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A study of the potential improvement of Sydvaranger Gruve´s process water treatment through experiments with different flocculants and coagulants

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June 2015

Abstract

Mining is the process or industry of extracting valuable minerals or other geological materials from the earth. The nature of mining creates a potential negative impact on the environment both during the mining operations and several years after the mine is closed. Over the years regulations designed to moderate the negative effects are adopted, and environmental issues and challenges have gotten more attention. The mining industries aim to improve production efficiency and at the same time take care of the environment according to best practice. The latter is the subject in this thesis, which aims to look at Sydvaranger Gruve AS's use of chemical treatment of process water within the mining industry.

Flocculants and coagulants are chemicals that are used in water treatment in many industries. In this approach the water resource is limited and the aim is to treat the process water in order to recirculate it. Despite the same mineral being processed the process water will not have the same properties due to the huge variations of influencing factors. Some theory regarding water treatment with chemicals exists, but there are still many assumptions and a lack of understanding. There are many chemicals on the market and it requires a lot of testing to assure that the most efficient chemical is used in the process water treatment.

Sydvaranger Gruve AS is a mining company located North in Norway close to the Russian border. The company has a history that dates back over a hundred years and it is known for its pioneering development of technology to process taconites, which is a low-grade ore. Sydvaranger Gruve AS is currently using a cationic coagulant with low molecular weight, Magnafloc LT 38, in combination with a slightly anionic flocculent with a medium molecular weight, Magnafloc 10.

The study presented in this thesis is based on existing literature, though the previous work in this area has proved to be limited. It is challenging to conclude the specific chemical reaction due to lack of literature, but assumptions will be made based on theory.

In this thesis the process is presented in the form of description and flowcharts. Influencing factors regarding the process and geology are identified and discussed. The existing theory regarding chemical water treatment is presented and various chemical products for water treatment are gathered from different suppliers. The procedure for testing is presented, the testing is performed in three main stages and are evaluated both quantitative and qualitative. A lot of effort has been put into finding a suitable chemical or a combination of chemicals and many chemicals were tested through experimental work. Zetag 8187, a strongly cationic flocculent with a medium high molecular weight, is the chemical that has shown the best result and has been examined further to compare its behavior against the chemicals in use today.

A quality assurance has been performed to illustrate the reliability of the test methods and procedures despite the large variations in the influencing factors. A risk assessment based on environmental issues has been done on the final chemical recommendation, Zetag 8187, versus the chemicals that are in use today, Magnafloc 10 and Magnafloc LT 38, in order to see if there are any environmental benefits by substitution of chemicals, other than performance. The results are presented and final recommendations are made based on the tests and other observations. Despite proving good results in small-scale tests, extensive plant scale tests should be carried out to verify the results shown in the thesis.

Acknowledgements

This thesis is submitted as a partial fulfilment of the requirements for the degree of Master of Technology at the University of Troms (UiT), in the study program of Energy, Climate and Environment, within the specialization of Technology and Safety in the High North. The work presented was conducted at the laboratory at the Sydvaranger Gruve AS production plant in the period between January 2015 and June 2015.

I would like to thank my main supervisors at Sydvaranger Gruve AS, Paul Inge Norkyn and Kari H. Hermansen. I appreciate the opportunity I was given by you and Sydvaranger Gruve AS to work with such an interesting and pertinent subject. It has been very exciting and has given me a very broad and profound insight to this subject. Thank you for the great conversations, advises and motivation. I would also like to thank my co-supervisors, Professor Maneesh Singh (UiT), and Professor Javad Barabady (UiT) for guidance and advice during my thesis. I would also like to thank Jan Erik Nilssen for all the encouragement and taking the first step towards the cooperation with Sydvaranger Gruve AS. Thanks to Thomas Bækø, Luke Fitzgerald, Mikko Marjakoski, Torbjørn Nilsen, Gerd Tharaldsen Norkyn, and all the other employees at Sydvaranger Gruve AS for highly appreciated advice and help when needed. Also, thanks to Hanne Torgersrud for review of the language and text.

Thanks to all the suppliers for chemicals and very much appreciated guidance: Nalco, BASF, Aquatech4you, Kemira and Clariant. Especially thanks to Nalco and BASF that took the time to visit and carry out some testing, this was very motivating.

Last, but not least, to my caring family and loving boyfriend Krister, thank you so much for the tremendous love and support. I could not have made it without you!

Finally, thanks to all my fellow students, we made it!

Ida Katrine Floer, June 2015

Definitions

The paper will use different terminologies, which are described in this section.

Aggregates - A particle formed by separate units collected.

Colloids - Particles with a size that ranges between 1 nm to 1 μm.

Coagulant - The Chemical composition that promotes destabilization of a suspension by reducing the energy barriers, the spatial extent between particles, or the surface potential.

Coagulation - the process associated with destabilization which include overcoming the factors which contribute to the stability of the suspension.

DLVO - Stands for Derjaguin, Landau, Vervey, and Overbeek, which developed a theory of colloidal stability that represent our understanding of interactions between colloidal particles and their aggregation behavior.

Flocculation - the transport phase that makes particles come into contact due to relative motion.

Flocculent - The Chemical composition that promotes particles to interact due to satisfied conditions.

Flocs - Small aggregated mass of flocculent and other materials suspended in or precipitated from a liquid.

Micro flocs - Same as flocs, only smaller in size.

NTU - Stands for Nephelometric Turbidity Unit. It is a measure of turbidity and the detector is always placed 90 degrees relative to the light source. A value of 0 is clear water, with increased content of particles the value increases.

Precipitate - Floc formed during turbid suspension using hydrolyzing coagulants will result in a precipitate, a space filling gel.

Segregation - particulate solids ability to separate by virtue of differences in size, as well as physical properties such as volume, density, shape and other properties of particles of which they are composed.

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Chapter 1

Introduction

Since the startup of Sydvaranger Gruve AS in 2009 there has been a huge focus both externally and internally on the environmental aspects of the water treatment, due to the adverse effects of tailings to the sea. The process water has to be recycled to conserve the limited amount of available water. Due to huge variations of properties within the process water the chemicals used in the water treatment have to be very resistant to changes. Since 2009 the company has been using a proprietory chemical called Magnafloc 10. Magnafloc 10 is a commonly used chemical within the mining industry and was put in use during the startup of production. Through operation it was shown that the chemical alone could not handle the variations within the process water and a new chemical, LT 38, was presented and used, when needed, in addition to Magnafloc 10. Since then, the geology of the operated mine pit has changed and so has the properties of the process water. The chemicals still serve its purpose, but difficulties are revealed when the process plant receives high grade of ore from the mine. Due to the huge effect this has on the properties of the process water the current chemicals cannot alone perform the water treatment according to given standards. This results in a lot of challenges that has to be solved by efficient logistic and planning, this is both time and cost consuming.

There is done some testing previously, in order to find a more suitable chemical, but without success. None of the chemicals tested was found to improve the water treatment significantly enough to substitute the chemicals used.

The mechanical aspect of the water treatment, in this case the thickener, is under dimensioned compared to the current production. Sydvaranger Gruve AS aim to increase the production capacity and any potential improvements that results in more efficient water treatment, will decrease the limitations for an increase in production.

Sydvaranger Gruve AS aim to operate according to the following work principles:

- The company shall use the best practicable materials and techniques, which aim to minimize the impact on the environment.
- The company shall aim to optimize the use of freshwater in their operations.
- The company shall continuously and systematically aim to minimize emissions and work to eliminate the risk of unplanned emissions from the business.
- The company aim to always have an open dialogue, about environmental issues, with the community and legal authorities.
- The company will work towards optimizing energy use and reducing emissions from the business.
- The company's intention is that employees and other stakeholders, whom they communicate with, are aware that their product is manufactured in an environmentally responsible manner.

[SydvarangerGruveAS, 2015a]

Additionally to the company's own policy, Sydvaranger Gruve AS is also required by law to constantly aim for operation within the terms of "best practice" regarding both environment and cost.

They are required to:

- prevent products prior consumer services from causing damage to health; this includes ensuring that consumer products and services are safe.
- prevent products from causing environmental disturbance, for example in the form of disturbance of ecosystems, pollution, waste, and noise.
- prevent environmental disturbance by promoting effective energy use in products.

[NorwegianGovernment, 2015]

And are also required, according to another section of the law, to apply the substitution principle quoted below:

"Any enterprise that use products containing chemical substances that may have effects such as are mentioned in the three points below, shall evaluate whether there are alternatives that entail a lower risk of such effects. If such alternatives exist, the enterprise shall use them provided that this does not cause unreasonable cost or inconvenience." [NorwegianGovernment, 2015]

The Substation principle in the Product Control Act can be achieved by either of the following:

- A chemical from a class that is inherently more benign than the once in use.
- A chemical from a comparable class, requiring a lower consumption.

[NorwegianGovernment, 2015]

This thesis present the results from a study that aim to identify the chemicals that maximize the recycling of the water from the tailings thickener and is a good candidate for the substitution principle.

1.1 Aim of the Research

The aim of this research is to identify the chemicals and the operating conditions under which they are most effective in reducing the amount of dispersed solids by coagulation and flocculation. Review of the production process and theory will be presented, as it is relevant for the Sydvaranger Gruve AS's water treatment. Laboratory tests will be performed in order to test what type of flocculants, alone or in combination with a coagulant, make it possible to maximize the recycling of process water.

The potential of improvement of efficiency within the water treatment will be discussed and recommendations will be made.

1.2 Scope of work

The thesis will focus on the following:

- Brief presentation of Sydvaranger Gruve AS, including history, geology of the mine and the production process.
- Study and presentation of existing theory and assumptions regarding chemical reactions and influencing factors that should be considered during laboratory testing.
- Presentation of methodology of laboratory work, data and results.
- Quality assurance and discussion of uncertainties and how limitations may affect the results.
- Presentation of a risk assessment of the recommended chemical for the water treatment.
- Recommendations of chemical and mechanical solutions for improvement of the water treatment and suggestions for further work.

1.3 Structure of the Thesis

The thesis has been divided into chapters based on topic.

Chapter 1 - contains the introduction, aim of research and scope of work.

Chapter 2 - gives a brief introduction to the thesis background, including history of Sydvaranger Gruve AS, the mines geology and its properties, as well as a presentation of the separation process.

Chapter 3 - includes the basic theoretical background required for understanding the water treatment process.

Chapter 4 - presents the method used during testing of chemicals and its results.

Chapter 5 - contains the aim and result of the tests quality control.

Chapter 6 - presents a risk assessment based on the chemical relevant for the continuous improvement of water treatment.

Chapter 7 - includes the discussion of the method and its results, as well as suggestions for further work.

Chapter 8 - includes the conclusion.

Chapter 2

Background

2.1 History

In 1866 mine inspector Tellef Dahl discovered iron ore deposit in Sør-Varanger. Later, in 1902, engineer Christian Anker outlined the occurrences of iron ore and invested a huge amount of resources and money to continue the work. In 1905 a contract between him and the Norwegian Government was ready and he was given permission to mine in Sør-Varanger. The company was named Aktieselskabet Sydvaranger. In 1907 the plant operation started and the first load of iron ore was railed from Bjørnevatn to Kirkenes, in 1910, [Kvammen, 2012].

In order to meet the requirements of the industrial market, a proportion of the product had to be exported as briquettes or pellets. The company met several challenges during the startup, one of them was the processing of the type of iron ore that existed in Sør-Varanger. The type was called taconite ore and is a low grade iron ore. There was little experience to count on and the largest challenge was marketing. The steelworks did not have the developed technology to handle such fine granulation product that came from the taconite ore. Some of the ore had to be converted to briquettes. This made AS Sydvaranger to a pioneering enterprise and it had only itself to trust, since it was the only company to process such a fine granulation product with a low grade. AS Sydvaranger developed unique knowledge of how to mine and process taconites in a remote and somewhat unfriendly physical environment, [Kvammen, 2012]. But due to almost direct ocean transport facilities from concentrator to consumer, and negligible rail transport from mine to shipping point, the product from AS Sydvaranger could reach the European industrial market fast and with competitive and even premium prices, [Lloyd, 1955]. Late December, in 1910, the first ship with briquettes left the harbour in Kirkenes, [Kvammen, 2012].

During the First World War, AS Sydvaranger met a lot of hardship. The German harbours were blocked, thus AS Sydvaranger could not ship their product to Germany. In 1930's brought some better years and the company got a reinforced position. In 1939 the company had around 1700 employees, [SydvarangerGruveAS, 2015b].

AS Sydvaranger and Sør-Varanger municipality was during the Second World War the second most bombed place besides Valetta in Malta. The Germans burned and destroyed almost everything before the Russians came and liberated the Norwegians. The Norwegian Government became owner in 1945, of 43 % of the share capital, through the Directorate of Enemy Property. Through hard work, war damage compensation from the Government, Marshall help from USA, and new investment from the Government including some private investors, the city and company rose from the burned grown and developed into a new mining community with new life, [Lund-Andersen, 1975]. The 1950's became very good years for the company. The world's demands of steel increased and so did the prices. At the end of the 1950's a new balance between demand and supply rose, and the prices started to decrease. In 1997 the company was closed down due to low iron prices, later it was bought up of a company named Arctic Bulk Minerals, who later withdrew themselves in 2001, [SydvarangerGruveAS, 2015b].

Tschudi Group bought AS Sydvaranger from the Sør-Varanger municipality and Varanger Kraft with the aim of restructuring and build out the harbor area. They started a demerger in 2007, in order to separate the permissions of mining, equipment, railroad and properties in both Bjørnevatn and Kirkenes into an own company which was called Sydvaranger Gruve. Later that year Northern Iron Limited was established in order to buy Sydvaranger Gruve and place it at the Australian Stock Exchange to gain capital for start up. In 2009 the company was established and the production started. Today they produce around 2, 3 million tons of iron ore concentrate each year, and the quality has only rose since the beginning, [SydvarangerGruveAS, 2015b].

2.2 Geology

The iron ore processed in Kirkenes occurs on a peninsula between a long narrow fjord on the west side and the valley of the Pasvik River on the east side. The height varies between 100 and 170 meters above the sea level, and the area of the whole field covers about 7 by 3 miles and includes several distinct sites. The company's site includes the ore fields, the workshop and offices in Bjørnevatn, the railway from Bjørnevatn to Kirkenes and the process plant and offices in Kirkenes, [Lloyd, 1955].

The ore occurs as metamorphosed sediments of middle Precambrian age, Karelian formation. The area has been intensely folded and the ore is overlain and underlain by gneisses. Some places the ore is bounded in some directions by faults, other places it is bounded by granite, [Lund-Andersen, 1975]. The bedrock in the area is very old and the geological interpretations suggest that three colossal mountain ranges from Precambrian age collided. All the three mountain ranges are characterized by geosyncline sediments, folding and over shifts, which are all common among modern mountain ranges, [Lund-Andersen, 1975].

The oldest bedrock is interpreted to belong to the Belomoridiske Orogeny. It consists of a huge amount of clay rich material and the bedrock is estimated to be at least three billion years old. The other mountain range include the iron ore formation, which rests discordant over clay rich bedrock and is interpreted to belong to the Sweco fenno-Karelian orogeny, also known as Norvego-Samider. It is estimated to be about 2500-2900 million years old. The youngest of the Precambrian mountain ranges is the Karelian, these are characterized by their copper and nickel occurrences related to greenstone volcanism and intrusive alkalizes [Lund-Andersen, 1975].

A mining company in Russia processes the nickel occurrences in the Karelian bedrock at the Russian side. In this region the Karelian bedrock is given the name Petsamo formation. The formation extends to Norway and Finland, but so far there is not done any findings of nickel-copper ore. The Petsamo formation is interpreted to be younger than the iron ore formation since a lot of iron ore fragments exist in the Petsamo formations conglomerates, [Lund-Andersen, 1975]. All the three mentioned mountain ranges are of Precambrian age. They are folded, eroded and superimposed by a fourth mountain range from the Caledonian age.

The biotite hornblende-bearing gneisses that lay in interacting layers with iron sediments, are interpreted to old basaltic lava even though you can find some metamorphic marl and clay sediments among them. This generates the iron ore to be precipitation ore due to basic extrusions which is called taconite ore. The ore occurrences have one time been cohesive in one or several horizons, but due to deformation and metamorphism the occurrences have been fragmented, [Lund-Andersen, 1975].

The ore consists in average of about 30 % Fe_3O_4, but some places richer ore occurs due to metamorphism and hydrothermal processes. These can consist of up to 50 % Fe_3O_4. Other places where granite is the main igneous rock, processes have made the ore partly to disappear, [Lund-Andersen, 1975]. Two main types of ore exist in the field: a relatively good iron ore with a stable iron magnetite content from 28 to 35 %, and another which has more variable iron magnetite content between 5 and 30 %. The type that has a high content is named Hengmalm or Bjørnevannstypen, while the other more variable type is called Liggmalm or Tverrdalstypen, [Malmdatabasen, 2013].

Hengmalm is characterized by a relatively stable content of iron magnetite, smaller sections with lower grade can occur locally, but the average content from the operated ore will be about 30 %. The mineral content in this type of ore is about 40 to 60 % quartz, 40 to 50 % magnetite and 0 to 10 % amphibole. The amphibole commonly grows parallel to the bonding, which gives better beneficiation and operating characteristics than the Liggmalm. The mineral content of the Liggmalm is 40 to 50 % quartz, 30 to 50 % magnetite and 10 to 40 % amphibole. Characteristic for this type is that the amphibole often is enriched with an angle at the bottom, this means that the ore can be characterized as quartz, magnetite and amphibole bounded. This structure makes the ore very tenacious and resistant to mechanical influences [Malmdatabasen, 2013].

A third and minor type of ore is the rich high grade ore. This has a grade between 40-55 % iron magnetite and is a result of a secondary process where quartz is removed through metamorphoses [Malmdatabasen, 2013].

As we can see from Figure 2.1 the Hengmalm type is located north in the Bjørnevatn deposit. In the middle the Liggmalm occur. Further south we can locate a mine pit named Kjellmannsåsen, this pit is different from the others due to several sequences of high grade ore. The surrounding rocks are called the general term gangue or waste rock. These mainly consist of the minerals quartz, feldspar, biotite, hornblende and epidote. Small amounts of sulfides are found irregular in the mining area, mainly in the ore. The silicates that constitute the waste rock are stable and decomposition does not take place [Malmdatabasen, 2013].

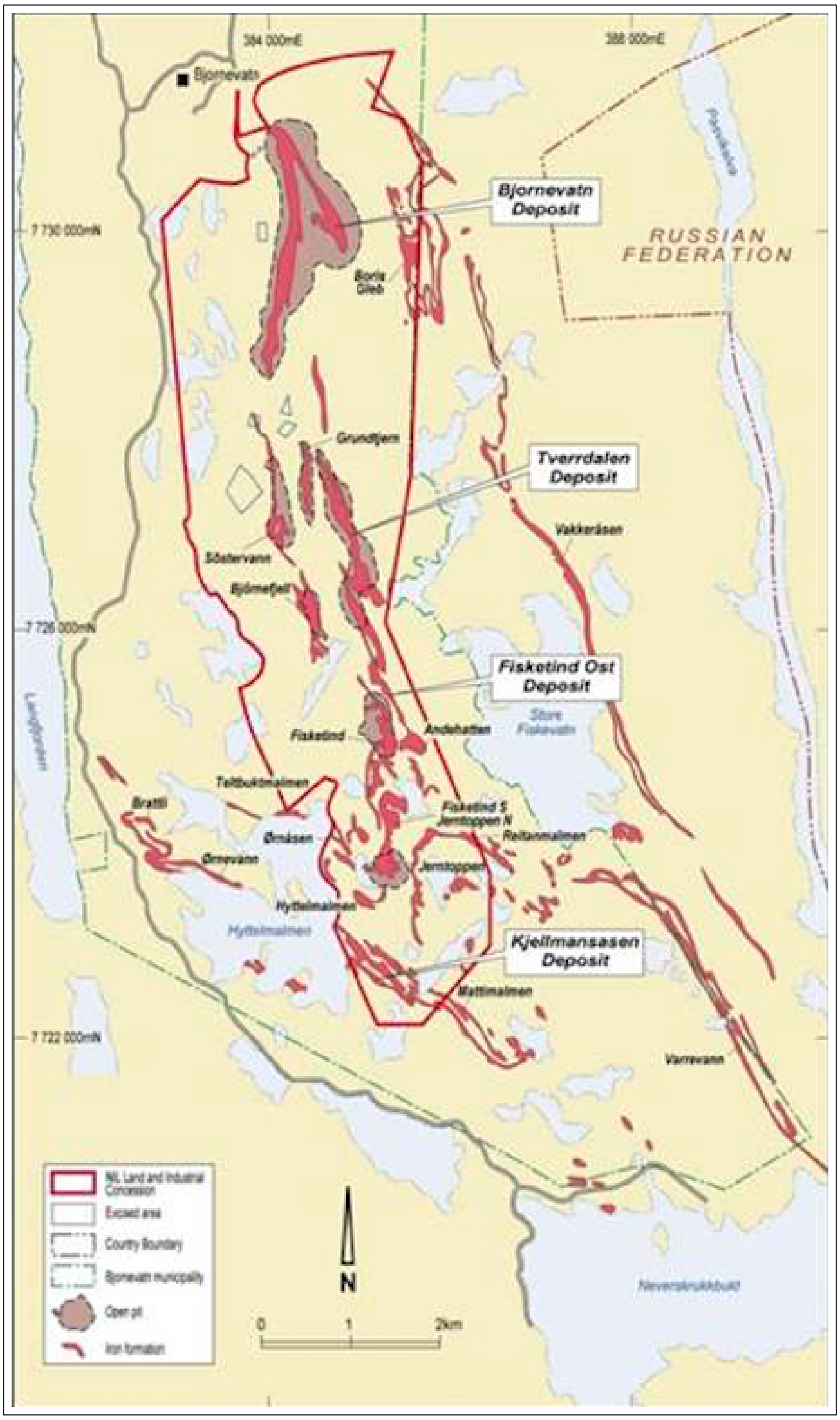

Figure 2.1: Overview of the mining area and its deposits. [Malmdatabasen, 2013].

2.3 The Separation Process

The separation process starts with unprocessed iron ore from Bjørnevatn. The material is processed in Kirkenes, and the product is iron ore concentrate. The plant exists mainly of crushers, mills, cyclones, magnetic separators, stacksizers and filters. The plant's main flow line and its flocculation and disposal system is briefly presented in this section and illustrated in Figure 2.2.

2.3.1 Processing Line

The mine and its crushing system - The blasted iron ore is transported by dumpers and crushed by a primary crusher. It is transferred by rail, approximately 9 km, from the mine in Bjørnevatn to the process plant in Kirkenes. The iron ore then goes through a secondary and tertiary crusher.

Primary grinding - After crushing, the rock goes through a primary mill in a closed loop with a primary cyclone . The feed to the primary mill has a typical magnetite grade of about 40 wt. % and 28,5 wt. % of iron ore, [Norkyn, 2015]. The milled product is fed to primary magnet separators to recover magnetite. The non-magnetic tailing is processed to the thickener.

Secondary grinding - The iron ore is then processed in a secondary grinding consisting of secondary mills, secondary cyclones and secondary magnet separators. The non-magnetic tailings from these loops are also processed to the thickener.

Final upgrading - The iron ore fines that pass through the primary and secondary grinding then reaches the stacsizers, which decrease the silica content before dewatered by tertiary magnet separators. The tailings from these mechanisms are processed to the thickener.

Dewatering - The final concentrate is dewatered by using scanmec filters and a pressure filter. The concentrate typically contains about 68 wt. % of iron ore, [Norkyn, 2015]. The conveyors transport the final iron ore concentrate to the harbour where it is shipped to costumers.

