

Anna Toikkanen

STUDY OF CHARACTERISTIC IMPROVEMENTS OF SPENT  
ION EXCHANGE RESIN

Degree Programme in Environmental Engineering  
2015

# STUDY OF CHARACTERISTIC IMPROVEMENT OF SPENT ION EXCHANGE RESIN

Toikkanen, Anna

Satakunta University of Applied Sciences

Degree Programme in Environmental Engineering

January 2015

Advisor: Ketola, Mari. Head of Chemistry, TVO Oyj

Supervisor: Hannelius, Timo. Lecturer, Satakunta University of Applied Sciences

Number of pages: 59

Appendices: 35

Keywords: Ion exchanger resin, boiling water reactor, condensate purification, final disposal, viscosity, polymer, VLJ-repository.

---

## ABSTRACT

This thesis work was done to Teollisuuden Voima Oyj. Purpose was to study the effects of certain additives on the flow properties of the ion exchange resin. Purpose was to improve the flow properties of the bulk and the dried bulk. Spent ion exchange resin has caused problems by forming blockages in pipelines, when pumped into the waste treatment unit. The other purpose of this thesis was to get the dried bulk's characteristics so that the amount of bitumen could be decreased. Bitumen is used, when dried ion exchange resin and inert are prepared for the final disposal.

In the theory section of this thesis, soluble and insoluble impurities of boiling water reactor were discussed. Also condensate purification and ion exchange were introduced. Rheology was studied to explain the particle flow and viscosity. The processes that are related to the subject were surveyed.

Thesis was implemented in TVO's water chemistry laboratory. The main analysis was carried out with a viscosity instrument, Viscometer DV-E. The bulk was done from fresh unused ion exchange resin and inert material. Also drying test and enrichment test were implemented at the TVO's laboratory. Radioactive material was avoided and real process materials were left untouched. Certain additives, those which already had a permission to be added into the final disposal, were analyzed with Viscometer.

Pilot tests were conducted at Satakunta University of Applied Sciences process laboratory. Centrifugal pump test, hose pump test, and funnel test were done to test the flow properties of the bulk.

Results from the laboratory tests showed improvements in viscosity behavior by using one additive. Drying tests did not reveal any significant improvements. Flow tests at the process laboratory were carried out with the additive, which were noticed to improve the viscosity of the bulk. However, any improvements were not observed. One possible reason for the blockages was noticed; when starting to pump the bulk out of the tank, where it was left to settle for a while, the bulk formed dryer thick layer on the walls. After while this layer collapsed and block the pipe.

# TUTKIMUS KÄYTETYN IONINVAIHTOHARTSIN OMINAISUUKSIEN PARANTAMISEKSI

Toikkanen, Anna

Satakunnan ammattikorkeakoulu

Degree Programme in Environmental Engineering

Tammikuu 2015

Ohjaaja: Ketola, Mari. Kemian jaospäällikkö, TVO Oyj

Ohjaaja: Hannelius, Timo. Lehtori, Satakunnan ammattikorkeakoulu

Sivumäärä: 59

Liitteet: 35

Avainsanat: Ioninvaihtohartsi, kiehutusvesilaitos, lauhdeveden puhdistus, loppu sijoitus, viskositeetti, polymeeri, VLJ-luola.

---

## TIIVISTELMÄ

Tämä opinnäytetyö tehtiin Teollisuuden Voima Oyj:lle. Sen tarkoituksena oli tutkia tiettyjen polymeerien vaikutusta käytetyn ioninvaihtohartsin ominaisuuksiin. Tiettyjen apuaineiden toivottiin parantavan hartsin virtausominaisuuksia ja samalla kuivatun hartsin muita ominaisuuksia. Käytetty ioninvaihtohartsi aiheutti ongelmia muodostaen tukoksia putkistoihin, joissa massa siirretään jätteen käsittelylaitokselle. Kuivatun massan ongelmana oli liian suuri bitumin kulutus. Bitumia sekoitetaan hartsin ja inertin joukkoon valmistettaessa massa loppusijoitukseen.

Työn teoriaosassa tutustuttiin kiehutusvesi laitoksen liuennesiin ja liukenemattomiin epäpuhtauksiin sekä lauhteen puhdistukseen ja ioninvaihtoon. Reologiaa käsittelevässä osassa tutkittiin viskositeettia ja partikkelien käyttäytymistä nesteessä. Aiheeseen liittyviä prosesseja tarkasteltiin myös työtä varten.

Opinnäytetyö tehtiin TVO:n vesikemian laboratoriossa. Pääanalyysina oli viskositeettimittaus, joka suoritettiin Viscometer DV-E laitteella. Kuivauskoe ja massan rikastus toteutettiin myös vesikemian laboratoriossa. Massa valmistettiin puhtaista käyttämättömistä hartseista ja inertistä. Aktiivisia tuotteita haluttiin kokeissa välttää. Apuaineet, jotka olivat jo valmiiksi käytössä TVO:n prosesseissa ja joilla oli jo lupa loppusijoitukseen, testattiin ensin viskositeettimittarilla.

Pilottitestit tehtiin Satakunnan ammattikorkeakoulun prosessilaboratoriossa. Keskipakopumppu-, letkupumppu- ja suppilotestit suoritettiin virtausominaisuuksia tutkittaessa.

Laboratoriokokeiden tulokset näyttivät viskositeetin parannusta yhden apuaineen kohdalla. Kuivauskokeissa ei löytynyt mitään huomattavia muutoksia. Virtauskokeissa käytettiin tätä samaa apuainetta, joka antoi laboratoriossa hyvän tuloksen. Se ei kuitenkaan tuonut toivottua tulosta pilottikokeissa. Mahdollinen teoria tukkeumien aiheuttajasta kuitenkin löytyi. Kun seissyttä massaa alettiin pumpata ulos säiliöstä, niin säiliön reunoille jäi paksu kerros kuivempaa massaa. Seinämä sortui myöhemmin tukkien pohjalla olevan putken.

## CONTENT

1	INTRODUCTION .....	7
2	POWER PLANTS IN OLKILUOTO.....	8
2.1	Teollisuuden Voima Oyj.....	8
2.2	Power Plants .....	9
2.2.1	Boiling Water Reactor.....	9
2.2.2	Uranium and Fission .....	9
2.3	Predisposal Management of Low and Intermediate Level Nuclear Waste and Final Disposal .....	10
2.3.1	Environmental Aspects of Nuclear Waste .....	12
3	THEORETICAL BASIS .....	14
3.1	Soluble and Insoluble Impurities .....	14
3.2	Condensate Purification .....	14
3.3	Ion Exchange .....	17
3.3.1	Powdered Ion Exchange Resin.....	19
3.3.2	Inert Material.....	20
3.4	Rheology.....	20
3.4.1	Viscosity.....	21
3.4.2	Particle Flow in Fluid.....	21
4	OBJECTIVES OF THESIS .....	22
4.1	Objectives of This Thesis .....	22
5	PROCESS DESCRIPTION.....	23
5.1	Feed Water .....	23
5.2	Condensate Cleanup System, 332.....	24
5.3	Demineralized Water, 733-water .....	24
5.4	Backwash and Precoating of Filters, 332C1-7.....	25
5.5	System 342.....	29
5.5.1	Flocculation, Sedimentation and Decantation in 342 T41 (T42).....	30
5.6	System 343.....	31
5.6.1	Drying .....	32
5.6.2	Immobilization into Bitumen .....	33
5.6.3	Filling Device, Transporting system, and Storage .....	33
6	IMPLEMENTATION OF THE THESIS.....	34
6.1	Laboratory Tests .....	34
6.1.1	Brookfield Digital Viscometer MODEL DV-E .....	34
6.1.2	Preparation of Pure Bulk .....	35
6.1.3	Viscosity Tests of Bulk and Additives.....	36

6.1.4 Additive A .....	37
6.1.5 Additive B .....	38
6.1.6 Additive C .....	38
6.1.7 Drying Test.....	39
6.1.8 Small Scale Filtering and Enrichment Test.....	39
6.2 Pilot tests at SAMK's Process Laboratory .....	42
6.2.1 Flow Test with Centrifugal Pump .....	42
6.2.2 Flow Test with Hose Pump .....	43
6.2.3 Funnel Test.....	44
7 RESULTS AND DATA-ANALYSIS.....	45
7.1 Laboratory Tests .....	45
7.1.1 Viscosity Test.....	45
7.1.2 Additive A .....	46
7.1.3 Additive B .....	47
7.1.4 Additive C .....	48
7.1.5 Drying test.....	49
7.1.6 Small Scale Filtering and Enrichment Test.....	51
7.2 Pilot Tests at SAMK's Process Laboratory.....	52
7.2.1 Flow Test with Centrifugal Pump .....	52
7.2.2 Flow Test with Hose Pump .....	53
7.2.3 Funnel Test.....	53
8 CONCLUSION AND DISCUSSION.....	55
8.1 Consideration of the Results .....	55
8.2 Discussion of Implementation in Plant Scale .....	56
REFERENCES.....	57

## APPENDICES

### APPENDIX 1

Material Safety Data Sheet of RESIN A (käyttöturvallisuustiedote)

### APPENDIX 2

Material Safety Data Sheet of INERT A

### APPENDIX 3

Material Safety Data Sheet of ADDITIVE A (käyttöturvallisuustiedote)

### APPENDIX 4

Material Safety Data Sheet of ADDITIVE B (käyttöturvallisuustiedote)

### APPENDIX 5

Material Safety Data Sheet of ADDITIVE C

### APPENDIX 6

Results of Additive A

### APPENDIX 7

Results of Additive B

### APPENDIX 8

Results of Additive C

### APPENDIX 9

Results of hose pump test with Solution A

## 1 INTRODUCTION

This theses work was done for Teollisuuden Voima Oyj. The purpose of this thesis was to study the possible means to improve the characteristics of powdered spent ion exchange resin waste. Liquid waste of ion exchange resin causes problems as it is easily flocculating and blocking the pipes. Study was done to investigate the impact of addition of additives into the waste. Also the dried waste characteristics were under study, to see if an additive, same as used with liquid waste would improve them. The problem with dried waste appears when it is mixed with bitumen. At this moment it needs too much bitumen to get the mixture to flow fluently.

Process water is cleaned with ion exchange resin and after use it is contaminated, thus its disposal is carried out under regulations. Used ion exchange resin is disposed in to the VLJ-repository. Disposal of radioactive waste is strictly regulated and there for the substances that can be added there are strictly defined.

Powdered ion exchange resin is used on the surfaces of precoated filter with inert material under and on top of it. Thus the used resin waste includes inert, resin, and impurities from the process waters. Precoated filters and powdered resin is used in nuclear power plants to clean the process water from impurities, both solid particles and dissolved ionic compounds. Before disposal ion exchange resin is dried and mixed with bitumen and then closed into the metal barrels. Barrels are transformed into the VLJ-repository, which is the disposal placement for low- and intermediate radioactive waste.

In the study certain additives, which already had permission to be placed in VLJ-repository, were analyzed to observe the possible changes in the behavior of the liquid waste. After the addition of additive the waste was dried and dry material was studied to observe all the changes.

## 2 POWER PLANTS IN OLKILUOTO

### 2.1 Teollisuuden Voima Oyj

TVO is in 1969 established Finnish nuclear power company. In Olkiluoto, Eurajoki TVO has two operating power plants, Olkiluoto 1 (OL1) and Olkiluoto 2 (OL2). Both of them have net output about 880 MW. Sixth of all electricity used in Finland is produced by OL1 and OL2. TVO produces electricity at cost price for its shareholders, and it is an unlisted public company. [1]

Nuclear power plants in Olkiluoto have been producing electricity for Finland already for 35 years. OL1 were plugged into the national electrical grid in 1978 and OL2 in 1980. During the operational years Olkiluoto 1 and 2 have showed to be among the most reliable nuclear plants in the world. Nuclear power is claimed to be environmental friendly, and it has been calculated that in Finland the Olkiluoto plant units are saving about 12 million tons of carbon dioxide emissions during one year when compared to having same amount of electricity produced from coal. [2]

At the moment TVO is constructing a new power plant in Olkiluoto, OL3. [1] Olkiluoto 4 was already ratified in the Parliament of Finland for Finnish Government's favorable Decision-in-Principle in 2010. However, now in 2014, TVO was rejected when they applied to extend the period of validity of the existing Decision-in-Principle. That leaves OL4 without additional time and as it is now, TVO has till June 2015 to get the permanent construction permit. [3]



## 2.2 Power Plants

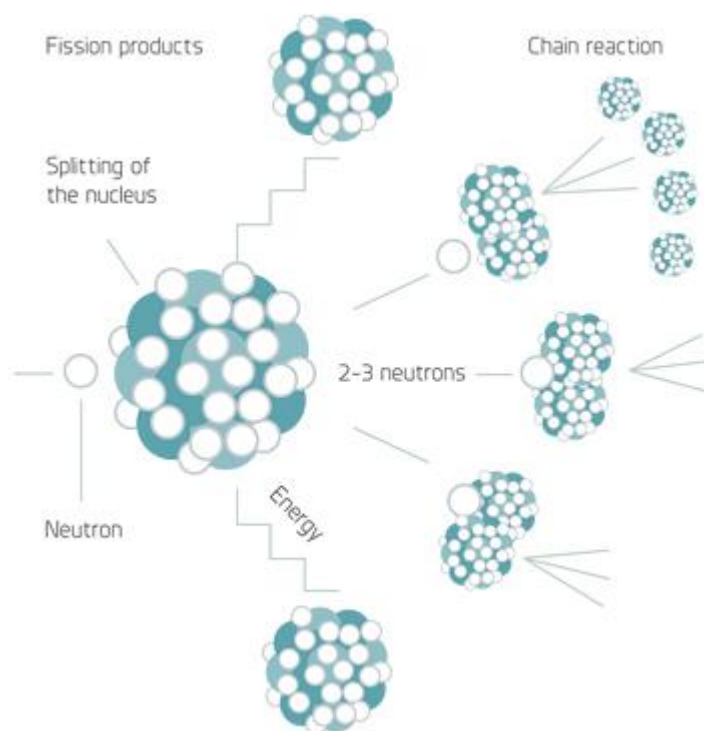
### 2.2.1 Boiling Water Reactor

OL1 and OL2 both are Boiling Water Reactors (BWR), and they produce electricity by heat produced by fission. Produced heat is turned into mechanical energy and further electricity. [4 /10-11/] In BWR-plant the heat, produced from fission-reaction, boils water into steam inside the reactor core. Produced saturated steam flows through the steam pipes to the turbines. At the turbines steam pressure is decreased, which allows steam to increase its volume up to thousand times. This increased volume pushes turbine blades and forces it into a rotary movement. A shaft transports this mechanical energy to the generator which produces electricity. From the turbine steam flows into the condenser and it is cooled down with seawater. Then water is reused in the same circulation again. [4 /10-11/]

### 2.2.2 Uranium and Fission

Radioactive uranium is used as fuel in OL1 and OL2 plants. Uranium is a common element on earth crust and it is slightly radioactive. The most common type of uranium in nature is U-238. Uranium is collected from earth crust mostly by extracting or mining. Small amount of it forms from residuals of other minerals. Before usage as fuel U-238 is enriched and presses in the form of a tablet. These tablets are collected together inside the fuel rods. [4 /7-9/]

In Olkiluoto 1 and 2 the produced energy is based on fission and a controlled chain reaction of U-238. As seen in picture 1 a neutron collides with the nucleus of U-238 and splits it. Collision releases 2 or 3 new neutrons, fission products, and a lot of energy. Some of the released neutrons continues the chain reaction and produces more energy. This way a small amount of uranium fuel produces a huge amount of energy. [4 /7-9/]



Picture 1 Nuclear reaction [4 /9/].

Fission products, which are byproducts of the fission reaction, are radioactive as they decay into other elements. In decay nuclei emits radiation. Neutrons, which are released, move about 20 000 km/s, but inside the reactor this speed has been reduced to about few thousand meters per second. In OL1 and OL2 this reducing is carried out with the water, which is treated so that there are no salts in it. [4 /7-9/] This water is demineralized water.

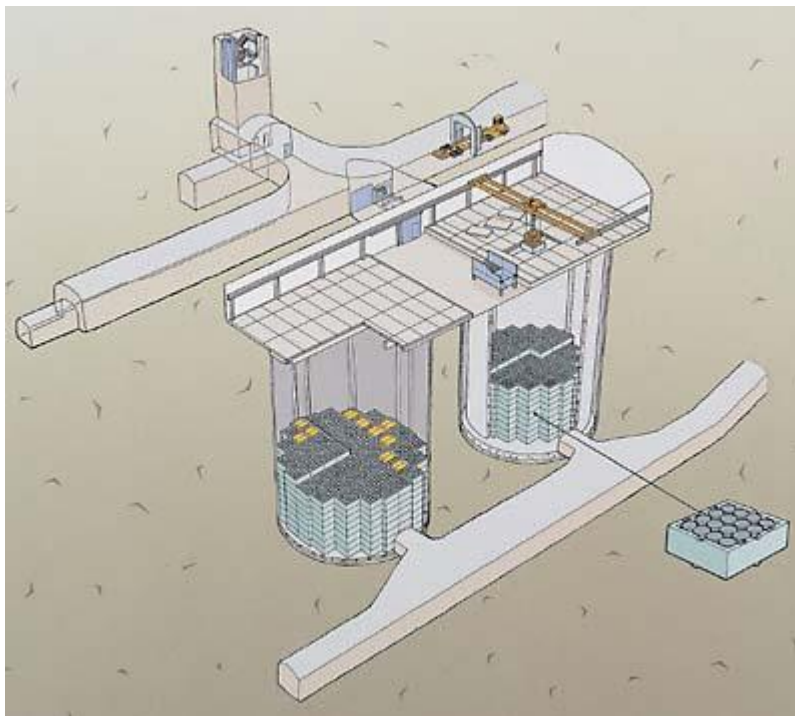
### 2.3 Predisposal Management of Low and Intermediate Level Nuclear Waste and Final Disposal

The Finnish law states that all nuclear waste that is produced in nuclear action in Finland has to be handled, stored, and disposed in Finland. The law also gives safety regulations for the places, equipment, and methods used in nuclear power plants when handling and storing nuclear fuel and the produced nuclear waste. Nuclear waste has to be disposed so that it will not pose any threat to the environment. The amount of produced nuclear waste must be kept as low as possible. In Finland, laws and standards strictly control the safety of nuclear waste management. According to the Finnish nuclear act Finnish Radiation and Nuclear Safety (STUK) sets detailed

regulations for safety issues. [6 /6 a §, 7 h §, 27 a §/] STUK belongs to the administration of the Ministry of Social Affairs and Health. [5]

When electricity is produced at a nuclear power plant, nuclear waste is always produced. Radioactive waste has to be isolated from all living nature for as long as it poses a threat to the environment. TVO is aiming at lower levels of emissions than what the authorities have regulated. [4 /11-12/]

Waste from uncontrolled area is recycled as in anywhere else, energy-, metal-, glass-, and bio waste. Controlled area waste is divided into low-, intermediate level operating waste, and high level spent fuel. Controlled area differs from the uncontrolled area with respect to radioactivity. All waste from the controlled area has to be handled as radioactive waste. Classification is based on the radiation level of the waste. VLJ-repository (Picture 2) is the storage for low and intermediate level radioactive waste. Waste is either packed into barrels and the barrels are placed inside concrete containers, or straight into concrete containers. Containers are moved into the silos, which are excavated into the bedrock in the plant area. Bulk from condensate clean up systems is intermediate waste and it is disposed in barrels, which are placed in concrete containers, as mixture of bitumen and dried bulk into the VLJ-repository. There are two silos, MAJ and KAJ, in the repository for operating waste. MAJ-silo is for low-level radioactive waste and KAJ-silo is for intermediate waste. Silos can be seen in picture 2. [4 /12/], [7 /22-23/], [8]



Picture 2 VLJ-repository, MAJ- and KAJ-silos. [Rauma Chamber of Commerce].

Final disposal is for spent nuclear fuel, which is high level radioactive waste. Spent fuel is cooled down in spent nuclear fuel interim storage for about 40 years before eventually moved into final disposal. Spent fuel is stored in water in interim storage tanks. Radioactive spent fuel must be isolated from the environment as long as its activity is decreased to a harmless level. The final disposal location will be constructed into the bedrock in Olkiluoto plant area. The spent fuel will be sealed more than 400 meters deep underground. [4 /12-13/]

### 2.3.1 Environmental Aspects of Nuclear Waste

Nuclear energy production is strictly regulated in Finland. Environmental issues are handled in Environmental Impact Assessment Procedure (EIA), Environmental Permit, and Environmental Programs and Plans. Programs and Plans include among others The National Conservation Programs associated with the Conservation of Nature, Landscapes, and Cultural Environments. A statutory EIA is a procedure, which clarifies all the environmental impacts of the project. The EIA includes the impacts for human health, living conditions, and comforts e.g. biodiversity, usage of natural sources, infrastructure, and soil, water systems and climate are also clarified. Mean-

ing for this procedure is to provide information and participation for the citizens, and to introduce those environmental impacts that should be considered. EIA does not include any decisions and it is implemented before permits, however it gives valuable information for the State Administrative Agency (AVI) in the permit decision. [9]

AVI claims an environmental permit for every action, which potentially can cause any danger to the environment. Environmental Permit regulates among other things emissions and reducing them. Therefore licensed activity should not pose any harm to health or any significant harm to environment or danger for it. [10]

Authority for TVO's Environmental permit is the Southern Finland Regional State Administrative Agency, and as a supervising authority Southwest Finland Centre for Economic Development, Transport and the Environment. Environmental department of the municipality of Eurajoki and Ministry of Employment and the Economy are other authorities that take part in TVO's regulatory issues. The latter is responsible for the EIA procedure. [11 /14/]

TVO operates by principles of sustainable development and implements it by taking the environmental aspects into consideration in all its actions. TVO's objective is to further decrease the already low radioactive emissions. Prediction of potential damages to the environment is essential in order to plan, prepare, and prevent any exceptional events. TVO focuses to produce as little as radioactive waste as possible, and also aim to reduce the amount of spent nuclear fuel, by optimizing the use of it. [11 /23/]

### 3 THEORETICAL BASIS

#### 3.1 Soluble and Insoluble Impurities

Water purity level in Boiling Water Reactor needs to be high. However some impurities are accumulated into the water during the operation of the plant. Water gathers soluble and insoluble metallic species and also nonmetallic species mostly through feed water system. Some of the metallic species originates from slow corrosion of the process equipment material, e.g. vessel internals and piping. [14 /2-28/]

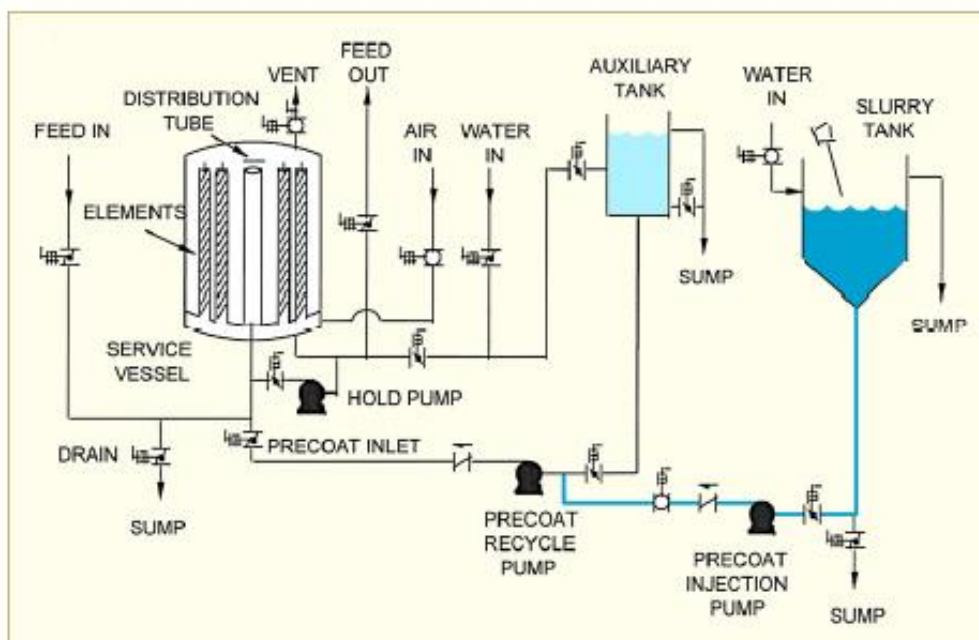
In OL1 and OL2 the metallic impurities are cleaned from condensate with precoated filters in the cleanup system. Condensate going through the cleanup system is analyzed by water chemistry laboratory. Condensed water coming into the cleanup system and water after every seven filters is analyzed every other week, also the feed water is tested once a week. Chrome (Cr), Manganese (Mn), Iron (Fe), Cobalt (Co), Nickel (Ni), Copper (Cu), and Zinc (Zn) is analyzed with 0,01  $\mu\text{g/l}$ . accuracy. There is ICP-MS Thermo XSeries II in use for analyzing metallic impurities in water chemistry laboratory. [12] It is a quadruple inductively coupled plasma mass spectrometer [13].

