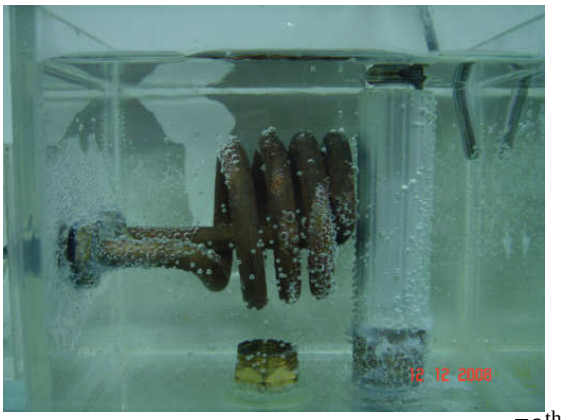
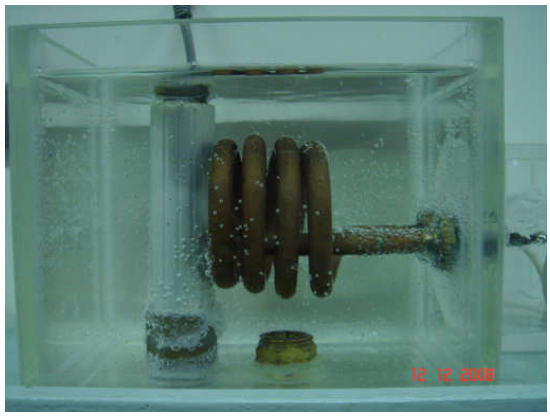
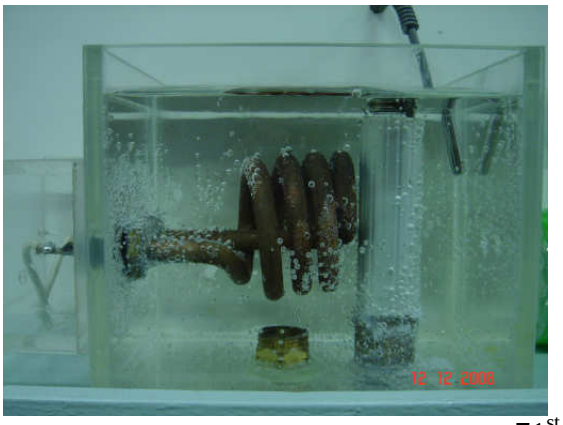


Figure 12.17 – 65th – 68th hour

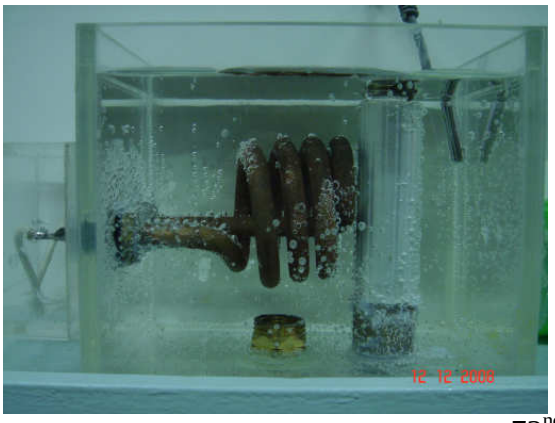
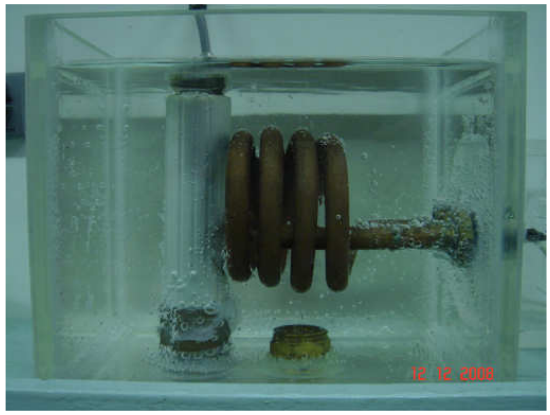
69th Hour