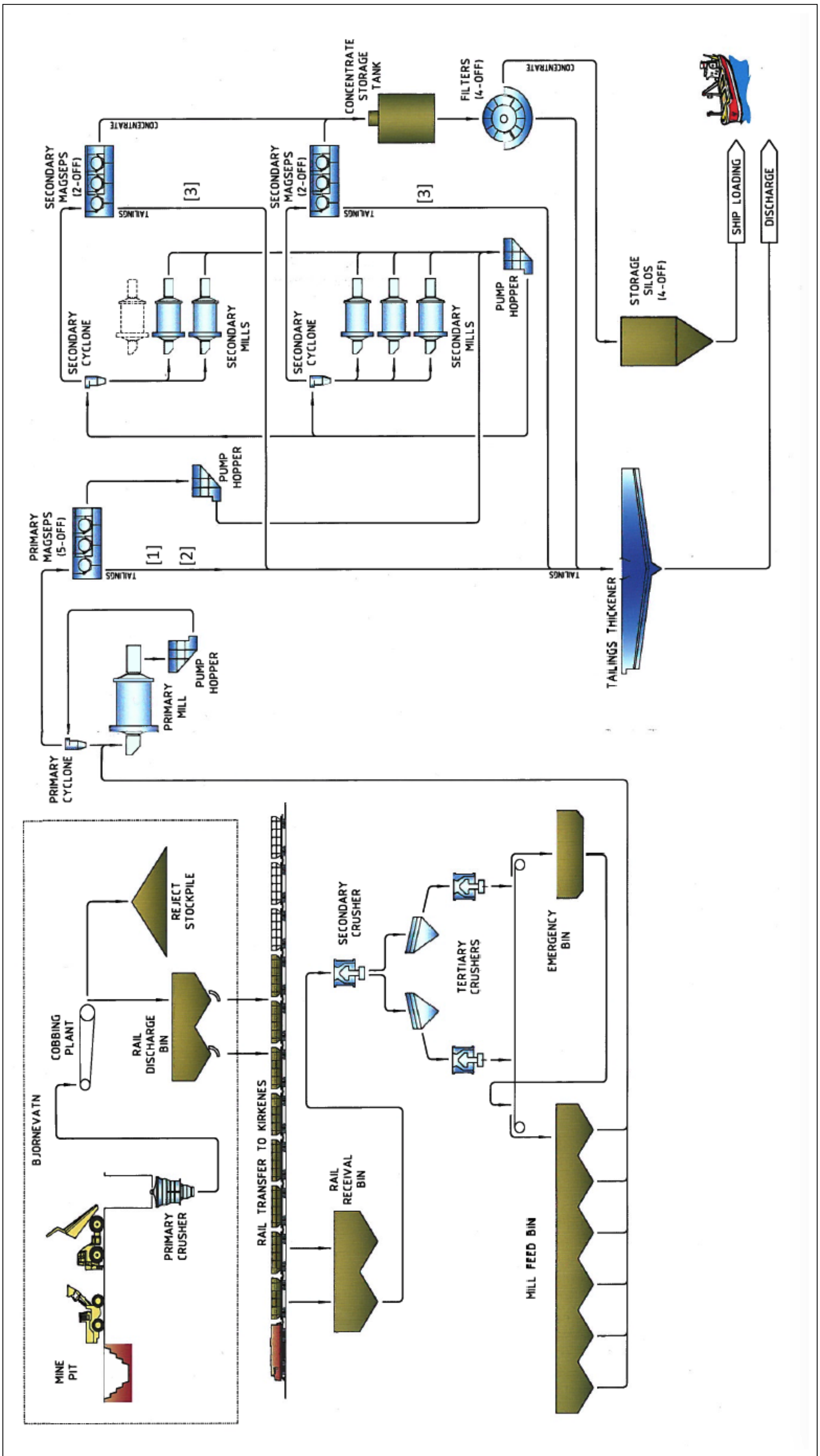

Figure 2.2: Overview of the separation process, [SydvarangerGruveAS, 2014b].

2.3.2 Tailings and Flocculation System

99 % of the iron ore present in the rock is extracted by the separation process implying that iron ore is just a minor component of the tailing sludge in the thickener. Tailings from each subsystem in the plant are collected in a feeder distributor. This feed is then processed to the thickener. The tailing contains of silicate minerals like amphibole and hornblende. The water treatment process has to make these minerals floc in order to recover and recycle the process water. The thickener is water treatment system that makes it possible to recycle and reuse the process water, [Norkyn, 2015].

From Figure 2.3 we can see a drawing of the tailings treatment system. One of the chemicals, the coagulant which is known as LT 38, is added in the feed distributor before the thickener. Since it is added in the feed distributor it is able to blend in the tailings before the flocculant, Magnafloc 10, is added. The flocculant is added at the top of the thickener. Sydvaranger Gruve AS is given a concession by the Government and is granted a consumption of 55 tons of LT 38 and 50 tons of Magnafloc 10 each year, [Hermansen, 2015].

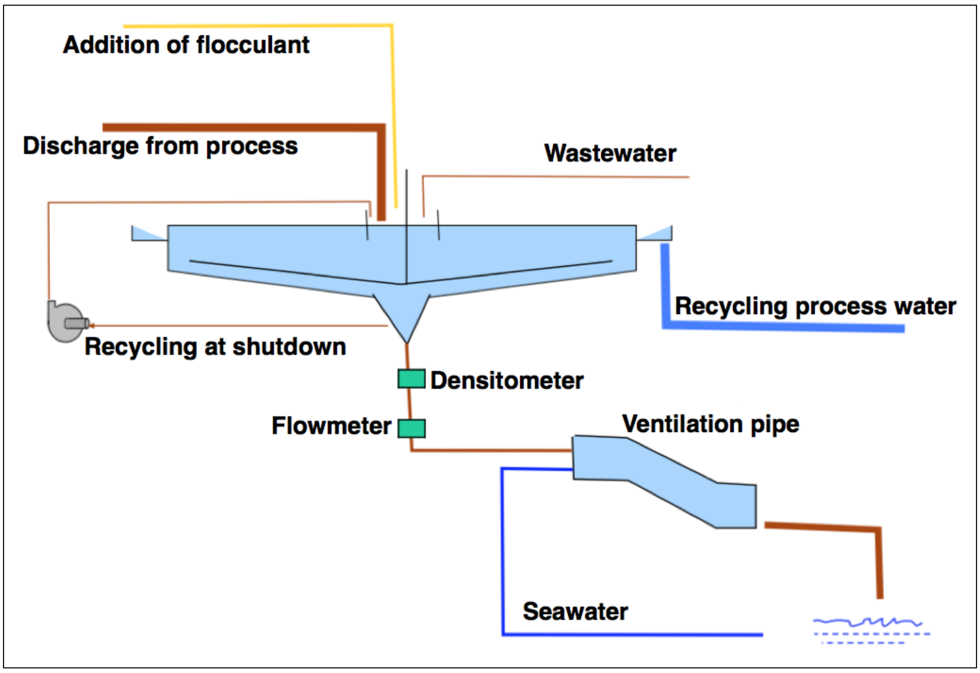

Figure 2.3: Illustrates Sydvaranger Gruve's water treatment system, [SydvarangerGruveAS, 2009].

The coagulant is a liquid solution and does not need any treatment before it is pumped into the feed distributor. The usage of the coagulant varies between 0 to 6 liters per hour. Magnafloc 10 is a powder and needs to be dissolved and diluted with water in a blending tank, before it is added in the thickener. The solution in the blender tank is between 0, 25 % and 0, 29 %. This mixing ratio is possible to adjust by changing the frequency of the pump that delivers powder to the blender. The flocculant solution is pumped in a continuous flow which varies between 1, 1 m^3/h and 2,1 m^3/h depending on the settings of the pump. The pumping capacity will influence the blending properties of the chemical, increasing flow will result in reduced maturation time, [Stenman, 2015].

The thickeners diameter is 38 meters and the cone starts after 2,8 meters. The inlet flow varies around 3500 and 4000 m^3/h, and its solid content is about 8 - 9 %. The discharge flow is usually around 400-450 m^3/h. The solid content of the discharge is measured online and varies between 62 to 68 % depending on the condition of the plant. The solid content is also measured physically by an operator every third hour. It is possible to increase the discharge to the sea, but the company has restrictions regarding discharge, given by the Government. Figure 2.3 illustrates how the thickeners recycling mechanism of the discharge works. If the process is shut or something is wrong it is possible to recycle the discharge back into the thickener again, [Stenman, 2015].

Turbidity in the thickener is measured every second hour by an operator. The turbidity is a measure of the cloudiness of a fluid caused by a huge amount of particles, that generally are invisible to the naked eye. Under normal conditions the turbidity lies between 400 - 600. If the turbidity is above 700, the dosage of coagulant or flocculent is usually increased by the process operator. If the turbidity is under 400, the dosage is usually decreased, [Stenman, 2015].

The rate of increase or decrease of the turbidity, decides the rate of increase or decrease of dosage of coagulant. If the turbidity exceeds a 1000, the process operator at the control room will increase the discharge from the thickener. If the turbidity exceeds 2000 there is too much load on the thickener and the feed at the primary mill will be stopped, [Stenman, 2015].

2.3.3 Tailing disposal system

A ventilation pipe is placed after the thickeners discharge valve, in order to ventilate the discharge and add seawater. This is done to achieve a better settlement in the seabed. The air bubbles will decrease the density of the discharge and give the particles longer settlement range. Due to density differences, the freshwater would have the same effect if the discharge were not mixed with seawater. The freshwater has a lower density than seawater and the discharge would have a longer settlement range. The system contributes to a faster and more efficient settlement of the sediments and makes the process cause less disturbance on the environment, [Stenman, 2015].

Chapter 3

Theoretical background

Removal of suspended particles from water is the major goal of water treatment. This chapter will examine particles in water and their interactions and look at the theoretical basis of interactions between suspended particles during coagulation and flocculation.

3.1 Water Quality and Surface characteristics

Water quality depends on the contamination of particles and the waters solubility. The particles affect the water properties in many different ways. The most important properties that can be influenced, regarding coagulation and flocculation, are pH, alkalinity, taste, color and turbidity. Turbidity is influenced by particle-sizes and requires one or several different separation methods. As Figure 3.1 illustrates, particles that are greater than a couple μm can be removed by sedimentation, which include flocculation and filtration. While particles that are smaller either has to be filtered by different membrane filters or the suspension has to be added coagulants so the particles aggregates and the technology for larger particles can be applied.

Small particles have a bigger surface to volume ratio, which implies that their interfacial properties may dominate in particle dynamics. Water may consist of a wide range of materials, which usually imply great diversity in the interfacial properties, but there are many common patterns of behavior, which allow characteristics to be described without including every range of material, [Bache and Gregory, 2007].

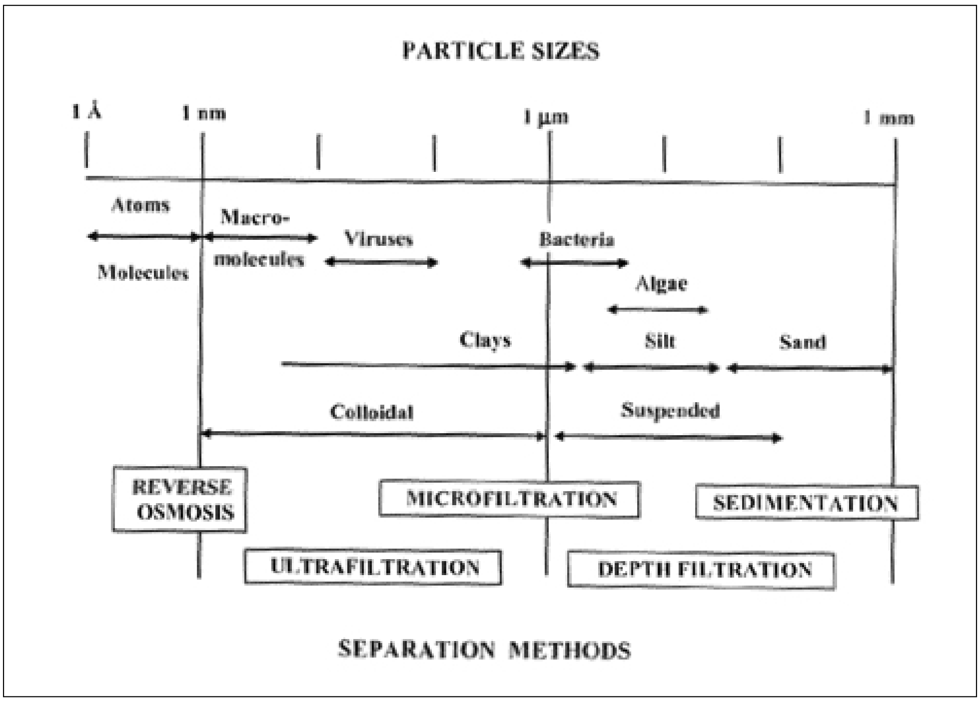

Figure 3.1: Illustration of size ranges for particles with associated separation processes, [Bache and Gregory, 2007].

Hydrophobic, hydrophilic and amphipathic characteristics

Ions, molecules and atoms may exert repulsive forces on each other, but these forces do not stop them from interfacing. Depending on the pH some ionisable functional groups will change the charge of the surface by giving away electrons. When surface changes occur, electric interactions will arise. These interactions extend over greater areas than chemical bonds and will induce temporary dipoles. Between these temporary dipoles the Van der Waals force will be active, and these forces will be explained later in this chapter, [Bache and Gregory, 2007].

Surface solvent interactions also affect particle behavior. Three main categories exist: hydrophobic, hydrophilic and amphipathic. Materials that are hydrophilic are soluble in water. Polar and ionic groups are present and they have an affinity for water. Water molecules are also polar. When they reorient in a way that the polarized charge concentration faces the opposite charge of the ion, they break the hydrogen bond to their closest neighbor, creating a hydration shell, as illustrated in Figure 3.2, [Bache and Gregory, 2007].

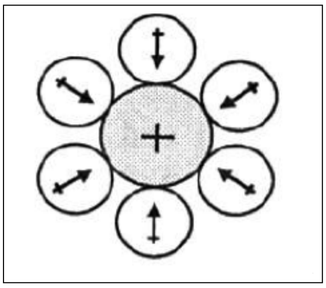

Figure 3.2: IIllustration of a cation surrounded by dipoles, [Bache and Gregory, 2007].

A hydrophobic interaction is not polar and has no affinity for water. It does not contain any ionic groups or hydrogen bonding sites. The substance is heavily soluble in water, but is easily absorbed on non-polar surfaces. The absorption is not a result of attraction between the substance and the surface, but a result of rejection of a hydrophobic substance from the water column. Substances that contain both hydrophobic parts and hydrophilic groups are said to have amphipathic characteristics, [Bache and Gregory, 2007].

3.2 Forces Between Colloids

Interactions between colloids are strongly influenced by their electro kinetic charge. Process water in mining industries usually have a negative charge, since most suspension encountered in the mineral industry contain negatively charged particles, [Wills, 2006]. Particles with similar charge will repeal each other. This will prevent agglomeration and flocculation, as illustrated in Figure 3.3, resulting in charged colloids dispersed in suspension. By reducing or eliminating charge, the colloids will flocculate as illustrated in Figure 3.4, [Ravina, 1993].

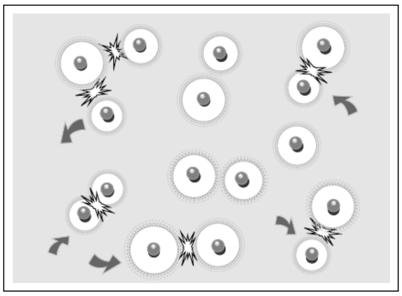

Figure 3.3: Illustrates charged particles that repel each other, [Ravina, 1993].

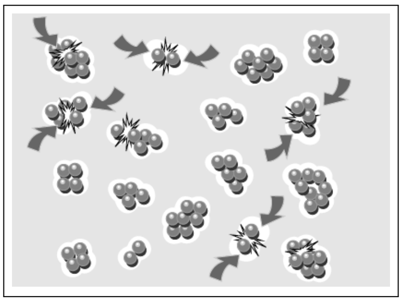

Figure 3.4: Illustrates uncharged particles that collides and aggregates, [Ravina, 1993].

3.2.1 Repulsive Forces

Particles with surface charge in a solution will be balanced by an equivalent number of oppositely charged counter-ions. The ions are affected by two opposing influences: electrostatic attraction and thermally diffusive motions. Electrostatic attraction causes the ions to cluster around the charged particle due to attraction, and the thermally diffusive motions work against clustering and reducing concentration gradients. In the situation illustrated in Figure 3.2 and 3.4, the attraction force is larger than the thermally diffusive motions, causing clustering, [Bache and Gregory, 2007]. The layer of positive counter-ions that surround the negative colloid, illustrated in Figure 3.5 is known as the Stern layer. The positive Stern layer will repel positive excessive ions, which are attracted by the negative colloid. Surrounding the Stern layer there it exists a diffuse layer of positive ions with a high concentration near the colloid. This concentration that gradually decreases with distance away from the colloid until it reaches equilibrium with it surroundings, [Ravina, 1993]. Figure 3.5 illustrates a negative colloid, but the same concept applies for a positive charged colloid.

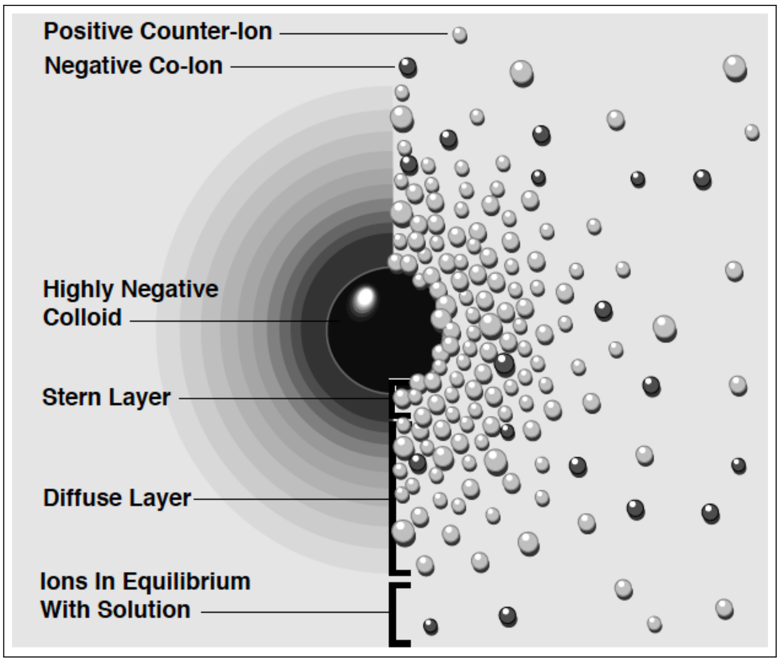

Figure 3.5: Illustrates two ways to visualize a double layer. The left view illustrates change in charge density around the colloid, while the right side illustrates the distribution of positive and negative ions around the colloid, [Ravina, 1993].

The Stern layer in combination with the diffusive layer are referred to as the double layer. The thickness depends on the concentration of ions in the solution, as illustrated in Figure 3.6. High concentration of ions implies more ions available to neutralize the colloid, thus a thinner double layer. Low concentration of ions implies less available ions, thus a thicker double layer, [Ravina, 1993].

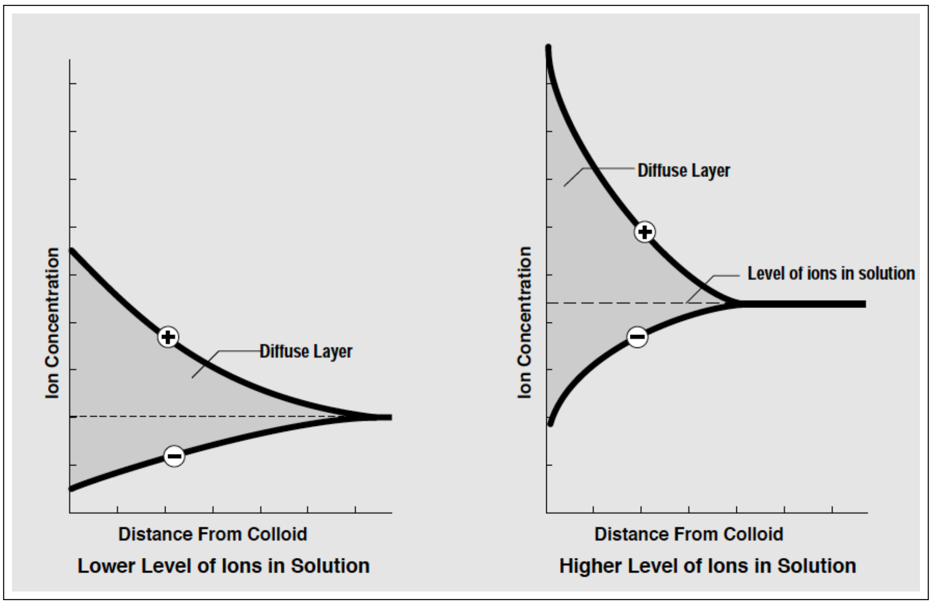

Figure 3.6: Illustrates how the double layer thickness is dependent on ion concentration and the distance from a colloid, [Ravina, 1993].

The negative colloid and its positively charged atmosphere result in an electrical potential across both the Stern layer and diffuse layer. This potential is highest at the surface of the colloid and decrease progressively with distance. Outside of the diffuse layer the potential is zero. This potential indicates the strength of the repulsive force between colloids and it is dependent on distance. The electrical potential at the junction of the Stern layer and diffuse layer is called the zeta potential (β), while the electrical potential at the surface of the colloid is called the surface potential, both are illustrated in Figure 3.7.

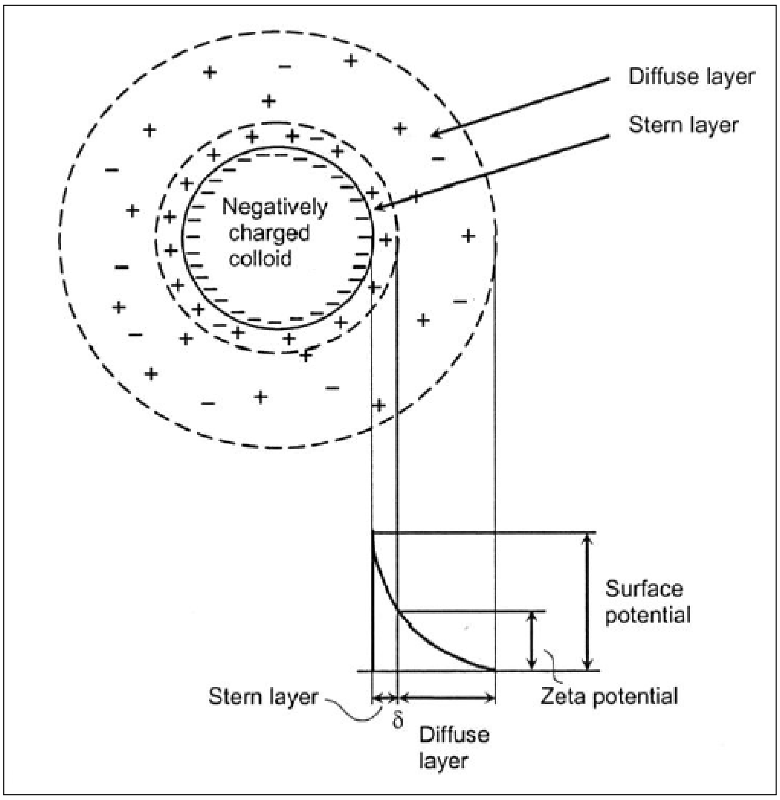

Figure 3.7: Illustration of an electrical double layer around a colloid with a negative charge, [Bache and Gregory, 2007].

The ratio between zeta potential and surface potential depends on the thickness of the double layer. Zeta potential is a good approximation of surface potential when the double layer is thick. If the double layer is thin, the zeta potential will only be a fraction of the surface potential; both examples are illustrated in Figure 3.8. It is not possible to measure the surface potential, but zeta potential can easily be measured. Changes in zeta potential indicate changes in the repulsive force between colloids and can therefore be used for effective coagulation control, [Ravina, 1993].