#### 3.2 Condensate Purification

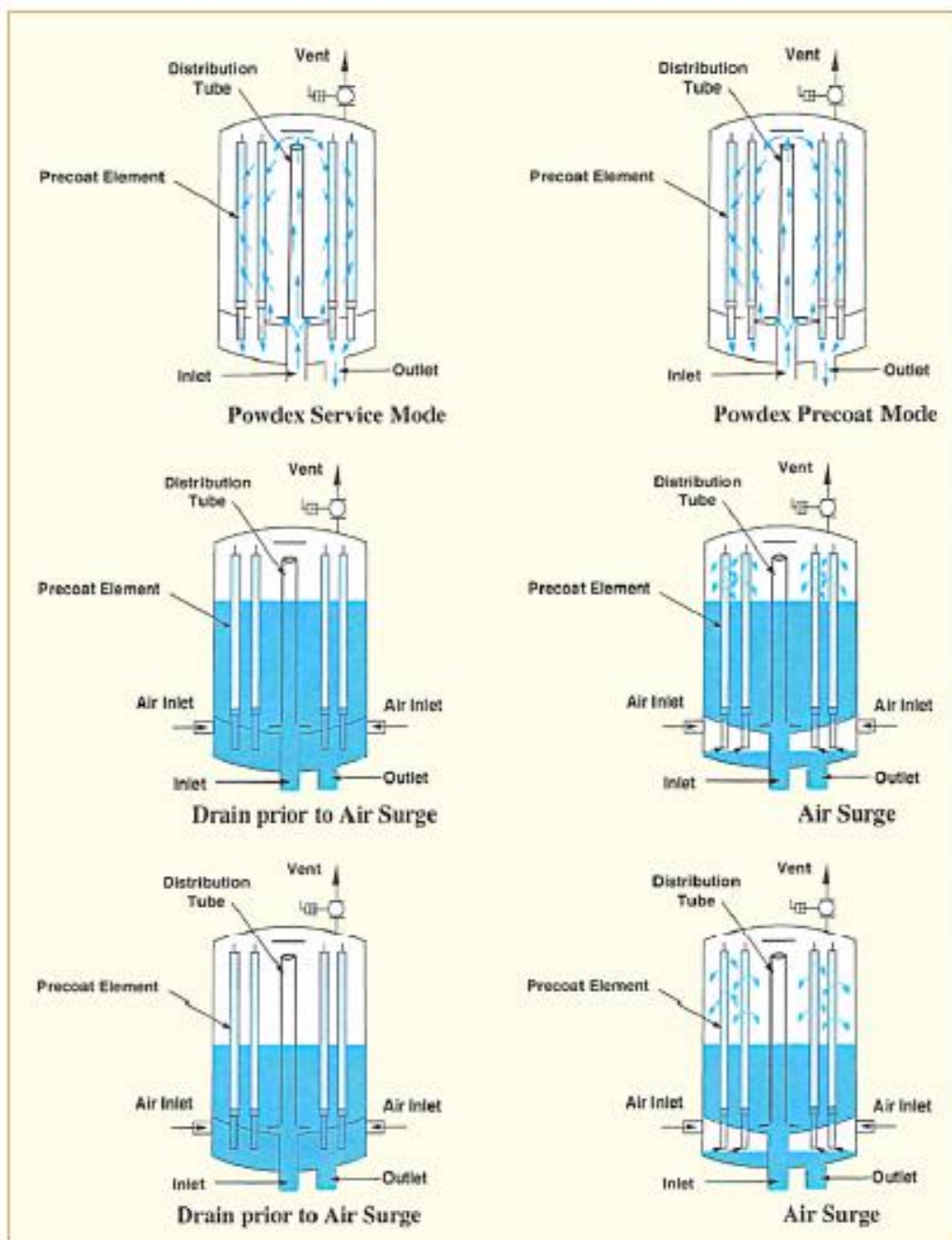
Nuclear plant's feed water needs to be ultra pure, but it cannot be purified before the reactor, because of the high enthalpy of the water. Thus the condensate is purified right after turbines and cooling. Precoated filters are well-trying purification method for process water in the boiling water reactors, because in this method chemicals are not added into the water.

Deionization and mechanical filtration method, which is called the Powdex process, was developed in the 1960's; the process is shown in picture 3. Powdex process uses powdered cation and anion resin. Resins were flocculated and settled slowly in the

water. Precoat filters use these flocculates on top of them as mechanical and ionic purification layers. The advantages of the precoat filters are high purification of particulate impurities and corrosive products. Disadvantages though are high amount of radioactive waste and small ionic capacity. [14 /4-1, 4-5,6/]



Picture 3 Overview of the Powdex process condensate polishing. [14 /4-5/].



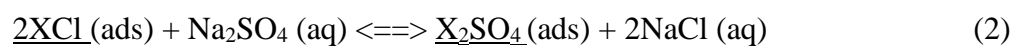
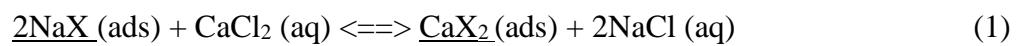
Picture 4 Necessary operational steps for precoating and filtration. [14 /4-5/].

In picture 4 the main steps of the precoat filter operation are shown. Picture 4 represents the inlet and outlet of the filter. It shows also how the fluid is moving inside the filter, through the precoat rods. Picture 4 shows how the filter is backwashed by air surge from opposed direction. [14 /4-1, 4-5,6/]



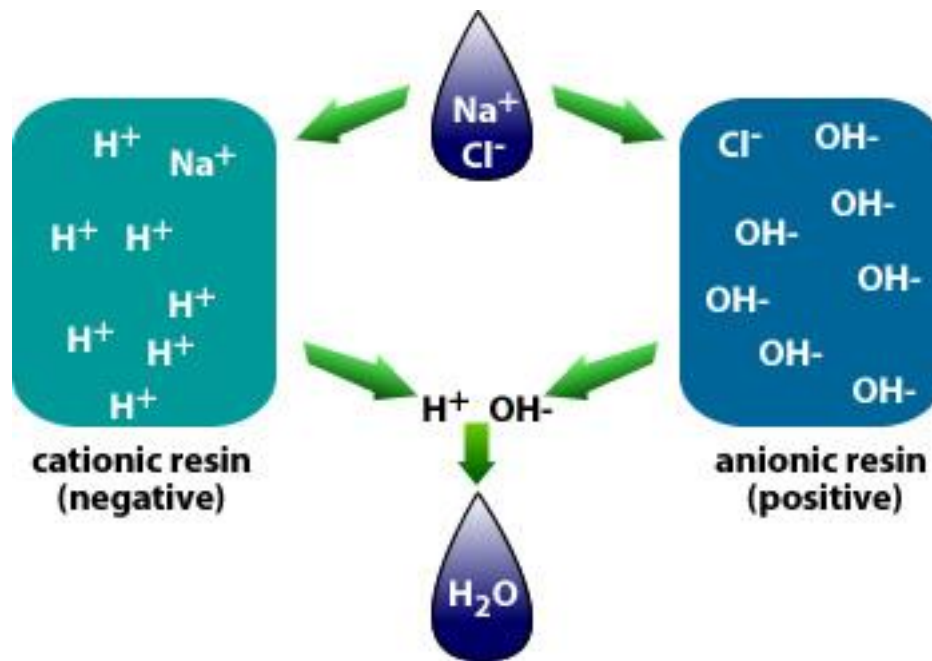
### 3.3 Ion Exchange

Basic operation of ion exchangers is to exchange ions with the same sign ions from electrolyte solution. For that ion exchangers carry exchangeable anions and cations. There are cation- and anion exchangers and mixtures of them. Typical cation exchanger is presented in equation (1), and typical anion exchanger is presented in equation (2).



X is structural unit group of ion exchanger, solid phases are underlined, and aq. means aqueous solution. [15 /5/] Ads. refers to adsorption, which means the retention of substance on the surface of another.

Ion exchanger's exchangeable ion, cation or anion, breaks off from structural unit and replaces the ion, same sign, from solution. Ion from the solution then attaches to the structural unit. Ion exchange is usually reversible. After all exchangeable ions have been changed, resin becomes saturated. Regeneration means that resin is treated with solution including those changeable ions and they are changed back. In picture 3 changeable ions are hydroxide ( $\text{OH}^-$ ) and hydrogen ion ( $\text{H}^+$ ), as in resins used in OL1 and OL2 condensate cleanup system. After exchange the hydroxide and the hydrogen ion reacts with each other and form water. [15 /5/]



Picture 5. Ion exchange

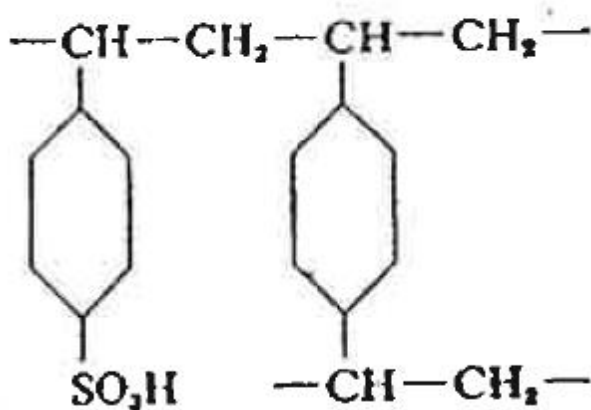
[<http://www.tdsmeter.com/education?id=0009>. Referred on 16.10.2014]

OL1 and OL2 use powder resin, which provides also a mechanical filtration. Filters are covered with resin and inert. Small particle size and fast ion exchange kinetics ensure high purification with significantly high water flow through. Powder resin is also competing against bead resin by having such a large surface area. Resin covered filters are major issue to the plant. They purify ionic impurities as well as solid particles. Ion exchange is highly important for the plant, because it removes all the corrosion products and leaves behind clean water. [Append 1 /3-4/] Ion exchange resin also removes other ions like sodium and chloride and also eliminates radioactive elements [16 /4-1/].

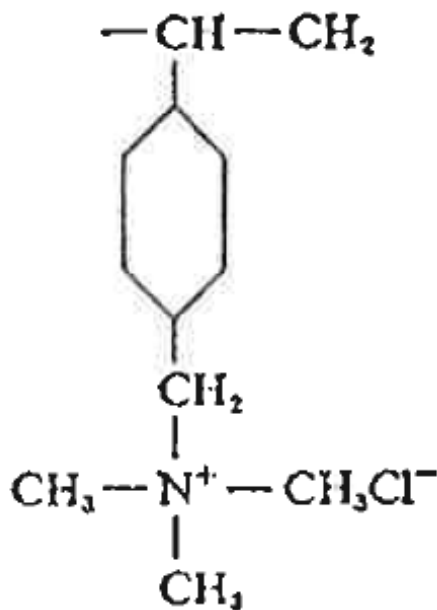
Used resin affects the plant's operations and costs in many ways, the cost does not come from the purchased resin only. There are also environmental impacts, due to radioactive solid waste that forms when resin is replaced. Resin replacement has to be carefully considered, due to its effects on plants efficiency, e.g. the purity of the water decreases over the time the resin is used and the amount of outlet water reduces. Consequently, the selection of resin has to be evaluated closely, considering all the following aspects: Overall efficiency, resin prize, costs of disposal and use, environmental issues, disposal of the waste, life time of the resin, resins impurity elimination capability, and chemical environment of the process. [16 /4-1/]

### 3.3.1 Powdered Ion Exchange Resin

In condensate cleanup system Resin A (1:1) and Resin B (2:1) resins are being used. Half of the filters have 1:1 resin and the other half have the strong cationic resin. These resins contain sulfonated styrene divinylbenzene copolymer as  $H^+$  (Picture 6), and styrene divinylbenzene copolymer with functional group of quaternary ammonium as  $OH^-$ . In picture 7 is anion exchanger where the  $OH^-$  has been changed into the  $Cl^-$ . 1:1 resin includes  $H^+$  25% and  $OH^-$  25%, and 2:1 resin includes ~33% and ~17% respectively. Both of them have water content of about 50 % [Append 1]



Picture 6 Sulfonated divinylbenzene [17 /12/].



Picture 7 Quaternary ammonium, where the OH<sup>-</sup>-group has been changed into the Cl<sup>-</sup> [17 /12/].

### 3.3.2 Inert Material

In precoating of the filter elements, inert material is used; it is put under and above the ion exchange resin. Inert material which is used in TVO's filters is Inert A. It does not take part in any chemical reactions. Inert material extends the filter cycle time by protecting the elements, decreasing the degradation of resin, and making the resin layer even so that the particles of resin do not shift away from the element. [18 /27/]

### 3.4 Rheology

Rheology was invented in 1929, or actually the term rheology was first used then. It was used in the branch of science, which studied materials and how they deform when they are exposed to forces. Everything flows, but how the flow goes, depends on the affecting force, direction, magnitude, and time. This is the basic idea behind

rheology. Rheology offers quantitative parameters to measure complex materials and give them specific behavior. [19] Rheology was studied in this thesis because it is a study for fluid flow and particle movements. Characteristics of a spent ion exchange resin can be explained by the rheological science. Viscosity is a part of rheological studies.

#### 3.4.1 Viscosity

Viscosity is a measurement of fluid behavior. It is a physical property of a fluid together with density, thermal conductivity, and molecular diffusivity. Viscosity depends on temperature, pressure, and composition of the fluid. [20 /1/] Viscosity can also be defined as internal friction, this occurs when two parts of the fluid are moving with each other, influencing each other. Amount of the force needed to cause the movement is directly proportional to the friction; this movement is called "shear". There is shearing when fluid is physically moved or distributed, physical moving is defined as e.g. pouring, spreading, spraying, or mixing. Shear rate then is smaller when fluid's viscosity is lower and higher shear rate occurs when viscosity increases. Highly viscous fluids, therefore, require more force to move than less viscous materials [21 /15/]

#### 3.4.2 Particle Flow in Fluid

Characters that influence on individual particles are composition, size, and shape. Density and conductivity depend on particle composition, if the particle is completely uniform. However usually particles are porous or the second material is blended in forming a continuous matrix by particles. Settling rate and surface area of particle depends on particle size. Particle shape can be regular or irregular, regular shapes might be cubic, spherical, or rectangular and irregular particles can be what shape ever like broken glass. [20 /1/]

## 4 OBJECTIVES OF THESIS

### 4.1 Objectives of This Thesis

The objective of thesis work was to find a solution to problems caused by spent ion exchange resin and the inert material, used with the resin. Bulk, that is produced from resin, inert material and washing water, causes blockage problems in pipelines. It also causes problems in final disposal, by needing too much bitumen to become fluidized after it has been dried. According to the start-up meeting the problem with the amount of the bitumen is that it takes room from other waste in the VLJ-repository and disposal the radioactive waste is expensive.

Bulk made from ion exchange resin, inert material, and water was studied with Brookfield's DV-E viscometer, and the aim was to find additive that would increase the movability of the bulk in the pipes, and at a same time would improve the dried material's characteristics.

It was challenging to get the bulk to be realistic and to find the additive that is allowed in the final disposal. During the time of this thesis the chemical suppliers did not offer any new additives to be tested. Thus the three polymers that were already accepted were used. Those polymers are used in water purification and with some ion exchange resins. Start-up meeting defined that the polymer would be able to be pumped into the process after storage tank, right before the pump.

## 5 PROCESS DESCRIPTION

Used powdered ion exchange resin is flushed away from filters, the large amounts of used powdered resin comes from condensate cleanup systems (but also from reactor water cleaning filters, feed water cleaning filters, and fuel tank water cleanup system from OL1 and OL2 and interim storage water tanks' clean up filters), thus condensate cleanup system is the main process relating to the study of the thesis. Other processes that relates to the subject of the thesis are feed water system, flocculation, decantation, drying, bituminization, and final disposal.

### 5.1 Feed Water

The basic purpose of feed water system is to supply water into the reactor. In the simplest form of the feed water-condensate circulation the feed water is pumped with high pressure into the reactor, where it vaporizes in constant pressure into saturated steam, which continues into the turbines, where pressure is decreased and steam expands transforming part of the thermal energy into the mechanical energy, after that wet steam enters into the condenser and cools down. Saturated steam means that the steam holds as much water as possible. Wet steam stands for the steam, which holds some water droplets in it. [14 /1-2/]

Feed water circulation defines thermal efficiency of the plant. The most important thing for the efficiency of the plant from thermodynamic aspect is the temperature difference between the steam, vaporized from feed water, and condensate. The higher is the difference between the two is, the higher the efficiency of the plant. Adding pre-heater into the process before reactor can increase this difference. However the efficiency of the plant cannot be increased endlessly, there are different aspects that need to be considered. Costs of the process might become too high, or operational features can come in the way, and safety aspects are also very important to consider. [14 /1-2/]

## 5.2 Condensate Cleanup System, 332

The aim of the condensate cleanup system, system number 332, is to purify the condensed water from corrosion products. Water is in the form of condensed steam that comes from turbines and has vaporized in the reactor. After cleanup the water goes back into the reactor as feed water. Condensate cleanup system includes seven filters, 332C1-332C7 and all the filters contain 251 elements. Filters are connected parallel into circulation and resin trap is located after every filter. Pulverized ion exchange resin is used as precoat on every filter elements, precoating is not used on resin trap elements. 332C1, C3-C6 are twisted antioxidant-treated rods, and their nominal-pore size is 54 $\mu\text{m}$ . Filter 332C7 also has antioxidant treated and twisted rods, which nominal pore size is 4 $\mu\text{m}$ . [22]

The overall flow of condensate water is evenly divided between all seven filters. The divided flow through every filter is about 180kg/s per each filter. The flow of condensate keeps the ion exchange resin on filter elements, and the resin traps are backup system, in case some resin is washed away from the elements. Resin cannot end up into reactor. At the both plants, OL1 and OL2, the 332C7 filter differs from all the others, C7 filter is not precoated, unless a cooling water leakage is detected. [22]

## 5.3 Demineralized Water, 733-water

All the water in processes mentioned this thesis is demineralized water. System 733 in TVO indicates demineralized water- distribution system. [23 /5/]

The main function of the 732-system is to produce demineralized water and deliver it to the storage tanks, where the distribution system takes the water. This system has also pipelines to the OL3 technical ring. Before three ion exchange trains there is humus filter. One of the three trains is used at ones. After them there is mixed bed exchanger. After mentioned process machines the water flows through parallel coupled osmosis equipments. There is a resin arrester for the ion exchange resin, which might go through the filter. Ion exchange train consist four ion exchangers. After the ion exchanger train the water's conductivity is 0,1  $\mu\text{S}/\text{cm}$  and it is delivered to system 733's tanks in OL1 or OL2. [24 /5,6/]



#### 5.4 Backwash and Precoating of Filters, 332C1-7

Condensate cleanup filters are backwashed after the pressure difference through the filter is increased into 1,6 bar. Filter C7 is backwashed after 21 running days or after the pressure difference increases up to 0,35 bar. Package of elements inside the filters can be changed, and they are changed when backwashing does not help to decrease the pressure difference. In Picture 8 the used rods can be seen, when they are removed, and in pictures 9 and 10 are the new rods that are installed in to the filter. The age of the filter elements varies between 3 and 5 years. [22]



Picture 8 Old rods being removed, during the filter change [Saarimaa, 2010]



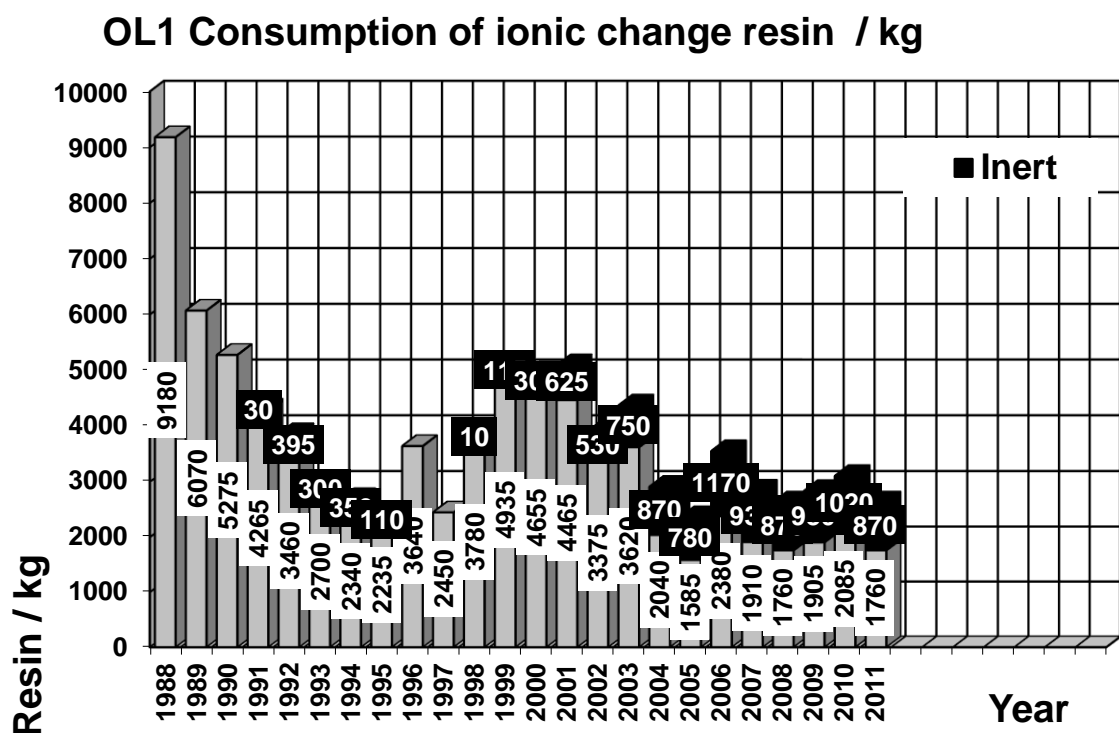
Picture 10 OL2's 332-filter rods being changed in 9.11.2010 [Saarimaa, 2010].



Picture 9 OL2's 332-filter rods being changed in 9.11.2010 [Saarimaa, 2010].

Backwashing is done by pumping water into the filters from opposite direction than normal flow. Inert and resin falls off and it is pumped into a waste vessel T41 (T42). After the backwash, the filters are precoated again. Precoating is done with inert material, Inert A, and Ion exchange resin, 1:1 or 2:1 strong cationic resin, Resin A or Resin B, respectively. First 20 kg of inert is mixed with water and then pumped into the filter. It goes on the surface of elements and stays there because the flow is pushing it against the walls. Inert protects the surface of elements and it blocks the pores of the elements, so smaller particles stays on the elements and do not go through the filter. The ion exchange resin is applied in similar manner, mixing 60 kg of resin with water and then pumped on the top of inert material. On the top of the ion exchange resin 10 kg of inert material is added which protects the resin layer, and thus the particles of the resin stay on the elements and do not flow around the filter. Ion exchange resin and inert material are pumped into the filter separately to form layers. [25 /2/]

Consumption of powdered resin in condensate cleanup system at OL1 and OL2 in year 2011 was 3880 kg. In year 2012 and 2013, the quantities were 3715 kg, and 3840 kg respectively. In the same years the consumption of inert were 1890, 1830, and 1890 kg respectively. Cycle time, running time between backwashing, for filters were at OL1 approximately 68,01 days and at OL2 approximately 73,84 days in year 2013. Filter C7 was not taken into calculations, because there is no ion exchange resin or inert material. [27] Consumption of resin (grey area) and inert (black area) in OL1 during the years 1988-2011 can be seen in picture 11.