70th Hour




71st Hour

72nd Hour

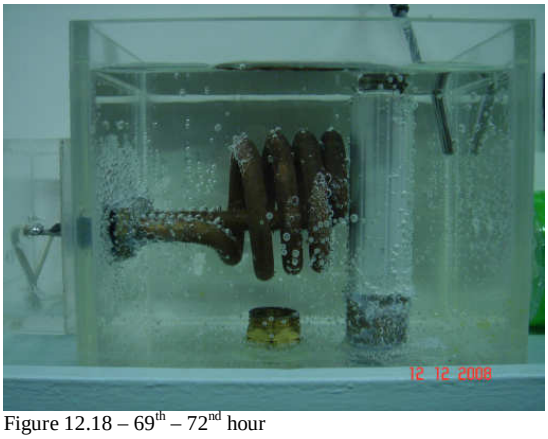
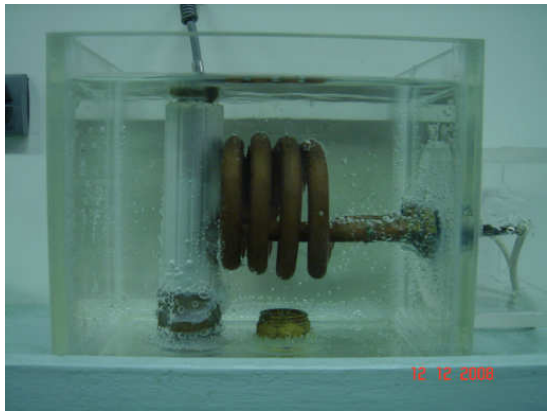
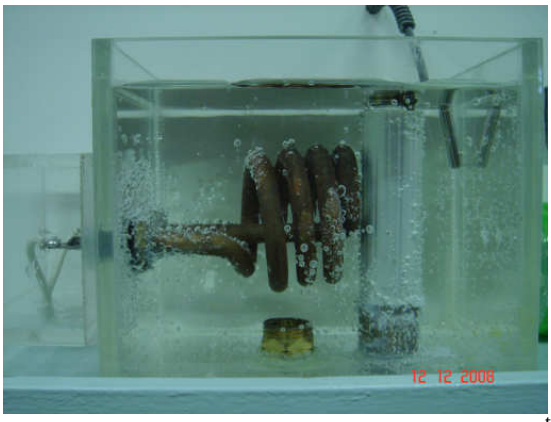
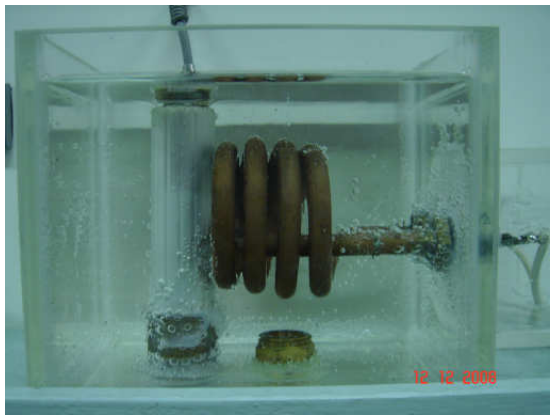