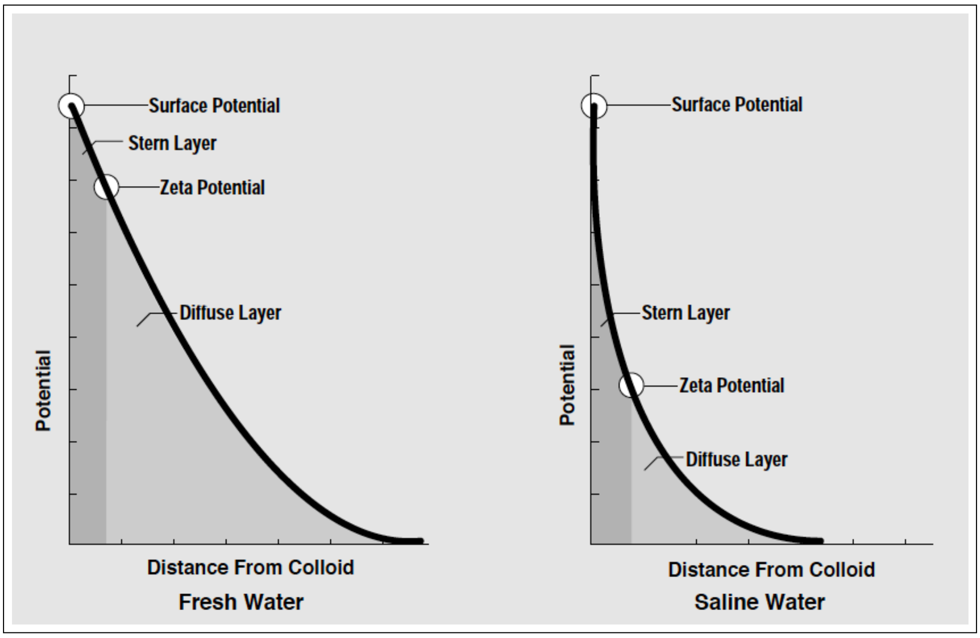

Figure 3.8: Illustrates how the relation between zeta potential and surface potential depends on the level of ions in the solution. In saline water, with a high concentration of ions, the ions will compress the double layer and its potential curve. In fresh water, with a low concentration of ions, the double layer will be thick, thus have a higher zeta potential, [Ravina, 1993].

3.2.2 Attractive Forces

The Van der Waals force is the attraction between neutral particles. If the distance between the particles are small enough the attraction between neutral particles, the Van der Waals force, is stronger than the repel force between the counter-ions, and the particles will coalesce due to charge offsets of the particles, [Ravina, 1993].

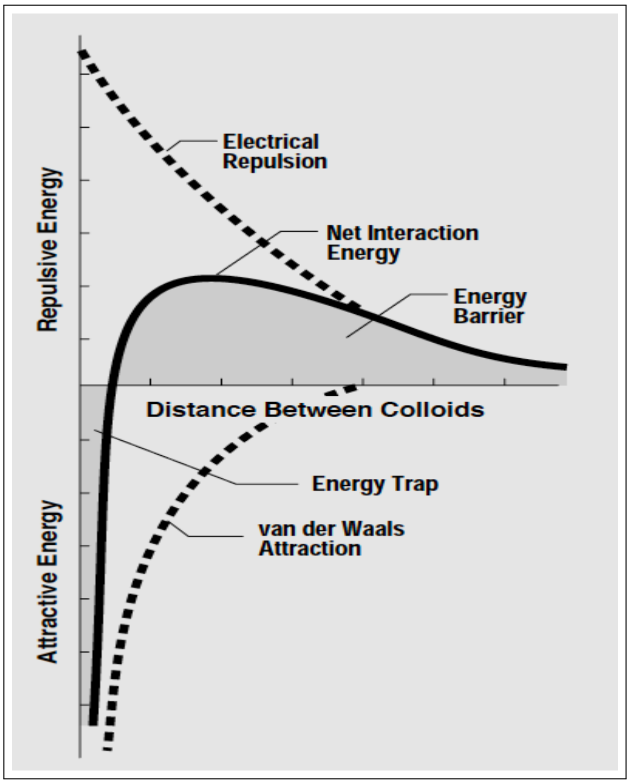

Figure 3.9: Illustrates the net interaction curve from the DLVO theory, [Ravina, 1993].

3.2.3 Energy Barrier

DLVO theory combines the Electrical repulsive force curve with the Van der Waals attraction curve and the result is the net interaction energy graph, illustrated in Figure 3.9. To get the net interaction energy the lowest energy is subtracted from the larger energy, and the net interaction energy curve is formed. The repulsive section is called the energy barrier, and its maximum height indicates how resistant the system is to effective coagulation. The net interaction curve may shift from attractive to repulsive and back to attractive with increasing distance between particles. In order for particles to exceed the energy barrier they must have a sufficient kinetic energy due to speed and mass, including a collision course. When the energy barrier is passed, the net energy is attractive and the particles agglomerates. The attractive region of the graph is often referred to as an energy trap, since the colloids are trapped together by Van der Waals forces, [Ravina, 1993].

3.2.4 Reducing the Energy Barrier

To get an effective coagulation, the energy barrier must be lowered or removed in a way that makes the net interaction attractive. This may be done in two ways: by compressing the double layers or by reducing the surface charge, [Ravina, 1993].

Compress the Double Layer

Compressing the double layer can be accomplished by increasing the ionic concentration. Adding salt to the system will increase the ionic concentration. As the repulsive energy barrier is compressed, as illustrated in Figure 3.10, particle agglomeration occur rapid, as the colloids will be trapped together by Van der Waals attraction, [Ravina, 1993].

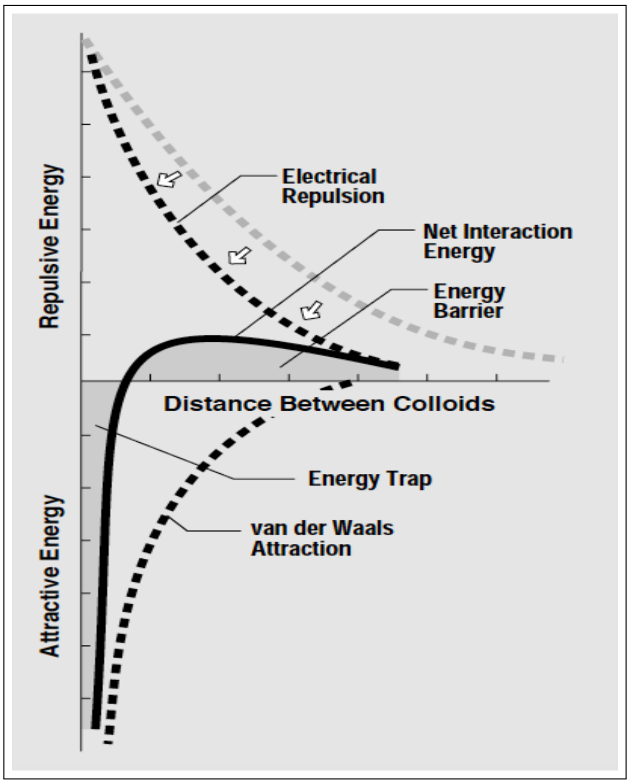

Figure 3.10: Illustrates the double layer compression and its reduction of the repulsive energy by increasing ionic concentration, [Ravina, 1993].

Reducing the Surface Charge

By reducing the surface charge, the zeta potential is automatically reduced, thus lowering the energy barrier. Adding coagulant can reduce the charge, as illustrated in Figure 3.11. It does not have to be reduced to zero, but to a point where the particles'kinetic energy, due to velocity and mass, allows the collision to exceed the repulsive force. At fixed values of velocities, particles with a greater mass will have a higher kinetic energy, causing the larger particles to floc before the smaller once, with a lower mass, [Ravina, 1993].

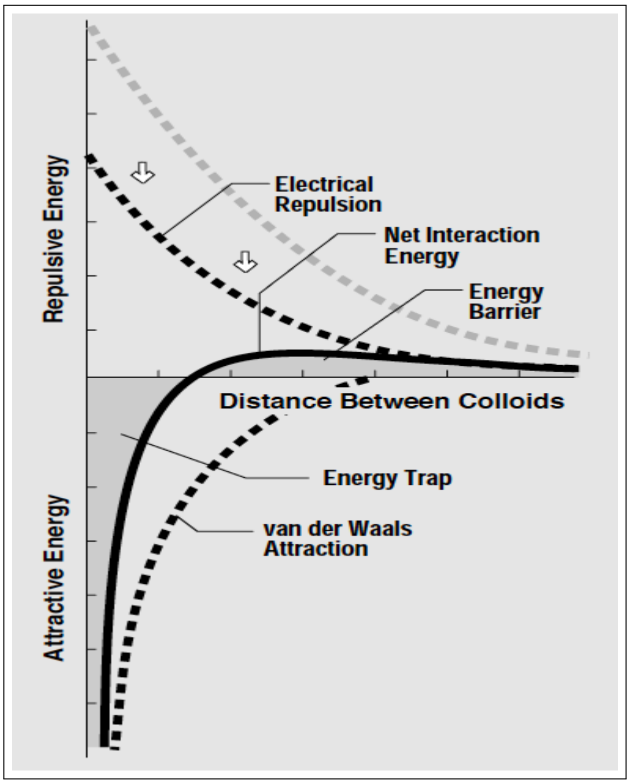

Figure 3.11: Illustrates how coagulant addition can lower the surface charge and reduce the repulsive energy curve, [Ravina, 1993].

3.3 Flocculation and Coagulation

Flocculation may be described as the process where particles come into contact with each other and settles due to relative motion. The phase where the particles are brought together is called the transport phase. In order to achieve this phase two conditions have to be met: sufficient supply of building materials and a thermodynamic state that is conductive to bond formation. Nucleation on particle surface, inter-particle aggregation and adsorption of materials, all give supply of building materials in the suspension. The supply rate depends on both concentration and transport factors, [Bache and Gregory, 2007].

The coagulation process overcomes factors that stabilize the suspension, and particles may collide, resulting in bond formation and flocculation, [Bache and Gregory, 2007]. Coagulation takes place when the energy barrier is reduced or eliminated as a result of destabilization. Flocculation occurs as a result of destabilized particles, when the colloids collide due to hydraulic shear forces in the mix and flocculation basin. Microflocs are formed by a few colloids that bridge or entrap, which in turn result in visible flocs. The line between flocculation and coagulation is in practice unclear since many chemicals can perform both functions. Coagulants main function is charge neutralization, but as they can absorb onto several colloids, they often bridge them together, thus flocculating, [Ravina, 1993]. Flocculation and coagulation is a result of the following four mechanisms:

- Double layer compression
- Charge neutralization
- Bridging
- Colloid entrapment

[Ravina, 1993]

The mechanisms will be described separately, but water treatment often involves simultaneous use of several of them.

3.3.1 Double Layer Compression

An electrolyte that retains its identity and does not adsorb to a colloid is called indifferent. Addition of an indifferent electrolyte will change the ionic concentration resulting in compression of the double layer. This is called "salting out" and is illustrated in Figure 3.12. It is important to notice that the electrolyte does not change the charge of the colloid, but compresses its sphere. By comparing to Figure 3.5 the difference in charge radius is remarkable, [Ravina, 1993].

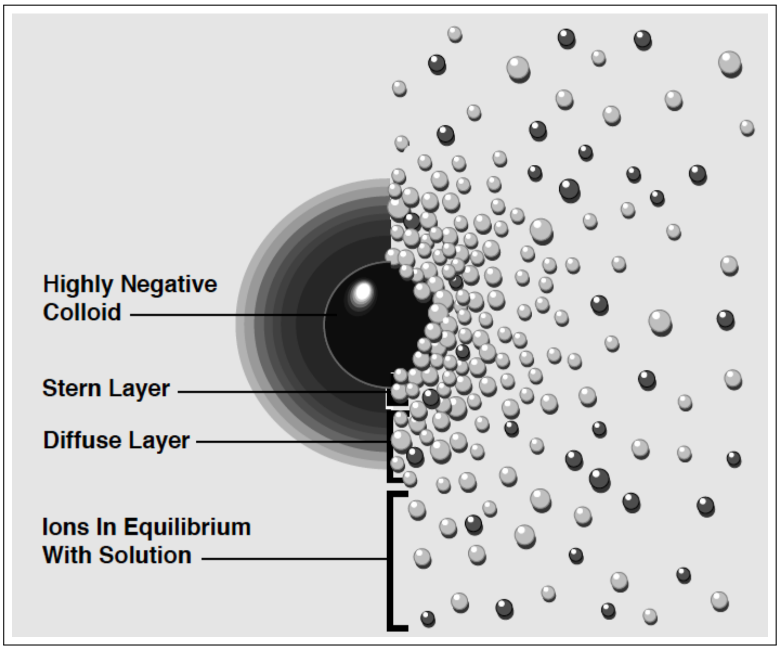

Figure 3.12: Illustrates the double layer compression after adding an indifferent electrolyte, [Ravina, 1993].

3.3.2 Charge Neutralization

Charge neutralization lower the energy barrier and form stable flocs, due to Van der Waals forces. Adding inorganic coagulants or cationic polymers are often used to neutralize charge. If the colloids have a negative charge the colloids'surface will absorb positively charged coagulant thus neutralizing the charged colloid close to zero net charge, as illustrated in Figure 3.13. As the zeta potential gets closer to zero the particles gets unstable. It is important to avoid overdosing, since increasing the dose of coagulants will continue the adsorption and charge reversal may take place. This will increase the energy barrier and reestablish the stable suspension. In order to avoid overdosing, the zeta potential can be monitored and imply dosing concentrations, [Ravina, 1993].

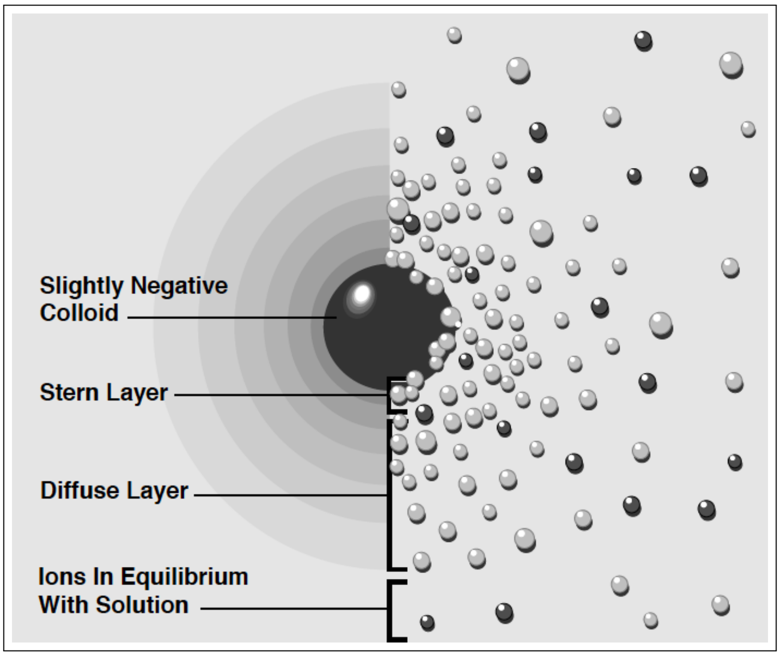

Figure 3.13: Illustrates colloids reduction in charge, which drops the repulsive energy curve making Van der Waals force dominating the net force, [Ravina, 1993].

3.3.3 Bridging

Polymer bridging is a process that increases the size of the floc. The polymer bridges by adsorbing on one side of the particle, and has sufficient length that ignores the repulsing force from another similar particle, and therefore adsorbs this one as well, as illustrated in Figure 3.14. Another type of bridging is electrostatic bridging. This is attraction between the negative charge of a particle and the positive charged deposit, as illustrated in Figure 3.15, [Bache and Gregory, 2007].

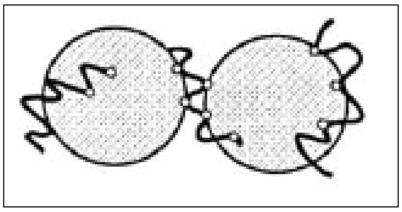

Figure 3.14: Particles adsorbed by a polymer, [Bache and Gregory, 2007].

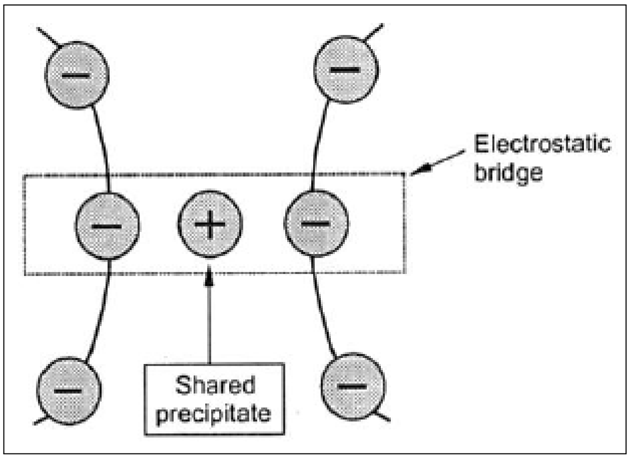

Figure 3.15: An electrostatic bridge due to point charges, [Bache and Gregory, 2007].

Often bridging is used in conjunction with charge neutralization, resulting in fast settling and shear resistant flocs. A cationic polymer with low molecular weight can be added to neutralize the charge and then a slight anionic polymer with high molecular weight is added to bridge between the micro-flocs, as illustrated in Figure 3.16, [Ravina, 1993]. The bridging mechanism is usually the dominant mechanism if the colloids and polymers have the same charge or if a non-ionic polymer is used. In order for bridging to be likely to occur, two conditions have to be met: the polymer has to be of sufficient length to overcome the energy barrier and the adjacent particle has to have available sites in order to anchor other segments, [Bache and Gregory, 2007].

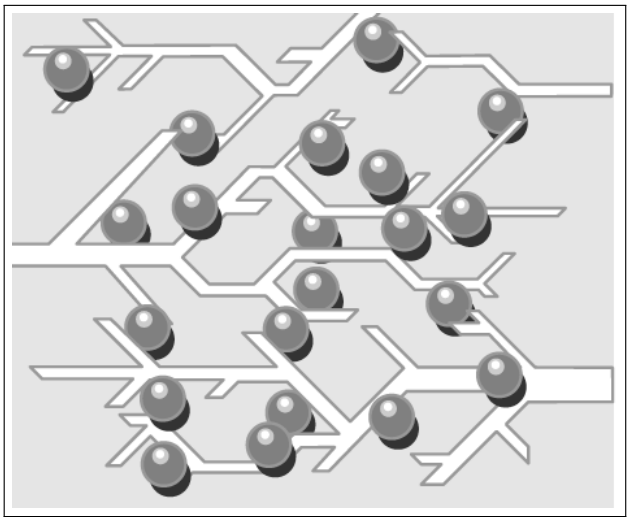

Figure 3.16: Visualization of how polymer chains attach to several colloids, [Ravina, 1993].

3.3.4 Colloid Entrapment

Colloid entrapment involves adding relatively high doses of coagulant that precipitate as hydrous metal oxides. Colloid entrapment and decrease in turbidity takes place when the coagulant dose increases. The coagulant dose is far more than required to neutralize the charge, some charge neutralization may occur, but the colloids are literally swept from the bulk of the water by enmeshment into the settling hydrous oxide floc, as illustrated in Figure 3.17, [Ravina, 1993]. Colloid entrapment is known as sweep coagulation and refers to water colloids that become enmeshed in a voluminous precipitate obtained from coagulants. These are flocs that form clusters. More precipitate increase the particle number. This is the reason why sweep floc is advantageous in coagulation of low turbidity water, it adds to the particle number and boost the flocculation rate. When the flocs develop, a positively charged precipitate will cover the structure. At low concentrations of coagulants a small linkage between the particles will exist . At higher concentrations of coagulants this linkage will be weaker, thus overdosing of coagulants will reduce the floc strength, [Bache and Gregory, 2007].

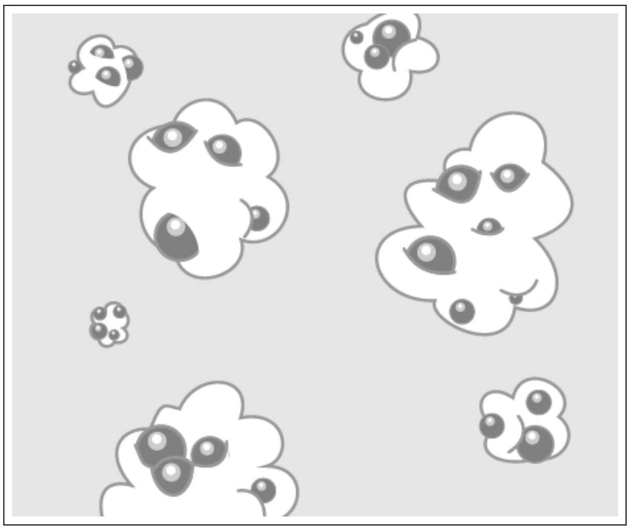

Figure 3.17: Visualization of how polymer chains attach to many colloids, [Ravina, 1993].

3.3.5 Selecting the right chemical for water treatment

There exist many chemicals suitable for water treatment on the market. The right concentration of the proper chemical may improve the water quality as well as reduce the sludge volume and overall operating cost. Polymers are widely used in water treatment and are becoming more and more popular in water treatment; this section will therefore only discuss this type of water treatment chemicals.

Characterizing Polymers

A polymer is a chain of monomers or small subunits and can be used as a coagulant or flocculent in water treatment. They can have different types and numbers of subunits, thus different molecular weight. The chains may be branched or linear and some are soluble in water. The polymers that are soluble in water are called polyelectrolyte. In order to be soluble in water they have to contain a polar group or an ionisable group. Many of them also contain a hydrophobic group, [Bache and Gregory, 2007].

Charge density

The ionisable group decide if the polymer is cationic, anionic, non-ionic or ampholytic. The charge density is defined as a percentage of the mol fraction of ionogenic groups, relative to the other groups the polymer contains. This density is sensitive to pH in solutions where de-protonation can occur, which include removing of a proton (H^+), [Bache and Gregory, 2007].

Polymers with very low or none charge density are called non-ionic. They are often used to flocculate solids through bridging, and polyacrylamide is often a typical example of a non-ionic polyelectrolyte, [Ravina, 1993].

Anionic polymers have a negative charge, the charge can vary from close to non-ionic to very strong anionic. They are normally used for bridging to flocculate solids. Anionic polyelectrolytes can sometimes flocculate negative charged solids, since a colloid with a net negative charge may have some positive, as well as negative sites. Acrylamide- based anionic polyelectrolytes, with high molecular weight, are often used to assure a bridging mechanism, which is the case in Sydvaranger Gruve AS's water treatment. They are effectively capable of flocculating large particles, but smaller colloids will remain in the water phase. This is why they often are used in combination with coagulants that assure neutralization of charge, [Ravina, 1993], which also is the case in Sydvaranger Gruve AS's water treatment.

Cationic polyelectrolytes are polymers with a positive charge, which often varies in both charge densities and weight. Cationic polyelectrolytes with a high charge density and high molecular weight, often work both as a bridging mechanism and a charge neutralizer, [Ravina, 1993].

Molecular weight

A wide range of polymer lengths can be found in the same batch, but its molecular weight is decided by the average measure of length. There are no specific methods required when reporting molecular weight, thus two similar polymers with the same published molecule weight may be quite different, [Ravina, 1993].

Structure

Molecular weight and charge density influence both size and structure of a polymer in a solution. In a good dissolved solution, the polymer has high affinity with the water, and the isolated polymer will expand due to this affinity. When the polymer expands it will increase the number of segment-solvent contacts. If a solution has low affinity with the polymer, the isolated polymer will contract and the mixing will be poor. The polymer in a solution with high affinity will get an increase in the charge density, as the segment solvent contracts. The polymer coil will extend due to electrostatic repulsions between segments. Polymers that have attachment of small colloids to all its active sites will lose its charge and become neutral. The molecules will then tend to contract to its original coil and draw the attached solids into a coherent floc. An anionic polymer will be tightly coiled in a solvent with high ionic strength or with low pH. In a solvent with low ionic strength in natural or alkaline pH the anionic polymer will extend. The same will happen to a cationic polymer in the opposite situation. The shape and structure of a polymer have a huge impact on flocculation and sedimentation due to its impact on bridging, [Bache and Gregory, 2007]. Similar polymers with the same composition of monomers, molecular weight, and charge characteristics may perform different due to different structures that link the monomers together, [Ravina, 1993].