Picture 11 Yearly usage of inert and resin in OL1 [22]

## 5.5 System 342

The function of system 342 is to process all the radioactive liquid waste from controlled areas. Water is processed so that it can be either reused in the plant or released into the cooling water channel. Release into cooling water channel needs low activity level at maximum 396 GBq ( $\beta$  and  $\gamma$ )/year [27 /28/]. Residuals from the system are transported into the 343-system to be transformed into a form that can be disposed. Ion exchange resin is one of the residuals from the system 342. [27 /7/]

There are 6 lines in the liquid waste management system. Line 4 in the system is for ion exchange resin, for powdered and granule resin. Line 4P is only for the powdered resin from 324 C1 (fuel tank), 332 C1-C7 (condensate cleanup system), and 342 C11-C12 (excess water system). This line leads into storage tank T41 or T42. Storage capacity of the tanks are calculated to be about half a year' worth of spent resin and inert. Line 4P is constructed so that the risks of blockages have been considered, e.g. pipe diameter sufficient, wide fittings, and gentle elbows. Line 4's instructions define the need of the flushing. [27 /9, 29/]

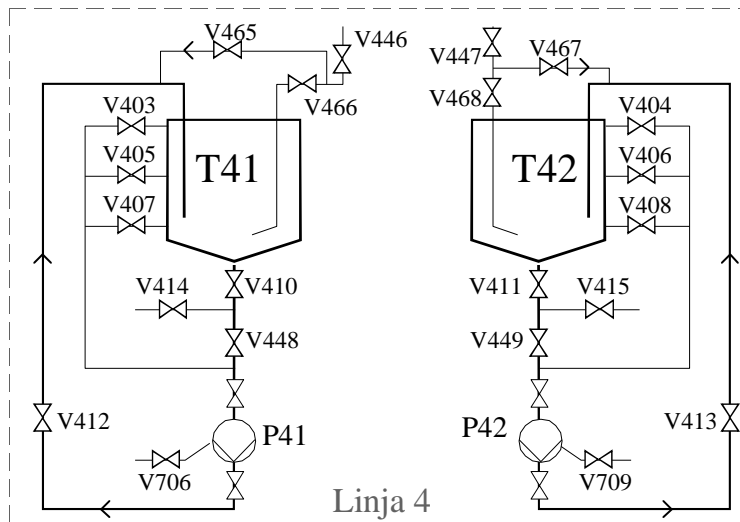
#### 5.5.1 Flocculation, Sedimentation and Decantation in 342 T41 (T42)

The waste water from backwash is led into a storage tank from each filter. Tank is 342T41 (or T42) with volume of 75 m<sup>3</sup>. Tanks are filled one by one, so that almost all short-lived radionuclides are decayed before transporting the bulk into the system 343.

In the storage tank the bulk sediments into the bottom. With flocculent (Additive A) the sedimentation is enhanced. Sometimes used ion exchange resin and inert material bulk can stand in the vessel even for a year. [18 /27/] Sedimentation happens when gravitational force is acting on the particle with bigger strength than the friction force of surrounding fluid. Sedimentation depends on the particle sizes, height of the suspension, diameter of the vessel, concentration of the suspension, and possible additives. [20 /237-244/] Particles in the fluid might have a tendency to flocculate; the effect of flocculation is creation of flocks. Flocks are large lumps of joined particles. With appropriate additives this flocculation can be enhanced and speeded up. [20 /245/] As was discussed excessive addition of this kind of flocculent polymer could act opposite and actually disperse the particles.

Clear waste water on the top of the tank is decanted away from the vessel and the bulk (consisting of ion exchange resin, inert material and water) is then pumped into the drying vessel. Decantation is started from the highest pipe fitting, from which moved step by step to lower pipe fitting as long as the over flow stays clear. Decanta-

tion is controlled with bulk surface gauge and water surface is controlled from the screen and from the surface gauge. Bulk surface is also controlled by ocular, because the gauges cannot be trusted completely. Clear water is lead into the cleanup through the filters as overflow. [28 /3/] Additive A is an anionic flocculent and it is prepared from dry powder in the laboratory. It is added into the storage tank to enhance the sedimentation of the bulk. [18 /27/].



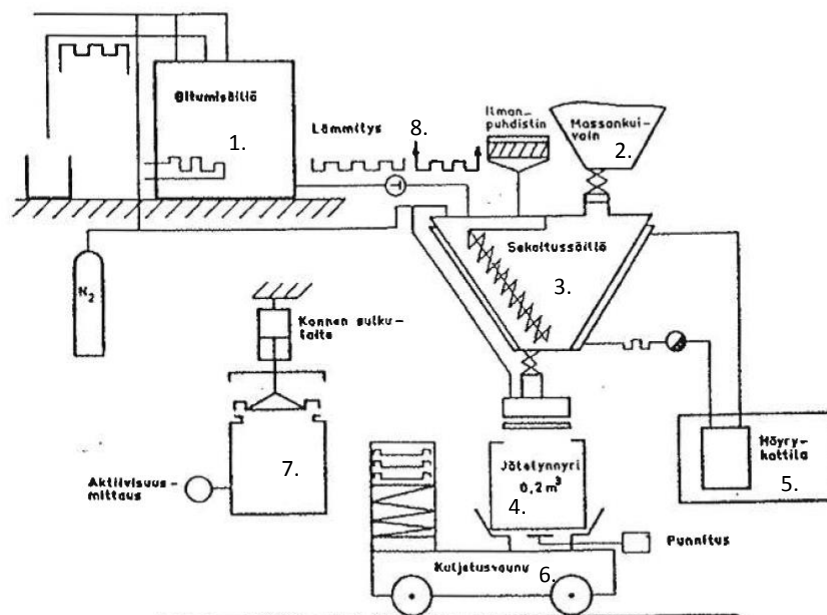
Picture 12 Tank 342T41/42 and their circulation pumps. [27].

To avoid blockages, circulation, as seen in picture 12, is used. Before pumping, pressurized air is pushed into the tank's cotton cone. After this appropriate valves are opened and P41 or P42 (pumps can be seen in the picture 12) is turned on. Decision to circulate the bulk is case-specific, thus the piping is easily blocked. [29]

## 5.6 System 343

Function of the system 343 is to receive all the solid waste from controlled areas. One of its purposes is to receive powdered ion exchange resin, dry it, place dry bulk and bitumen mixture into a 200 liter barrels, close them, and transport them into the storage. System is remote controlled, because the waste from controlled area can be contaminated and thus radioactive. System can be used when suitable amount of waste is gathered into the storage tank. [30 /6-14,20/]

Used ion exchange resin is active waste, which is disposed into the KAJ-silo. Bituminization is used in TVO to immobilize the radioactive waste [17 /12/]



Picture 13 Bituminization station of TVO. 1. Bitumen storage tank, 2. Bulk dryer, 3. Mixing tank, 4. Waste barrel, 5. Steam heater, 6. Trolley, 7. Activity measuring, and 8. Pipe heating [17 /17/].

Storage tank 343 T3, refilling pump 343 P7, dispenser pump 343 P2, and mixer 343 T2 are parts of the bituminization station. Storage tank and dispenser pump are located out of the controlled area. Bitumen is mixed with dried bulk in mixer 343 T2. [30 /11/]

### 5.6.1 Drying

Main components of the drying station are dryer 343 T1, ejector 343 Q1, condensate tank of ejector 343 T4, centrifugal pump 343 P1, screw mixer 343 A1, and heat exchanger 343 E1. Bulk that comes into the dryer is heated with steam and ejector sucks all the produced steam away from the vessel. The casing of the drying tank is heated up to 130°C, which heats the ion exchange resin and inert bulk up to about 110°C. Otherwise bulk is dried with the help of heat and vacuum. [30 /7/], [31 /4/]



Often drying is the last operation for material, but with radioactive waste it has to be prepared for final disposal after drying. Drying in this case is the final removal of water. [20 /901/]

### 5.6.2 Immobilization into Bitumen

Radioactive waste that includes ion exchange resin is immobilized into bitumen in TVO's process. In this process dried resin is mixed with bitumen at high temperature, ratio should be about 1:1-1,5. Bituminization has many good features for disposal practice. Low porosity, low radionuclide leaching rate, high resin load, resistance to chemical and micro-organisms, and having a small volume are features to mention. [32]

Bitumen is kept fluidized with proper temperature. The entire bitumen system is warmed, so that bitumen will not cool down and solidify into it. Bitumen tank is filled with nitrogen gas to prevent oxidation of bitumen. [28 /11, 12/] Amount of added bitumen is defined by practical experiment and by the activity level of dry resin, so that the barrel's activity level does not increase too high. After mixing bitumen and resin waste the mixture is spilled into the barrels, if it does not spill properly, more bitumen is added. Barrels are measured for activity level, and then carried, by strict regulations, into the VLJ-repository [31 /22-25/].

### 5.6.3 Filling Device, Transporting system, and Storage

There are two handling places for barrels in this system, one for filling and one for closing. Transporting system includes a trolley, which transports barrels inside the system. When barrels are closed, activity level is measured as well. [30 /7-8/]

## 6 IMPLEMENTATION OF THE THESIS

### 6.1 Laboratory Tests

Laboratory tests were conducted in TVO's water chemistry laboratory. In this study it is assumed that the unused ion exchanged resin has same properties than the spent ion exchanged resin. This assumption is done because the real bulk might be too heavily contaminated and it is important in all cases to avoid every unnecessary radioactive contamination. Further studies and calculations showed that the amount of iron in the spent ion exchange resin changes the composition of the bulk quite much. However, it was considered that if tests with clean ion exchange resin show any improvements in behavior of bulk, it could be tested in real process. Small scale filtering test was conducted, with the aim to get some enriched resin without radiation for comparison purposes.

#### 6.1.1 Brookfield Digital Viscometer MODEL DV-E

Viscosity is measured at given shear rates with DV-E Viscometer. It measures the torque that is required to move the spindle in the fluid. Torque represents the resistance to flow of fluid. By changing size of the spindle different ranges of viscosities can be measured. When the spindle size increases, the drag of fluid increases as well and lower viscosity levels can be measured. Same result occurs if the spindle speed is increased. Measurement comes from spring deflection that comes from the fluids resistance to flow. Viscometers spring is calibrated and the spindle rotates through it, rotary transducer then gives torque of the fluid. Used units in SI-system are for viscosity mPa•s and for Torque Newton-m. [33 /5/]

Viscometer's manual instructs that the torque % should be between 10 and 100, otherwise the result is not so accurate. To find out proper spindle and speed, a test sample, 500 ml bulk, was analyzed and torque percentages were detected. The bulk was

found out to be very low viscous, thus the biggest spindel and highest speed gave about 20-30% of torque, and hence they were chosen for analyzes. [33 /11/]

### 6.1.2 Preparation of Pure Bulk

The bulk, in the 342T41 (42) tank, is about 10 w-% of dry material, at maximum it has been 20 w-%, but that thickness is extremely rare. The real amount of pumped sludge, after decantation of pure water, is about 1000 liter. It was scaled to 5 liters for laboratory experiments, thus scaling was 200:1. Bulk was prepared according to [23], which is an instruction that is used in production scale when filters are precoated. On one filter element surfaces 20 kg of inert material and then 60 kg of ion exchange resin is pumped and still added on the top 10 kg of inert material. Moisture content of ion exchange resin is about 50 w-% and moisture of inert is about 2,9 w-%. Those numbers show that dry material of one filter is 30 kg resin and about 29 kg inert, so the ratio of dry material is then about 1:1 of resin inert, respectively. In process half of the filters have 1:1 resin and half of the filters have 1:2 resin. [34]

The bulk preparation was started with measuring the amount of dry material in 5 liters of bulk. 10 w-% includes 500 g dry material, and with the ratio 1:1 resin and inert content is 250g dry resin and 250 g dry inert. Important aspect when calculating the amounts of the resin and inert for the bulk, was to take into consideration the amount of water content in them. Moisture content of resin was about 50 w-%, so it makes about 500g of resin, and 2,9 w-% moist in inert adds up to about 258 g. As mentioned before half of resin is 1:1 and half is 1:2 resin, so amounts are 250 g 1:1 resin and 250 g 1:2 resin. These amounts of resin and inert were weighted and mixed with about 4,25 liters of water. In picture 12 there is 10 w-% bulk. Thicker, 20 w-%, bulk includes 1000g dry material, and it means about 1000 g resin, 500 g 1:1 resin and 500g 1:2 resin, and 515 g inert. However that much dry material could not be mixed with 3,5 liters of water to get total of 5 liters of bulk, the bulk was too dry to mixed in the laboratory gadgets. Therefore it was prepared by mixing the dry content with more water first and then waited until it settles, and after that the excess water was poured away. 15 w-% bulk was reached in about 30 days of settling, so that was

used as comparison for 10 w-% bulk. Bulk that thick could not be measured with the viscometer used in the laboratory, so it was only compared by visual estimation.



Picture 14 The resin-inert bulk, 10 w-% of dry material.

Additive A was prepared according to the instruction, but in smaller amount. Instruction shows how to prepare 5 liters of Additive A, however only 250 ml was prepared for laboratory tests. In 250ml of Additive A; 1,55g Additive A-powder and 6ml of 2-propanol was used. They were mixed up properly with water in a mixer for an hour [35 /4/]. Additive A was added in both thicknesses (10 w-% and 15 w-%) as in the real process. In the actual process, 5 liters of Additive A is used into the total volume of 40-50 m<sup>3</sup>. Same scaling, as before with the bulk preparation, was used, 200:1, and ended up with amount of 0,1 ml Additive A into the 5 liter of bulk. [35 /3/] Additive A was measured and added into the bulk and mixed thoroughly, then left to settle.

### 6.1.3 Viscosity Tests of Bulk and Additives

At first testing the measurement equipment, viscometer, and pure bulk was carried out. The suitable spindle for these tests was found by measuring the bulk and observing the torque percentages. If the torque was lower than 10 % it could be concluded that the measurement was not accurate. Torque can be varied by changing the speed or the spindle. For the test, speed was adjusted in 100 and the biggest spindle, which

measures the lowest viscosities, were chosen. The torque stayed between 15-30% in every measurement [37 /15/]. After this, ten consecutive measurements were conducted with pure bulk. Readings were taken in 0-4 minutes and the test measurements were done to see if weather the analysis be and repeatable.

#### 6.1.4 Additive A

First additive to study was Additive A, it is an anionic polymer (Appendix 3). It is a same solution, which is used in tank 342 T41 (T42) for settling the bulk. The bulk, which is settled, comes from condensate clean up system and few other filters, which uses much less resin. The Additive A was prepared from the powder as mentioned earlier. A 500 ml sample, as homogenous as possible, was measured into an 800 ml plastic decanter, and then the sample was mixed well, and placed under Viscometer for measurement. At first pure bulk was measured two times, proper mixing was done between them. After those the certain amount of Additive A was added into the sample, mixed again, and placed under measuring equipment. Readings were read in 15s, 30s, 45s, 60s, 75s, 90s, 120s, 150s, 180s, 210s, and 240s for every sample. Measurements with Additive A addition were conducted four or five times, within the specified time frame of 4minutes.

The influence of 2,5ml Additive A addition was measured first, measurement was repeated five times. Second measurement was done 6 minutes after the first one, and third measurement 12 minutes from the first one, fourth was done 90 minutes after, and the last, fifth measurement, two hours after first one. Additive A was tested at the same practice for 5 and 10 ml addition.

Tests were repeated for 2,5 and 5 ml. Tests were implemented so that the pure bulk was measured three time, mixed in between measurements, and after addition it was measured four times. Readings were written down in every 15 seconds. With both amounts of Additive A the measurement was repeated two times.

### 6.1.5 Additive B

Additive B (Append 4) is a polymer that is used in waste water purification. It is used for flocculation of solid particles in waste water. Waste water includes some particles and Additive B is added there to increase the particle size of them, so they settle easier in secondary settling tank. [38 /34/] Additive B is cationic polymer [Appendix 4]. This polymer was tested because it was already in use and it has permission to VLJ-repository.

The measurements of the Additive B were implemented with 500 ml samples of pure bulk and 5 and 10 ml additions of Additive B. 500 ml of pure bulk, as homogenous as possible, was measured into an 800 ml plastic decanter. The bulk was measured three times, mixed well in between the measurements, and then Additive B was added, mixed and measured. Measurement was repeated four times; sample was only mixed well in between the measurements. Measurements were done with 5 and 10 ml addition of Additive B.

### 6.1.6 Additive C

Additive C, which is polyacrylic acid (Appendix 5), has been used with some resins, which have been in used, but not nowadays. Additive C is used with resin to enable the right flock size. Bigger amount of Additive C will increase the volume of the flock and at the same time decrease the sizes of flocks. If the volume is small the bigger is the flock size. Bigger the volume of flocks of the resin is the smaller is the flock size of the resin and the better is the filtration capability of the resin. Although the bigger flock size will increase the pressure difference slower. [39 /2/] The Additive C was taken into measurements, because adding bigger volume the solution might give opposite results and acts as a dispergent. And it had already approval into the VLJ-repository.

Additive C was diluted to 1:10 solution, because the dosage was small, and bigger amounts are easier to measure. Dosages in processes are estimated by experience and

laboratory tests. 10 ml of Additive A was measured into the graduated flask, and then the flask was filled up to the mark. The solution was mixed properly.

The measurements with Additive C were done with 500 ml, as homogenous as possible, sample. Pure bulk was first measured three times to get the comparison for the addition measurements. After that the Additive C was added and the sample was mixed well. Next the bulk, where the Additive was added, was measured five times, mixed in between the measurements. Measurements were done with 2,5, 5, and 10 ml additions. Addition to these one measurement with 15 ml of Additive C was carried out, by three times of measuring the pure bulk and then four times after Additive C addition.

The measurements with 2,5, 5, and 10 ml additions were repeated two times. In each of them the bulk was measured three times, and then after addition of Additive C the sample was measured four times.

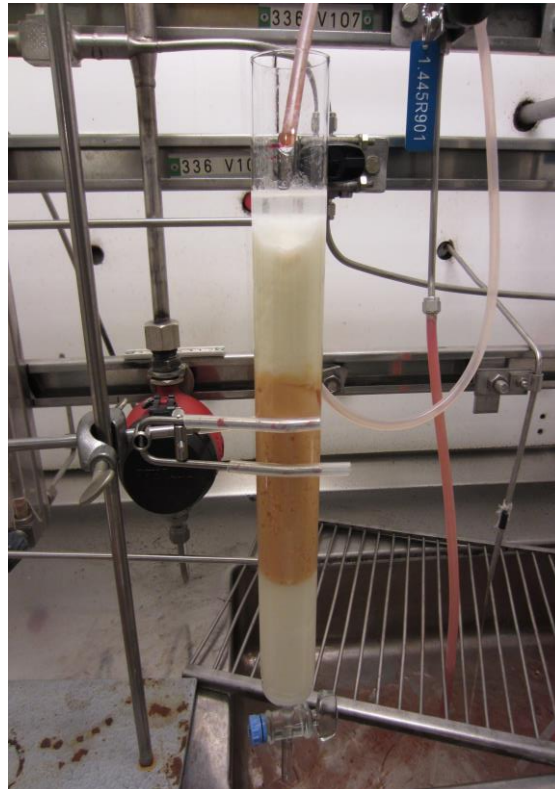
#### 6.1.7 Drying Test

After viscosity measurements small portion of bulk was placed in weighted porcelain evaporation dish. The dish and bulk were weighted also together. Then the dish was placed into the oven in about 105 °C. Dish was weighted in to observe the rate of drying. One sample of every Additive was dried. The dried bulk was then observed with the help of metal spoon and metal funnel.

#### 6.1.8 Small Scale Filtering and Enrichment Test

Small scale enrichment experience was conducted with feed water, which contains only small amount of tritium. Tritium is an isotope of hydrogen it is naturally occurring, radioactive radio nuclei. Very weak form of radiation is emitted from tritium it emits low-energy beta particles. Radiation from tritium cannot penetrate the skin and it is stopped by the air in very short distance. Tritium is able to bond with water and forms tritiated water, which is radioactive and can penetrate human body through digestion. [40 /3-4/]

Glass column was filled with Resin A and Inert A, in the same order and scale as in a real filter. First 20g of inert was put in the bottom of the column, then 60g of resin in the middle of the column, and then again 10g of inert on the top of the column. Filter column was placed under the side tube of the feed water's sampling tube (Picture 15,16, and 17) on 1.10.2014. [34 /2/]



Picture 15 Enrichment test, Resin and inert were placed in a column, and feedwater flowed through it.





Picture 16 Enrichment test after one week, notice reddish layer, which appears because of the iron in the feed water.



Picture 17 Enrichment test after three week.

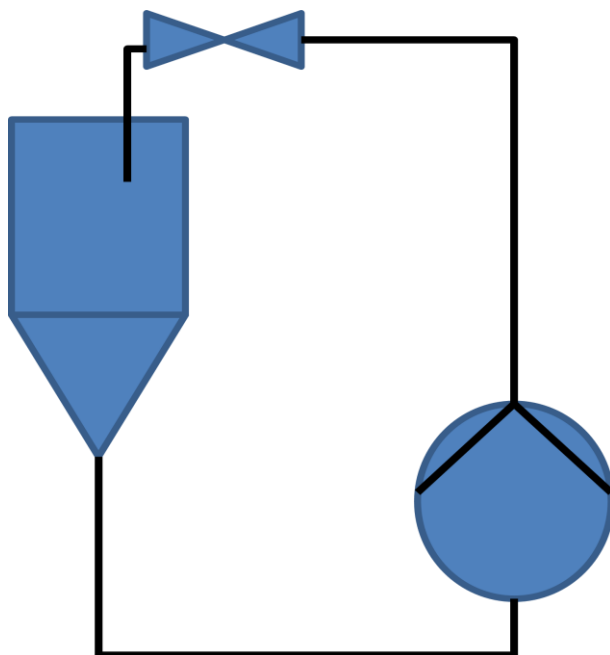
The test was carried out on OL1 and the average iron content of the feed water, was 0,14 µg/l between RX13-RX14 (meaning the time between annual outages of years 2013 and 2014). Compared to condensate water, which included 5,0 µg/l during the same period of time, feed water iron content is really small. However this test was not implemented to get any material for testing, but to see what kind of changes the impurities does for the bulk. [41 /10,4/]

The analyze that was done in chemistry lab, during the weekly analyzes, showed that the iron content was in OL1 feed water 0,3 µg/l [12] and the water flow through the column was measured to be about 1,6 ml/s. Thus the amount of iron, which should be trap into the filter, is about 41 µg/d. Therefore the column was planned to be left there for quite long time, although under control and regularly analyzed by visual estimations.

## 6.2 Pilot tests at SAMK's Process Laboratory

### 6.2.1 Flow Test with Centrifugal Pump

The purpose of this test was to find out how the bulk acted inside the pipes and how the clumps are formed. First the bulk was pumped at a steady pressure after which it was then left for a while to settle. Small amount of bulk was prepared for centrifugal pump to test pumping properties. Centrifugal pump consisted of cone shaped container, pipe going into the pump's suction side, pipe leaving the pump and going through one 90 degrees elbow, and one valve and finally back to the container. Picture 18 shows a simple schematic figure of the pump and its fittings. Two liters of water and 220 g of dry solid material were poured into pump's container. Dry solid consisted of 220 g of resin including the moisture content of about 50 w-%, half 1:1 and half 1:2 resin, and 114 g inert material with the moist content of about 2,9 w-%. Before adding the solids pump circulated only water and solids were added little by little.