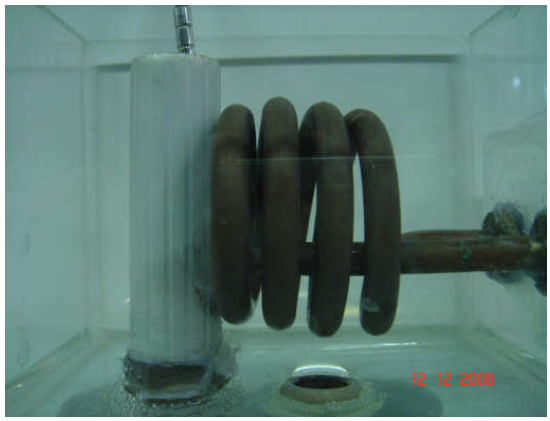
Figure 12.18 – 69th – 72nd hour

73th Hour

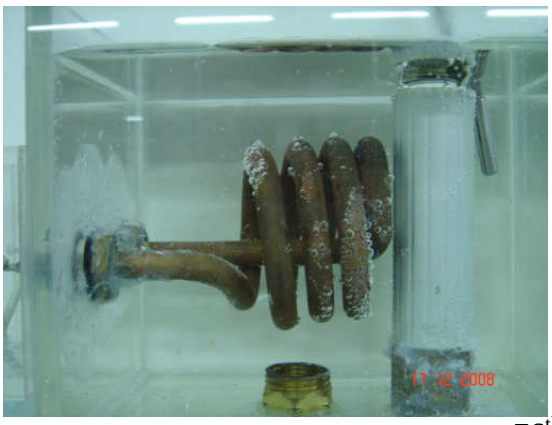


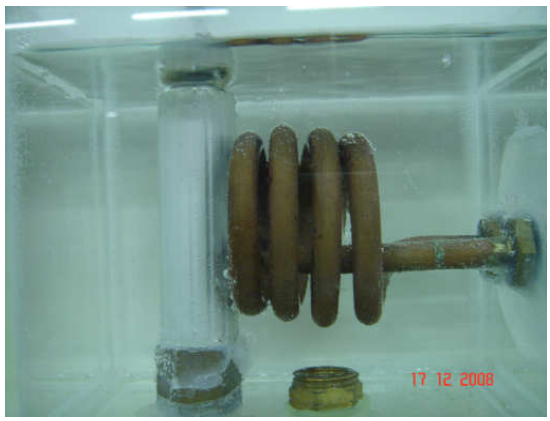


74th Hour

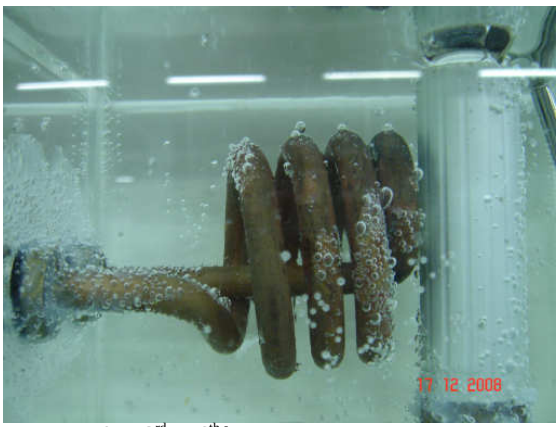


75th Hour





76th Hour



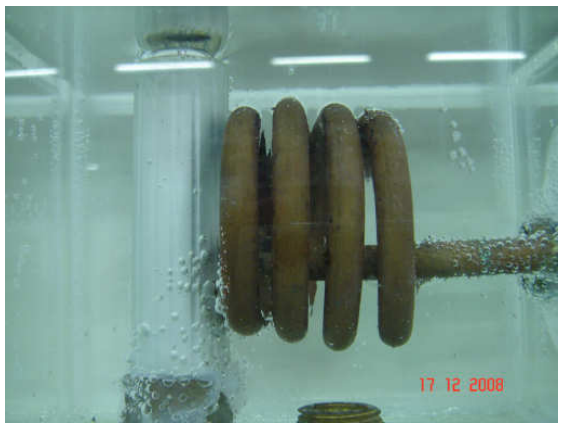