There are many different products available, thus selecting the right polymer for the given treatment is complicated. In general, the molecular weight and the relative charge density cannot both be increased within the same polymer. This often result in a tradeoff between charge density and molecular weight or in a solution that combines several chemicals, [Ravina, 1993].

3.4 Mixing Factors

Different types of mixing are required from different coagulation and flocculation methods within different types of waters. In order to destabilize the suspension the coagulant has to reach all particles, or else this leads to an inefficient process. Rapid mixing enhances the dispersion and accelerates the initial stages of growth which is ideal to achieve uniformity, as illustrated in Figure 3.18, [Bache and Gregory, 2007].

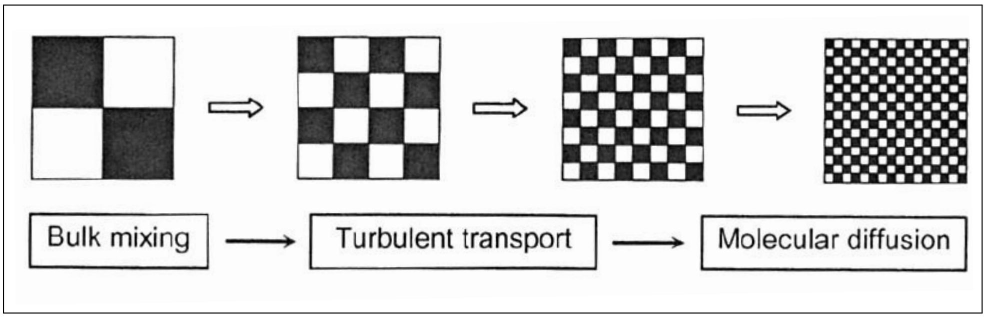

Figure 3.18: Illustration of transfer of particles from large scale to a smaller scale in order to reach a more even distribution, [Bache and Gregory, 2007].

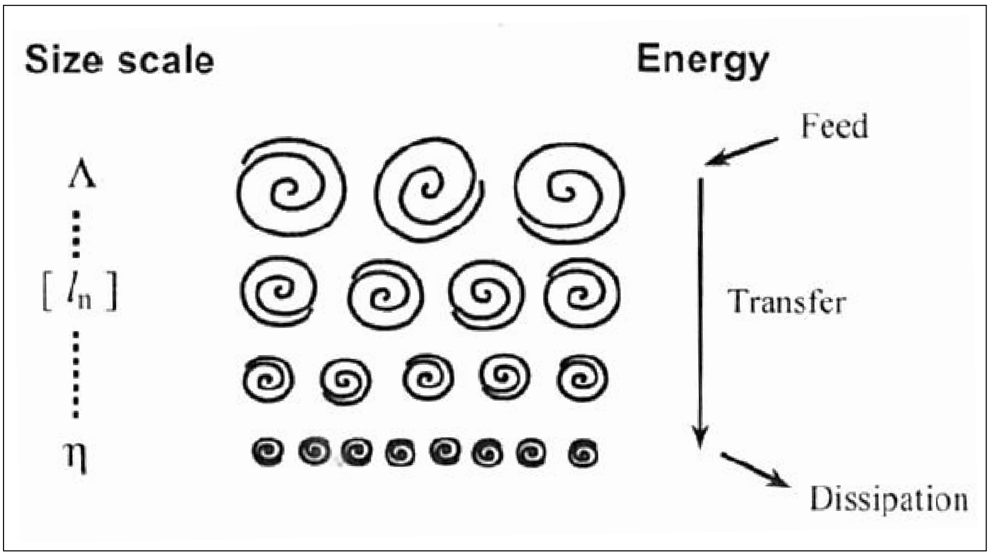

Figure 3.19: Illustration of energy routing in eddies, [Bache and Gregory, 2007].

Turbulent motion
Turbulent motion has turbulent energy, which is transferred from large-scale fluid motions to small-scale fluid motions, which eventually is dissipated in heat, as illustrated in Figure 3.19. The rate of energy dissipation per unit mass is an important factor regarding the existence of both flocculants and coagulants in the suspension. Fluid elements may eventually be deformed into thin ribbons due to vortex stretching making them more amenable to segregation. During mixing it is inevitable that flocs get transported into the vortices, these conditions may conduce to rupture, if the mixing factors are not customized according to the chemicals used, or opposite, [Bache and Gregory, 2007].

Rate of energy dissipation
Rate of energy dissipation per unit mass is an important parameter in characterizing turbulent flow. Energy dissipation is at its maximum close to the stirring source (energy source) and decrease further away. Mixing is most efficient where the energy transfer rate is high. Where dispersion of flocculants is desirable, the liquid should circulate frequently through regions with high intensity turbulence. The mixing time is dependent on the time it takes for the mixers to rotate, but only a few circulations is required for the variations in concentration to be muted, as illustrated in Figure 3.20, [Bache and Gregory, 2007].

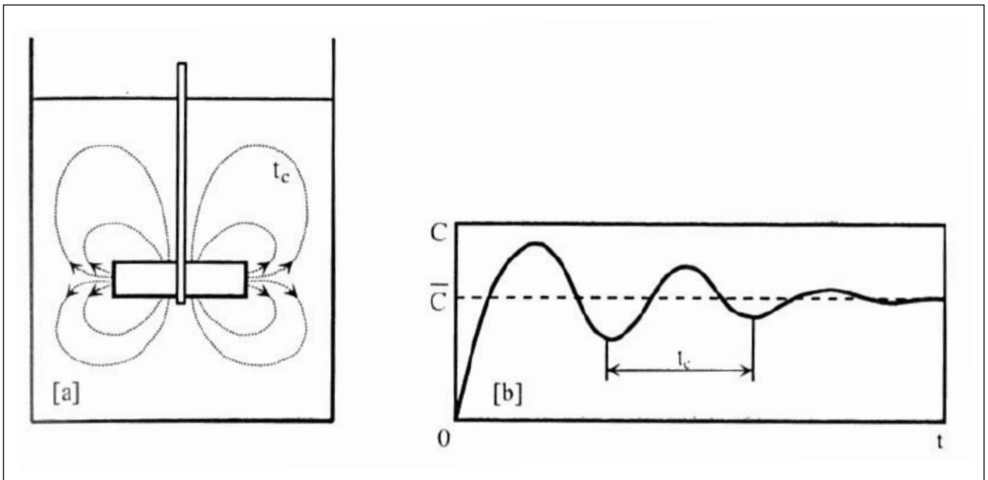

Figure 3.20: A) Illustration of a stirred tank and its flow pattern and circulations, [Bache and Gregory, 2007]. B) Illustration of a batch operated tank with the tracer concentration as a function of time, [Bache and Gregory, 2007].

Strength
Floc strength is an important factor, due to its entry in a variety of fluid regimes as it passes through the water works. The flow may be turbulent and the floc may be subjected to relatively high stress before settling independent on site. All flocs are subjected to this force, but this seems to impact the large flocs more as they are more fragile. The stress conditions are lower in the settled floc deposit, due to the boundary layer and the laminar flow. Flocs in suspension will experience a larger range of flow related forces. Their strength is dependent on the cohesive forces between the particles, solids volume concentration and structure. The net influence from the flow related forces is difficult to predict, so information are often gained by subjecting flocs to known shear conditions until they rupture. Figure 3.21 illustrates the relationship between turbulent kinetic energy, floc size and strength. Generally, larger flocs are more vulnerable to breakage than smaller flocs, but any floc can be broken if it is exposed to sufficient kinetic energy which enables separation, [Bache and Gregory, 2007].

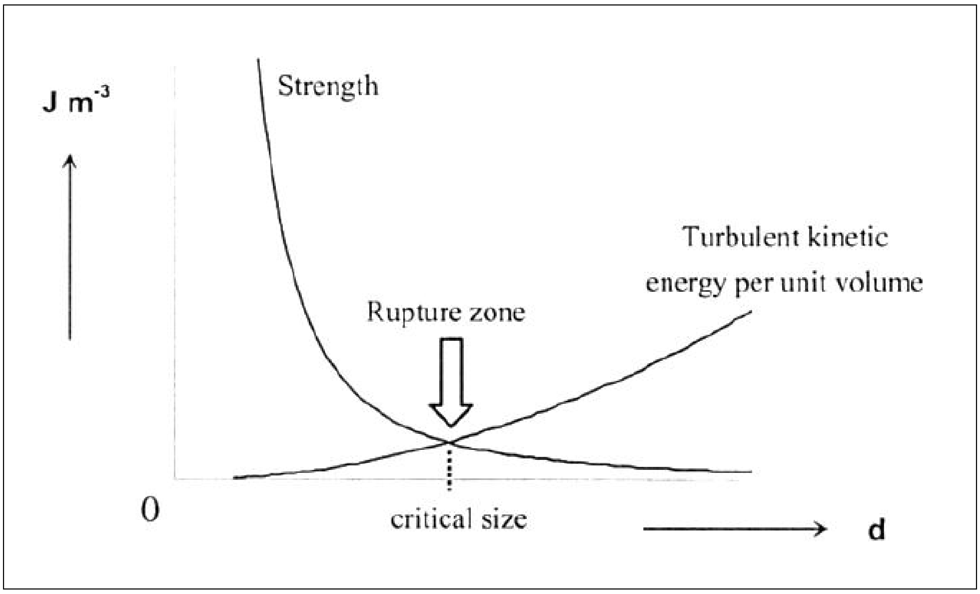

Figure 3.21: Illustration of the relationship between turbulent kinetic energy and the floc size and strength, [Bache and Gregory, 2007].

Flocs formation may be reversible or non-reversible. Increasing shear rate applied to the floc until it breaks and then restore the original shear rate, as illustrated in Figure 3.22, prove if the floc formation is reversible or not. If the flocs are formed again with the same size, the flocs are reversible. Some tests have been applied on this matter and shown that where cationic polyelectrolytes are used in order to destabilize clay particles, almost full reformation was documented. While sweep coagulated particles have shown to be non-reversible. When bonds are reformed their collision efficiency factor is reduced. This cause increased separation distances which reduce the strength of the electrostatic attractive forces, [Bache and Gregory, 2007].

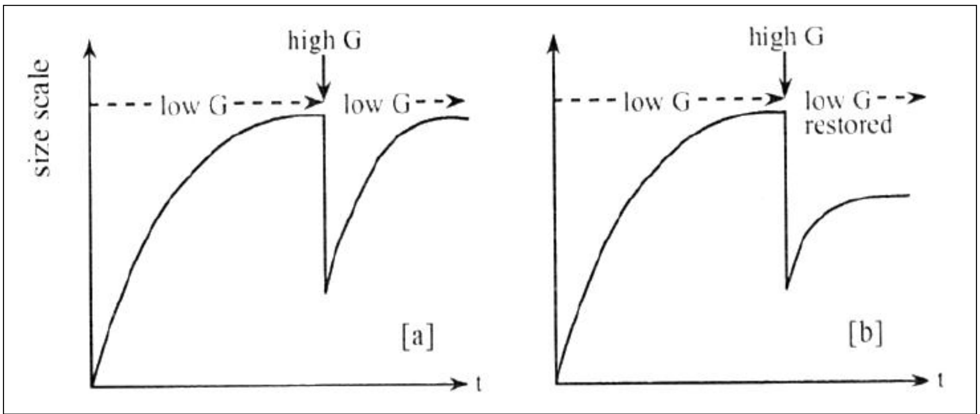

Figure 3.22: Illustration of the size of a flocculent under cyclic-shearing, G is the velocity gradient. A) The equilibrium size is restored, implying bond reformation. B) Reduction in the equilibrium size, implying irreversibility and restructuring, [Bache and Gregory, 2007].

Real scale system versus small scale system

Water treatment processes are continuous and the distribution of floc size in a steady state is usually varying slowly. The distribution is an important factor because many separation processes discriminate on the basis of particle size and the efficiency is often based on mass removal. It is difficult to obtain the optimum and scaled-up mean velocity gradient found in small-scale mixers due to energy distribution, which have several scaling-parameters and is system dependent. This parameter might even not be the optimum value for the real scale system, despite this there is a reasonable expectation that identified patterns of behavior in small-scale should continue to exist. Another important factor is the impact of the shear, these are system-specific and huge variations might be a result if this is not taken into account, [Bache and Gregory, 2007].

Temperature and pH
In some cases temperature impact different factors like chemistry and viscosity. This influence may be significant and may cause changes in coagulation, flocculation and the floc's properties. Small flocs, slow growth and residuals of poor quality are some of the reported issues at processes with low temperatures. Changing pH, increase the concentration of coagulants or adding floc aids are some of the solutions to compensate for changing temperatures. While some processes have issues when the temperature is low, others improve. For instance is lower temperature when treating colored water favorable due to the improved precipitate rate. Color seem to be less soluble in water with lower temperature, thus less coagulant is required, [Bache and Gregory, 2007].

To summarize the factors mentioned: in most cases low temperatures, pH below optimum value in combination with increased viscosity and smaller floc size, will reduce the speed of settling, and the flocculation will be less efficient. In practice the low temperature is often pointed out to be the issue when the situation is described as having a poor decrease of turbidity in combination with low temperatures, while it in fact is due to the lack of pH control and adjustment of concentration/dose of chemicals, [Bache and Gregory, 2007].

3.5 Practical application

It is up to the customer to consider charge type, charge density and molecular weight. In order to find the best suited product for the specific situation, comprehensive testing is required. Parameters that influence the test results are: type of water considered, coagulation mechanism, polymer characteristics and flocculation mechanism, as well as costs and further processing of the suspension. The tests should include ranking of floc formation time, floc size and settling rate. These tests can be done by a pilot plant in a smaller scale or in full scale at the given plant, [Bache and Gregory, 2007].

The optimum dose and concentration of flocculants can be determined partly by testing, but mainly in the process. There is often a limitation of concentration of chemical use, either regarding environmental conditions, regulations or operational problems. Guarantee of efficient plant performance cannot be justified although if identification and control of the optimum chemical dose and coagulation and flocculation pH is achieved through small scale testing. Requirements like mixing of chemicals, time between adding for example coagulant and flocculent due to reaction time, and the time between last addition and the treated waters discharge have to be identified in order to have an efficient treatment process. Many tests and experiments are done regarding flocculants and coagulants aid in practice. There exists a lot of experience with this process, but their tests are based on process performance, not on information regarding the state of the associated floc. The polymer-particle interactions and their role in destabilization are covered in research literature, but information of their function as a floc and when used together with a coagulant is lacking, [Bache and Gregory, 2007].

When the system chemistry is optimized, and the necessary aids applied, the aim of coagulation and flocculation is to render the solids phase into a state which enables effective separation. The nature of the water and the design of the process always have to be taken into account and this cause lack of general guidelines to follow. But when the process is optimized it separates particles from the water in an efficient way and makes the water ready for both reuse and deposit, [Bache and Gregory, 2007].

The acceptable limit for water quality is dependent on the specific plant requirements regarding efficiency of the process and reuse of water and in case of departure of waste water, the regulations given by the Government, [Bache and Gregory, 2007].

Small scale batch settlement tests should not be totally relied on due to the huge difficulties in recreating the same conditions in the small-scale batch as in the full-scale system. Parameters such as stirring velocity, temperature and concentration may not be the same in both the testing system and the full scale system.

The variations between basic existing theory and practice are some of the reasons why experiments are so useful and in most cases a requirement before real-scale testing is done. A lot of experiments and experience by real time testing is required in order to find the best coagulants and flocculants suited for the specific process. This may be time consuming and costly, but the operation might gain a lot if any good findings or improvements are done, [Bache and Gregory, 2007].

Chapter 4

Method and results

The aim of this thesis is to contribute and assure that Sydvaranger Gruve AS is operating within a standard of best practice regarding water treatment. The aim of the tests is to figure out if there are other chemicals that can contribute to improved water treatment.

Several suppliers of chemicals were contacted and Sydvaranger's facility was briefly presented to the suppliers. The companies sent several different chemicals that they recommended would be appropriate for testing at Sydvaranger Gruve AS's facility. Two of the companies also visited Sydvaranger Gruve AS and presented their products and technical support. They also came with recommendations on how to test chemicals and shared some of their experience.

A range of flocculants and coagulants were tested:

- Non-ionic, anionic and cationic
- High and low molecular weights
- High and low ionic charges

Name:	Supplier:	Powder/liquid:	Molecular weight:	Molecular charge:	Type:
UNIFLOC PDM	Aquatech4you	Liquid	HIgh	100 % cationic charge	Coagulant
UNIFLOC OAE 300	Aquatech4you	Liquid	Medium	30 % anionic charge	Flocculant
UNIFLOC PDMG 25	Aquatech4you	Liquid	Low	100 % cationic charge	Coagulant
UNIFLOC A 300	Aquatech4you	Powder	High	30 % anionic charge	Flocculant
UNIFLOC PDMG 90	Aquatech4you	Powder	Low	100 % cationic charge	Coagulant
UNIFLOC OCE 1000	Aquatech4you	Liquid	Medium	100 % cationic charge	Flocculant
PIX-105	Kemira	Liquid	Low	100% Anionic charge	PAC -coagulant
SUPERFLOC A-100	Kemira	Powder	Medium	10 % anionic charge	Flocculant
SUPERFLOC A-100 HMW	Kemira	Powder	High	10 % anionic charge	Flocculant
SUPERFLOC N-300	Kemira	Powder	Medium	Nonionic	Flocculant
SUPERFLOC N-100	Kemira	Powder	Medium	Nonionic	Flocculant
71605	Nalco	Liquid	High	30 % anionic charge	Flocculant
GR 204	Nalco	Liquid	Medium	65 % cationic charge	Flocculant
71408	Nalco	Liquid	Medium	25-30 % cationic charge	Flocculant
9916	Nalco	Powder	Medium	70 % cationic charge	Flocculant
71771	Nalco	Powder	Medium	Nonionic	Flocculant
74695	Nalco	Liquid	Low	100 % cationic charge	Coagulant
Zetag 4120	BASF	Powder	HIgh	20 % anion charge	Flocculant
Zetag 8187	BASF	Powder	High	80 % cation charge	Flocculant
Magnafloc LT32	BASF	Liquid	Low	100 % cation charge	Coagulant
Magnafloc LT37	BASF	Liquid	Low	100 % cation charge	Coagulant
Magnafloc 10/ Zetag 4100	BASF	Powder	Medium	8 % anion charge	Flocculant
Magnafloc 338/Zetag 4105	BASF	Powder	High	9 % anionic charge	Flocculant
Magnafloc 3105	BASF	Powder	Medium	18 % anionic charge	Flocculant
Magnafloc LT 38	BASF	Liquid	Low	100 % cationic charge	Coagulant
Zetag 9016	BASF	Liquid	High	60 % cationic charge	Flocculant
Zetag 9018	BASF	Liquid	High	80 % cationic charge	Flocculant
Ekoflock 91	BASF	Liquid	Low	100 % cationic charge	PAC - coagulant
FL 7226	Clariant	Liquid	Medium	48 % anionic charge	Flocculant
FL 39939	Clariant	Powder	High	32 % anionic charge	Flocculant

Table 4.1: List of chemical samples and their properties, [Appendix 3].

The list of chemical samples received and their data is presented in Table 4.1. The chemicals were tested for the first screening.

Equipment used to carry out the tests are listed below:

- Cylinders with lid (different sizes)
- Stopwatch
- Measuring cup
- Measuring syringe (different sizes)
- Chemicals (Flocculants and coagulants)
- Turbidity meter
- Particle size analyzer
- Oven

- Weight
- pH meter
- Thermometer
- Sample containers of 5 liters

4.1 Process Data

The chemicals were tested directly on the process water sampled from the plant. Information about the conditions of the process water was collected, as all the tests could not be done at the same time. The conditions of the water sample were collected in order to take into account the different aspects that could have an influence on the results. The different sample details that were collected and may have an influence on the result are listed below:

- pH
- Temperature
- Specific surface area
- Density (wt.%)

As the plant has variations regarding its operating state, relevant and available process data from the plant, which describe its operating condition, was recorded during the sampling. This was to make it possible to look at the operating conditions when the tests were performed. The process data describes factors that may impact the properties of the process water, as well as the results. The process data collected are listed below:

- Dosage of flocculant in the thickener
- Dosage of coagulant in the thickener
- The tonnage of input at the mill
- Water phase turbidity measured of the overflow in the thickener (NTU)
- Operating problems in the plant that may impact the process water
- Time the samples were collected
- Daily report
- Geological specifications from the mill feed

4.2 Daily reports

Daily reports were recorded on days when the samples were taken, [Appendix 10]. This gave some extra information about the operating conditions of both the mine and the plant during a time interval of 24 hours. Time when the sampling was done was also recorded in case of anything more needed to be checked.

Temperature and pH were measured since they were important factors that influences the performance of chemicals for water treatment. Some of the chemicals have limitations regarding efficiency within an interval of pH, while others favors different temperature intervals.

4.3 Process water quality

Alkalinity
It was taken an overflow sample from the thickener, which was sent to a laboratory in the Netherlands. The report from the water sample analyzed listed the amount of metals the water sample contained, both total and filtered amount. The sample was filtered with filters of 0,45 micron. The total alkalinity was measured to be 88mg/L, [Appendix 2]. This is a moderate value, which indicates that the process water is not sensitive to changes to small changes within the content of acid.

Charge
To figure out the charge of the process water a laboratory cationic demand controller was used. This displays a value with a negative or positive sign. If the sign is negative it means that the charge of the suspended particles are negative and a cationic chemical is required to neutralize the suspension. If the sign is positive it means that an anionic chemical is required to neutralize the suspension. The value depends on the charge, but even if the value is the same, different process water may require different concentrations to neutralize due to varying resistance, [BASF, 2015]. The process water was measured before every test and the values were between -280 and -400, which indicated that the water had a high negative charge.

Particle Size Distribution
The Nano DS Dual Light Scattering Particle Size Analyzer from CILAS was used to analyze the particle size distribution of the different samples. The dynamic light scattering uses Brownian motion to measure the size of nanoparticles. Dynamic light scattering is not as effective for analyzing particles larger than 3 microns or when analyzing blended products.

To overcome this challenge the Particle Size Analyzer integrates both dynamic and static light scattering. The result is a particle size distribution, which gives the diameter of the particles, cumulative value and a density distribution. The particle size analyzer has a range from 0,20 micron to 500 micron, [Marchet, 2015]. All the different process water samples was analyzed and given a particle size distribution. This was to be able to compare the particle size and the properties of the sample from different tests in case of any significant differences in reactions. The results from the CILAS scanning are presented in Appendix 1.

The density and flow of the discharge in the thickener was recorded in order to consider the throughput within the water treatment system.

4.4 Sampling

The samples of the sludge were collected directly from the plant. The relationships between the amounts of sludge collected from each pump were determined in a way that made the sample similar to the input in the thickener. This was to make the test as realistic as possible compared to the real reaction that would appear in the thickener, [Nilsen, 2015]. The samples were collected from the inlet of the pumps that received the discharge from other equipment, since the injection of coagulant in the process appeared before the inlet to the thickener, thus making it impossible to collect sample from the thickener without chemical addition. It was important to be accurate when sampling process water. The process water contain relatively heavy and coarse material so segregation could easily occur when sampling from high velocity. Segregation was avoided by removing the sample container before it overflowed. The sampling points were marked with [1], [2] and [3] at the flowchart in Figure 2.2, the relationships between amounts of sample collected from each pump were as follows:

- Pump nr. 15: 3 units 6/12 of the total sample, [1]
- Pump nr. 25: 2, 5 units 5/12 of the total sample, [2]
- Pump nr. 26: 0, 5 unit - 1/12 of the total sample, [3]

[Nilsen, 2015]

5 liters buckets were used to collect process water samples, one of these samples, a subsample, was not used for testing, but to measure the density of the suspension and the particles surface area. The weight of the bucket with the subsample was recorded and the sample was put in a container with high pressure for dewatering. After dewatering, the sample was put in the oven at 105 degrees Celsius for 2 hours, to assure that the humidity had been removed. The dry sample was then weighted, thus determining the percentage of solids. The dry sample was also analyzed by the CILAS, which determined the particles specific surface area, [Appendix 1]. Both percentage of solids and the specific surface area of the particles are factors that may influence the outcome of the tests. Comparing these may help understanding the differences within similar tests done at different samples.