Picture 18 Schematic picture of a centrifugal pump.

### 6.2.2 Flow Test with Hose Pump

This part of the testing was carried out to see the changes in the flow of bulk after adding the additive, Additive C. Test was implemented with a hose pump and a plastic barrel. Plastic barrel was filled with 40 liters of water and the pump was tested with it. Before starting to add solid material a mixer was placed into the barrel to mix the bulk. It was noticed, during addition of the solids, that one mixer was not enough and the bulk needed more powerful mixing. Thus another mixer was placed on the other side of the barrel, and so the bulk got properly mixed. 2,3 kg of inert material was added and 4,5 kg resins was also added, so overall dry solid content was about 4,5 kg, in percentages little over 10 w-%. However when the pump was tested it got plugged, and water was added into the bulk to turn it thinner. 10 liters of water was added and so the bulk was about 8 w-% of dry solids. With this thickness the hose pump was able to circulate the bulk. The bulk was mixed measurement time. After measuring the flow of pure bulk, the Additive A was added, first 25 ml, then 25 ml more, and then 100 ml more, and finally 100 ml still more. The flow was measured after each addition for 3-4 times 2 minutes per time.

### 6.2.3 Funnel Test

This test simulated the stimulate bulk flowing and settling. Volume of the funnel was about 2 liters and the diameter of the open end was about 5 cm. About one liter of 10 w-% (dry) bulk was poured into a plastic funnel. The funnel's open end was blocked up with a cap. The funnel was left over night to settle. After uncapping the funnel, the flow was observed. The flow through the funnel's open end needed to be assisted with a metallic wire.

## 7 RESULTS AND DATA-ANALYSIS

### 7.1 Laboratory Tests

#### 7.1.1 Viscosity Test

First measurements showed that the bulk is quite unviscotic, thus the biggest spindle and highest speed were needed to get adequate results. Viscosity of pure bulk gave so high measurement uncertainty (Figure 1). Thus it was decided that really accurate measurements were not possible to carry out. So the accuracy, which is precise enough, was determined to be 1 mPas. Further investigation of figure 1 shows that deviation of results is larger after 1 minute of measurement time. This might happen because the bulk is settling more and more by time and the particles in the bulk are not evenly dispersed, thus the settling is individual for every sample. Some samples might include some lumps, which shows as higher viscosity and some samples might create more or less empty spaces between the particles, which shows as low viscosity. However that can be ignored because study is implemented for bulk, which is being pumped, therefore it do not have a lot of time to settle in the pipelines either. The first 45 to 60 seconds are most important and observing this time frame conclusion for this certain situation could be drawn. Measurement was repeated ten times to see how repeatable it is, and how it could be compared to other measurements.

Viscosity is supposed to decrease in case of increasing the characteristics that are at issue. Lower viscosity fluids movability is higher in the pipes and they are more unlikely to form blockages.

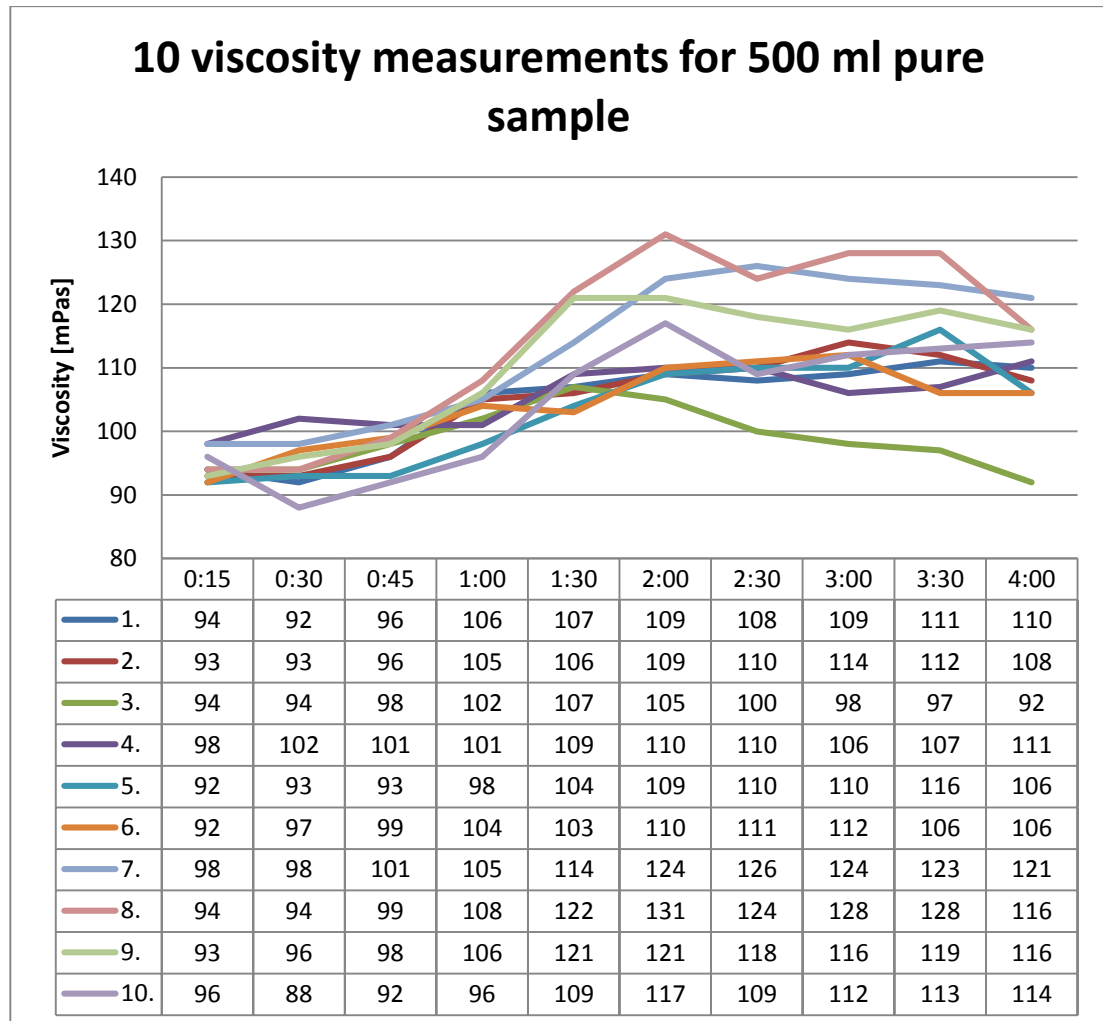


Figure 1 Viscosity measurements with pure bulk.

### 7.1.2 Additive A

Results, of the measurements of the Additive A, show no significant improvement in viscosity of the bulk. After adding the additive and during the mixing the bulk changed, it got smoother and stickier.

Addition of 2,5 ml of Additive A decreases the viscosity little, however when observing the detailed figures from the measurements (Appendix 6) , the results show that the viscosity stays high for first minutes, and after few minutes of measuring it starts to decrease. This event does not fit in to the objectives of this thesis. Adding 5 ml of Additive A gives the same event, which shows as high viscosity results at first,

but after a while it decreases. 10 ml just made the bulk sticky and thick, and the test result complied with the visual estimation.

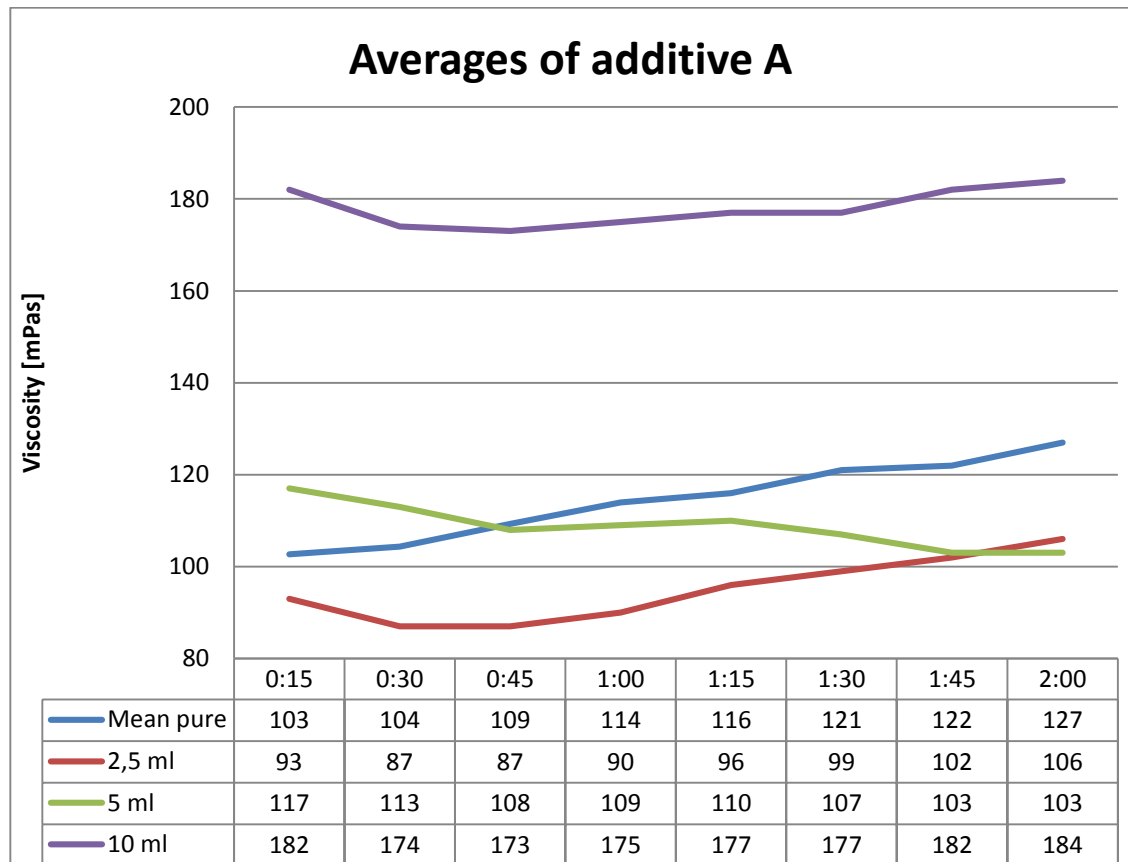


Figure 2 Average values of Additive A additions, 2,5, 5, and 10 ml addition are showed in dependence of time, x-axis.

### 7.1.3 Additive B

Additive B seemed to turn the bulk smoother. However the results of the measurements show that the viscosity only increased after addition. Measurements for this additive were not continued because the results were so clear, as can be seen in figure 3. Detailed results can be seen in Appendix 7.

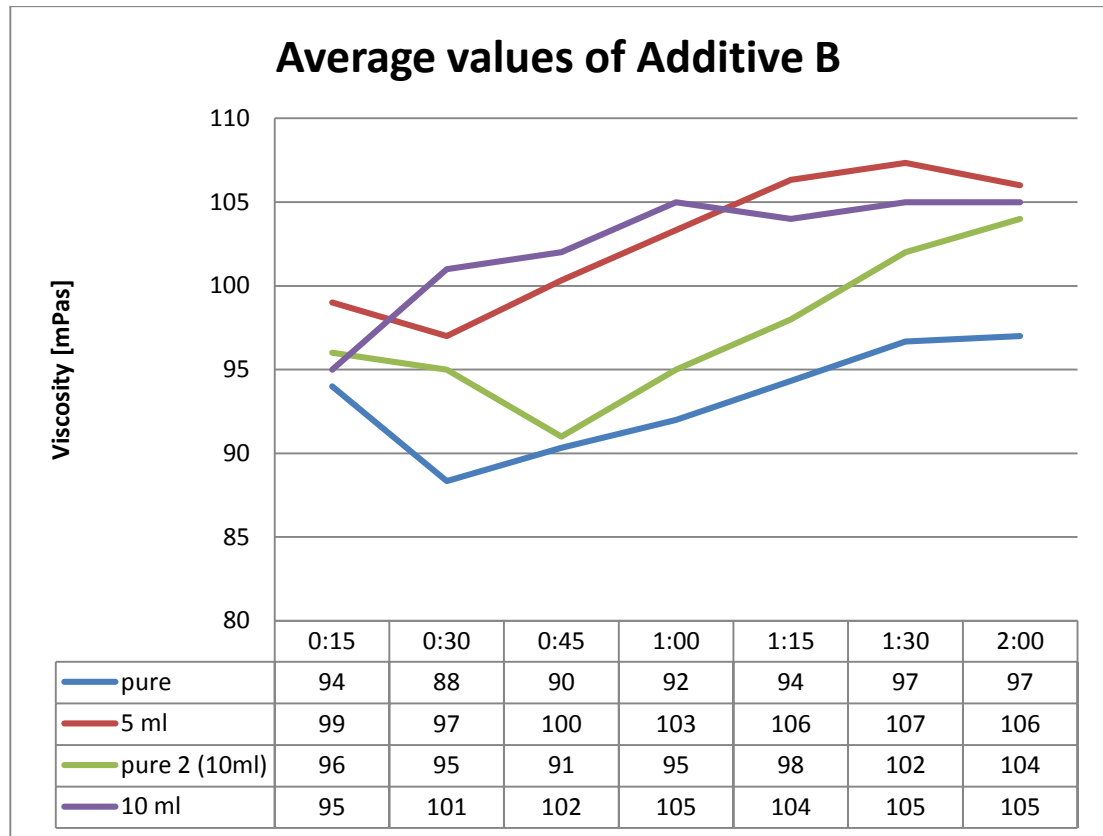


Figure 3 Average values of Additive B additions 5 and 10 ml addition are showed in dependence of time, x-axis.

#### 7.1.4 Additive C

Bulk, after addition of Additive C, seemed to be smoother and slicker. Results of the measurements (figure 4) showed the same, viscosity decreased in every measurement that was conducted. Any significant differences cannot be seen in between the amount of added Additive. Only the addition of 15 ml seems to be too high and it was shown even when mixing the bulk, because it got stickier and thicker. Although after 30 seconds it stabilized and decreases into a level of every other addition amounts. Appendix 8 shows all the results from the measurements with Additive C.

As the figure 4 shows, the dosage of 2,5 to 10ml gives almost the same result in every sample. Considering that the Additive C is diluted to 1:10, the real amount of Additive C into 500 ml sample is 0,25-1,0 ml. That means 0,5-2 ml/l addition of Additive C per one liter of bulk. Detailed results are attached as appendix 8.



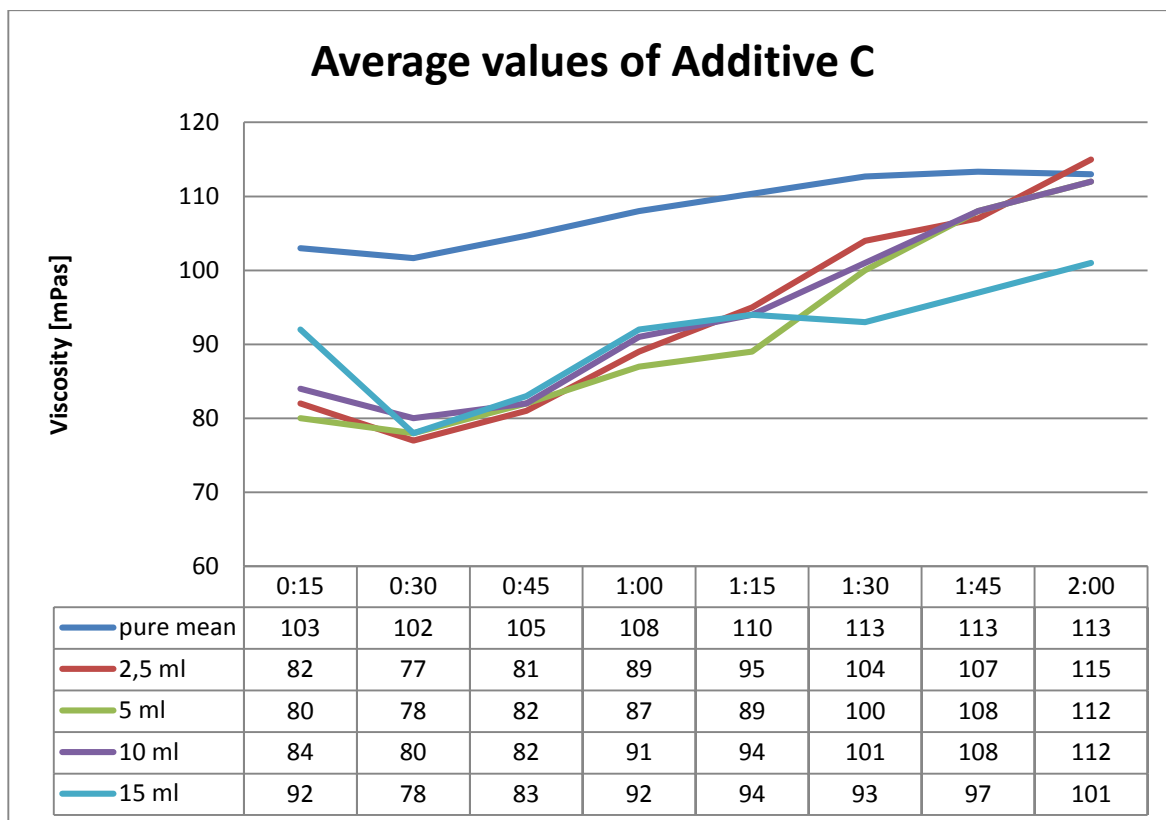
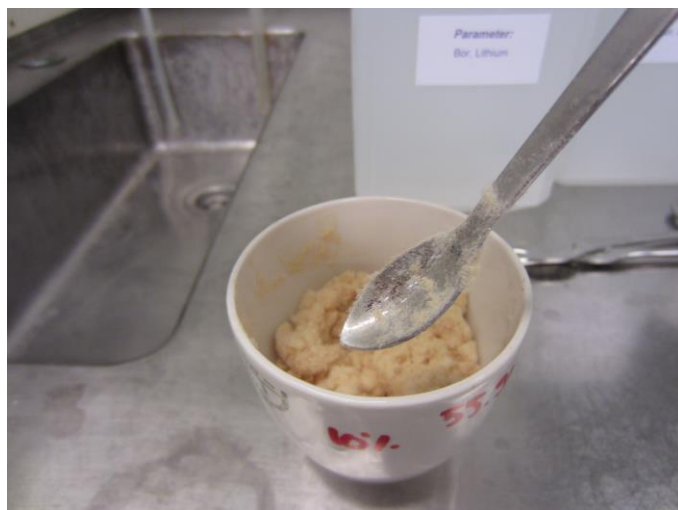


Figure 4 Average values of Additive C additions, 2,5, 5, and 10 ml (+ one measurement on 15ml) addition Viscosity is showed in dependence of time, x-axis.

### 7.1.5 Drying test



Picture 19 Dried pure bulk.

Bulk with about 10 w-% of dry material was completely dry after about 21 hours. Pure bulk was electrical and stuck to the spoon (picture 19) and on the walls of the funnel. Bulk with any of the Additives did not show any differences in the behavior, in these analyzing methods.

	Dish (g)	Dish + bulk (g)	Bulk (g)	Date	Time
10 w-%	55,94	118,64	62,70	22.9.2014	10:20
		95,50	36,56		14:20
		62,04	6,1	23.9.	7:15
		62,04	6,1		14:50
		62,02	6,08	24.9.	8:00
20 w-%	56,46	86,71	30,25	22.9.2014	10:20
		66,28	9,82		14:20
		62,56	6,1	23.9.	7:15
		62,56	6,1		14:50
		62,53	6,07	24.9.	8:00

Table 1 Drying test with pure bulk.

Table 1 shows the weighing results of the bulk. There was 62,70 g of the 10 w-% bulk in one dish. The calculated amount of dry material was about 6,2 g. The result of the drying test was 6,08 g, which was accurate, considering the nature of the sample material and homogeneity of it. 30,25 g of the 20 w-% sample was dried and 6,07 g of dry bulk was left over. Calculated amount of dry was 6,05 g, which is really close to actual amount.

Comparing to real dried bulk the pure dried bulk was electrical, cotton, and "puffy" and the real dried bulk was sandy, loose, and dark reddish. Do the error in this analyze can be considerable, because the real bulk includes significant amount of impurities, which are changing the characteristics of the bulk.

### 7.1.6 Small Scale Filtering and Enrichment Test

Column was taken away and emptied on 1.12.2014. Wet resin and inert were weighted and placed into the oven to dry. The wet bulk weighed 403,90 g (whole weight - empty decanter =>  $673,67 \text{ g} - 270,25 \text{ g} = 403,42 \text{ g}$ ). Calculated amount of dry material before enrichment was about 45 g. During the 61 days, which column were in the place, the calculated amount of collected iron could be 2,5 g ( $41 \mu\text{g/d} \times 61 \text{ d}$ ). Comparing this amount with the iron content of the condense water, which was  $5 \mu\text{g/l}$ . In condensate water the filter would have collected about 42 g iron [ $5 \mu\text{g/l} \times 0,0016 \text{ l/s} \rightarrow (0,008 \mu\text{g/s} \times 60 \text{ s} \times 60 \text{ min} \times 24 \text{ h}) \times 61 \text{ d}$ ].

After 24 h the bulk was dry (weighing results were the same two times in a row) and the weighing result was taken. The whole decanter weighed 327,06 g. The weight of the decanter was subtracted and the result was that bulk weighed 56,81 g. According to the calculations and moist content of the inert and resin the amount of impurities is about 12 g ( $57 \text{ g} - 45 \text{ g}$ ). 45 g was the dry material that was placed into the column, it includes 60 g resin, ~50 w-% moisture, and 30 g inert, moisture content of 2,9 w-%. Increased weight is about 27 % and that is significant. Uncertainty of the measurements is quite big though. Amount of dry material can be varying due to different moisture contents. Weightings were not conducted with high-resolution scale. The flow through the filter was varying.

Some coloring occurred on the top of the inert, as can be seen in picture 20. Coloring appeared there during the first week. My opinion is that it is ferric oxide,  $\text{Fe}_2\text{O}_3$ , to be precise hematite, which is reddish.



Picture 20 Filtering test on 1.12.2014.

## 7.2 Pilot Tests at SAMK's Process Laboratory

### 7.2.1 Flow Test with Centrifugal Pump

Water flowed easily through the pipes and even after the solids were added, the mixture moved well. After noticing that the bulk flowed it was left to settle for a while, for circa 30 minutes. After the settling time the pump was started again, however the pipes were blocked, and nothing moved through them. The pipe fitting under the container was opened to get the bulk away. It flowed nicely from the middle of the container, but a thick wall of bulk was remained on the walls of container. After most of the bulk had flown out some of the bulk from the walls collapsed into the pipe and blocked it. The bulk was quite dry and did not mix with water easily and finally it

had to be dug up. The pipes were so severely blocked that the pump had to be dismantled, but still it was hard to remove the bulk from the pipes.

In my opinion reasons for these blockages were too small pipe, too stiff elbow on it, and too small conduit clip for the valve. To pump this kind of fluid, the process equipments need to be in accordance with that. It requires wide enough pipes, gentle elbows, wide fittings, no settling possibilities inside the pipes, and altogether nothing extra on the way.

### 7.2.2 Flow Test with Hose Pump

Hose pump also got blocked with the 10 w-% (dry) bulk. After adding water, the bulk flowed fine and steadily. When mixing was stopped and the bulk got to settle, even for a little while, it formed such a thick mass that the pump was not able to suck it.

The flow was steady before addition of Solution A. It was measured four times and each measurement gave a flow of 2,5 l/min (see appendix 9). After each addition of Additive A the result was the same, steady 2,5 l/min. All the addition steps were measured three times.

To me this shows that more water could be used for mixing the bulk, before pumping it to the dryer tank. Laboratory scale test results were not repeated in pilot scale. In the laboratory tests flocculent addition improved viscosity, but in the pumping tests Additive A did not have any influence on the results.