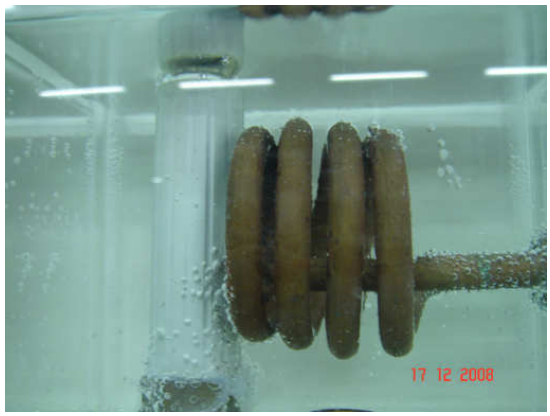
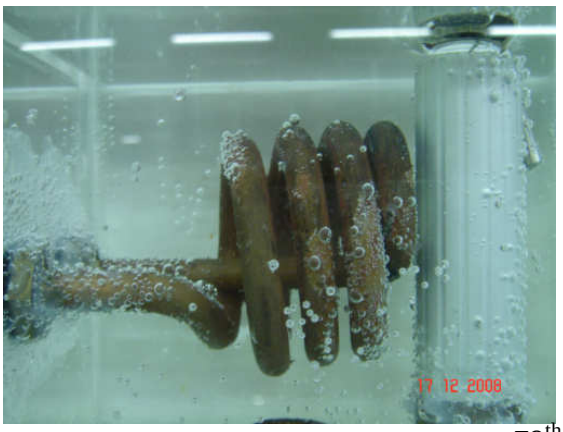


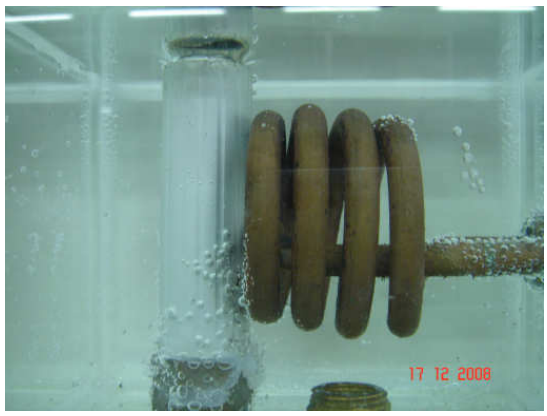
Figure 12.19 – 73rd – 76th hour

77th Hour

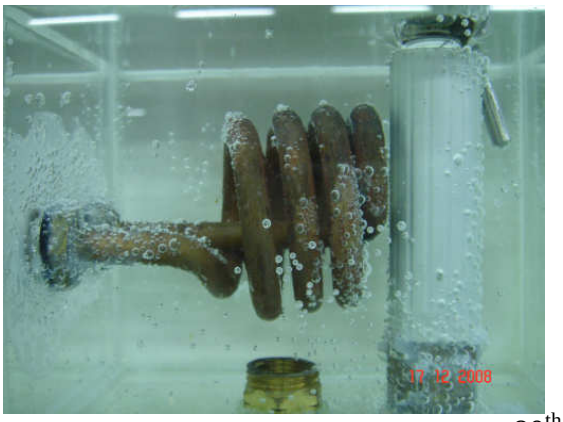


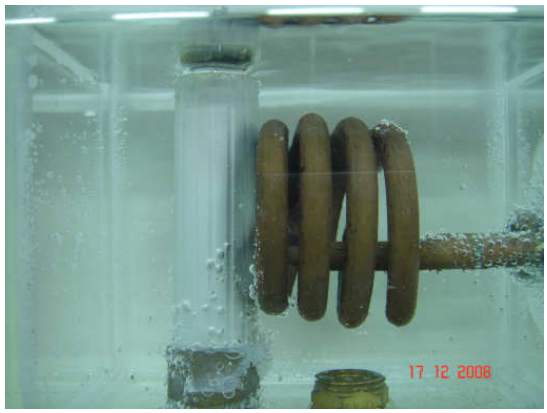
78th Hour





79th Hour





80th Hour

Figure 12.20 – 77th – 80th hour