4.5 Mixing of chemicals

The chemicals were in both powder and liquid form. They were all mixed to 0, 1 % concentration:

- 0,4 grams of the powder products mixed with 400 ml water
- 0,4 ml of the liquid products mixed with 400 ml water

The powder products were mixed with magnetic stirrers in measuring cups while the liquid products were shaken in plastic containers. The solutions were then poured in plastic containers and marked with name and concentration. The powders were solved to a 0, 1 % solution due to its hard solubility, and the liquid products were made with the same concentration to simplify and avoid dosing errors.

Powder products may have up to 99 % active agents, while liquid products vary normally between 35-50 % active agents, [Bjurling, 2015]. This thesis will not consider the percentage of active ingredients, but only the amount of product used.

The products were mixed the day before and if the solutions were older than 3 days, new chemical solutions would be mixed, due to degradation in some of the products. It was used different concentrations during the tests to emphasize different reactions factors. A calculation sheet presented in Appendix 9 calculated the dosages of the chemical solutions required to reach a given concentration, [Appendix 9].

4.6 First Screening

The main screening was done to eliminate the chemicals that showed poor or no reaction. By excluding ineffective chemicals at an early stage, within a simplified test, time consuming testing with flocculants and coagulants that seemed to have no or poor competitive effect on the process water was avoided. These tests results were based on descriptions and measurements of turbidity.

4.6.1 Method

The tests were done at the same varying dosing rate at 400 ml samples. The slurry was mixed thoroughly with the chemicals and the reaction was recorded. The following were described and denoted:

- Flocculant/coagulant dosage
- Weight of water sample
- Settling rate description
- Floc size
- Compaction
- Water phase clarity (NTU)

The process water samples were taken in 5L containers. The process water was stirred close to a homogenous solution before the containers of 400 ml were filled with sample. To make sure that the containers contained as similar sample as possible with respect to particles, the containers with samples were weighted, and only deviations around 35 grams or less was accepted. The process water samples used were collected from the plant during a short time interval. The test chemical was added to the sample and by pouring the sample in another container and back again the suspensions was mixed. This was repeated 10 times to assure proper mixing. If two chemicals were added the coagulant was added first and the suspension was inverted 5 times before the flocculent was added, and the suspension was inverted another 5 times. When the mixing was done the container with sample was put in tranquility and the reaction was described. The water phase clarity was measured after 1 minute. If there was no or poor reaction, the flocculants would not be tested further with a coagulant, due to its negative results.

If the test with the flocculent had a positive result, it would be tested further with a relevant coagulant. None of the products from different suppliers was combined in the same solution. Only products from the same supplier was combined and tested together.

Concentrations of chemicals
In the tests where only the flocculants were added, the same sample was used for the different concentrations within the same flocculent. In these tests 1 ppm was added first, then the concentration was increased to 3 ppm by adding 2 ppm. Finally the third test was performed with together 5 ppm.

For the tests where both coagulant and flocculent was added the samples had to be new every time in order to be able to vary the coagulant concentration at the same time adding the coagulant first.

In the tests with both a coagulant and a flocculent, the first sample was added 0, 25 ppm coagulant and 0, 75 ppm flocculent. This is equal to 1 ppm as tested in the previous tests with only flocculent. The concentrations made it possible to compare these tests results and look at the differences with replacing 1/4 of the chemical with a coagulant. The second sample was added 0, 5 ppm of coagulant and 2, 5 ppm flocculent. Together this is equal to the concentration added in the second tests performed with only flocculent. Finally the third sample added received 1, 25 ppm coagulant and 3,75 ppm flocculent. These together gave a concentration of 5 ppm, which is equal to the final tests with highest concentration of only flocculent.

4.6.2 Process Data

The process data that was collected when the sample was taken for the first screening is shown in Table 4.2. As we can see the mill feed was 650 tons per hour and usually it should be around 150 tons more. The operators have decreased the mill feed due to overload at the thickener. The iron content of the feed was only about 19 % and should usually be above 30 %. This gives a lot of particles in the inlet of the thickener.

The turbidity was 511, which was acceptable. The Magnafloc 10 concentration was normal, and the feed of LT 38 was zero due to the efficient reaction between Magnafloc 10 and this type of process water.

Date:	11.03.2015
Test number:	**1. Screening**
MF10 feed concentration:	1,9 m^3/h
LT38 feed concentration:	0 L/h
NTU from overflow at thickener:	511
Time:	19:00
Feed on the mill (tons):	650
Status at the facility:	Cannot increase the feed to the primary mill due to problems at the thickener, the iron % is low, this gives the thickener a lot of particles, the discharge from the thickener is limited.
Mill feeds % of iron magnetite:	19,00
% solids in test sample (weight %):	25,85
pH of sample:	9,13
Tailings flow from the thickener:	441 m^3/h
Tailngs density from the thickener:	473 tons/h

Table 4.2: Presents the process data collected during the first screening, [Appendix 4].

4.6.3 Results

Most of the chemicals showed negative results with concentrations as low as 1 ppm. With increasing concentrations the results became clearer and it was easier to classify the reactions.

Table 4.1 illustrates some of the results with a concentration of 3 ppm. The reactions are not good, but fairly improved from the first test with only 1 ppm. Only the results from the promising tests are presented in Table 4.1, the rest of the results are presented in Appendix 4. At the top, all of the results from tests only using flocculants are presented. At the bottom of the list the results from flocculants tested with their coagulants are presented. These tests are comparable somehow due to the same chemical concentration added. These results helped to indicate if the flocculants improved their efficiency when a coagulant was used.

	1,2 ml of 1000 ppm solution added in 400 ml sample gives 3 ppm in watersample:					
Name:	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC OCE 1000	488	bad settling	small	poor	no clear water phase	no reading
UNIFLOC OAE 300	482	bad settling	small	poor	no clear water phase	no reading
UNIFLOC A 300	477	good settling	medium	medium	medium clear water phase, some fines	531
SUPERFLOC A-100	491	medium settling	medium	medium	medium clear water phase, some fines	890
SUPERFLOC A-100 HMW	497	good settling	medium	medium	medium clear water phase, some fines	831
SUPERFLOC N-300	483	good settling	small	medium	medium clear water phase, some fines	914
SUPERFLOC N-100	489	medium settling	small	medium	medium clear water phase, some fines	927
71605	500	bad settling	small	poor	no clear water phase	no reading
GR 204	476	bad settling	small	poor	no clear water phase	no reading
71408	496	bad settling	small	poor	no clear water phase	no reading
9916	474	medium settling	small	medium	medium clear water phase, some fines	791
71771	497	medium settling	small	medium	medium clear water phase, some fines	884
Zetag 4120	504	medium settling	small	medium	medium clear water phase, some fines	888
Zetag 8187	474	medium settling	small	poor	medium clear water phase, some fines	853
Magnafloc 10 / Zetag 4100	509	good settling	medium	medium	medium clear water phase, some fines	952
Magnafloc 338/Zetag 4105	478	good settling	medium	medium	medium clear water phase, some fines	868
Magnafloc 3105	483	good settling	medium	medium	medium clear water phase, some fines	928
Zetag 9016	475	bad settling	small	poor	no clear water phase	no reading
Zetag 9018	501	bad settling	small	poor	no clear water phase	no reading
FL 33939	505	bad settling	small	poor	no clear water phase	no reading
FL 7226	500	bad settling	small	poor	no clear water phase	no reading

	0,3 ml of 1000 ppm solution coagulant and 0,9 ml of 1000 ppm solution flocculant added in 400 ml sample gives 0,5 ppm + 2,25 ppm:					
Name (coagulant+flocculant):	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC PDMG 25 + UNIFLOC A 300	506	medium settling	medium	meidum	medium clear water phase, some fines	908
UNIFLOC PDM + UNIFLOC A 300	520	medium settling	medium	meidum	medium clear water phase, some fines	865
UNIFLOC PDMG 90 + UNIFLOC A 300	495	medium settling	medium	meidum	medium clear water phase, some fines	908
PIX-105 + SUPERFLOC A-100 HMW	481	medium settling	medium	meidum	medium clear water phase, some fines	792
PIX-105 + SUPERFLOC N-300	496	medium settling	medium	meidum	no clear water phase	no reading
PIX-105 + SUPERFLOC N-100	505	medium settling	medium	meidum	no clear water phase	no reading
74695 + 9916	478	medium settling	small	meidum	medium clear water phase, some fines	860
74695 + 71771	480	medium settling	small	meidum	medium clear water phase, some fines	869
Magnafloc LT32 + Zetag 8187	496	medium settling	small	meidum	medium clear water phase, some fines	870
Magnafloc LT32 + Magnafloc 10 / Zetag 4100	474	good settling	small	meidum	medium clear water phase, some fines	733
Magnafloc LT32 + Magnafloc 338/Zetag 4105	502	medium settling	small	meidum	medium clear water phase, some fines	500
Magnafloc LT37 + Zetag 8187	473	medium settling	small	poor	no clear water phase	no reading
Magnafloc LT37 + Magnafloc 10 / Zetag 4100	474	medium settling	small	meidum	medium clear water phase, some fines	784
Magnafloc LT37 + Magnafloc 338/Zetag 4105	491	good settling	medium	meidum	medium clear water phase, some fines	839
Magnafloc LT 38 + Zetag 8187	482	medium settling	small	meidum	medium clear water phase, some fines	816
Magnafloc LT 38 + Magnafloc 10 / Zetag 4100	471	medium settling	medium	meidum	no clear water phase	no reading
Magnafloc LT 38 + Magnafloc 338/Zetag 4105	483	medium settling	medium	meidum	medium clear water phase, some fines	711
Ekoflock 91 + Zetag 8187	-	-	-	-	-	-
Ekoflock 91 + Magnafloc 10 / Zetag 4100	-	-	-	-	-	-
Ekoflock 91 + Magnafloc 338/Zetag 4105	-	-	-	-	-	-

Figure 4.1: Presents the chemicals and their test results with a total concentration of 3 ppm, [Appendix 4].

Table 4.2 illustrates the same tests as in Table 4.1, only with a higher concentration of chemicals. Also here, only the chemicals that showed positive results are presented, the rest of the results are presented in Appendix 4. According to the table some of the chemicals shows a decreasing turbidity rate which indicate good reactions and improved water clarity.

	2 ml of 1000 ppm solution added in 400 ml sample gives 5 ppm in watersample:					
Name:	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC OCE 1000	488	medium settling	small	poor	medium clear water phase, some fines	670
UNIFLOC OAE 300	482	bad settling	small	poor	no clear water phase	no reading
UNIFLOC A 300	477	fast settling	medium	medium	clear water, some fines	294
SUPERFLOC A-100	491	medium settling	medium	medium	medium clear water phase, some fines	506
SUPERFLOC A-100 HMW	497	good settling	medium	medium	medium clear water phase, some fines	497
SUPERFLOC N-300	483	good settling	medium	medium	medium clear water phase, some fines	404
SUPERFLOC N-100	489	good settling	medium	medium	medium clear water phase, some fines	478
71605	500	medium settling	small	poor	no clear water phase	no reading
GR 204	476	medium settling	small	poor	no clear water phase	no reading
71408	496	medium settling	small	poor	no clear water phase	no reading
9916	474	good settling	medium	medium	clear water	81,7
71771	497	good settling	medium	medium	clear water, some fines	218
Zetag 4120	504	medium settling	medium	medium	medium clear water phase, some fines	815
Zetag 8187	474	medium settling	medium	medium	clear water	133
Magnafloc 10 / Zetag 4100	509	good settling	big	medium	clear water, some fines	279
Magnafloc 338/Zetag 4105	478	good settling	medium	medium	medium clear water phase, some fines	383
Magnafloc 3105	483	good settling	medium	medium	medium clear water phase, some fines	645
Zetag 9016	475	bad settling	small	poor	no clear water phase	no reading
Zetag 9018	501	bad settling	small	poor	no clear water phase	no reading
FL 33939	505	medium settling	small	poor	medium clear water phase, some fines	536
FL 7226	500	bad settling	small	poor	no clear water phase	no reading

	0,5 ml of 1000 ppm solution coagulant and 1,5 ml of 1000 ppm solution flocculant added in 400 ml sample gives 1,25 ppm + 3,75 ppm:					
Name (coagulant+flocculant):	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC PDMG 25 + UNIFLOC A 300	477	medium settling	medium	medium	medium clear water phase, some fines	553
UNIFLOC PDM + UNIFLOC A 300	490	medium settling	medium	medium	medium clear water phase, some fines	485
UNIFLOC PDMG 90 + UNIFLOC A 300	470	medium settling	medium	medium	medium clear water phase, some fines	558
PIX-105 + SUPERFLOC A-100 HMW	476	medium settling	medium	medium	medium clear water phase, some fines	752
PIX-105 + SUPERFLOC N-300	467	bad settling	small	poor	medium clear water phase, some fines	887
PIX-105 + SUPERFLOC N-100	499	medium settling	medium	medium	medium clear water phase, some fines	893
74695 + 9916	473	medium settling	small	medium	medium clear water phase, some fines	687
74695 + 71771	480	medium settling	small	medium	medium clear water phase, some fines	698
Magnafloc LT32 + Zetag 8187	471	medium settling	small	medium	clear water, some fines	325
Magnafloc LT32 + Magnafloc 10 / Zetag 4100	474	good settling	medium	medium	clear water, some fines	249
Magnafloc LT32 + Magnafloc 338/Zetag 4105	481	medium settling	medium	medium	medium clear water phase, some fines	447
Magnafloc LT37 + Zetag 8187	471	medium settling	medium	medium	medium clear water phase, some fines	260
Magnafloc LT37 + Magnafloc 10 / Zetag 4100	475	medium settling	medium	medium	clear water, some fines	240
Magnafloc LT37 + Magnafloc 338/Zetag 4105	474	medium settling	medium	medium	medium clear water phase, some fines	613
Magnafloc LT 38 + Zetag 8187	475	medium settling	medium	medium	medium clear water phase, some fines	800
Magnafloc LT 38 + Magnafloc 10 / Zetag 4100	474	medium settling	small	medium	clear water, some fines	319
Magnafloc LT 38 + Magnafloc 338/Zetag 4105	476	good settling	medium	good	clear water, some fines	193
Ekoflock 91 + Zetag 8187	472	bad settling	small	poor	no clear water phase	no reading
Ekoflock 91 + Magnafloc 10 / Zetag 4100	487	medium settling	medium	medium	medium clear water phase, some fines	809
Ekoflock 91 + Magnafloc 338/Zetag 4105	478	medium settling	medium	medium	medium clear water phase, some fines	766

Figure 4.2: Presents the chemicals and their test results with a total concentration of 5 ppm, [Appendix 4].

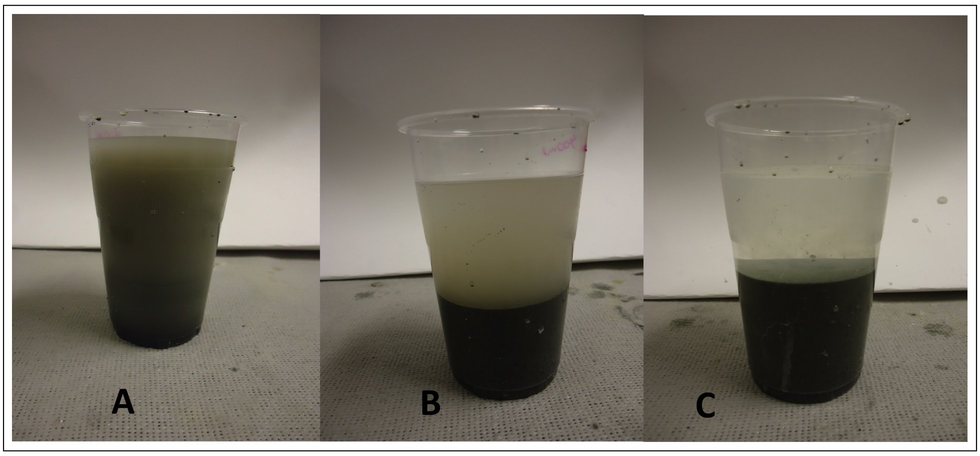

Figure 4.3: Figure A) Illustrates the suspension of process water without any chemicals. Figure B) Illustrates the suspension of process water after 1 minute, with a concentration of 5 ppm of Superfloc A-100. The turbidity was 506 after 1 minute of settling. Figure C) Illustrates the suspension of process water after 3 minutes, with a concentration of 5 ppm of 9916. The turbidity was 81,5 after 1 minute of settling.

The samples with an unclear water phase and an unreadable turbidity was not diluted for turbidity measure. This would be time consuming and without any effect on the result, as the turbidity anyway would be too high to consider for further screening. The turbidity that was in an interval too high for the equipment to measure were not in an area of interest for the first screening.

Figure 4.3 illustrates some of the tests. For the first screening of flocculants, only the chemicals that had a good reaction, and a turbidity of less than 500 at a concentration of 5 ppm was taken further to test in combination with a coagulant. If many chemicals from the same supplier had results within a small interval that was close to 500, only the chemical with the lowest turbidity and the best settling rate from all the concentrations tested was considered for further testing. The chemicals that had good results during first screening with only flocculants are listed below. These were tested in combination with coagulants in the second step of the first screening.

- Unifloc A 300
- Superfloc A-100 HMW
- 9916
- 71771

- Zetag 8187
- Magnafloc 10
- Magnafloc 338

For the testing with a combination of coagulants and flocculants only the chemicals that had a turbidity less than 350 at a concentration of 1,25 ppm of coagulant and 3,75 ppm of flocculants were evaluated as good enough for second screening. The combination of flocculants and coagulants listed below were good enough to be tested in the second screening.

- 74695 + 9916
- Magnafloc LT 32 + Magnafloc 10
- Magnafloc LT 37 + Zetag 8187
- Magnafloc LT 38 + Magnafloc 10
- Magnafloc LT 38 + Magnafloc 338

In addition to these chemicals there were three other flocculants that stood out. These tests showed poorer results in combination with a coagulant, than the tests with flocculent alone at a concentration of 5 ppm. The chemical combination listed below were evaluated as relevant for the second screening due to good results with only flocculent, despite their poor results in combination with a coagulant.

- Unifloc PDM + Unifloc A 300
- PIX-105 + Superfloc N-300
- 74695 + 71771

The difference was so significant that these flocculants were chose to be tested further in the second screening to see if the negative or ineffective impacts of coagulants were significant and if the flocculants would work more efficient alone.

4.7 Second screening

The second screening was done to select the best-suited and most effective chemical or chemicals to test and evaluate further for a full scale test. The second screening was more precise than the first screening. Cylinders of 500 ml were used as containers and measurements and observations were recorded.

The following was recorded:

- Flocculant/coagulant dosage
- Weight of water sample
- Settling rate
- Settling description
- Floc size
- Compaction
- Water phase turbidity after three minutes

4.7.1 Method

The process water samples were in 5 liters containers and had to be stirred close to a homogenous solution before the cylinders of 500 ml were filled with sample. These cylinders had to contain approximately the same amount of particles so they were weighted. The samples tested in the second screening were collected from the plant under a short time interval.

The cylinders were inverted 5 times before chemicals were added to ensure that the solutions were in suspension. If a coagulant was going to be tested with a flocculent, the coagulant was added first, and the cylinder was inverted 10 times. Then the flocculent was added and the cylinder was inverted another 10 times. When the cylinder was placed on the table and the lid was removed the clock started measuring time. The time would be recorded when the interface position of the settling passed 500 ml, 450 ml, 400 ml, 350 and 300 ml, and 250 ml. A syringe of process water was drawn after 3 minutes in order to measure the turbidity.

Graphs with height of water phase versus time were made to compare the settling rate for the different chemicals and concentrations. The best chemical or chemicals tested was a base for further testing in the third and final screening process.

Chemical concentrations The flocculants were tested alone at concentrations of 1 ppm, 3 ppm and 5 ppm. The flocculants were then tested with a coagulant at the given concentrations (coagulant/flocculent): 0,5ppm/1ppm, 0,5ppm/2ppm, 0,5ppm/3ppm, 1ppm/2ppm, 2,5ppm/5ppm and 2,5ppm/7ppm. Only one sample was used for testing a flocculent at different concentrations. A different sample was used for testing a flocculent with fixed concentrations of coagulant, but varying concentrations of flocculent. This gave three different samples for testing six combinations of different concentrations of chemicals.

4.7.2 Process Data

The process data collected during process water sampling is presented in Table 5.1. The mill feed was low due to operational problems at a blasting area in the mine, additionally an excavator was having some problems. These two problems combined made it difficult to deliver enough rock to the process plant, thus low mill feed. The iron content was ok and the turbidity at the thickener was medium high despite the dosing of both coagulant and flocculent. The dosing of coagulant was relatively low which could indicate two things: either the coagulant decreased the turbidity in such an effective way that they decreased the required dose, or the coagulant had such a low effect that increasing concentration of coagulant would not decrease the turbidity. Despite the low feed at the mill the turbidity was relatively high thus indicating process water with properties suited for testing.

Date:	15.03.15
Test number:	**2. Screening**
MF10 feed concentration:	2,1 m^3/h
LT38 feed concentration:	1 L/h
NTU from overflow at thickener:	675
Time:	14:30
Feed on the mill (tons):	600
Status at the facility:	The mine stugguling with delivrability of rock due to shutdown of a blasting area and problems with OK 01, an excavator.
Mill feeds % of iron magnetite:	23,60
% solids in test sample (weight %):	26,37
pH of sample:	9,0
Tailings flow from the thickener:	19,0
Tailngs density from the thickener:	415 m^3/h
Tailngs density from the thickener:	446 tons/h

Table 4.3: Presents the process data collected during process water sampling for second screening, [Appendix 5].

4.7.3 Results

The results from the second screening are presented in water phase versus time graphs. The graphs do not give any indications of turbidity other than the comment behind description of lines. Those tests that were unable to give a turbidity measure due to high content of particles do not have any notations behind the descriptions of the lines. A reference graph was drawn based on observations from a cylinder only containing sample, representing a test without any chemical water treatment. The graph's x-axis is cut at 200 seconds despite that some of the data goes further. This is to give an easily readable and comparable presentation of the graphs due to results in varying intervals. Figure 4.4 illustrates how the tests were performed.

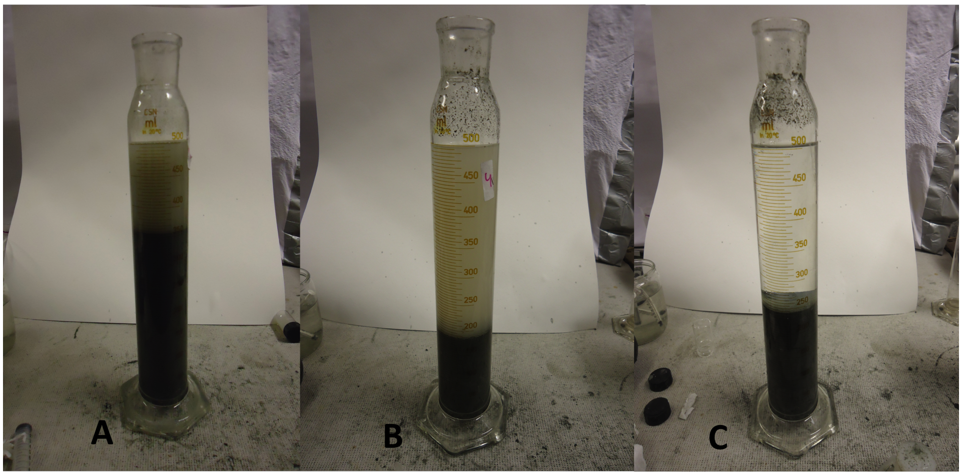

Figure 4.4: Figure A) Illustrates the suspension of process water without any chemicals. Figure B) Illustrates the suspension of process water after 1 minute, with a concentration of 2,5 ppm of coagulant 74695 and 7 ppm of flocculent 71771. The turbidity was 910 after 3 minutes of settling. Figure C) Illustrates the suspension of process water after 3 minutes, with a concentration of 2,5 ppm of coagulant LT38 and 7 ppm of flocculent Magnafloc 338. The turbidity was 522 after 3 minutes of settling.