### 7.2.3 Funnel Test

The results of the funnel test were similar to the observation in the centrifugal pump test. There were thick layer of bulk on the walls of the funnel, and even the rest did not flow right through. A metal wire was used to mix the bulk in the funnel and some water was added by pouring it into the funnel to force the bulk to flow out. Bulk on the walls was dry, and as the bulk on the middle of the funnel was forced to flow

through, it only got dryer on the walls. It needed throughout mixing and more water to get the bulk out of the funnel, even with such a big opening. Picture 21 shows how the bulk flowed out of the funnel after mixing and adding some water.

Mixing the bulk with water, from the same pipe as outlet of the bulk, is not necessarily sufficient as the already settled bulk needs better mixing and maybe some water dilution before it can be pumped safely through the pipes.



Picture 21 Funnel test.

## 8 CONCLUSION AND DISCUSSION

### 8.1 Consideration of the Results

Objective of this thesis was to improve the characteristics of spent ion exchange resin waste so that it would flow better in the pipes and the dry waste would mix up better with bitumen.

Further studies of this subject would need powdered ion exchange resin, which is enriched with impurities. Enriched resin would have same qualities and characteristics than real waste bulk. Enrichment could be done e.g. with hematite, which is the main impurity in the process.

Flow properties were studied with viscosity measurements, pumping tests, and settling tests. Viscosity measurements gave encouraging results for Additive C. Additive C decreased the viscosity in every measurement just the way that was defined to be the best circumstances considering the actual process. The viscosity decreased immediately after mixing the bulk and stayed low for about 45 seconds, after which it started to increase to the level of pure bulk measurements.

Viscosity measurement was not the best analyze for this kind of material but it certainly gave differences between samples. Thus the objectives of the measurements were reached.

Tests with dry bulk did not give desired results; as a matter of fact they did not give any results. Better and more precise measurement methods needs to be developed to studies further the characters of dry bulk.

## 8.2 Discussion of Implementation in Plant Scale

Additive C was the only additive that gave promising signs with viscosity meter. The dosage that decreased the viscosity was 0,25-1 ml/0,5liters of the bulk, that means 0,5-2 ml/l of the bulk. This amount can be tried out in the process scale. This dosage means that 0,5-2 liters of additive is pumped into the 1000 liters of bulk pumped from storage tank into the waste management unit. Flow rate of the additive depends on the bulk's flow rate.

Conclusion that can be drawn from this study is that the best way to avoid blockages is to add more water into the bulk and mix it well and thorough. Mixing should reach all the way to the tank's walls to decrease the possibility of the bulk gathering to the walls of the tank. This would prevent the sudden collapse of the dryer bulk to the bottom. Extra water will change the drying step of the process by adding the amount that needs to be dried. Drying would consume more energy due to increased volume of water to be vaporized.

One solution to avoid the blockages would be a mixer into the tank 342 T41 and T42. The mixer would have to be the kind of which mixes the bulk thorough and reach all the way to the walls of the tanks.



## REFERENCES

- [1] *TVO in Brief, TVO's web page. Available at <http://www.tvo.fi/TVO%20in%20brief>. Referred 24.9.2014.*
- [2] *TVO Annual Report 2013, TVO in brief, TVO: an overview. Available at <http://www.tvo.fi/tvooverview>. Referred 25.9.2014*
- [3] *TVO, News, TVO's web page. Available at <http://www.tvo.fi/news/908>. Referred 30.9.2014.*
- [4] *TVO: Ydinsähköä Olkiluodosta. 2012, Helsinki. Publisher Teollisuuden Voima Oyj, Eura Print.*
- [5] *Website of the STUK, Finnish Radiation and Nuclear Safety Authority. Page updated 04.09.2013. Available at [http://www.stuk.fi/en\\_GB/](http://www.stuk.fi/en_GB/). Referred 7.10.2014.*
- [6] *Nuclear energy Act, 1987. Finlex. Available at <http://www.finlex.fi/en/laki/kaannokset/1987/en19870990>. Referred 7.10.2014.*
- [7] *Posiva: Environment and Sorting Guide. 2013, Euraprint.*
- [8] *Website of TVO Oyj. Available at <http://www.tvo.fi/Nuclear%20waste%20management>. Referred 27.10.2014.*
- [9] *Website of Posiva. Required Permission and Procedures and Tarvittavat luvat ja Menettelyt. Available at <http://www.posiva.fi>. Referred on 17.11.2014.*
- [10] *Website of Aluehallintovirasto, 2013. Ympäristöluvut. Available at <https://www.avi.fi/web/avi/ymparistoluvat>. Referred on 17.11.2014.*
- [11] *TVO, 2012. Environmental Report 2011. Eura Print Oy.*
- [12] *WiLab LIMS, TVO's software for results of laboratory analyzes.*
- [13] *Thermo Scientific. XSeries 2 ICP-MS Manual.*
- [14] *Cowan, R., Rühle, W. & Hettiarachchi, S., 2011. Introduction to Boiling Water Reactor Chemistry, Volume 1. Sweden: Advanced Nuclear Technology International.*
- [15] *Helffferich, F., 1995, originally published in 1959. Ion Exchange. United States of America: Dover Publications.*
- [16] *Nordmann, F., Rochester, D., Kysela, J. & Odar, S. 2011. LCC7 Special Topic Report: Operational Issues and Practices. Sweden: Advanced Nuclear Technology International.*
- [17] *Valkiainen, M., 1990. Bitumoidun jätteen ominaisuudet- yhteenveto. Helsinki: Teollisuuden Voima Oy.*
- [18] *Tompuri, K., 2011. Instruction 118993, Prosessissa käytettävät apuaineet - materiaaliyhje. TVO intranet, Olkidoc.*

[19] Janmey, P. A. & Schliwa, M., 2008. *Rheology*. National Institute of Health, Public Access. Available at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2895991/>. Referred 5.11.2014

[20] Richardson, J.F., Harker, J.H. & Backhurst, J.R., 2002. *Chemical Engineering: Particle Technology and Separation Processes*. Volume 2, Fifth edition. Netherlands: Elsevier, Butterworth Heinemann. Pages 1229.

[21] Brookfield Engineering Laboratories, 2014. *More Solution to Sticky Problems*. USA.

[22] Saarimaa R., 2014 (updated on demands). *Condensate cleanup system, educational material of the TVO Oyj*. Available at TVO's intranet.

[23] Nousiainen, P., 2011. *FSAR 106343, 733-OL1/OL2- Distribution System for Demineralized Water - Final Safety Analysis Report*. Available at TVO's intranet, Olkidoc

[24] Väisänen, H., 2014. *FSAR 106342, OL1/OL2/OL3- Final Safety Analysis Report for System 732 - Water Demineralizing System*

[25] Malinen, A., 2014. *Operation bulletin 102135, 332-suodattimen massaus*. TVO intranet, Olkidoc.

[26] Saarimaa, R., 2014. *332-SEURANTA*. Available at TVO intranet <http://intra3/kemia/prosessi/332/SEURANTA.html>.

[27] Nousiainen, P., 2012. *FSAR 106148: OL1/OL2 Nestemäisten jätteiden käsittelyjärjestelmä - lopullinen turvallisuusseloste*. TVO intranet, Olkidoc.

[28] Vuori, P., 2014. *Instruction 126654, Säiliön 342 T41 ja T42 dekantointi*. Available at TVO intranet, Olkidoc.

[29] Vuori, P., 2009. *Instruction 126653, Säiliön 342 T41 ja T42 kiertopumppaus*. Available at TVO's intranet, Olkidoc.

[30] Rautanen M. 2014, *FSAR 106149, 343-OL1/OL2- kiinteiden jätteiden käsittelyjärjestelmä - lopullinen turvallisuusseloste*. TVO intranet, Olkidoc.

[31] Vuori, P., 2014. *Instruction 133101, 343-Bitumiaseman käyttö*. TVO intranet, Olkidoc.

[32] Wang, J. & Wan, Z 2014 2014. *Treatment and disposal of spent radioactive ion exchange resins produced in the nuclear industry*. China: Laboratory of environmental technology. Available on Science direct.

[33] Brookfield Engineering Laboratories, 2014. *More Solutions to Sticky Problems*. USA.

[34] Malinen A., 2014. *Instruction 102135, 332-suodattimen massaus*. TVO intranet, Olkidoc.

- [35] Alanen J., 2014. *Instruction 101619, Magnafloc 342-flokkausaneliuoksen valmistus. TVO intranet, Olkidoc.*
- [36] Pöyhönen, E-S., 2013. *Instruction 126656, 342-15 kemikaalin annostelu 342 P93 avulla. TVO intranet, Olkidoc.*
- [37] Brookfield, *Model DV-E Operating Instructions, Manual No. M98-350-J0912.*
- [38] Pöyhönen, E-S., 2013. *Instruction 105640. 0.739 Jäteveden puhdistusjärjestelmä. TVO intranet, Olkidoc.*
- [39] Saarimaa, R., 2013. *Instruction 146815. Flokkautumisen apuaineen, Additive A, lisästarpeen määrittäminen. TVO intranet, Olkidoc.*
- [40] *Public health goals for chemicals in drinking water, Tritium, California. Director; Denton, J. E., 2006. Referred 6.10.2014. Available at <http://www.oehha.ca.gov/water/phg/pdf/PHGtritium030306.pdf>*
- [41] Vaitinen J., 2014. *Report 158948, OLI/OL2-lauhteiden ja syöttöveden metallipitoisuudet RX13-RX14. TVO intranet, Olkidoc.*

MATERIAL SAFETY DATA SHEET OF RESIN A

KÄYTTÖTURVALLISUUSTIEDOTE

24.4.2013

sivu 1

Muutokset edelliseen käyttöturvallisuustiedotteeseen on kirjoitettu *kursiivilla*.

**1. KEMIKAALIN JA VALMISTAJAN TUNNISTUSTIEDOT**

- 1.1 Kemikaalin tunnistustiedot**
- 1.2 Valmisteen käyttötarkoitus**  
Jauhehartsi voimalaitosten lauhteenpuhdistukseen
- 1.3 Valmistajan tunnistustiedot**
- 1.4 Hätäpuhelinnumero**

**2. KOOSTUMUS JA TIEDOT AINEOSISTA**

**2.1 Koostumus**

Nro		Paino-%
1	Sulfonoitu styreeni-divinyylibentseeni kopolymeeri, H <sup>+</sup> -muoto	~ 25
2	Styreeni-divinyylibentseeni kopolymeeri, johon on liitetty kvaternäärinen amiini, OH <sup>-</sup> -muoto	~ 25
3	Vesi	~ 50

**3. VAARALLISTEN OMINAISUUKSIEN KUVAUS**

- 3.1 Luokitus**  
Tätä tuotetta ei ole luokiteltu vaaralliseksi sosiaali- ja terveysministeriön luokitusperusteasetuksen 807/2001 mukaan.
- 3.2 Silmäkosketus**  
Tuote saattaa aiheuttaa lievää ärsytystä.
- 3.3 Ihokosketus**  
Pitkäaikainen tai toistuva ihokosketus saattaa aiheuttaa lievää ärsytystä.
- 3.4 Hengitys**  
Pöly saattaa sisään hengitettäessä aiheuttaa ärsytystä hengitysteissä.

**4. ENSIAPUOHJEET**

- 4.1 Silmäkosketus**  
Huuhtelee silmiä runsaalla vedellä vähintään 15 minuuttia. Ota yhteys lääkäriin, jos ärsytys jatkuu.

## KÄYTTÖTURVALLISUUSTIEDOTE

24.4.2013

sivu 2

- 4.2 Ihokosketus**  
Pese iho huolellisesti vedellä ja saippualla.
- 4.3 Hengitys**  
Hyvä yleisilmastointi riittää.

**5. OHJEET TULIPALON VARALTA**

- 5.1 Sammutusaineet**  
Hiilihapposammutin, jauhesammutin ja vesisuihku.
- 5.2 Erityiset altistumisvaarat**  
Pollettaessa muodostuu rikin, typen ja hiilen oksideja.
- 5.3 Erityiset suojaimet tulipalon torjuntaa varten**  
Käytä täydellistä suojaruustusta ja paineilmahengityslaitetta.

**6. OHJEET ONNETTOMUUSPÄÄSTÖJEN VARALTA**

- 6.1 Henkilövahinkojen estäminen**  
Roiskeet voivat aiheuttaa liukkaita pintoja. Käytä asianmukaisia henkilökohtaisia suojaruusteita, kts. kohta 8.
- 6.2 Ympäristövahinkojen estäminen**  
Estä tuotteen pääsy lattiakaivojen ja viemärin kautta ympäristöön.
- 6.3 Puhdistusohjeet**  
Kerää vuotanut tuote sopiviin säiliöihin uudelleenkäyttöä tai hävittämistä varten.

**7. KÄSITTELY JA VARASTOINTI**

- 7.1 Käsitteleminen**  
Kuivaan jauheeseen saattaa kertyä staattista sähköä. Pidä tuote poissa avotulesta ja kuumilta pinnoilta. Tuote saattaa aiheuttaa liukkaita pintoja. Jos tuotetta käytetään voimakkaiden hapettimien kanssa, on asiantuntijan arvioitava turvalliset käyttöolosuhteet.
- 7.2 Varastointi**  
Estä tuotteen kuivuminen. Varastoi +0 – 30 °C.
- 7.3 Erityiset käyttötavat**  
Tuotteelle ei ole ohjeita erityiskäyttöä varten.

**8. ALTISTUMISEN EHKÄISEMINEN JA HENKILÖNSUOJAIMET**

- 8.1 Altistuksen raja-arvot**  
Kohdassa 2 mainituille yhdisteille ei ole annettu raja-arvoja.
- 8.2 Altistumisen ehkäiseminen**  
Ei toimenpiteitä normaaleissa työskentelyolosuhteissa.

KÄYTTÖTURVALLISUUSTIEDOTE

24.4.2013

sivu 3

**8.2.1 Työperäisen altistuksen torjunta**

**8.2.1.1 Hengityksensuojaus**

Hengityssuojainta ei tarvita normaaleissa työskentelyolosuhteissa. Kuivaa jauhetta käsitellessä hengityssuojaimen käyttöä suositellaan.

**8.2.1.2 Käsiensuojaus**

Käytä työkäsineitä.

**8.2.1.3 Silmiensuojaus**

Käytä hyväksytyjä suojasilmälaseja.

**8.2.1.4 Ihonsuojaus**

Vältä ihokosketusta. Suojaa iho ainetta käsiteltäessä.

**8.2.2 Ympäristöaltistuksen ehkäiseminen**

Kts. kohta 12.

**9. FYSIKAALISET JA KEMIALLISET OMINAISUUDET**

**9.1 Yleiset tiedot**

Olomuoto	Kiinteä (jauhe)
Väri	Kermanvalkoinen
Haju	Lähes hajuton

**9.2 Terveyden, turvallisuuden ja ympäristön kannalta tärkeät tiedot**

pH	4-7 (10-prosenttisessä vesiliuoksessa)
Kiehumispiste	Ei sovellettavissa
Leimahduspiste	Ei sovellettavissa
Syttyvyys	Ei sovellettavissa
Räjähdysominaisuudet	Ei sovellettavissa
Hapettavat ominaisuudet	Ei sovellettavissa
Höyrynpaine	Ei sovellettavissa
Suhteellinen tiheys	1,1-1,4 g/cm <sup>3</sup> (vesi = 1 g/cm <sup>3</sup> )
Vesiliukoisuus	Liukenematon
Rasvaliukoisuus	Liukenematon
Jakautumiskerroin	Ei sovellettavissa
Viskositeetti	Ei sovellettavissa
Höyryntiheys	Ei sovellettavissa
Haihtumisnopeus	Ei sovellettavissa

**10. STABIILISUUS JA REAKTIIVISUUS**

**10.1 Vältettävät olosuhteet**

Vältä yli 150 °C lämpötiloja.

**10.2 Vältettävät materiaalit**

Voimakkaat hapettimet

**10.3 Vaaralliset hajoamistuotteet**

Rikin, typen ja hiilen oksidit sekä amiinit kuumennettaessa

KÄYTTÖTURVALLISUUSTIEDOTE

24.4.2013

sivu 4

**11. TERVEYSVAIKUTUKSIIN LIITTYVÄT TIEDOT**

**11.1 Väitön myrkyllisyys**

**Hengitettynä:** Höyryjen muodostuminen epätodennäköistä fysikaalisista ominaisuuksista johtuen.  
**Nieltynä:** Suurina määrinä nautittuna saattaa aiheuttaa lievää pahoinvointia.  
**Ihon kautta:** Ihon kautta imeytyminen epätodennäköistä fysikaalisista ominaisuuksista johtuen.

**11.2 Ärsyttävyys**

**Iho:** Ei yleensä ärsytä ihoa  
**Silmät:** Voi aiheuttaa lievää ja satunnaista ärsytystä. Jauhe voi ärsyttää tai aiheuttaa hiertymävaurioita mekaanisesta vaikutuksesta johtuen.

**12. TIEDOT KEMIKAALIN VAARALLISUUDESTA YMPÄRISTÖLLE**

**12.1 Ekotoksisuus**

Ei sovellettavissa.

**12.2 Liikkuvuus**

Ei sovellettavissa.

**12.3 Pysyvyys ja hajoavuus**

Ei sovellettavissa.

**12.4 Biokertyvyyspotentiaali**

Ei sovellettavissa.

**12.5 Muut haitalliset vaikutukset**

Ei sovellettavissa.

**13. JÄTTEIDEN KÄSITTELY**

Ioninvaihtohartsit eivät sinänsä ole ongelmajätettä, ja ne voi hävittää loppusijoittamalla kaatopaikalle. Jos määrä on suuri, on syytä ottaa yhteyttä kaatopaikan pitäjään ja sopia erän toimittamisesta. Poltto sen sijaan ei sovi käsittelytavaksi ainakaan klooria sisältäville hartseille.

Kuitenkin on huomattava, että hartsit ovat ongelmajätettä, jos niihin on sitoutunut ongelmajätteeksi luokiteltavaa ainetta yli tietyn pitoisuusrajan. Pitoisuusraja riippuu sitoutuneen vaarallisen aineen ominaisuuksista. Vaaralliseksi luokitellut pitoisuusrajat on määritelty direktiivissä 2001/118/EC.

**14. KULJETUSTIEDOT**

Ei sovellettavissa.

**15. KEMIKAALEJA KOSKEVAT MÄÄRÄYKSET**

Tätä tuotetta ei ole luokiteltu vaaralliseksi valmistusdirektiiveissa 67/548/EEC ja 88/379/EEC.

KÄYTTÖTURVALLISUUSTIEDOTE

24.4.2013

sivu 5

**16. MUUT TIEDOT**

Tämä tiedote sisältää teknisiä ja käyttöturvallisuuksiä parhaan tietomme mukaan. uskoo tässä tiedotteessa olevien tietojen olevan paikkansapitäviä ja luotettavia käyttöturvallisuuksiä päiväyksen ajankohdaksi. On suositeltavaa tarkistaa kansalliset ja alueelliset säädökset, jotka ovat voimassa asiaankuuluvilla aloilla, kuten työturvallisuudessa ja ympäristönsuojelussa.

Operational Safety Bulletin of RESIN B is about the same, so it is unnecessary to attach both of them here.



MATERIAL SAFETY DATA SHEET OF INERT A

Material Safety Data Sheet

<b>Product:</b>	<b>Page:</b> 01 of 02
<b>Date of issue:</b> June 29th, 2000	<b>Version:</b> 4

**\*1. Identification**

trade name:  
manufacturer:

**2. Composition and data on components**

ground extruded polyacrylonitrile

**3. Hazard identification**

non-hazardous product

**4. First aid measures**

after inhalation: remain calm, arrange for fresh air, consult physician  
after skin contact: inoffensive  
after eye contact: flush out with open eyes with plenty of water, then  
consult ophthalmologist as soon as possible

**5. Fire fighting measures**

extinguishing media: water, foam, extinguishing powder

**6. Accidental release measures**

cleaning/collecting by means of mechanical apparatus

**7. Handling and storage**

handling:  
avoid raising of dust; arrange good ventilation/exhaustion  
in case of fire and explosion:  
take provisions against dust explosion and electrostatic charge;  
keep away from any source of ignition  
storage:  
dry; protect from light; below 120°F (50°C); shelf life at least 3 years

**8. Exposure controls and personal protection**

general protection:  
avoid inhalation and eye contact with dust  
personal protection:  
wear filter masque P1 and protecting spectacles

Material Safety Data Sheet

<b>Product:</b>	<b>Page:</b> 02 of 02
<b>Date of issue:</b> June 29th, 2000	<b>Version:</b> 4

**9. Physical and chemical properties**

appearance	: powder
color	: white
odor	: odorless
flash point	: > 480°F (250°C)
specific gravity	: appr. 72.5 lb/ft <sup>3</sup> (1.16 g/cm <sup>3</sup> )
bulk weight	: appr. 8 lb/ft <sup>3</sup> (125 kg/m <sup>3</sup> )
pH-value	: neutral (inert)

**10. Stability and reactivity**

conditions to be avoided:

do not heat above about 480°F (250°C) to avoid decomposition

hazardous decomposition products:

nitrogen oxydes

dangerous reactions:

if dispersed in air pulverized organic products are able to explode;  
strong oxydants, e.g. nitric acid, can cause violent reactions

**11. Toxicological information**

non-toxic

**12. Ecological information**

environmental endangerings are not known; nevertheless, product should be disposed of according to regulatory guidelines

**13. Disposal considerations**

disposal must be made according to official regulations

**14. Transport information**

under EC regulations product is not to be classified as dangerous;  
avoid storage at temperatures above 120°F (50°C) and exposure to sunlight

**15. Regulatory information**

directive on labelling of dangerous materials: not required for this product

**16. Other information**

sections marked with "\*" have been changed in comparison to latest version

*This data is based on our present knowledge. However, it shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.*

## MATERIAL SAFETY DATA SHEET OF ADDITIVE A

### Käyttöturvallisuustiedote Direktiivin 91/155/EEC mukaan

Versio 17.02.2003

(000000.0000)

#### 1. Kemikaalin ja sen valmistajan, maahantuojan tai muun toiminnanharjoittajan tunnistustiedot

Kauppanimi	
Kemikaalin tunnistustiedot	Anioninen akrylamidi kopolymeeri
CAS-nro	Valmiste
Käyttö	Flokkulanti

Valmistaja, maahantuoja, muu toiminnanharjoittaja

Puhelin  
Fax-nro

Tiedot

Hätänumero (24 h)

+41 61 632 07 79, (09) 471 977  
(MYRKYTYSTIETOKESKUS)

#### 2. Koostumus ja Tiedot Aineosista

Tuote ei sisällä aineosia, jotka on luokiteltu terveydelle haitallisiksi, konsentraatioissa jotka tulee ottaa huomioon EC direktiivien mukaan.

#### 3. Vaarallisten ominaisuuksien kuvaus

Ei ole luokiteltu haitalliseksi EU-direktiivien mukaisesti.

Saattaa aiheuttaa vähäistä ihoärsytystä, erityisesti toistuvassa tai pitkäaikaisessa altistuksessa.

Saattaa aiheuttaa silmien ärsytystä, joka pitäisi lakata tuotteen poistamisen jälkeen.

Saattaa aiheuttaa ärsytystä hengityselimissä mikäli pölyä hengitetään.

Tämäntyyppisellä tuotteella on taipumus muodostaa pölyä kovakouraisessa käsittelyssä. Se ei pala helposti, mutta kuten monet orgaaniset jauheet, saattaa muodostaa ilmaan syttyviä pölypilviä.

Vältettävä pölynmuodotumista ja pidettävä poissa sytylähteiden luota.

Erittäin liukasta kastuessaan.

#### 4. Ensiapuohjeet

##### Ihokosketus

Roiskeet huuhdeltava saippualla ja runsaalla vedellä. Saastunut vaateus pitäisi pestä ennen uudelleenkäyttöä.

##### Roiskeet silmiin

Huuhdeltava välittömästi runsaalla vedellä vähintään 15 minuutin ajan. Mikäli ilmenee silmien ärsytystä otettava yhteys lääkärin

##### Hengitys

Sirrettävä raittiseen ilmaan. Avataan hengitystiet. Tunnettaessa pahoinvointia, hakeuduttava lääkärin hoitoon.