74695 and 9916 are both products from Nalco. 74695 is a liquid coagulant with a 100 % cationic charge and a low molecular weight. 9916 is a powder flocculent with 70 % cationic charge and a medium molecular weight. Figure 4.5 presents the testing results. The chemicals had a poor reaction and a very slow settling rate. The floc size was very small and the compaction was not good. The turbidity decreased with increasing concentration of chemicals, but lowest turbidity measured was only 883 at a concentration of 2,5 ppm of coagulant and 7 ppm of the flocculent.

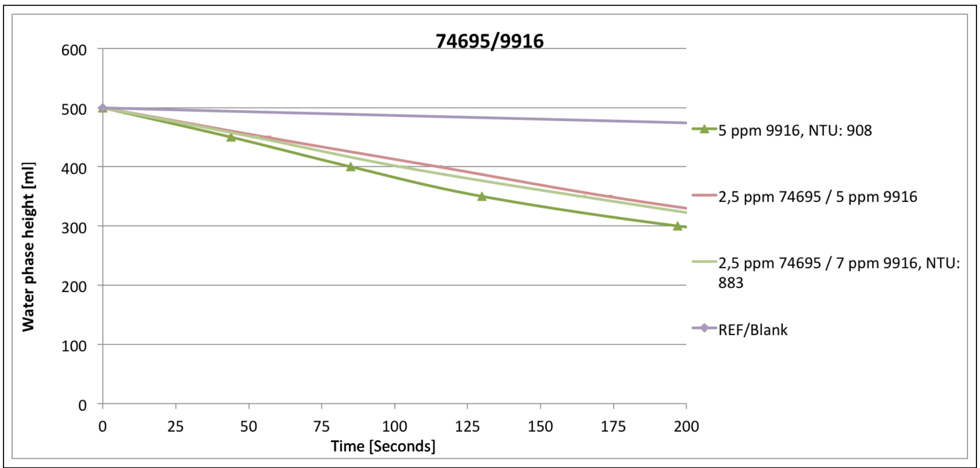

Figure 4.5: Illustrates the coagulant 74695 and the flocculent 9916's test results, [Appendix 5].

Flocculent 71771 is also a product from Nalco and was therefore tested with the coagulant 74695. 71771 is a powder product with a nonionic charge and a medium molecular weight. According to Figure 4.6 the two products combined had an overall poor reaction with a slow settling rate, except for the test with the highest concentrations, which had a steeper settling rate. The flocs were small and the compaction of the settled material was medium. Despite this the water phase only reached a turbidity of 822 at a concentration of 5 ppm of 71771.

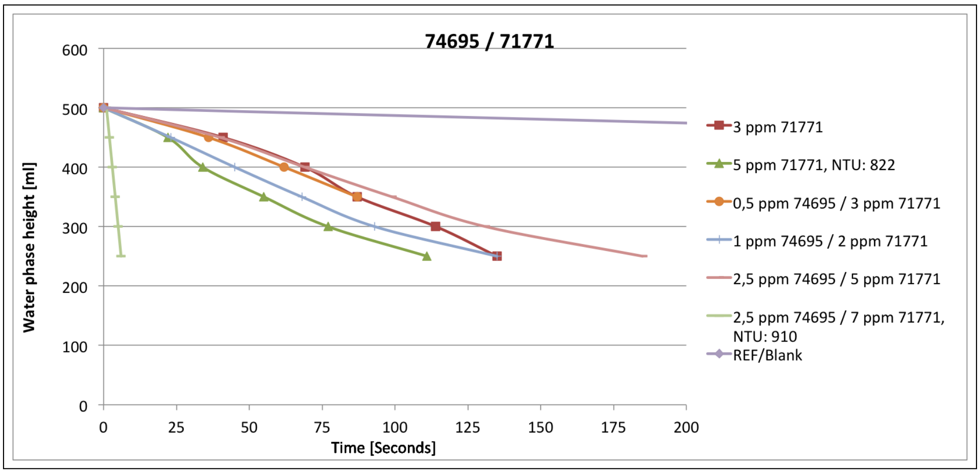

Figure 4.6: Illustrates the coagulant 74695 and the flocculent 71771's test results, [Appendix 5].

Zetag 8187 is a cationic flocculent with 80 % charge and a high molecular weight. LT 32 is a liquid cationic coagulant with a 100 % charge and a low molecular weight, both are products from BASF. Figure 4.7 presents the test results. The chemicals had a good reaction and the settling rate seemed to vary a lot with differing concentration. The flocs were small when the chemical concentration was low, but increased in size when the chemical concentration increased. The compaction improved with higher chemical concentration, but was overall classified as medium. The turbidity of the water phase had a steep decreasing rate that declined further as the chemical concentration increased. At concentrations of 2.5 ppm of LT32 and 7 ppm of Zetag 8187 it reached its lowest value of 23, 3.

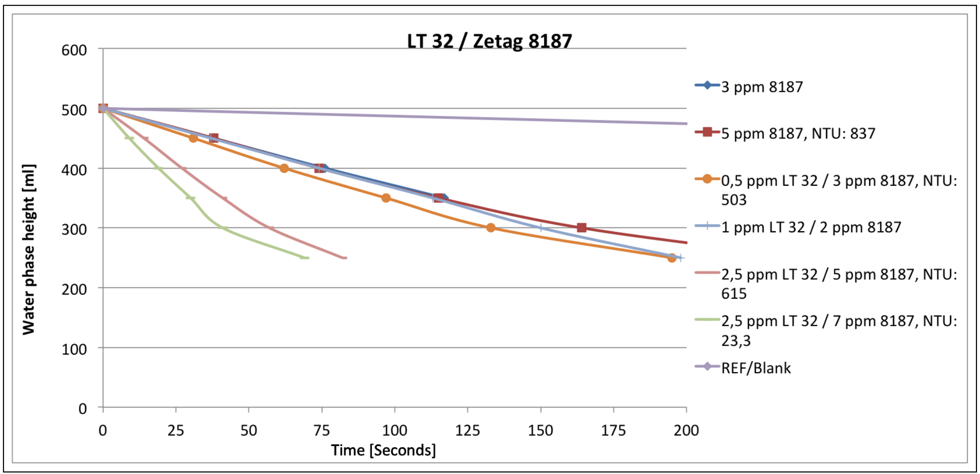

Figure 4.7: Illustrates the coagulant LT 32 and the flocculent Zetag 8187's test results, [Appendix 5].

The flocculent Zetag 8187 was also tested with another coagulant from BASF, LT 37. LT 37 also has a 100 % cationic charge and is a liquid product, but differs from LT 32 due to higher molecular weight. Figure 4.8 presents the test results. The chemicals had similar reaction as the test with LT 32 and Zetag 8187, but the turbidity seemed to decrease earlier with LT 37. The settling rate varied quite a lot with varying concentrations, also in this reaction. The flocs were small, but increased to medium in size with the highest chemical concentrations. The compaction was medium, but on the highest concentration tested it was registered a higher settling bed than for the tests with a lower concentration. The higher settling bed might be a result of more particles settled and a clearer water phase with a settling rate that flattens out when the settling bed get closer to the bottom of the cylinder. But this could also be a result of bigger flocs and poorer compaction. The water phase was very clear at two of the highest concentrations and reached a value of 28, 5.

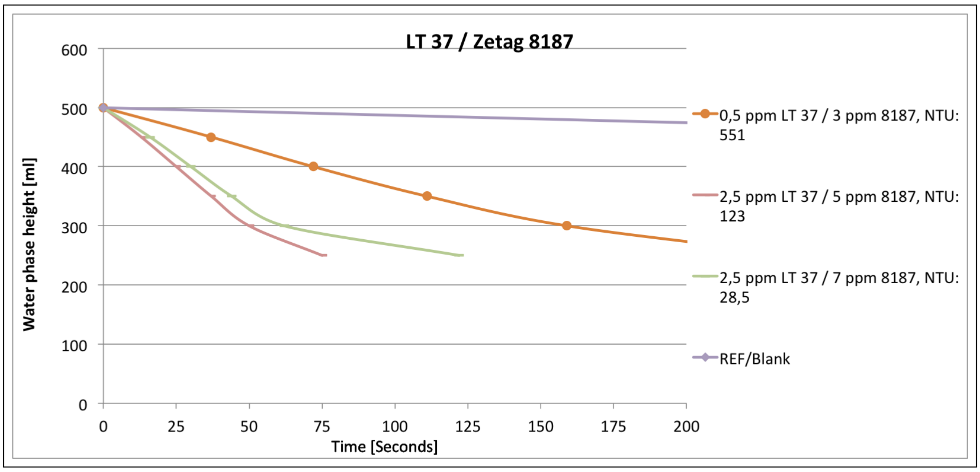

Figure 4.8: Illustrates the coagulant LT 37 and the flocculent Zetag 8187's test results, [Appendix 5].

Magnafloc 10 is also a product from BASF. This is the flocculent used by Sydvaranger Gruve AS in their water treatment. It is a powder flocculent with 8 % anionic charge and a high molecular weight. Together with this flocculent Sydvaranger Gruve uses the coagulant named LT 38. It is a liquid coagulant with 100 % cationic charge and low molecular weight, but higher than both LT32 and LT37. Figure 4.9 presents the test results. The chemicals had a medium reaction with a relatively steep settling rate. The flocs had a medium size and the compaction of the settling bed was good. The turbidity decreased with increased concentration. The lowest turbidity measured was 636 at a concentration of 2, 5 ppm of LT 38 and 7 ppm of Magnafloc 10.

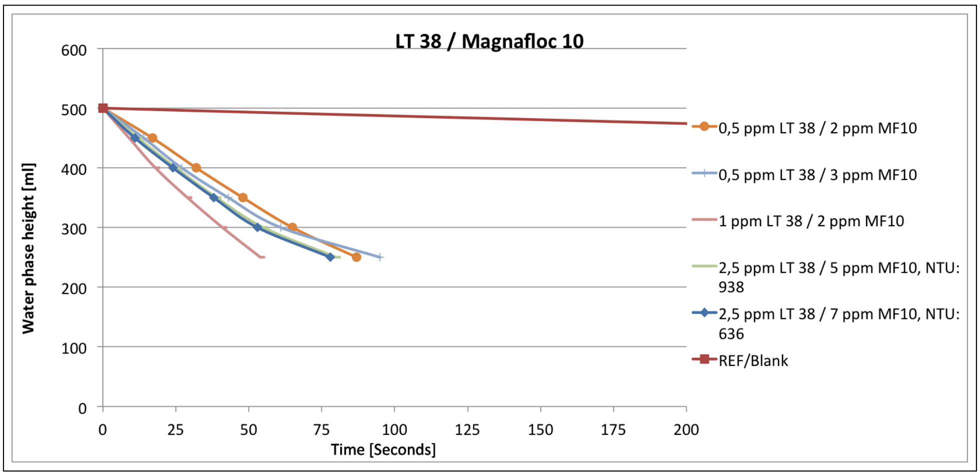

Figure 4.9: Illustrates the coagulant LT 38 and the flocculent Magnafloc 10's test results, [Appendix 5].

Magnafloc 10 and LT 37 is another combination of chemicals delivered from BASF. LT 37 is as mentioned similar to LT 38, but with a lower molecular weight. Figure 4.10 presents the test results. The reaction was medium, it had a steep settling rate, but not as steep as the combination of Magnafloc 10 and LT 38. The flocs had a medium size with good capability of compaction. The lowest water phase turbidity measured was 600 at a concentration of 2, 5 ppm of LT 37 and 7 ppm of Magnafloc 10.

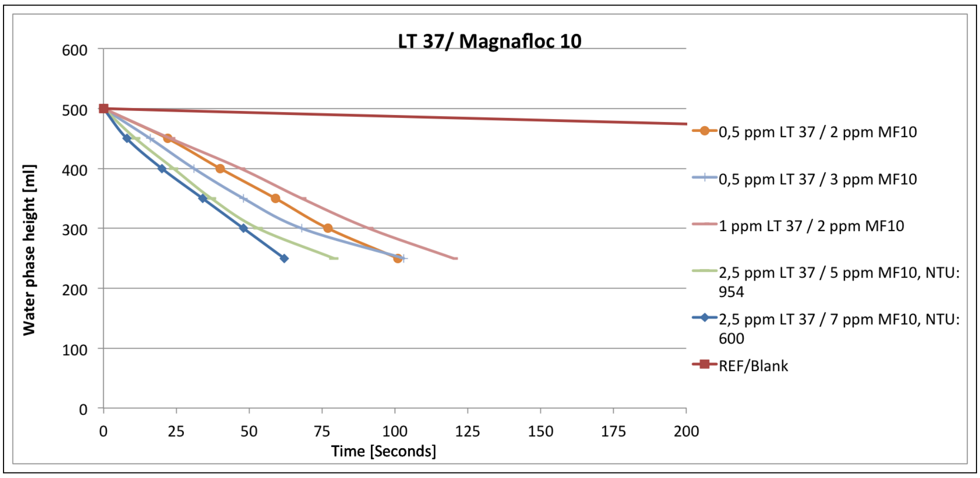

Figure 4.10: Illustrates the coagulant LT 37 and the flocculent Magnafloc 10's test results, [Appendix 5].

Maganfloc 10 and LT 32 is the last combination from BASF consisting of Magnafloc 10. LT 32 is similar to LT 38 and 37, but has a lower molecular weight than both of them. Figure 4.7 presents the test results. The chemicals had a medium reaction with a settling rate similar to LT 38 and Magnafloc 10. The flocs had a medium size and the compaction was good. The best result was at a concentration of 0, 5 ppm of LT 32 and 3 ppm MF 10 and it had a turbidity of 449.

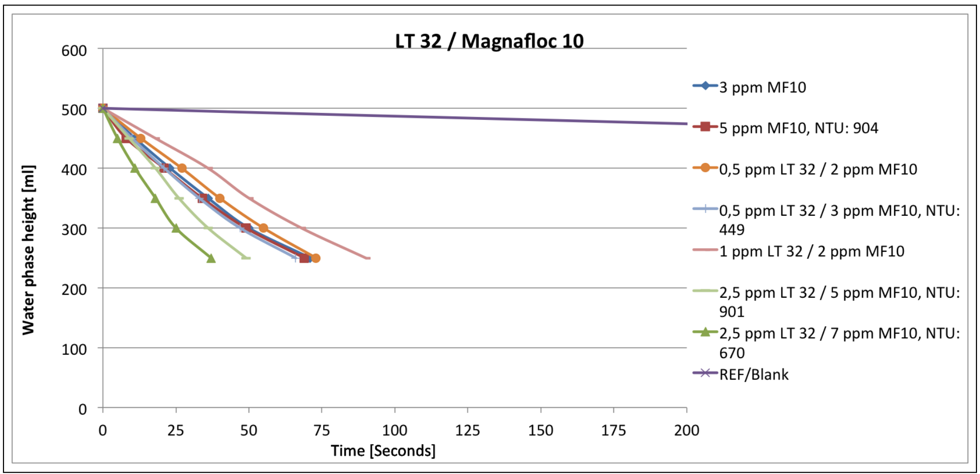

Figure 4.11: Illustrates the coagulant LT 32 and the flocculent Magnafloc 10's test results, [Appendix 5].

Magnafloc 338 is a powder from BASF and is very similar to Magnafloc 10, but it has 9 % anionic charge and a little higher molecular weight. Figure 4.12 presents the test results. The reaction was medium and the settling rates were very varying depending on different concentrations. The flocs size was varying from small to medium and the compaction was good. The water phase had a turbidity of 522 at a concentration of 2,5 ppm of LT 38 and 7 ppm of Magnafloc 338.

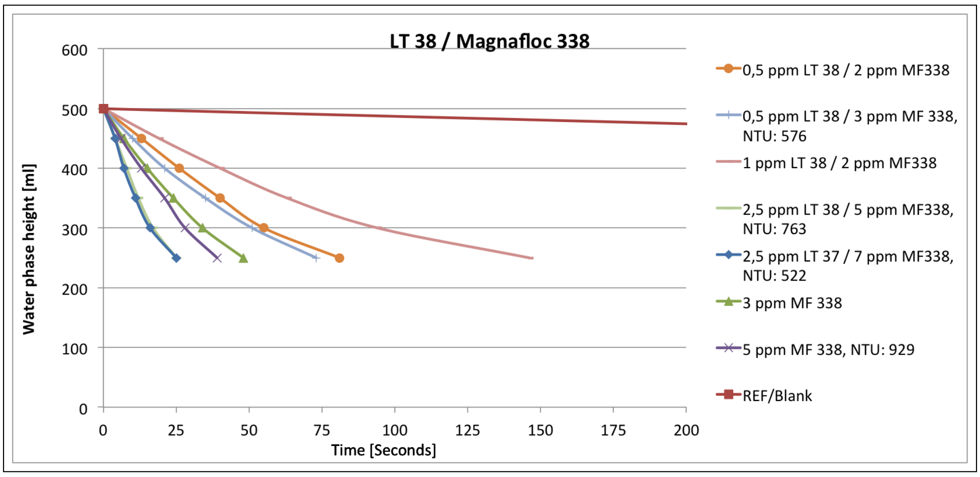

Figure 4.12: Illustrates the coagulant LT 38 and the flocculent Magnafloc 338's test results, [Appendix 5].

Unifloc PDM and Unifloc A 300 are products from Aquatech4you. Unifloc PDM is a liquid coagulant with a 100 % cationic charge and high molecular weight. Unifloc A 300 is a powder flocculent with a 30 % anionic charge and low molecular weight. Figure 4.13 presents the test results. The reaction was medium and the settling rate was good. The flocs were big and the compaction was medium. The lowest turbidity measured was 553 at a concentration of 0, 5 ppm of Unifloc PDM and 2 ppm Unifloc A 300.

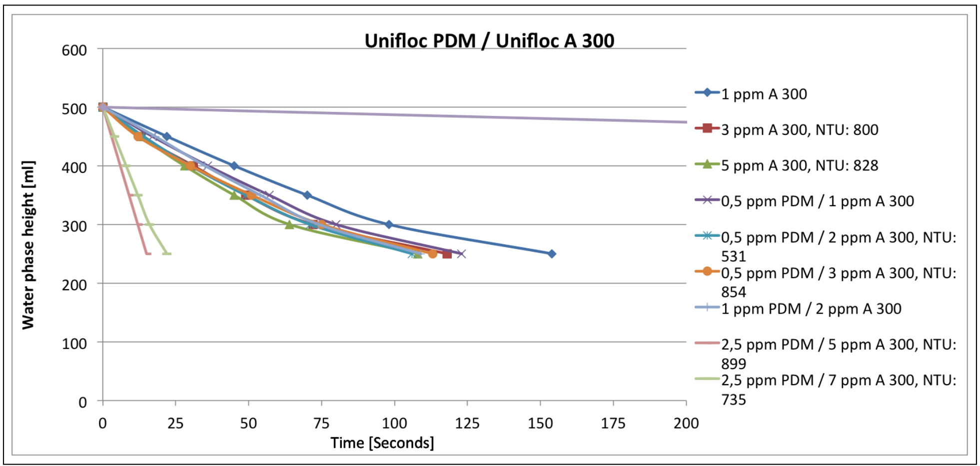

Figure 4.13: Illustrates the coagulant Unifloc PDM and the flocculent Unifloc A 300's test results, [Appendix 5].

PIX-105 and Superfloc N-300 are products from Kemira. PIX-105 is a liquid PAC-coagulant with a 100 % anionic charge and a low molecular weight. The results from the test is presented in Figure 4.14. The reaction was poor only using flocculent and the settling rate was medium. The flocs were small and the turbidity was too high to measure. The PIX-105 was recommended to have eight times the concentration of a normal coagulant in order to be comparable. This was the reason for the test with such a high concentration. The turbidity was measured to be 50, 3 at a concentration of 20 ppm of PIX-105 and 5 ppm of Superfloc N-300 and the flocs had a medium size. Despite this, the settling rate was slow and the compaction was poor. PIX-105 also required a relative high concentration dosage in order to be effective, which would be unrealistic to use at the plant, despite these low turbidities.

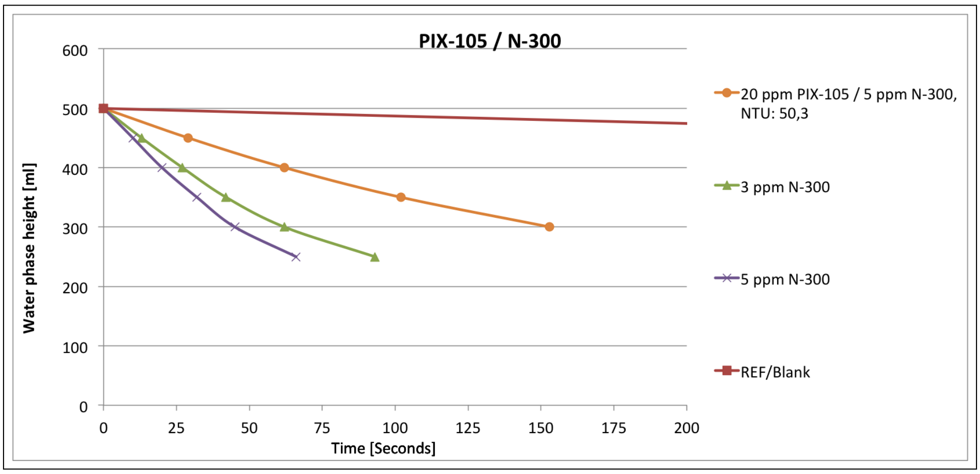

Figure 4.14: Illustrates the coagulant PIX-105 and the flocculent Superfloc N-300's test results, [Appendix 5]

The chemicals tested showed varying results and they all had an improved reaction with increasing concentration. Some of them had high settling rate, but with relatively low turbidity, while others had a relatively low settling rate, but with a lower turbidity. Based on the experimental results Zetag 8187 was found to have the best performance, with a surprisingly low turbidity, hence it was decided to test it further in the third screening.

4.8 Third Screening

The aim of the third and final screening was to evaluate the chemical that had been analyzed to have the best impact on the process water samples in the second screening. The chemical chosen from the second screening was the flocculent Zetag 8187. Since it was difficult to evaluate the exact effect coagulants had under conditions given in the second screening, both the coagulants tested with Zetag 8187 was tested in the third screening. This included coagulant LT 32 and LT 37.

Another coagulant that was tested with Zetag 8187 was LT 38. This was not a coagulant that showed good results combined with Zetag 8187 in the first screening, but it was chosen based on the suppliers recommendations.

Magnafloc 10 and LT 38 are the combination of chemicals that Sydvaranger Gruve AS uses in their process, thus Magnafloc 10 was tested with LT 38 in the third screening. This was used as a reference test that the other tests were compared to. The chemicals Magnafloc 10 and Zetag 8187 was also tested alone with different concentrations to look at their limitations and advantages when used alone.

The third screening was done in two innings. Process description number 1, describes the process data for the testing only including Magnafloc 10 and Zetag 8187. Process description number 2, describes the process data for the rest of the tests done in the third screening, including the flocculants in combination with the coagulants.

4.8.1 Method

The process water samples were in 5 liters containers, which had to be stirred close to a homogenous solution before the cylinder of 2000 ml was filled with sample. To assure that the cylinder contained approximately the same amount of particles the cylinder with sample was weighted. The process water samples from the plant were collected during a short interval of time.

When the chemicals were measured and ready, the cylinder with sample was inverted 5 times to assure suspension before the chemicals was added. The coagulant was added first then the cylinder was inverted 10 times before the flocculent was added and the cylinder inverted another 10 times. When the chemicals and sample was blended the cylinder was placed on the table and the timer started.