##### Nieleminen

Ei saa oksennuttaa. Tajuttomalle tai kouristelevalle ei saa antaa mitään suuhun. Tarkistetaan hengitys ja pulssi, ja tarvittaessa laitetaan elvytysasentoon ja otetaan yhteys lääkäriin. Jos tajuihinsa huuhdellaan suu vedellä. Annetaan välittömästi vettä mukillinen (noin 600 ml) ja jatketaan veden juomista kupillinen (200 ml) kerrallaan 10 minuutin välein. Kutsu lääkäri välittömästi.

## Käyttöturvallisuustiedote Direktiivin 91/155/EEC mukaan

Versio 17.02.2003

(001 000 0000)

### 5. Ohjeet tulipalon varalta

#### Sopivat sammutusaineet

Vaahhto, kuivajauhe, hiilidioksidi (CO<sub>2</sub>), vesisuihkun/-sumun asemesta

#### Sammutusaineet, joita ei pidä käyttää turvallisuussyistä

Ei tiedossa

#### Erityiset suojaimet tulipaloa varten

Kuten kaikissa tulipaloissa, joissa on mukana kemikaaleja:täydellinen kemikaalisuojavaatetus, suojakäsineet, saappaat ja raitisilmalaite

#### Hajoamistuotteet

hiilen oksideja

#### Lisätietoja

Erittäin liukasta kastuessaan.

### 6. Ohjeet onnettomuuspäästöjen varalta

#### Ohjeet henkilövahinkojen estämisestä

Vältettävä pölyn muodostumista Käytettävä asianmukaisia suojavarusteita. Tehokas pölysuojain.

#### Ohjeet ympäristövahinkojen estämiseksi

Ainetta ei saa huuhtoa pintaveteen, käymälään tai pohjavesijärjestelmiin

#### Puhdistusohjeet

Lakaistaan ja lapioidaan tarkoituksenmukaisiin astioihin hävittämistä varten. Jäännökset tai pienet vuodot pitäisi ruiskuttaa kokonaan pois runsaalla vesimäärällä. Käsittele ja hävitä pesuvesi paikallisten ohjeiden mukaisesti. Maahan kaatunut, kastunut tuote tai maahan kaatunut nestemäinen liuos aiheuttavat liukastumisvaaran Tämän tyyppinen vuoto tulisi peittää maalla tai hiekalla ja toimittaa hävitettäväksi varmistaen ettei jätettä jää jäljelle.

### 7. Käsittely ja Varastointi

#### Käsittely

Orgaanisen jauheen ollessa kyseessä saattaa muodostua syttyviä pölypilviä. Vältettävä pölyn muodostumista ja sytytyslähteitä. Varmistettava hyvä ilmanvaihto/ilmanpoisto. Syöminen, juominen ja tupakointi on työtiloissa kielletty. Saatunut vaarutus on välittömästi riisuttava ja pestävä ennen uudelleen käyttöä. Pese kädet ennen taukoja ja heti käytön jälkeen.

#### Varastointi

Suojattava märiltä ja kosteilta olosuhteilta. Pidettävä kuivassa viileässä paikassa. Vältettävä äärimmäisiä lämpötiloja.

Kastuessaan erittäin liukasta.

### 8. Altistumisen ehkäiseminen ja henkilösuojaimet

#### Raja-arvo(t)

CIEL-TWA Cibon itse määrittelemä raja-arvo, 8 tuntia (aika arvioitu)

ei testattu

#### Tekniset toimenpiteet/varotoimenpiteet

Varmistettava riittävä ilmanvaihto, eteenkin suljetuissa tiloissa. Huolehdittava asianmukaisesta poistoilmanvaihdesta tiloissa, joissa pölyä muodostuu.

#### Hengityksensuojaus

Jos muodostuu pölyä, tehokas hengityksensuojain (Kertakäyttöinen, EN149 FFP2S) Puoli- tai kokokasvosuojajanaamari P2-tyyppisellä hiukkassuodattimella (eurooppalainen standardi).

#### Käsiensuojaus

PVC-stä tai muusta muovista valmistetut käsineet kumikäsineet

#### Silmiensuojaus

suojalasit

#### Ihonsuojaus

**Käyttöturvallisuustiedote Direktiivin 91/155/EEC mukaan**

Versio 17.02.2003

(001111 3333)

Kevyt suojavaatetus.

**9. Fysikaaliset ja kemialliset ominaisuudet**

<b>Olomuoto</b>	jauhe	
<b>Väri</b>	väriltön	
<b>Haju</b>	hajuton	
<b>Sulamis/Jäätymislämpötila</b>	ei määriteltävissä	
<b>Pehmenemispiste</b>	ei määriteltävissä	
<b>Kiehumispiste/kiehumisalue</b>	ei määriteltävissä	
<b>Suhteellinen tiheys</b>	ei määriteltävissä	
<b>Bulk-tiheys</b>	0.75 g/cm <sup>3</sup>	Tyypillinen arvo
<b>Leimahduspiste</b>	ei määriteltävissä	
<b>Syttymislämpötila</b>	ei määriteltävissä	
<b>Kuvaus</b>	Kuten monien orgaanisten jauheiden kohdalla saattaa muodostua syttyviä pölypilviä.	
<b>Hapettavat ominaisuudet</b>	ei määriteltävissä	
<b>Vesiliukoisuus</b>	Liukoinen, muodostaa viskoosisen liuoksen vedessä	
<b>Liukoisuus</b>	ei testattu	
<b>Höyrynpaine</b>	ei testattu	
<b>Jkaantumiskerroin (aineosille) Log Pow</b>	ei määriteltävissä	
<b>pH-arvo</b>	ei testattu	
<b>Dynaaminen viskositeetti</b>	ei testattu	
<b>Räjähdyshaara</b>	ei määriteltävissä	
<b>Haihtumisluku</b>	ei testattu	
<b>Höyryntiheys</b>	ei testattu	

**10. Stabiiliisuus ja reaktiivisuus**

<b>Vältettävät olosuhteet</b>	Ei erityisiä turvatoimenpiteitä lukuunottamatta hyviä kemikaalien käsittelyn toimintatapoja. Vältettävä märkiä tai kosteita olosuhteita. Äärimmäiset lämpötilat.
<b>Vältettävät materiaalit</b>	Reaktiiviset kemikaalit.
<b>Haitalliset hajoamistuotteet</b>	Palamisen seurauksena saattaa muodostua: hiilen oksideja

**11. Terveysvaikutuksiin liittyvät tiedot**

<b>Akuutti myrkyllisyys rotta</b>	LD50 > 2000 mg/kg	Analoginen samankaltaisten tuotteiden kanssa
<b>Akuutti myrkyllisyys ihon kautta</b>	ei testattu	
<b>Akuutti myrkyllisyys hengitettäessä</b>	ei testattu	
<b>Akuutti silmien ärsytys/syövyttävyys</b>	Ei ärsyttävä	Sopimuksenvarainen menetelmä

**Käyttöturvallisuustiedote Direktiivin 91/155/EEC mukaan**

Versio 17.02.2003

(00:00:0000)

**Akuutti myrkyllisyys**  
(ärsyttävyys, syövyttävyys  
jne.)

Ei ärsyttävä

Sopimuksenvar  
ainen  
menetelmä

**Akuutti herkistyminen ihon  
kautta**

ei testattu

**12. Tiedot kemikaalin vaarallisuudesta ympäristölle**

<b>Myrkyllisyys;kalat</b> <i>Seeprakala (Brachydanio rerio) 96 h</i>	LC50	357 mg/l	OECD 203 / EEC C 1
		Testeistä tuotevalikoimalle.	
<b>Akuutti myrkyllisyys: Vesikirppu (Daphnia)</b> <i>Daphnia magna 48 h</i>	EC50	212 mg/l	OECD 202 / EEC C 2
		Testeistä tuotevalikoimalle.	
<b>Akuutti myrkyllisyys; bakteerit</b> <i>Pseudomonas putida 24 h</i>	EC50	892 mg/l	
		Testeistä tuotevalikoimalle.	
<b>Akuutti myrkyllisyys: Levät</b> <i>Chlorella vulgaris 72 h</i>	EC50	> 1000 mg/l	OECD 201 / EEC C 3
		Testeistä tuotevalikoimalle.	
<b>Biologinen hajoavuus</b>		ei testattu	

**13. Jätteiden käsittely**

**Jätteet jäännöksistä / käyttämättömistä tuotteista**

Noudatettava paikallisia säädöksiä.

**Likaantunut pakkaus**

Saastuneet pakkaukset tulee käsitellä kemikaalijätteenä. Puhtaat pakkaukset tulee hävittää paikallisten määräysten mukaan.

**14. Kuljetustiedot**

Leimahduspiste	ei määriteltävissä
ADR/RID	Luokka: Vapaa
IMO	Luokka: Vapaa
ICAO	Luokka: Vapaa

**15. Kemikaaleja koskevat määräykset**

Luokitus

Luokitusta ei tarvita

## Käyttöturvallisuustiedote Direktiivin 91/155/EEC mukaan

Versio 17.02.2003

(000 0000 0000)

Lisätietoja Käyttöturvallisuustiedote saatavana ammattilaisten käyttöön pyynnöstä.

### 16. Muut tiedot

R-lausekkeet

-

Tärkeimmät muutokset

Kohta 3 ;Kohta 6 ;Kohta 15 ;Kohta 16

on rekisteröity tavaramerkki.

#### **Tärkeää**

Tätä ainetta ei ole tarkoitettu käytettäväksi tuotteissa, jotka on erityisesti tarkoitettu kosketuksiin limakalvojen, kehon nesteiden tai hiertyneen ihon kanssa, tai jotka on tarkoitettu implantoitavaksi ihmisen kehoon, ellei valmista tuotetta ole testattu kansallisesti ja kansainvälisesti pätevien turvallisuustestivaatimusten mukaisesti. Koska edellämainittuja mahdollisia käyttökohteita on hyvin runsaasti, ei pysty suosittelemaan tätä ainetta turvallisena ja tehokkaana näihin käyttökohteisiin eikä ottamaan vastuuta aineen käytöstä tällaisissa käyttökohteissa.

Tätä tuotetta tulee varastoida, käsitellä ja käyttää hyvän teollisen käytännön ja laillisten määräysten mukaan. Tiedot perustuvat nykyiseen tietämykseen ja niiden tarkoitus on kuvata tuotteitamme turvallisuusvaatimusten näkökulmasta. Siksi niitä ei tulisi käsittää erityisten ominaisuuksien takuuna.

MATERAIL SAFETY DATA SHEET OF ADDITIVE B

**KÄYTTÖTURVALLISUUSTIEDOTE**

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

**KOHTA 1: AINEEN TAI SEOKSEN JA YHTIÖN TAI YRITYKSEN TUNNISTETIEDOT**

**1.1 Tuotetunniste**

**Kauppanimi**

**1.2 Aineen tai seoksen merkitykselliset tunnistetut käytöt ja käytöt, joita ei suositella  
Aineen ja/tai seoksen käyttötapa**

Flokkulantti

**Suosittelavia käyttörajoituksia**

**1.3 Käyttöturvallisuustiedotteen toimittajan tiedot**

**1.4 Häätäpuhelinnumero**

Myrkytystietokeskus: Puh. 09 471 977 tai 09 4711

**KOHTA 2: VAARAN YKSILÖINTI**

**2.1 Aineen tai seoksen luokitus**

**EU-direktiivien 67/548/ETY tai 1999/45/EY mukainen luokitus**

Ei ole vaarallinen aine tai seos EU direktiivien 67/548/ETY tai 1999/45/EY mukaan.

**2.2 Merkinnät**

**EY-direktiivien mukaiset merkinnät (1999/45/EY)**

Lisätietoja

: Tuotetta ei tarvitse merkitä EU-direktiivien mukaan.  
Vuodot ovat märkänä hyvin liukkaita.



## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys: 14.03.2014

Eräitä seoksia koskevat erityisvaatimukset : Käyttöturvallisuustiedote toimitetaan ammattikäyttäjälle pyynnöstä.

### 2.3 Muut vaarat

**Ohjelta;** Muodostaa liukkaita/rasvaisia kerroksia veden kanssa.

## KOHTA 3: KOOSTUMUS JA TIEDOT AINEOSISTA

### 3.2 Seokset

Seoksen kemiallinen luonne Kationinen polyakryyliamidi kopolymeeri.

CAS-/EU-numero/REACH-rekisteröintinumero	Aineosan nimi	Pitoisuus	Asetuksen (EU) 1272/2008 mukainen luokitus	EU-direktiivien 67/548/ETY tai 1999/45/EY mukainen luokitus
77-92-9 201-069-1 01-2119457026-42	Sitruunahappo	<10 %	Eye Irrit. Luokka 2,H319	Xi ,R36

### Lisätietoja

Tässä kohdassa mainittujen R-lausekkeiden täydelliset tekstit ovat kohdassa 16.  
Tässä kohdassa mainittujen H-lausekkeiden täydelliset tekstit ovat kohdassa 16.

## KOHTA 4: ENSIAPUTOIMENPITEET

### 4.1 Ensiaputoimenpiteiden kuvaus

#### Hengitys

Sirrettävä raittiiseen ilmaan. Otettava yhteys lääkäriin mikäli oireet jatkuvat.

#### Ihokosketus

Roiskeet huuhteltava runsaalla vedellä.

#### Roiskeet silmiin

Huuhteltava välittömästi runsaalla vedellä vähintään 15 minuutin ajan. Otettava yhteys lääkäriin mikäli oireet jatkuvat.

#### Nieleminen

Hakeuduttava lääkärin hoitoon.

### 4.2 Tärkeimmät oireet ja vaikutukset, sekä välittömät että viivästyneet

## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

Oireet : Tietoa ei ole käytettävissä.

### 4.3 Mahdollisesti tarvittavaa välitöntä lääketieteellistä apua ja erityishoitoa koskevat ohjeet

Hoito : Oireiden mukainen hoito.

## KOHTA 5: PALONTORJUNTATOIMENPITEET

### 5.1 Sammutusaineet

Sammutusaineet : Jauhe

### 5.2 Aineesta tai seoksesta johtuvat erityiset vaarat

Tuote aiheuttaa kastuessaan liukastumisvaaran. Vaarallisia savukaasuja voi vapautua. (yli 300°C)  
Ammoniakki, hiiloksidi (COx)  
Pölyräjähdysvaara.

### 5.3 Erityiset varotoimenpiteet tulipaloa varten

Käytettävä paineilmalaitetta ja suoja-pukua.

### 5.4 Muita ohjeita

Pöly voi muodostaa räjähtävän seoksen ilman kanssa.

## KOHTA 6: TOIMENPITEET ONNETTOMUUSPÄÄSTÖISSÄ

### 6.1 Varotoimenpiteet, henkilönsuojaimet ja menettely hätätilanteessa

Käytettävä henkilökohtaista suojaruustusta.

### 6.2 Ympäristöön kohdistuvat varotoimet

Ei saa päästää ympäristöön.

### 6.3 Suojarakenteita ja puhdistusta koskevat menetelmät ja -välineet

Kerättävä mekaanisesti talteen sopiviin säiliöihin hävittämistä varten. Pienet vuodot voidaan huuhdella runsaalla vedellä, jotta saadaan tuote poistetuksi. Huuhtelua tehostaa, esim. natriumkloridi.

## KOHTA 7: KÄSITTELY JA VARASTOINTI

### 7.1 Turvallisen käsittelyn edellyttämät toimenpiteet

Vältettävä pölyn muodostusta. Järjestettävä sopiva imutuuletus tiloihin, joissa voi muodostua pölyä. Kemikaalin käyttö edellyttää tehokasta ilmanvaihtoa tai sopivaa hengityksensuojainta. Kerättävä talteen liukastumisen välttämiseksi.

### 7.2 Turvallisen varastoinnin edellyttämät olosuhteet, mukaan luettuina yhteensopimattomuudet

Säilytettävä kuivassa paikassa. Tuotteen hajoamisen ja laitteiston syöpyksen välttämiseksi, älä käytä

## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

rauta-, kupari- tai alumiinisäiliöitä tai laitteita.  
Vältettävät materiaalit:  
Hapettavat aineet

### 7.3 Erityinen loppukäyttö

Ei mainittu luettelossa

## KOHTA 8: ALTISTUMISEN EHKÄISEMINEN JA HENKILÖNSUOJAIMET

### 8.1 Altistumisen raja-arvot

Ei sisällä aineita, joille on annettu enimmäispitoisuusrajoja.

### 8.2 Altistumisen ehkäiseminen

#### 8.2.1 Asianmukaiset tekniset torjuntatoimenpiteet

Käsiteltävä hyvän työhygienian ja turvallisuuskäytännön mukaisesti. Kädet pestävä ennen taukoa ja välittömästi tuotteen käsittelyn jälkeen.

#### 8.2.2 Henkilökohtaiset suojatoimenpiteet, kuten henkilönsuojaimet

##### Käsiensuojaus

Suojakäsineet

##### Silmiensuojaus

Sivusuojilla varustetut suojalasit. Silmänhuuhtelupullo, jossa puhdasta vettä

##### Ihonsuojaus / Kehon suojaus

Suojavaatetus. Häätäsuihku.

##### Hengityksensuojaus

Käytä hengityksensuojainta, jos ilmanvaihto on riittämätön. (suodatin P2)

## KOHTA 9: FYSIKAALISET JA KEMIAALLISET OMINAISUUDET

### 9.1 Fysikaalisia ja kemiallisia perusominaisuuksia koskevat tiedot

#### Yleiset tiedot (olomuoto, väri, haju)

Olomuoto

käntää, jauhe

## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

Väri valkoinen  
Haju hajuton

### Terveyden, turvallisuuden ja ympäristön kannalta tärkeät tiedot

pH 2,5 - 7  
(0,5 % liuos)  
Leimahduspiste ei määritettävissä  
Räjähätyvyys:  
Räjähädyraja, alempi tietoja ei ole käytettävissä  
Räjähädyraja, ylempi tietoja ei ole käytettävissä  
Höyrynpaine merkityksetön  
Bulkkitiheys 500 - 800 kg/m<sup>3</sup>  
Liukoisuus (liukoisuudet):  
Vesiliukoisuus liukenee  
Jakaantumiskerroin: n-oktanolii/vesi Mittausmenetelmä ei sovelu molekyyliarakenteen takia., Todennäköisesti jakaantumiskerroin hyvin alhainen koska tuotteen kaltaiset polyelektrolyytit ovat vesiliukoisia mutta eivät liukene lyhytjousiin n-alkoholeihin.  
Lämpöhajoaminen > 150 °C

### 9.2 Muut tiedot

Pintajännitys ei määritettävissä

## KOHTA 10: STABIILISUUS JA REAKTIIVISUUS

### 10.1 Reaktiivisuus

tietoja ei ole käytettävissä

### 10.2 Kemiallinen stabiilisuus

Stabiili

### 10.3 Vaarallisten reaktioiden mahdollisuus

Vaaralliset reaktiot : Vaarallista polymeroitumista ei tapahdu.

### 10.4 Vältettävät olosuhteet

Vältettävät olosuhteet : Vältettävä kosteulta.

## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

Tuote kovettuu kosteuden vaikutuksesta.  
Yli 70 °C lämpötilassa liukoisuus heikkenee.

### 10.5 Yhteensopimattomat materiaalit

Vältettävät materiaalit : Hapettavat aineet

### 10.6 Vaaralliset hajoamistuotteet

Vaaralliset hajoamistuotteet : Ammoniakki  
hilloksidit (COx)  
kloorivety (HCl)

: Ammoniakki

Lämpöhajoaminen : >150 °C

## KOHTA 11: MYRKYLLISYYTEEN LIITTYVÄT TIEDOT

### 11.1 Tiedot myrkyllisistä vaikutuksista

#### Välitön myrkyllisyys

Vastaava tuote:  
LD50/Suun kautta/rotta/OECD TG 401: > 2.000 mg/kg  
LD50/Ihon kautta/rotta/OECD TG 402: > 2.000 mg/kg

#### Ärsyttävyys ja syövyttävyys

Iho:  
Huomautuksia: Saattaa aiheuttaa ihoärsytystä.

Silmät:  
Huomautuksia: Saattaa ärsyttää silmiä.

#### Herkistyminen

Vastaava tuote:  
/OECD TG 406: Ei ole herkistävä.

#### Subakuutti, subkrooninen ja pitkäaikainen myrkyllisyys

Syöpää aiheuttavat vaikutukset

## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

Ei viitteitä syöpäsairauden vaaraa osoittavista ominaisuuksista polymeerillä.

Mutageenisuus

Ei viitteitä perimää vaurioittavista ominaisuuksista polymeerillä.

### KOHTA 12: TIEDOT VAARALLISUUDESTA YMPÄRISTÖLLE

#### 12.1 Myrkyllisyys eliöille

##### Myrkyllisyys vesieliöille

Annetut tiedot perustuvat rakenteellisesti tai koostumuksellisesti samantyyppisiä tuotteita koskeviin tietoihin. Vesieliövaikutukset johtuvat ulkoisesta (ei-systeemisestä) toimintamekanismista ja vaikutukset vähenevät merkittävästi (7-20 -kertaisesti) 30 minuutin kuluessa tuotteen sitoutuessa liuenneseen orgaaniseen hiileen ja epäorgaanisiin materiaaleihin, kuten saveen ja hiesuun.

LC50/96 h/Branchydanio rerio (seeprakala)/OECD TG 203: 1 - 10 mg/l

EC50/48 h/Daphnia magna (vesikirppu)/OECD TG 202: 10 - 100 mg/l  
LC50/72 h/levä:  
Menetelmä ei sovellu.

Testit OECD 202 ja OECD 203 tehdään ilman kiintoainelisäystä. Tuotteen voimakas adsorboituminen kiintoaineiden pintaan vähentää merkittävästi myrkyllisyyttä vesieliöille. Hydrolyysissä syntyvät hajoamistuotteet ovat selvästi vähemmän myrkyllisiä vesieliöille kuin itse tuote.

##### Myrkyllisyys muille eliöille

tietoja ei ole käytettävissä

#### 12.2 Pysyvyys ja hajoavuus

Biologinen hajoavuus:

Vastaava tuote:

/OECD TG 301B:

Vaikeasti biologisesti hajoava. Suuresta molekyylikoosta ja hydrofiilisyydestä johtuen polyelektrolyyttien

## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

kyky läpäistä biologisia membraaneja on olematon.

### 12.3 Biokertyvyys

Ei todennäköisesti ole biokertyvää.

Jakautumiskerroin: n-oktanolivesi: Mittausmenetelmä ei sovellu molekyyliarakenteen takia.,

Todennäköisesti jakaantumiskerroin hyvin alhainen koska tuotteen kaltaiset polyelektrolyytit ovat vesiliukoisia mutta eivät liukene lyhytketjuisiin n-alkoholeihin.

### 12.4.Liikkuvuus maaperässä

#### Kulkeutuvuus

Vesiliukoisuus: liukenee

Pintajännitys: ei määritettävissä

Adsorptio ja/tai desorptio: Kulkeutuvuutta rajoittaa voimakas adsorptio sekä epäorgaanisiin aineksiin (esim. savimaa, hietä) että liuenneeseen orgaaniseen hilleen (esim. luonnon humushapot).

Flokkautuu aktiivilietteen kanssa.

### 12.5. PBT- ja vPvB-arvioinnin tulokset

Tietoa ei ole käytettävissä.

Tätä tietoa ei ole saatavilla.

### 12.6 Muut haitalliset vaikutukset

Ei tunneta.

## KOHTA 13: JÄTTEIDEN KÄSITTELYYN LIITTYVÄT NÄKÖKOHDAT

### 13.1 Jätteiden käsittelymenetelmät

Tuote

Paikallisten ja kansallisten säädösten mukaisesti.

## KOHTA 14: KULJETUSTIEDOT

### 14.1 YK-numero

#### Maakuljetukset

Ei vaarallisuusluokitusta kuljetusmääräysten mukaan.