The time was recorded when the inter phase position of the settling passed, 1800 ml, 1600 ml, 1400 ml, 1200 ml, 1000 ml, and 800 ml. A syringe was drawn from the process water after two minutes to measure the turbidity. The compaction height was recorded after three minutes. The tests results are presented in time versus water phase height graphs, except one that is presented in turbidity versus concentration graph. The graph's x-axis is cut at 200 and 250 seconds despite that some of the data goes further. This is to give an easily readable and comparable presentation of the graphs due to results in varying intervals.

4.8.2 Process data

Table 4.4 illustrates the process data collected for the first tests within the third screening. This is the samples that was used for the tests presented in Figure 4.19, Figure 4.20, Figure 4.21, Figure 4.24, Figure 4.25, and Figure 4.26 with only flocculants, Magnafloc 10 and Zetag 8187. The primary mill feed was low due to problems with deliverability at the mine in Bjørnevatn. The plant decreased the mill feed from 700 tons/hour to 650 tons/hour. The iron content was low and the turbidity was 650, despite the chemical dose of 2,2 m^3/h of Magnafloc 10 and 5 liters/hour of LT 38. The pH was 8,97 and the temperature was 18,8 degrees Celsius. The density of the tailing from the thickener was around 451 tons/hour and the flow was 440 m^3/h.

Date:	20.03.15
Test number:	**3. Screening number 1:**
MF10 feed concentration:	2,2 m^3/h
LT38 feed concentration:	5 L/h
NTU from overflow at thickener:	650
Time:	17:00
Feed on the mill (tons):	Decreased from 700 to 650
Status at the facility:	Low production due to Bjørnevatn is not able to deliver.
Mill feeds % of iron magnetite:	24,60
% solids in test sample (weight %):	27,13
pH of sample:	8,97
Tailings flow from the thickener:	18,8
Tailngs density from the thickener:	440 m^3/h
Tailngs density from the thickener:	451 tons/h

Table 4.4: Presents the process data collected for the first sample, during the third screening, [Appendix 6].

Table 4.5 illustrates the process data collected for the first tests in the third screening. These samples were used for all the other tests in the third screening, including flocculants in combination with coagulants. The primary mill feed was 600 tons/hour due to shutdown of secondary mill number 6. The iron content of the primary mill feed was around 24,20 %. The turbidity was 611 despite that the dosage of Magnafloc 10 was 2,1 m^3/hour and the LT 38 dosage was 4 liters/hour. The thickeners tailing had a density of 458 tons/hour and a flow of 456 m^3/hour.

Date:	23.03.15
Test number:	**3. Screening number 2:**
MF10 feed concentration:	2,3 m^3/h
LT38 feed concentration:	4 L/h
NTU from overflow at thickener:	611
Time:	18:00
Feed on the mill (tons):	600
Status at the facility:	Mill 6 stopped due to grease problems.
Mill feeds % of iron magnetite:	24,20
% solids in test sample (weight %):	22,02
pH of sample:	9,12
Tailings flow from the thickener:	16,9
Tailngs density from the thickener:	456 m^3/h
Tailngs density from the thickener:	458 tons/h

Table 4.5: Presents the process data collected for the second sample during the third screening, [Appendix 6].

4.8.3 Results

Magnafloc 10 and LT 38 are the combination Sydvaranger Gruve AS are running at the plant. This was used as a reference when analyzing and comparing the results from the third screening. Figure 4.15 presents the results from the reference test with Magnafloc 10 and LT 38. The reaction was good and it had a steep settling curve. The flocs were big and the compaction was good. 97, 7 was the lowest turbidity measured and it was measured at a concentration of 2 ppm of LT 38 and 8 ppm of Magnafloc 10.

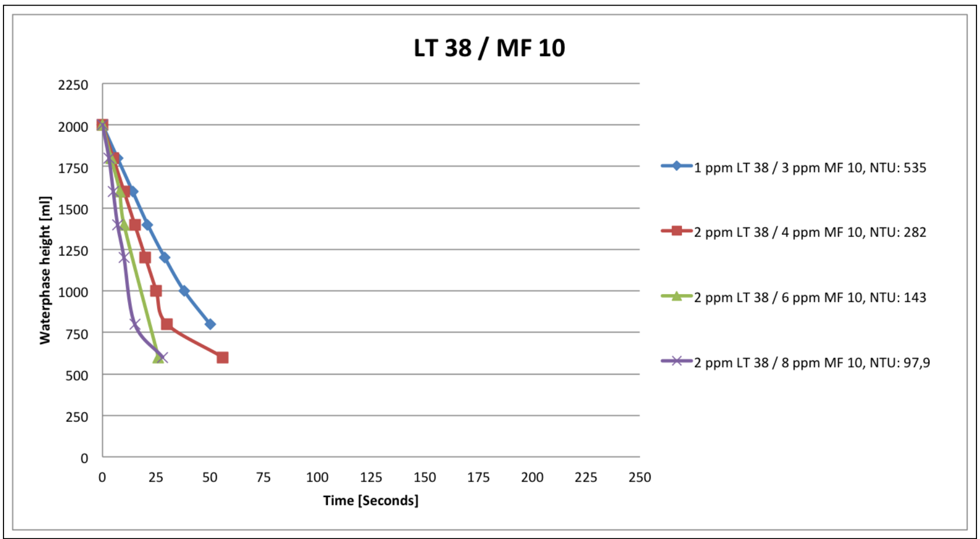

Figure 4.15: The graph illustrates the test results from the combination of coagulant LT 38 and flocculent Magnafloc 10, [Appendix 6].

Figure 4.16 illustrate the results from the test with LT 32 and Zetag 8187. The reaction improved with increasing concentrations of chemicals, but the settling rate was moderate. The flocs were between small to medium and the compaction was moderate. The lowest turbidity measured was 34,6 at a concentration of 2 ppm of LT 32 and 8 ppm of Zetag 8187.

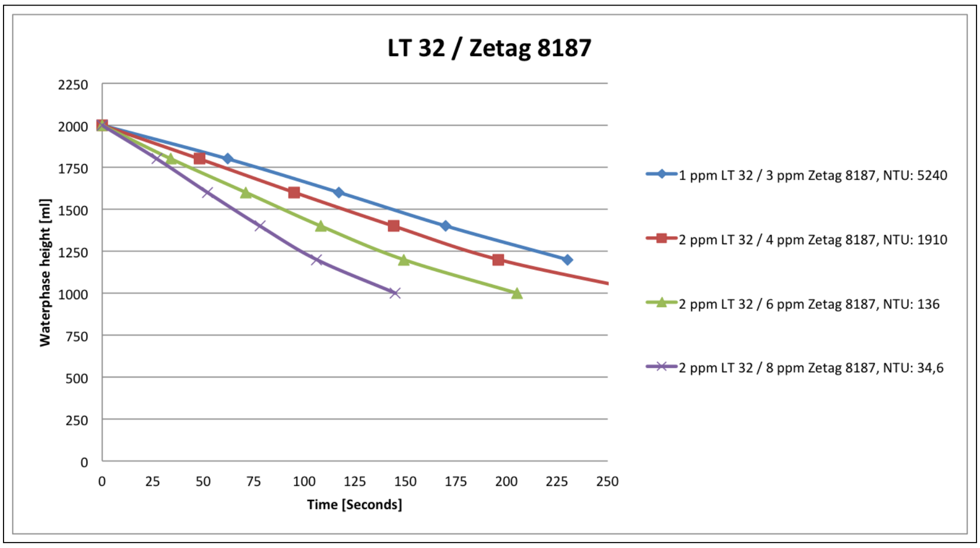

Figure 4.16: The graph illustrates the test results from the combination of coagulant LT 32 and flocculent Zetag 8187, [Appendix 6].

The results of the combination of LT 37 and Zetag 8187 are illustrated in Figure 4.17. The reaction was good with increasing concentrations of chemicals and the settling rates were moderate and similar to the settling rate resulting of LT 32 and Zetag 8187. The compaction was moderate, and the flocs size were increasing with the concentration of chemicals, but did not exceed medium size. The compaction was poorer than Zetag 8187 combined with LT 32's compaction. The lowest turbidity measured was 13, 76 at a concentration of 2 ppm of LT 37 and 8 ppm of Zetag 8187.

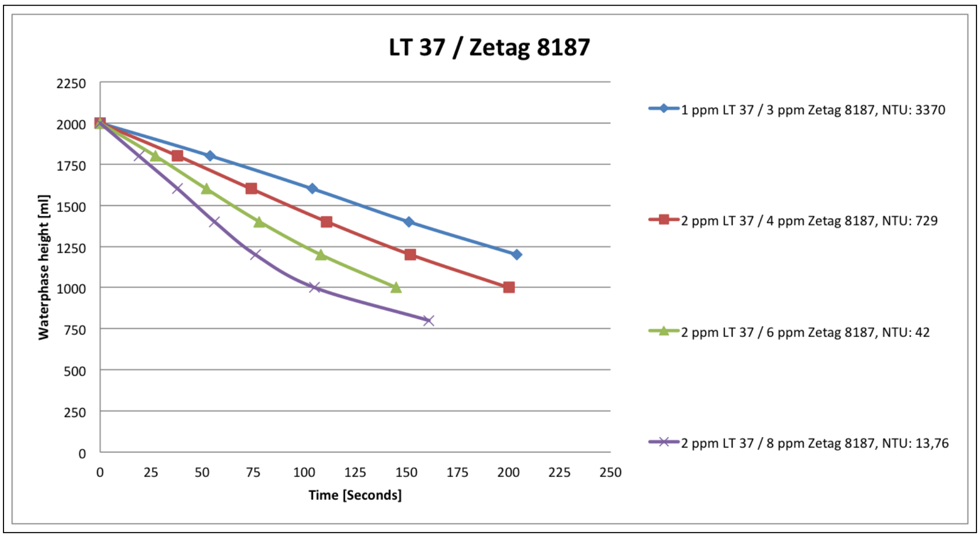

Figure 4.17: The graph illustrates the test results from the combination of coagulant LT 37 and flocculent Zetag 8187, [Appendix 6].

Figure 4.18 illustrates the test results from the tests done with the combination of coagulant LT 38 and flocculent Zetag 8187. The reaction was good and the settling rate was moderate. The settling rate and turbidity improved with increasing dosage of chemicals. The flocs were small to medium in size, but the compaction was poor. The turbidity of the water phase decreased rapidly and the lowest value was 15, 24 and measured at a concentration of 2 ppm of LT 38 and 8 ppm of Zetag 8187.

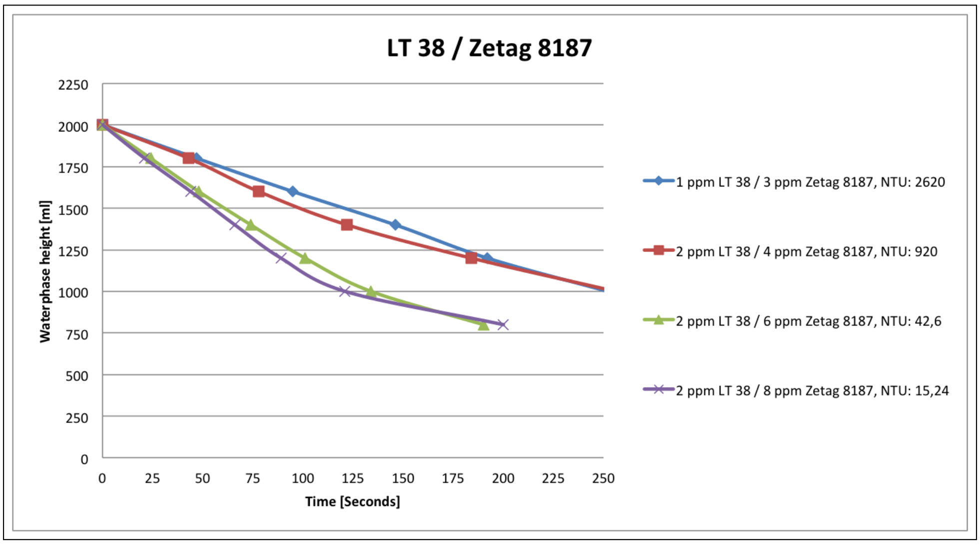

Figure 4.18: The graph illustrates the test results from the combination of coagulant LT 38 and flocculent Zetag 8187, [Appendix 6].

Figure 4.19 illustrates the tests done with only flocculent Magnafloc 10. The reaction was good and the settling rate decreased rapidly, except for the tests with 40 ppm and 60 ppm, which clearly illustrated overdosing of chemicals. The overdosing of chemicals was also confirmed by the increased turbidity. The flocs were big at high concentrations of chemical and the compaction was good. The lowest turbidities were measured at 18 ppm and 22 ppm with the values of 103 and 102. The turbidity decreased from 144 to 103 with an increase in concentration of 8 ppm. The decrease in turbidity was low despite an increase of 8 ppm of chemical, which indicated low effect of increased dosage in this interval.

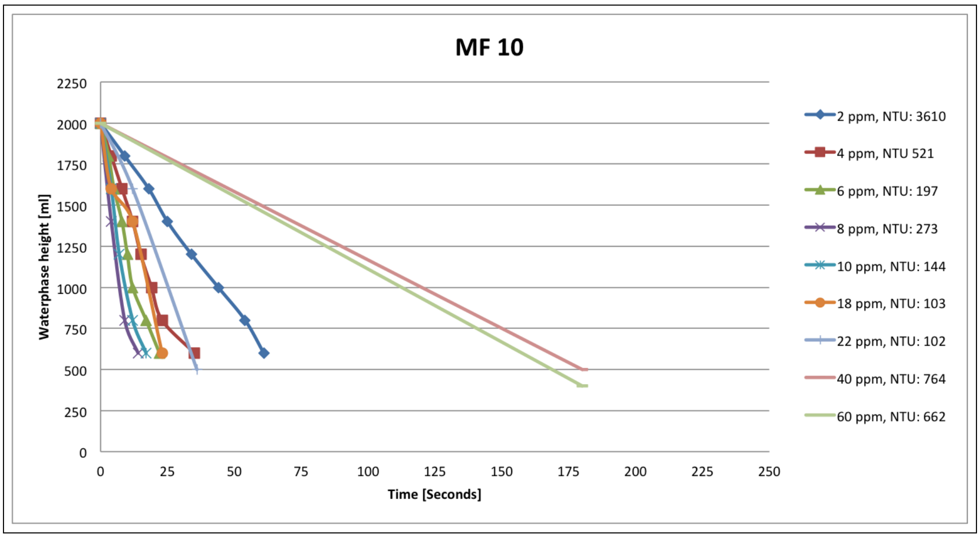

Figure 4.19: The graph illustrates the test results from Magnafloc 10, [Appendix 6].

The results from the tests performed only with the flocculent Zetag 8187 are presented in Figure 4.20. The reaction was poor at low concentrations, but very good closer to 6 ppm and 8 ppm. The settling rate was moderate for low concentrations, but improved rapidly for concentrations at 8 ppm and above. The flocs were medium in size and the compaction was moderate. The lowest turbidity had a value of 6, 91 and was measured at a concentration of 22 ppm, but already at a concentration of 10 ppm the turbidity was as low as 13, 24. A decrease in the turbidity which was remarkable was the one between 4 ppm and 10 ppm, where the turbidity decreased with 6496, 76 from 6510 to 13, 24.

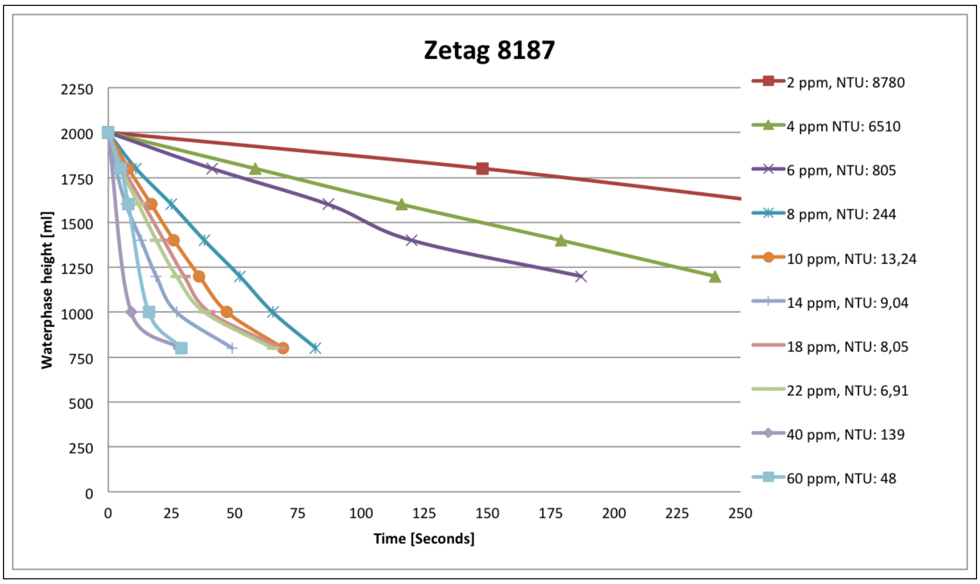

Figure 4.20: The graph illustrates the test results from Zetag 8187, [Appendix 6].

Figure 4.21 illustrates a graph with turbidity versus concentration axes. The graph gives an impression of the chemicals dosing properties. The graph is based on the data from the tests presented in figure 4.19 and 4.20. The curve representing Magnafloc 10 has a steep decrease in turbidity at a lower concentration than Zetag 8187. Despite this the turbidity reaches a much lower value in the curve representing Zetag 8187. Following the curve of Zetag 8187 we can see a slight increase in turbidity at higher concentrations. Nevertheless the value do not exceed 139, before it decreases again with a value of about 100 with 20 ppm additional added. If we follow Magnafloc 10's curve, the turbidity increases far more, it reaches 764 before it decreases with a value of about 100. This implies that about the same amount of chemical is required to reach the limit of overdosing, but the outcome and consequences according to turbidity is higher with Magnafloc 10 than with Zetag 8187. Figure 4.22 and Figure 4.23 illustrates how the overdosing is revealed when testing.

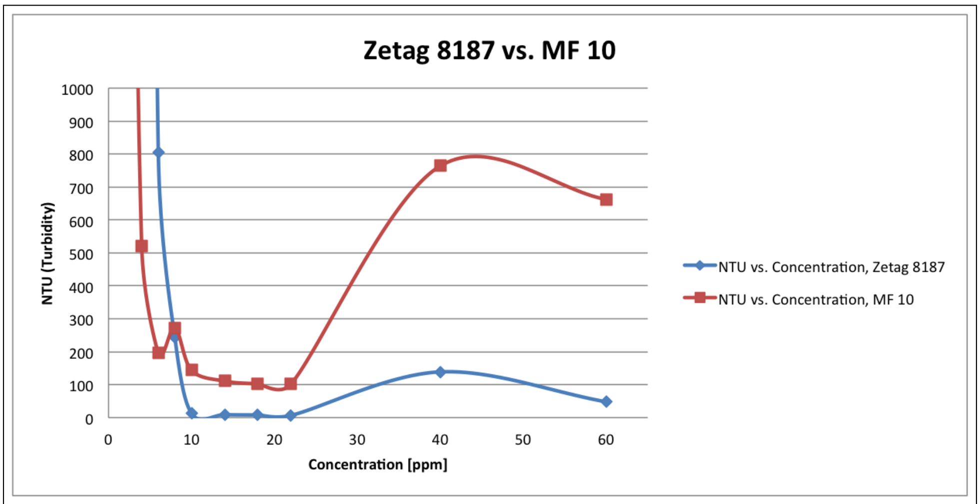

Figure 4.21: Illustrates the limitations of overdosing with respect to Magnafloc 10 and Zetag 8187, [Appendix 6].

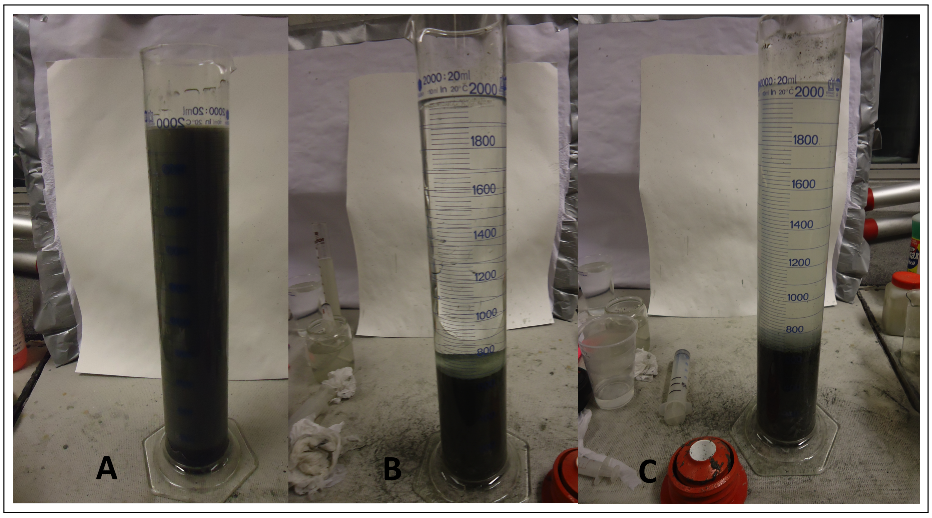

Figure 4.22: Figure A) Illustrates the suspension of process water without any chemicals. Figure B) Illustrates the suspension of process water after 2 minutes, with a concentration of 10 ppm of Zetag 8187. The turbidity was 13,24 after 2 minutes of settling. Figure C) Illustrates the suspension of process water after 4 minutes, with a concentration of 40 ppm of Zetag 8187. The turbidity was 111 after 2 minutes of settling.

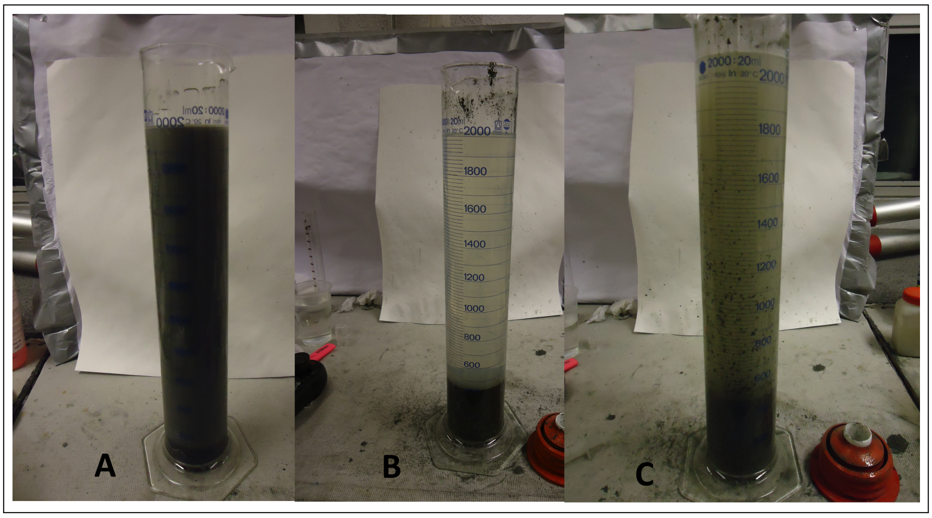

Figure 4.23: Figure A) Illustrates the suspension of process water without any chemicals. Figure B) Illustrates the suspension of process water after 3 minutes, with a concentration of 14 ppm of Magnafloc 10. The turbidity was 111 after 2 minutes of settling. Figure C) Illustrates the suspension of process water after 3 minutes, with a concentration of 40 ppm of Magnafloc 10. The turbidity was 764 after 2 minutes of settling.

During the testing some remarkable factors that impacted the results were reviled. The method used implies that some of the tests were done with a suspension and chemicals that already had reacted and settled. Three tests shared the same suspension if the concentrations added allowed the coagulant to be added without the suspension containing any flocculent. Every third test, the suspension tested would be new, not containing any chemicals. This seemed to impact the results in both directions depending on the chemicals tested.