#### Merikuljetukset

Ei vaarallisuusluokitusta kuljetusmääräysten mukaan.

#### Ilmakuljetukset

Ei vaarallisuusluokitusta kuljetusmääräysten mukaan.

### 14.6 Erityiset varotoimet käyttäjälle

## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

tietoja ei ole käytettävissä

### KOHTA 15: LAINSÄÄDÄNTÖÄ KOSKEVAT TIEDOT

#### 15.1 Nimenomaisesti ainetta tai seosta koskevat turvallisuus-, terveys- ja ympäristösäännökset tai -lainsäädäntö

Muut ohjeet : Ei ole.

#### Ilmoitustilanne

- : Kaikki tuotteen aineosat on mainittu EINECS-luettelossa (European Inventory of Existing Chemical Substances) tai niiden mainintaa EINECS-luettelossa ei ole vaadittu.
- : Kaikki tuotteen komponentit on mainittu Australian Inventory of Chemical Substances-luettelossa (AICS) tai niiden luettelointia ei ole vaadittu.
- : Kaikki tuotteen aineosat on mainittu Domestic Substances-luettelossa (DSL) tai niiden luettelointia DSL-listassa ei ole vaadittu.
- : Kaikki tuotteen aineosat on mainittu Kiinan listassa, tai niiden luettelointia Kiinan listassa ei vaadita.
- : Kaikki tuotteen komponentit on mainittu Japanin (ENCS)-luettelossa, tai niiden luettelointia ei ole vaadittu.
- : Kaikki tuotteen komponentit on mainittu Korean (ECL)-luettelossa, tai niiden luettelointia ei ole vaadittu.
- : Kaikki tuotteen komponentit on mainittu Filippiinien (PICCS)-luettelossa, tai niiden luettelointia ei ole vaadittu.
- : Kaikki tuotteen aineosat on mainittu TSCA-kemikaaliluettelossa tai niiden luettelointia TSCA-kemikaaliluettelossa ei ole vaadittu.
- : Kaikki tuotteen komponentit on mainittu Uuden-Seelannin(NZIoC) luettelossa tai niiden luettelointia ei ole vaadittu.
- : Taiwanin myrkyllisten kemikaalien valvontasäästösten inventaarilistatusta ei ole määritetty tuotteen osalta.

#### 15.2 Kemikaaliturvallisuusarviointi

Tälle seokselle ei tarvitse suorittaa kemikaaliturvallisuusarviointia.



## KÄYTTÖTURVALLISUUSTIEDOTE

Muutettu viimeksi: 13.12.2013 Edellinen päiväys: 00.00.0000

Päiväys:14.03.2014

### KOHTA 16: MUUT TIEDOT

**Kohdassa 3 mainittujen H-lausekkeiden täydelliset tekstit.**

H319 Ärsyttää voimakkaasti silmiä.

**Kohdassa 3 mainittujen R-lausekkeiden teksti**

R36 Ärsyttää silmiä.

**Koulutukseen liittyviä ohjeita**

Lue käyttöturvallisuustiedote ennen tuotteen käyttämistä.

**Lisätietoja**

Tämän käyttöturvallisuustiedotteen tiedot ovat parhaan tietämyksemme mukaan oikeita laatimispäivänä. Annetut tiedot ovat ainoastaan ohjeellisia turvallista käsittelyä, käyttöä, työstöä, varastointia, kuljetusta, jätteidenkäsittelyä ja päästöjä varten, eikä niitä saa käsittää takuuksi tai laatuspesifikaatioksi. Tiedot koskevat vain mainittua tuotetta, eivätkä välttämättä pidä paikkaansa, jos tuotetta käytetään yhdessä toisen tuotteen kanssa tai prosessissa, ellei erikseen mainittu tekstissä.

**Tiedotteen laatimisessa käytetyt tärkeimmät lähteet**

Säädökset, tietokannat, kirjallisuus, omat tutkimukset.

**Lisäykset, poistot ja muutokset**

Muuttuneet merkitykselliset kohdat on ilmaistu pystyviivoin.

MATERIAL SAFETY DATA SHEET OF ADDITIVE C

PRODUCT SAFETY DATA SHEET

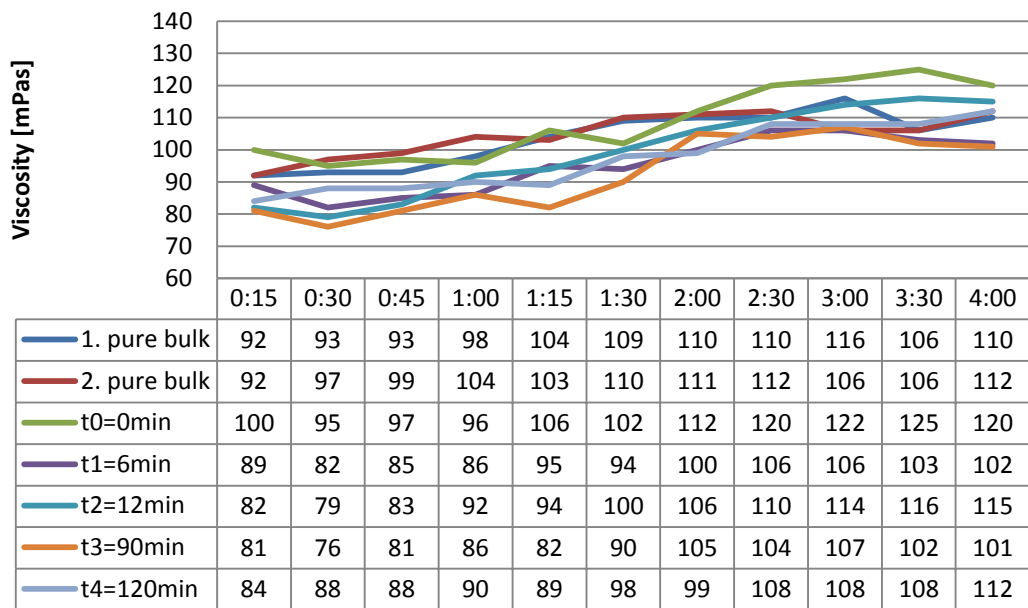
MANUFACTURER IDENTIFICATION DATA	
<b>SECTION 1</b>	<b>PRODUCT IDENTIFICATION DATA</b>
Trade name Product composition dry base	<b>POLYACRYLIC ACID</b>
<b>SECTION 2</b>	<b>MANUFACTURING SITE</b>
Manufacturer Address Phone Fax	+ + + +
<b>SECTION 3</b>	<b>COMPONENT DESCRIPTION</b>
Component 1 Component 2 Component 3	- Polyacrylic acid 24-26 % - Water 74-76 % - Individual residual monomers < 0,1 %
<b>SECTION 4</b>	<b>HEALTH HAZARD DATA</b>
Inhaled product Ingested product Eye contact Skin absorption	- inhalation of high solvent vapor or mist concentrations can cause: headache, nausea, irritation of nose, throat and lungs - material is possibly harmful if swallowed. - Material can cause substantial irritation - prolonged or repeated skin contact can cause moderate skin irritation
<b>SECTION 5</b>	<b>FIRE AND EXPLOSION HAZARD DATA</b>
Extinguishing method Special fire notations  Flash point Flammable limits	- Appropriate extinguishing media for surrounding fire. - Product can splatter above 100°C / 212°F. Polymer film can burn.  - N/A - See SECTION 9
<b>SECTION 6</b>	<b>SPILLAGE PROCEDURES</b>
Spillage remove  Waste disposal	-Use available equipment and containers to collect and separate the spilled product. Floor may be slippery - dispose in compliance with current regulations.
<b>SECTION 7</b>	<b>PRECAUTIONS TO BE TAKEN IN STORING</b>
	Do not store this material near strong bases. The minimum recommended storage temperature for this material is 1°C/34°F. The maximum recommended storage temperature is 49°C / 120°F.
<b>SECTION 8</b>	<b>SPECIAL PROTECTION ON HANDLING</b>
Protective equipment Eyes protections Local ventilation	-Neoprene gloves are suggested. -chemical splash goggles is suggested. -Normal ventilation suggested. No other special suggestions.

APPENDIX  
5 (2/2)

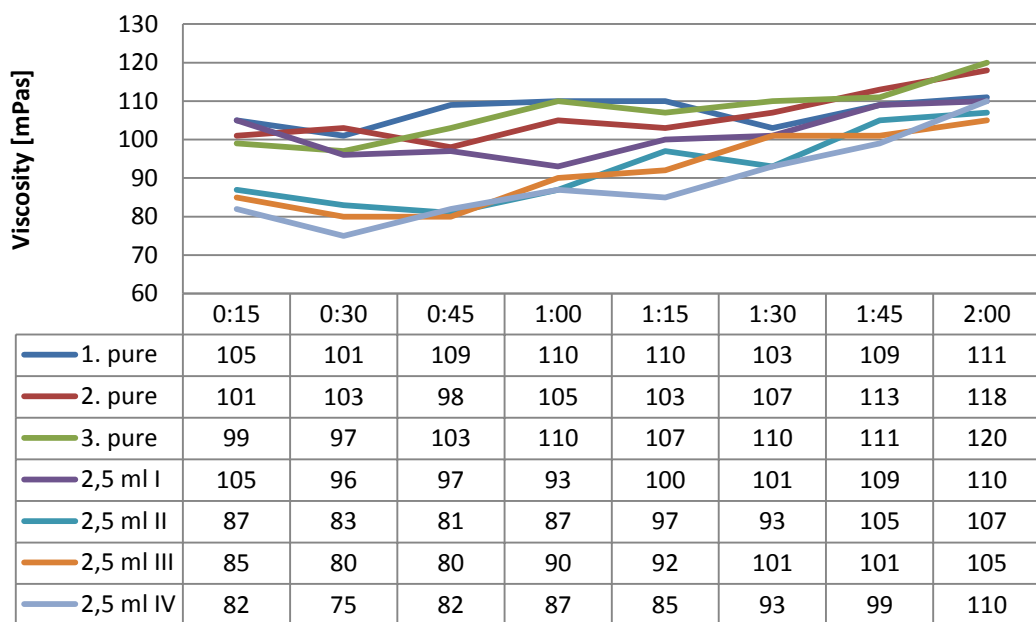
<b>SECTION 9</b>	<b>PHISICAL DATA</b>
Physical state Color Apperance Odor Boiling point Melting point pH Flammability Auto flammability Vapour pressure Vapour density Percent volatility Solubility in water Vapor density (air=1)	- liquid - colorless - clear - Acrylic odor - maximum - 0°C / 32°F approx - 2,1 - 3,0 - N/A - N/A - 17 mm Hg @ 20°C / 68°F - Fibre not volatile at 20°C - 75 - dilutable - > 1
<b>SECTION 10</b>	<b>REACTIVITY DATA</b>
Stability Conditions to avoid Decomposition	- Stable in normal conditions of temperature and pressure. - Avoid temperatures above 177°C / 350°F, the onset of polymer decomposition. - Thermal decomposition is dependent on time and temperature.
<b>SECTION 11</b>	<b>TOXICITY INFORMATIONS</b>
	Information are based on the toxicity profiles for a number of acrylic emulsions that are compositionally similar to this product. Typical data are: - Oral LD50 - rat: > 5000 mg/Kg - Eye irritation - rabbit: substantial irritation - Skin irritation - rabbit: moderate irritation
<b>SECTION 12</b>	<b>ECOLOGICAL INFORMATIONS</b>
	The product is ecologically harmless. Avoid environmental dispersion of treatment water.
<b>SECTION 13</b>	<b>WASTE INFORMATIONS</b>
	For disposal incinerate this material at a facility that complies with local and state regulations.
<b>SECTION 14</b>	<b>TRANSPORT</b>
	No particular precautions. According the local law for waste disposal.
<b>SECTION 15</b>	<b>REGULATORY INFORMATIONS</b>
	Not classified as hazardous
<b>SECTION 16</b>	<b>ADDITIONAL NOTES</b>
	This information is based upon current knowledge and product experience. This data does not offer any warranty for abnormal use of this product. assumes no legal responsibility for use or reliance of the above mentioned data.
<b>Date of emission:</b>	Rev.0 dated 06-10-2004 – Following 2001/58/CE directives

RESULTS OF ADDITIVE A

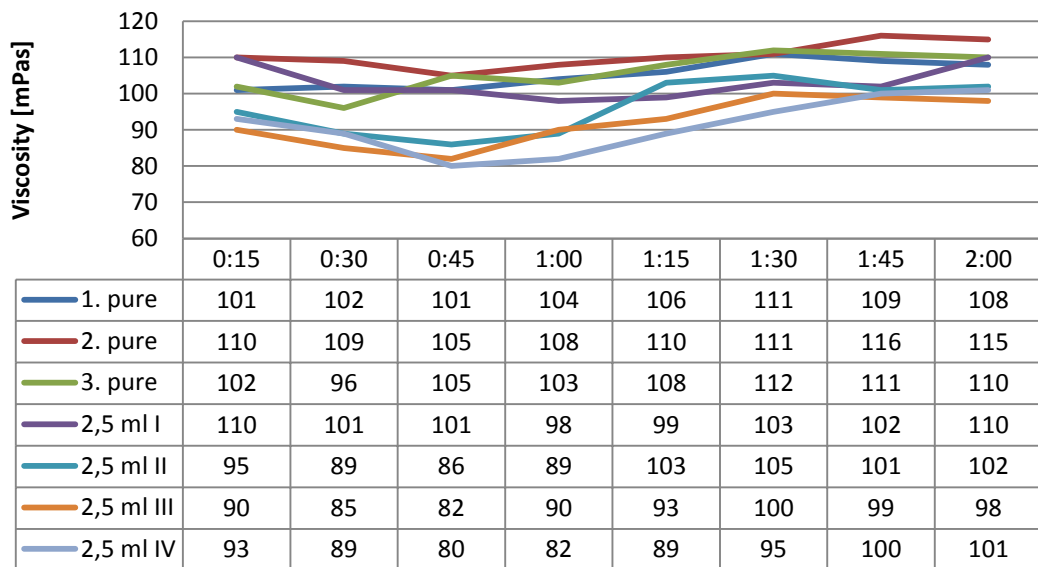
**Addition of 2,5 ml Additive A in 500ml sample**



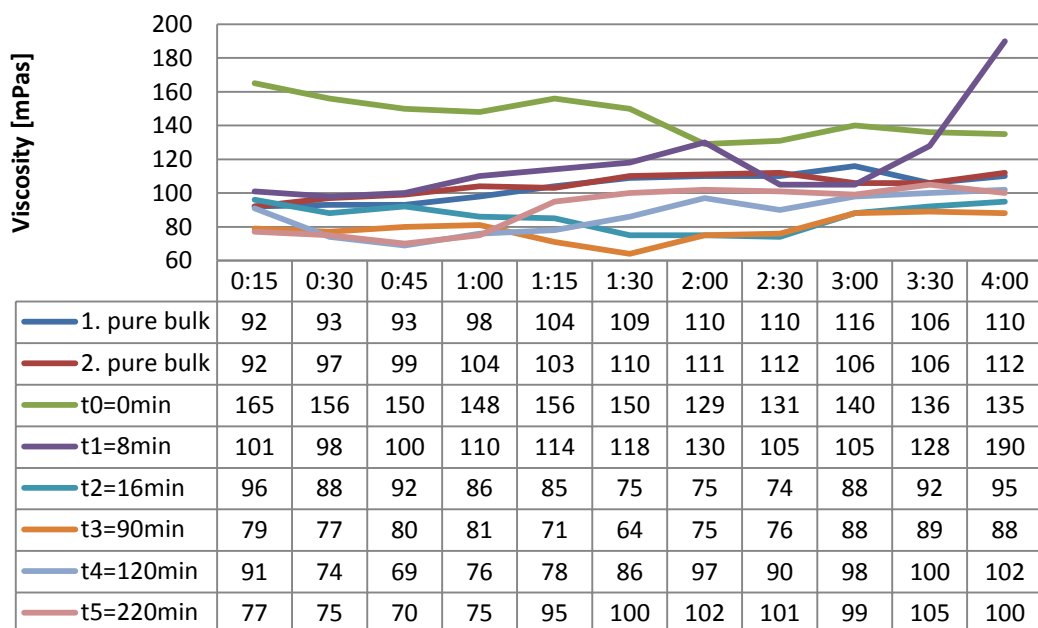
**Addition of 2,5 ml additive A in 500ml sample**



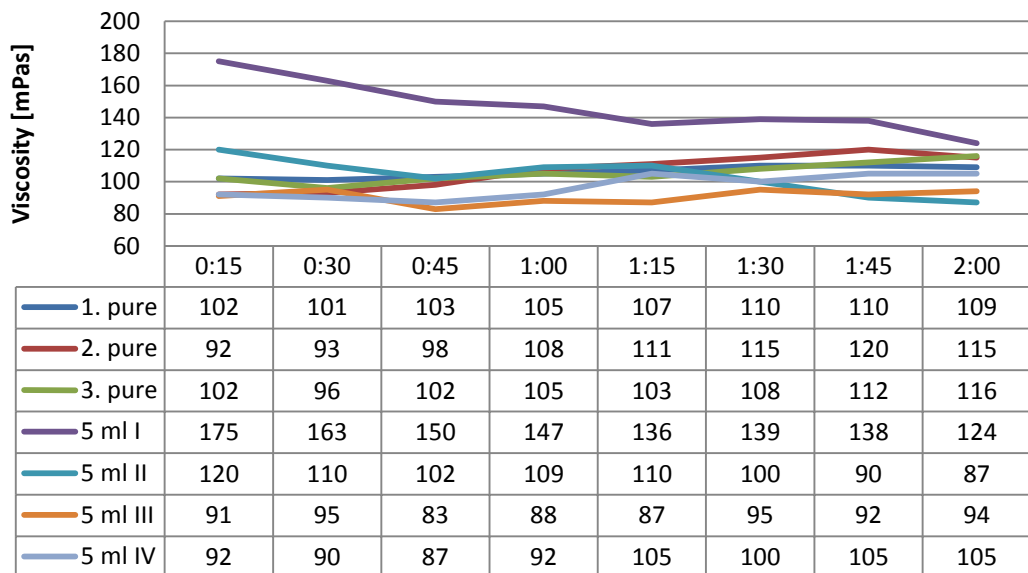
### Addition of 2,5 ml additive A in 500ml sample



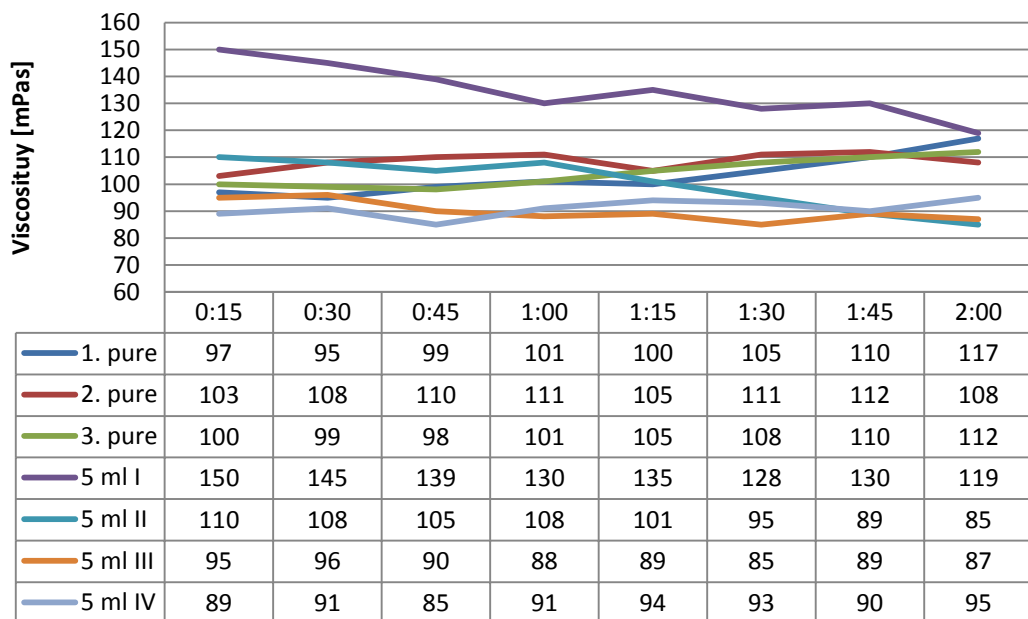
### Addition of 5 ml Additive A in 500ml sample



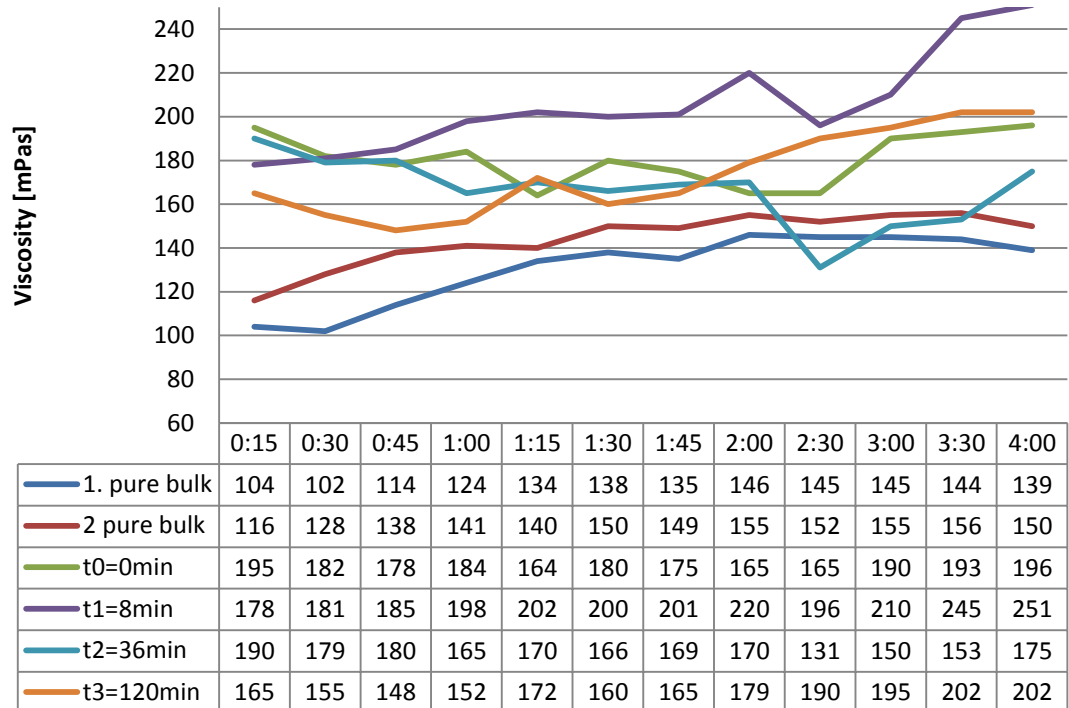
### Addition of 5 ml additive A in 500ml sample



### Addition of 5 ml additive A in 500ml of sample

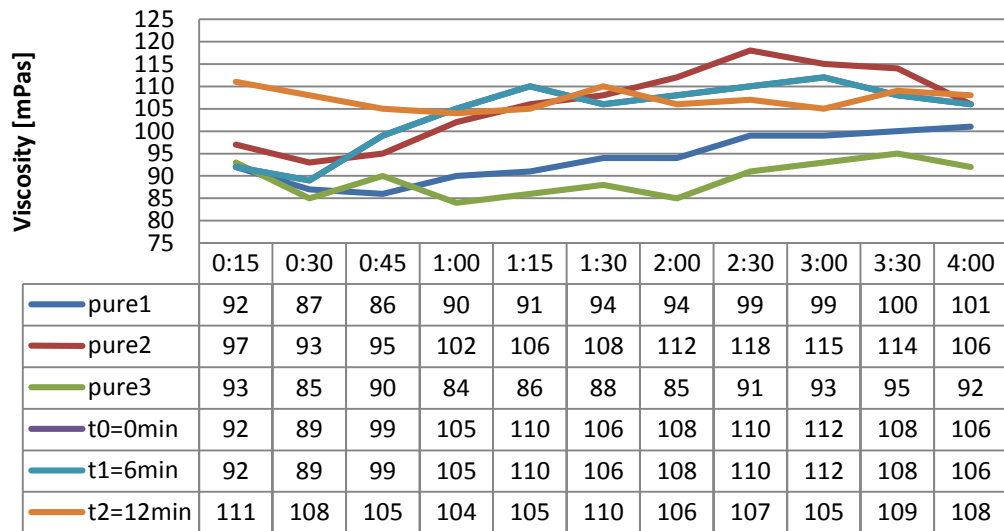


### Addition of 10 ml Additive A in 500ml sample

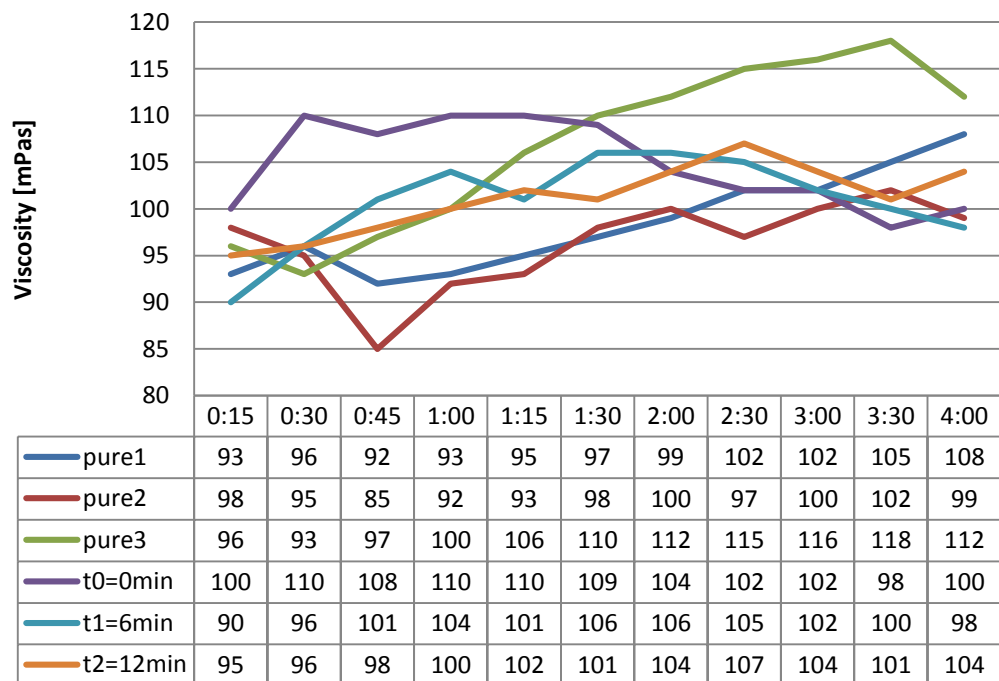


RESULTS OF ADDITIVE B

**Addition of 5 ml of Additive B in 500ml sample**



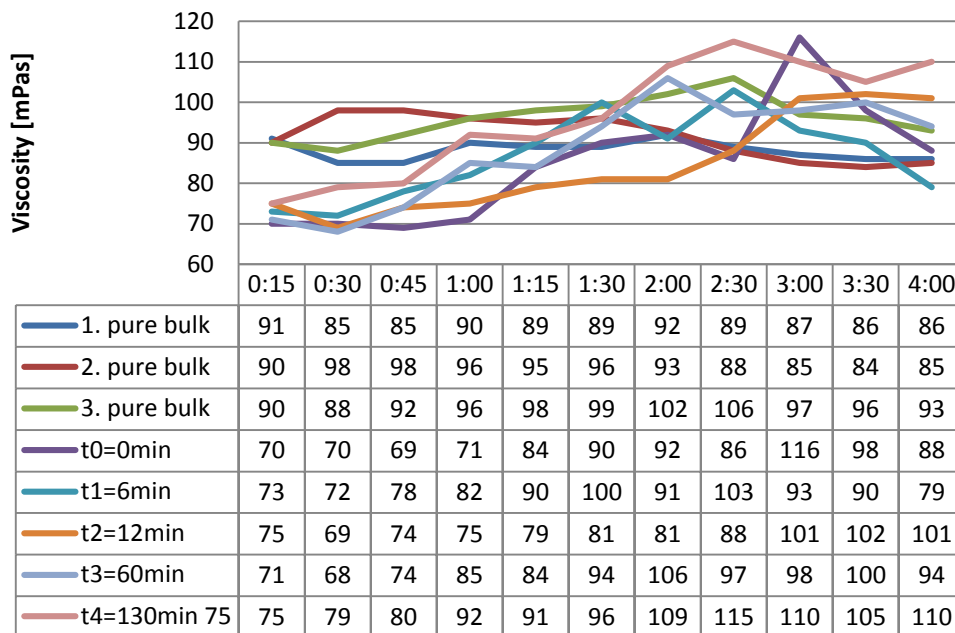
**Addition of 10 ml of Additive C in 500ml sample**



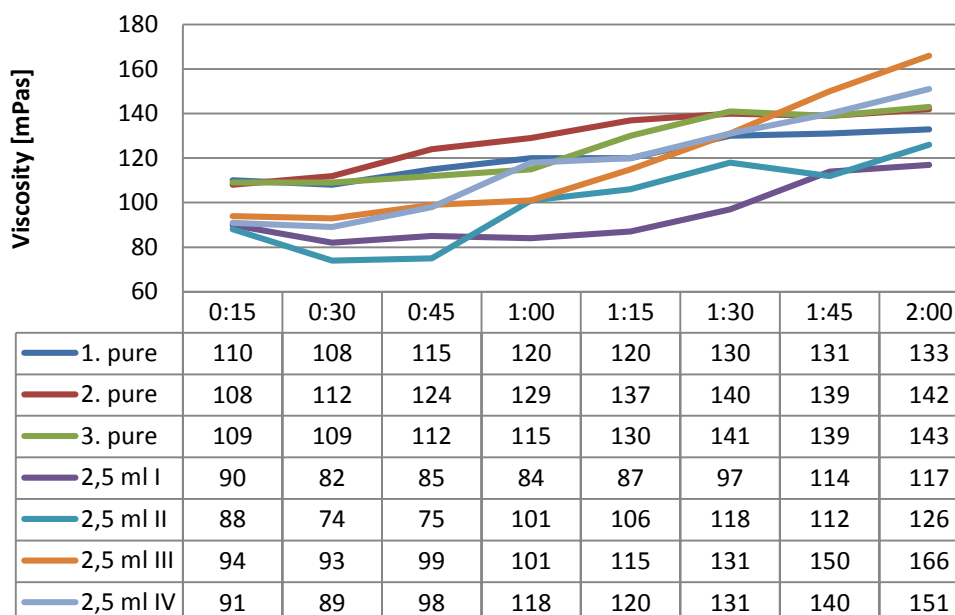


RESULTS OF ADDITIVE C

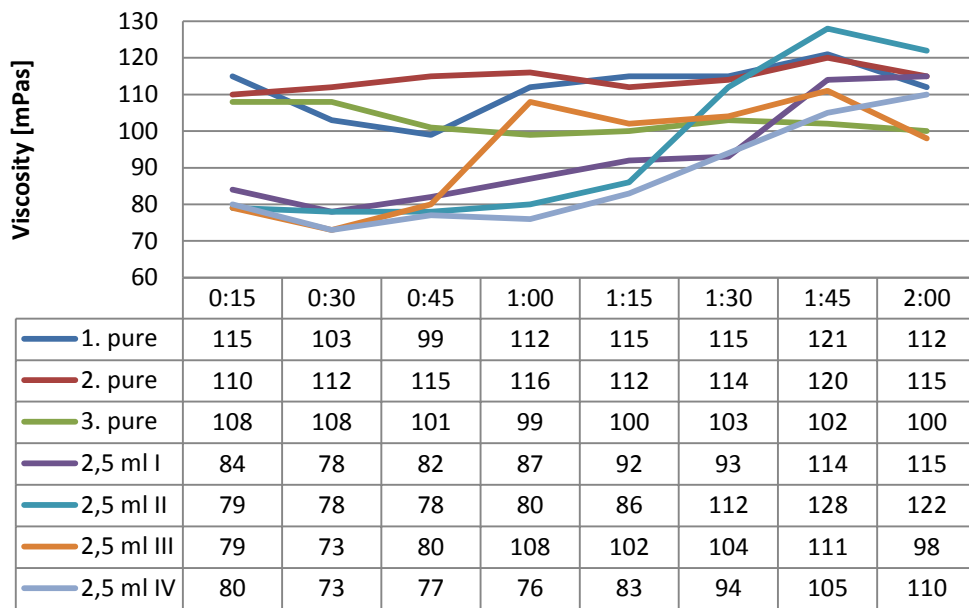
**Addition of 2,5 ml Additive C (1:10) in 500ml sample**



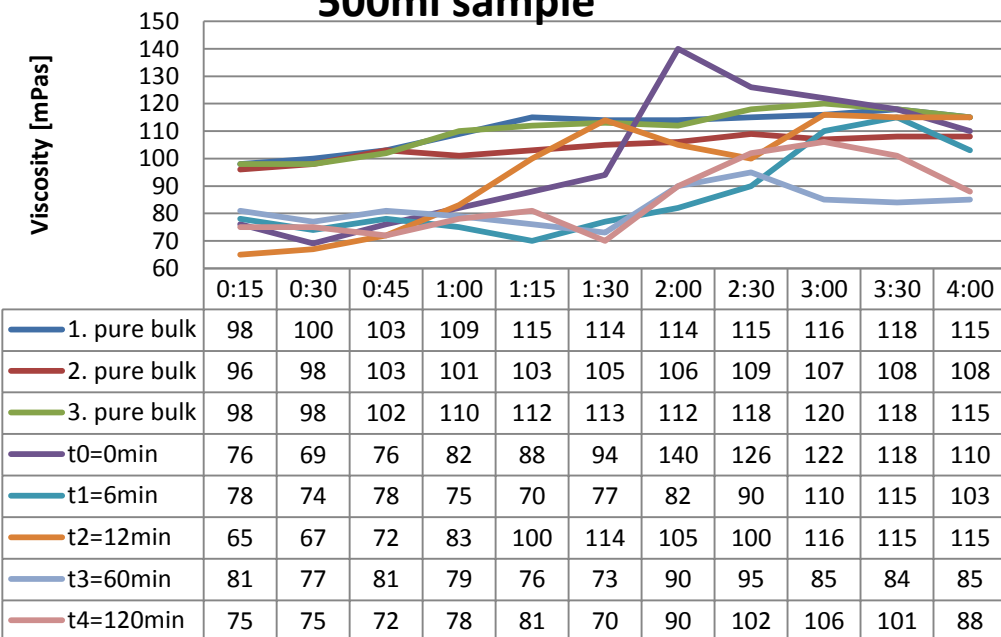
**Addition of 2,5 ml Additive C (1:10) in 500ml sample**



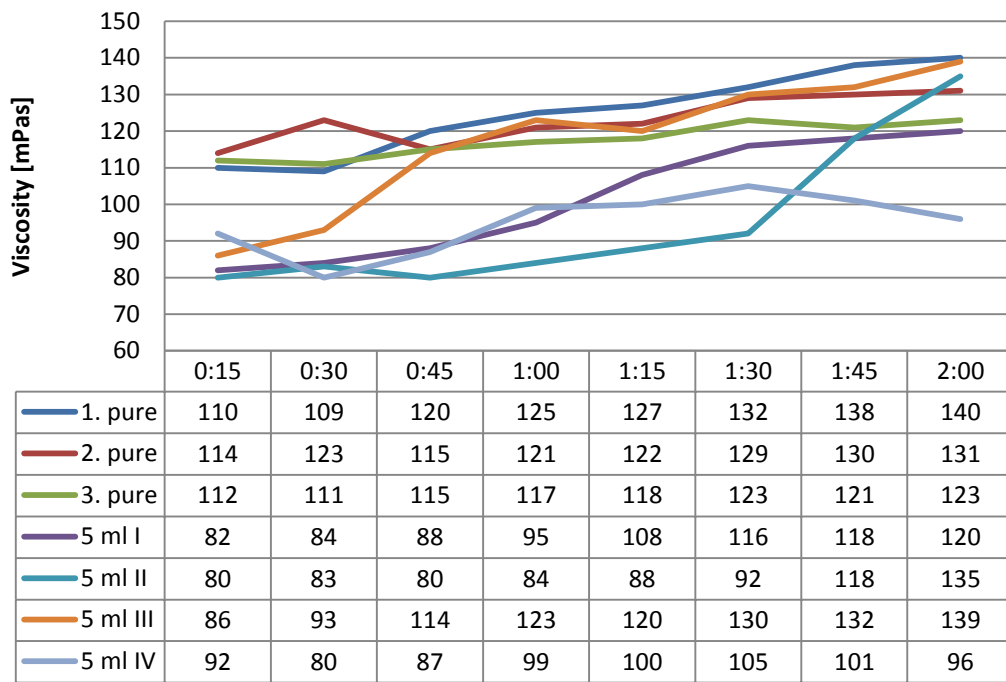
### Addition of 2,5 ml Additive C (1:10) in 500ml sample



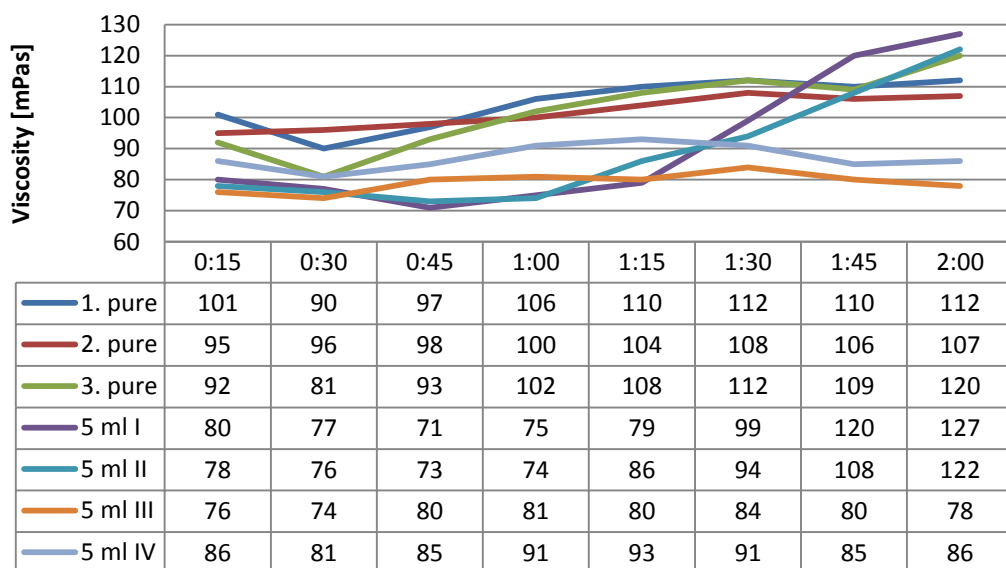
### Addition of 5 ml Additive C (1:10) in 500ml sample



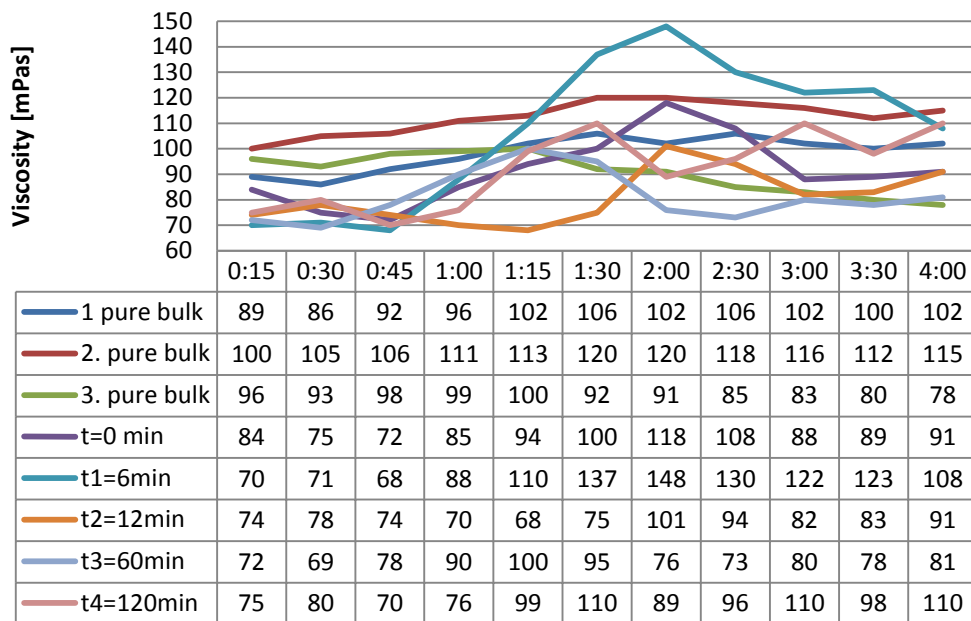
### Additon of 5 ml Additive C (1:10) in 500ml sample



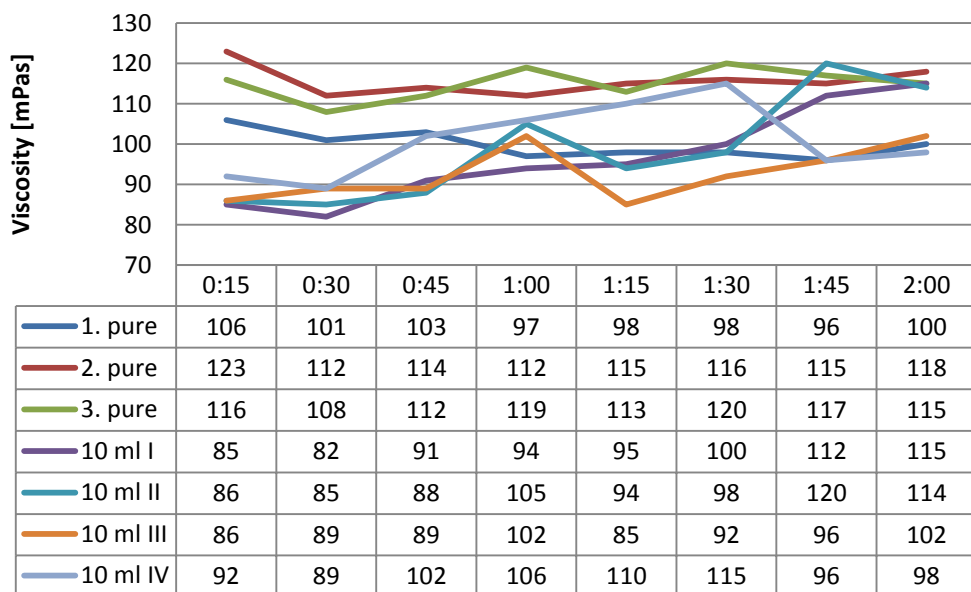
### Addition of 5 ml Additive C (1:10) in 500ml sample



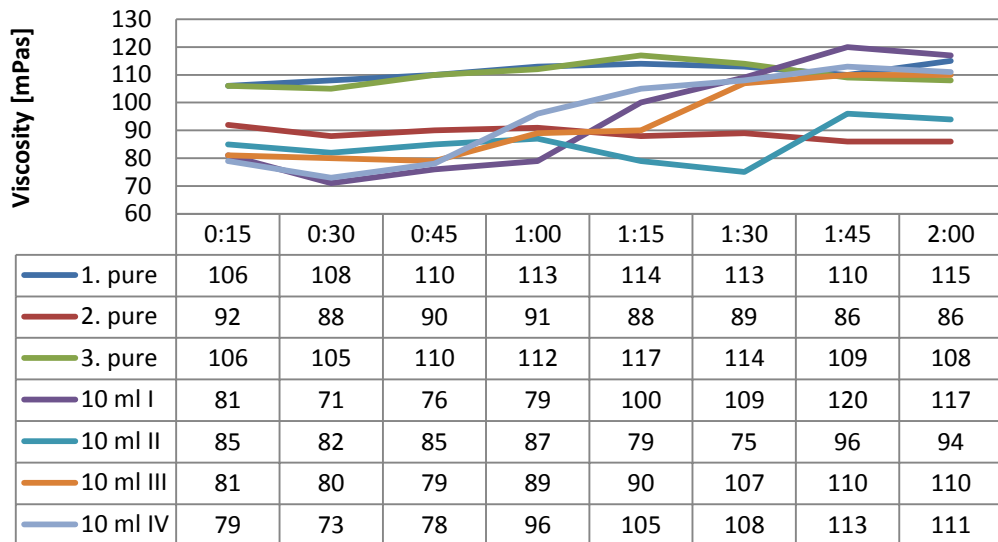
### Addition of 10 ml Additive C (1:10) in 500ml sample



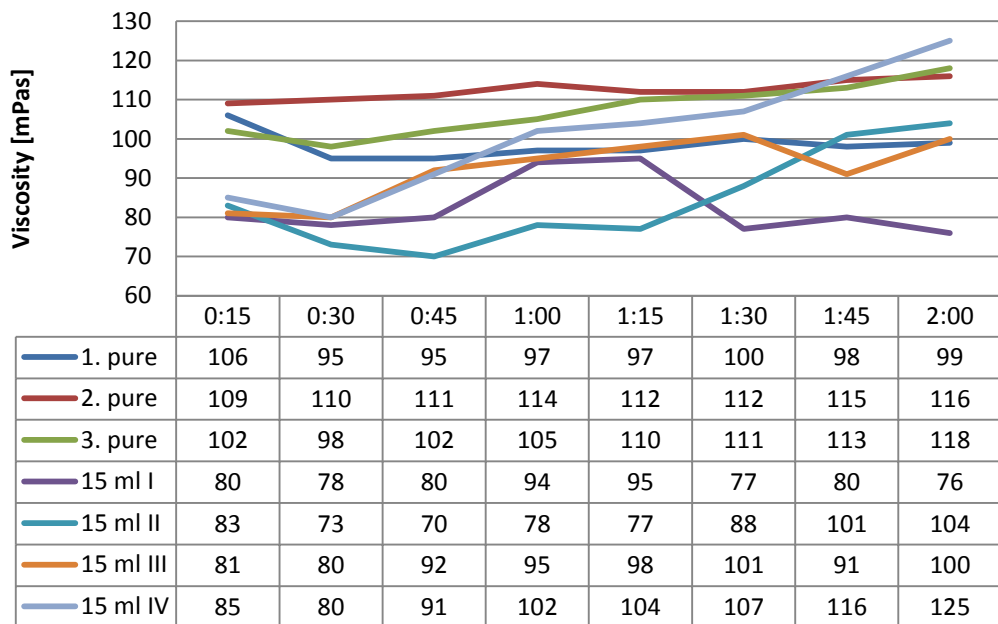
### Addition of 10 ml Additive C (1:10) in 500ml sample



### Addition of 10 ml Additive C (1:10) in 500ml sample



### Addition of 15 ml Additive C (1:10) in 500ml sample



## RESULTS OF HOSE PUMP WITH ADDITIVE A

Addition of Additive A	I	II	III	IV
Without	24 s/1 l 48 s/2 l	24 s/1 l 47 s/2 l	24 s/1 l 48 s/2 l	24 s/1 l 47 s/2 l
25 ml	25 s/1 l 49 s/2 l	24 s/1 l 48 s/2 l	25 s/1 l 48 s/2 l	
50 ml (added 25 ml)	24 s/1 l 48 s/2 l	25 s/1 l 48 s/2 l	24 s/1 l 48 s/2 l	
100 ml (added 50 ml)	24 s/1 l 47 s/2 l	24 s/1 l 48 s/2 l	24 s/1 l 49 s/2 l	
200 ml (added 100 ml)	24 s/1 l 47 s/2 l	25 s/1 l 47 s/2 l	24 s/1 l 48 s/2 l	

Mean flow of the pump is about 2,5 l/min.