Figure 4.24 illustrates two tests done with the same chemical, Magnafloc 10, and the same concentrations. The difference between these two tests is that one of them was added the chemical dosage little by little. First it was added 2 ppm, and then the suspension was allowed to settle before the cylinder was inverted 10 times and another 2 ppm was added and the suspension was allowed to settle again. Finally the cylinder was inverted and the last 2 ppm was added, the cylinder now contained together 6 ppm, and the suspension was allowed to settle for the third and final time before the turbidity was measured after 2 minutes.

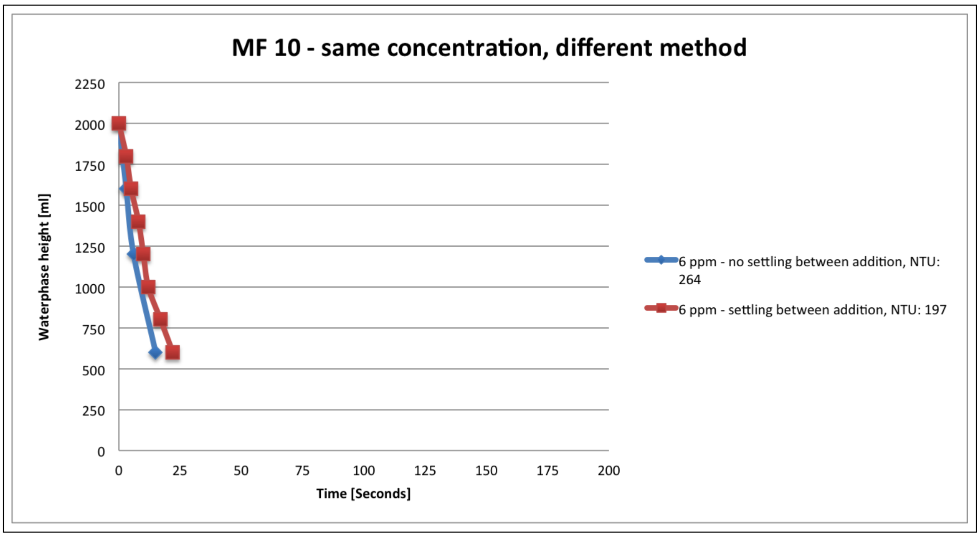

Figure 4.24: Illustrates tests done with same concentration of Magnafloc 10, but with different methods, [Appendix 6].

The other test was performed by adding 6 ppm directly in the suspension and let it settle for 2 minutes before the turbidity was measured.

The results presented in Figure 4.24 shows the differences in the methods with the same chemical, Magnafloc 10. The settling rate was very similar to each other, but the turbidity increased with 67, from 197 to 264 when no settling between additions of chemicals were applied. Magnafloc 10 favors settling between addition and the method used would then also be in favor for Magnafloc 10.

Figure 4.25 present the same differences in the results depending on the methods used, but with chemical Zetag 8187. The results imply that the test with no settling between additions was favored both in settling rate and turbidity. The method without any settling between the additions had a turbidity of 101, while the method with settling between addition had a turbidity value of 805, this is a difference of 704, which is a lot considering the same concentration of chemical was used. The water phase in the test with settling between additions used 187 seconds to reach the 1200 ml mark, while the test without settling between additions only used 59 seconds.

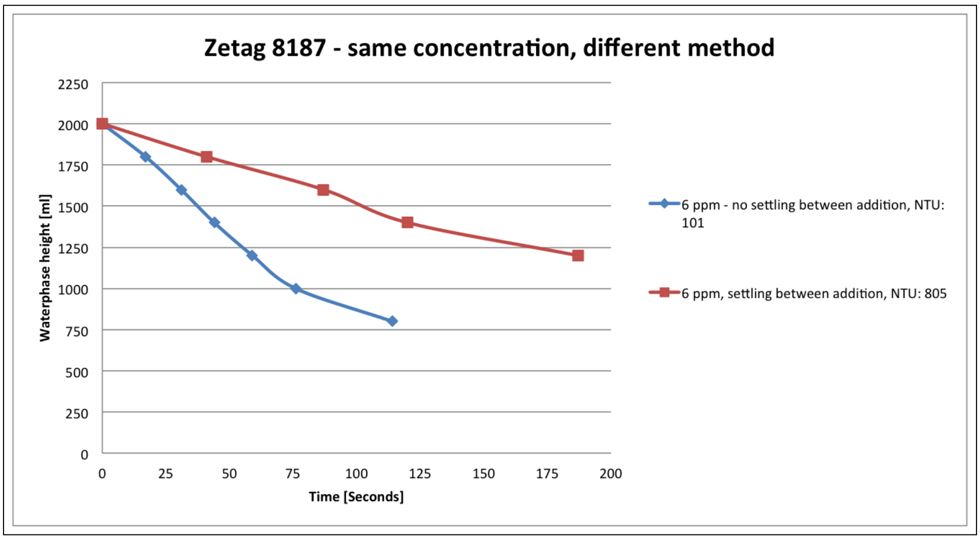

Figure 4.25: Illustrates test results done with same concentration of Zetag 8187, but with different methods, [Appendix 6].

Figure 4.26 illustrates the results of a test done with the same concentration of Zetag 8187, but with another method. In one of the tests, 8 ppm of the chemical was added to the suspension before the cylinder was inverted 20 times. In the other test only 6 ppm was added before the cylinder was inverted 10 times and then added 2 ppm more, before inverted again. The graph imply that the method with divided addition of chemicals was favored as it had a steeper settling curve and the turbidity decreased with 58, from 221 to 163. This means that an addition system that simulates these several additions of chemicals would most likely also be favored at the plant.

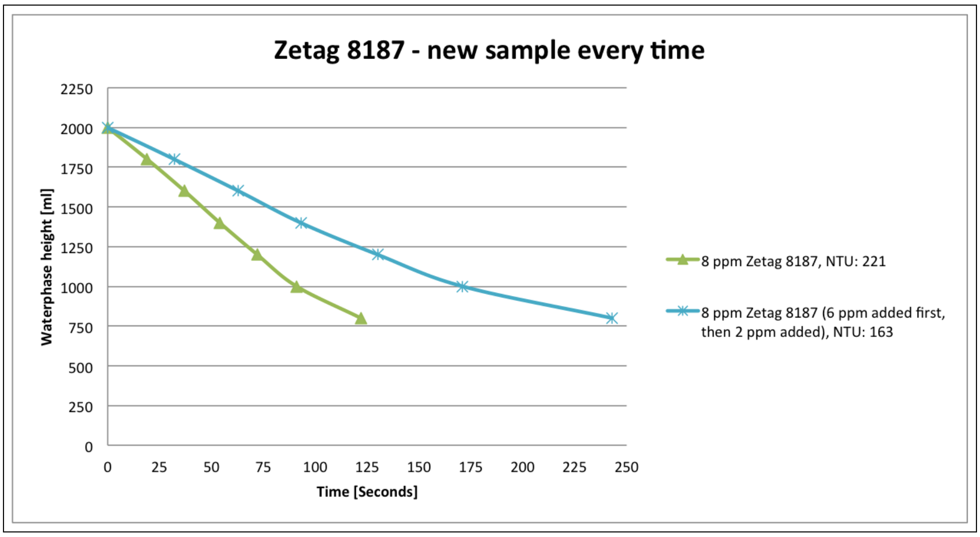

Figure 4.26: Illustrates test results done with the same concentration of Zetag 8187, but with different methods, [Appendix 6].

Chapter 5

Quality Control

The quality control was done in order to see if tests done within the same sample were comparable or not, and to examine the methods ability to reproduce results. The tests were done in 2000 ml cylinders with suspension from the same process water sample. The cylinders were weighted to assure similar amount of particles. The cylinder with suspension was inverted and then added a given concentration of 7 ppm of Zetag 8187, before the cylinder was inverted again. The settling rate was recorded and the turbidity was measured after two minutes.

5.1 Process data

The process data collected when the sample was taken for the quality control is presented in Table 5.1. The primary mill feed was 800 tons/hour, and the iron content was about 23, 70 %. The turbidity at the thickener was 584 and the feed of Magnafloc 10 was 2,2m^3/hour while the LT 38 concentration feed was 4 liters/hour. The content of solids of the test was 16, 93 %, the temperature was 19, 1 degree Celsius and the pH was about 9, 28. The tailing from the thickener had a flow of 407m^3/hours and a density of 441 tons/hour. The secondary mill number 7 had some downtime due to maintenance and the outlet from primary magnet separators 4 and 5 was clogged while sampling. The sample, which was supposed to be come from these magnet separators, was therefore replaced with outlet sample from primary magnet separators 1 and 2. These two outlets have more or less the same output and has been determined not to impact the testing results significantly.

Date:	19.03.15
Test number:	**Quality control**
MF10 feed concentration:	2,2 m^3/h
LT38 feed concentration:	4 L/h
NTU from overflow at thickener:	584
Time:	21:00
Feed on the mill (tons):	800
Status at the facility:	Mill 7 have had some down time due to maintenance. Outlet from primary magsep 4 and 5 was clogged so the process water sample was replaced with outled from primary magsep 1 and 2, this is more or less comparable material.
Mill feeds % of iron magnetite:	23,70
% solids in test sample (weight %):	16,93
pH of sample:	9,28
Tailings flow from the thickener:	19,1
Tailngs density from the thickener:	407 m^3/h
Tailngs density from the thickener:	441 tons/h

Figure 5.1: Process data collected during the process water sampling for the quality control, [Appendix 7].

5.2 Results

Figure 5.2 presents the results from the quality control tests. The settling rate for the different tests were very similar. The biggest deviations of settling rate was measured at 800 ml and was 71 seconds, this was the difference between test 1 and test 8. The turbidity seemed to vary more than the settling rate, it varied between 123 and 492, which is a difference of 369.

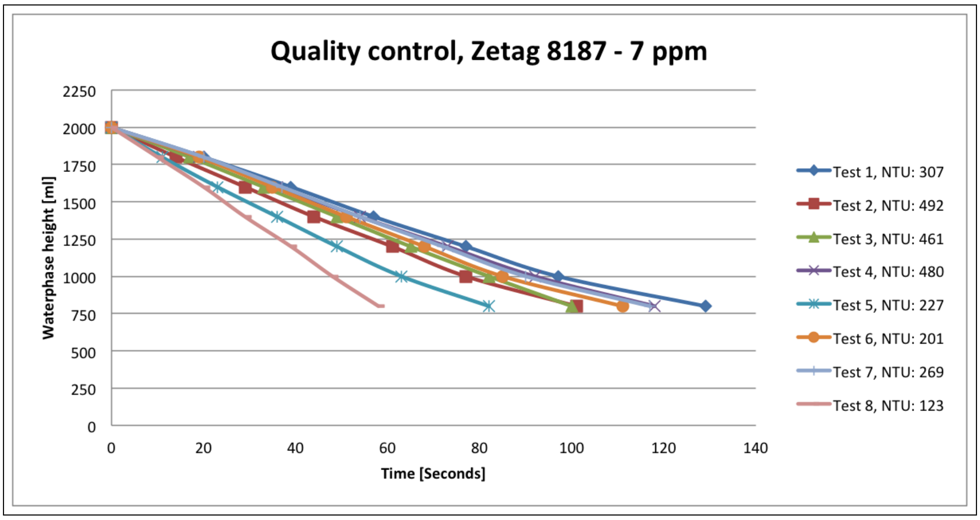

Figure 5.2: Presentation of the quality control test results, [Appendix 7].

The tests showed overall good precision and the deviations of test 8 and test 5 could indicate incidental errors. The result implied that the settling rate was reliable, but the turbidity could vary with a value of 370 plus/minus from test to test. These variations may be a result of variations within mixing and particle size within the sample, but these factors are very difficult to control. Controlling these factors would be very time consuming and require massive and expensive equipment. Consider the factors during testing and be able to discuss why the outcome was different is much more effective and meaningful as it is difficult to control all the factors in the thickener, but possible to adopt if the different factors and their impact is known.

Chapter 6

Risk assessment

If any chemicals should be evaluated as relevant for Sydvaranger Gruve AS, they have to be more beneficial for the company and the environment than those already in use. In compliance with the substation principle set in the Norwegian Product Control Act, Sydvaranger Gruve AS is required to test different chemicals with the aim to identify more environmental friendly substitutes, that can replace the chemicals currently used. As mentioned priviously in Chapter 1, the law says that:

The testing should aim to do findings that:

- prevent products prior consumer services from causing damage to health; this includes ensuring that consumer products and services are safe.
- prevent products from causing environmental disturbance, for example in the form of disturbance of ecosystems, pollution, waste, and noise.
- prevent environmental disturbance by promoting effective energy use in products.

[NorwegianGovernment, 2015]

The company is required to apply the substitution principle:
"Any enterprise that use products containing chemical substances that may have effects such as are mentioned above shall evaluate whether there are alternatives that entail a lower risk of such effects. If such alternatives exist, the enterprise shall use them provided that this does not cause unreasonable cost or inconvenience." [NorwegianGovernment, 2015]

The Substation principle in the Product Control Act can be achieved by either of the following:

- A chemical from a class that is inherently more benign than the once in use.
- A chemical from a comparable class, requiring a lower consumption.

[NorwegianGovernment, 2015]

As Sydvaranger Gruve AS already has chemicals that they may use under operation, it does not matter if the chemicals tested will improve the water treatment, if they are more toxic to the environment than those already in use. It is therefore important to consider environmental aspects of the chemical that is recommended to be tested further, [Hermansen, 2015]. Zetag 8187, Magnafloc 10 and LT 38's datasheets are compared and the result are given in Table 6.1, Table 6.2, Table 6.3, Table 6.4, and Table 6.5.

	Product	Zetag 8187		Magnafloc 10		Magnafloc LT38	
INFORMATION	**Supplier**	BASF		BASF		BASF	
	Classification	Regulation (EC) No 1272/2008: Classification not required according to GHS criteria. EU Directives 67/548/EEC or 1999/45/EC: Low acute LC50/EC50 for aquatic organisms, but do not cause any long lasting effect on the aquatic environment.		Regulation (EC) No 1272/2008: Classification not required according to GHS criteria. EU Directives 67/548/EEC or 1999/45/EC: No effect on the aquatic environment.		Regulation (EC) No 1272/2008: Chronic aquatic toxicity - Category 3 **H412:** Harmful, with long lasting effects to aquatic organisms. EU Directives 67/548/EEC or 1999/45/EC: **R52/53:** Harmful for aquatic organisms, may cause undesired long lasting effects in the aquatic environment.	
	Active substance	**Properties**	**Amount**	**Properties**	**Amount**	**Properties**	**Amount**
		Polyacrylamide, cationic	88-90 %	Polyacrylamide, anionic	91,0 %	PolyDADMAC, cationic	40 %
	Mixture	**Hazardous Substance(s)**	**(w/w) %**	**Hazardous Substance(s)**	**(w/w) %**	**Hazardous Substance(s)**	**(w/w) %**
		Adipic acid: Regulation (EC) No 1272/2008: CAS-number: 124-04-9 EG-number: 204-673-3 REACH registration number: 01-2119457561-38 Index-number: 607-144-00-9 According to Directive 1999/45/EC: Danger symbol: Xi R-number: 36	>= 2 % - <= 6 %	No data.		Chemical formula: $(C_8H_{16}NCl)_n$ IUPAC name: 2-Propen-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride, homopolymer CAS-number: 26062-79-3 Regulation (EC) No 1272/2008: Aquatic Chronic 3 – H412 According to Directive 1999/45/EC: R-number: 52/53	>= 10 % - <= 50 %

Table 6.1: Comparison of information of Zetag 8187, Magnafloc 10 and LT 38 collected from datasheets, [Appendix 8].

	Product	Zetag 8187	Magnafloc 10	Magnafloc LT38
	Physical and chemical properties	Physical state: amorphous powder Appearance: off-white pH (100 %): 4,6 Melting point: >250 °c Boiling point: no data available Evaporation rate: The product is not volatile in solid form Solubility in water: Forms a viscous solution Flash point: Not applicable Autoignition temperature: Not pyrophoric. Viscosity: undetermined Explosive properties: not explosive	Physical state: powder Appearance: off-white pH (100 %): 6 - 8 Melting point: no data available Boiling point: no data available Evaporation rate: The product is not volatile in solid form. Solubility in water: Forms a viscous solution Flash point: Not applicable Autoignition temperature: Not pyrophoric. Viscosity: 25-49 mPa.s (0,5 %(m), 25°C, 300 1/s) Explosive properties: not explosive	Physical state: liquid Appearance: straw yellow Odor: amine-like, slight odor pH value: approx. 5.5 Melting point: < 0 °C Boiling point: > 100 °C Flash point: A flash point determination is unnecessary due to the high water content. Vapor pressure: approx. 32 mbar (25 °C) Density: approx. 1.1 g/cm3 (20 °C) Solubility in water: miscible Viscosity, dynamic: 8,000 - 13,000 mPa*s (25 °C) Explosion hazard: not explosive Miscibility with water: miscible
WORK ENVIRONMENT	**Fire-fighting measures**	Suitable extinguishing media: dry powder and foam. Water spray and carbon dioxide are not suitable for extinguishing. If water is used, restrict pedestrian and vehicular traffic in areas where slip hazard may exist. Toxic gases/vapors, carbon oxides, nitrogen oxides, evolution of fumes/fog can be released in case of fire.	Suitable extinguishing media: dry powder and foam. Water spray and carbon dioxide are not suitable for extinguishing. If water is used, restrict pedestrian and vehicular traffic in areas where slip hazard may exist. Toxic gases/vapors, carbon oxides, nitrogen oxides, evolution of fumes/fog can be released in case of fire.	Suitable extinguishing media: water spray, dry powder and foam. If water is used, restrict pedestrian and vehicular traffic in areas where slip hazard may exist. Toxic gases/vapors, carbon oxides, nitrogen oxides, evolution of fumes/fog can be released in case of fire.
	Acute oral toxicity	Experimental/calculated data: LD50 rat (oral): > 5.000 mg/kg	Experimental/calculated data: LD50 rat (oral): > 5.000 mg/kg	Experimental/calculated data: LD50 rat (oral): > 5.000 mg/kg The product has not been tested. The statement has been derived from products of a similar structure and composition.
	Acute inhalation toxicity	Based on the ingredients is there no suspected sensitizing.	Based on the ingredients is there no suspected sensitizing.	No available data.

Table 6.2: Comparison of information of Zetag 8187, Magnafloc 10 and LT 38 collected from datasheets, [Appendix 8].

	Product	Zetag 8187	Magnafloc 10	Magnafloc LT38
	Acute dermal toxicity Skin corrosion/irritation	Experimental/calculated data: Skin corrosion/irritation rabbit: non-irritant (OECD Guideline 404)	Experimental/calculated data: Skin corrosion/irritation rabbit: non-irritant (OECD Guideline 404)	Experimental/calculated data: Skin corrosion/irritation rabbit: non-irritant (OECD Guideline 404)
	Serious eye damage/irritation	Non-irritant.	Non-irritant.	Non-irritant (OECD Guideline 405)
	Respiratory or skin sensitization	Based on the ingredients there is no suspected sensitizing.	No data.	No data.
	Long term effects	Contains no ingredient listed as a mutagen. Based on available data, the classification criteria for carcinogenicity are not met. Based on available data, the classification criteria for reproductive toxicity are not met.	Contains no ingredient listed as a mutagen. Based on available data, the classification criteria for carcinogenicity are not met. Based on available data, the classification criteria for reproductive toxicity are not met.	No available data.
	Occupational Exposure limits	No occupational exposure limit known. The product is not been tested, but the toxicology is been derived from products with similar structure or composition.	No occupational exposure limit known. The product is not been tested, but the toxicology is been derived from products with similar structure or composition.	No occupational exposure limit known. The product is not been tested, but the toxicology is been derived from products with similar structure or composition.
ECOLOGICAL INFORMATION	**Eco toxicity**	Evaluation of aquatic toxicity: Acute effects on aquatic organisms are only caused by the polymers cationic charge that gets neutralized completely in natural watercourses with irreversible adsorption of particles, hydrolysis and dissolved organic carbon. Fish and aquatic toxicity is drastically reduces through irreversible adsorption on suspended and/or dissolved organic material. The products of hydrolysis is not acute harmful for the aquatic organisms. A product with high cationic charge density was tested. Since the acute toxicity is depended on charge, equivalent products with lower charge density are expected to have lower toxicity.		Evaluation of aquatic toxicity: Acute harming on aquatic organisms. May cause unwanted long term effects in the aquatic environment. The product has not been tested. The statement has been derived from products of a similar structure and composition.

Table 6.3: Comparison of information of Zetag 8187, Magnafloc 10 and LT 38 collected from datasheets, [Appendix 8].

Product		Zetag 8187	Magnafloc 10	Magnafloc LT38
		Toxicity to fish: LC50: 1 - 10 mg/l, 96 hrs, Fish (static)	Toxicity to fish: LC50: > 100 mg/l, 96 hrs, Oncorhynchus mykiss (static)	Toxicity to fish: LC50: 10 - 100 mg/l, 96 hrs
		Toxicity to daphnia and other aquatic invertebrates: EC50: 10 - 100 mg/l, 48 hrs, Daphnia	Toxicity to daphnia and other aquatic invertebrates: LC50: > 100 mg/l, 48 hrs, Daphnia magna	Toxicity to daphnia and other aquatic invertebrates: EC50: 10 - 100 mg/l, 48 hrs
	Persistence and degradability:	Elimination information: Not readily biodegradable (by OECD criteria). Information about stability in water (hydrolysis): >70 % (28d) (pH-value > 6) Contact with water will disintegrate the product very fast.	Elimination information: Not readily biodegradable (by OECD criteria).	Elimination information: Not readily biodegradable (by OECD criteria).
	Bio accumulative potential:	The polymer will not be biologically available based on the properties of the structure. Accumulation in organisms is not to be expected.	The polymer will not be biologically available based on the properties of the structure. Accumulation in organisms is not to be expected.	The polymer will not be biologically available based on the properties of the structure. Accumulation in organisms is not to be expected.
	Results of PBT and vPvB assessment	According to the Annex XIII of Regulation (EF) No.1907/2006 concerning the Registration, evaluation Authorization and Restriction of Chemicals (REACH): The product does not contain a substance fulfilling the PBT persistent/bio accumulative/toxic) criteria or the vPvB (very persistent/very bio accumulative) criteria.	According to the Annex XIII of Regulation (EF) No.1907/2006 concerning the Registration, evaluation Authorization and Restriction of Chemicals (REACH): The product does not contain a substance fulfilling the PBT persistent/bio accumulative/toxic) criteria or the vPvB (very persistent/very bio accumulative) criteria.	According to Annex XIII of Regulation (EF) No.1907/2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH): The product does not contain a substance fulfilling the PBT persistent/bio accumulative/toxic) criteria or the vPvB (very persistent/very bioaccumulative) criteria.

Table 6.4: Comparison of information of Zetag 8187, Magnafloc 10 and LT 38 collected from datasheets, [Appendix 8].

Product	Zetag 8187	Magnafloc 10	Magnafloc LT38
Other adverse effects	The product does not contain any of the substances listed in the annex I in the Regulation (EF) No. 2037/2000, which breaks down the ozone layer. The product is not tested. The information regarding toxicity is derived from products with similar structure or composition.	The product does not contain any of the substances listed in the annex I in the Regulation (EF) No. 2037/2000, which breaks down the ozone layer. The information regarding toxicity is derived from products with similar structure or composition.	No data.

Table 6.5: Comparison of information of Zetag 8187, Magnafloc 10 and LT 38 collected from datasheets, [Appendix 8].

These three chemicals are all agents that coagulate or flocculate small particles in suspension and increase the rate of settling. Based on a study done by Boethling and Nabholz, cationic polymers with a high molecule weight, mainly migrates to particles and will not remain in the water phase. The writers estimate that 90 % of the chemical agents the suspension contains, will be transmitted to solid, [Boethling and Nabholz, 1996]. Zetag 8187 and LT 38 are both cationic polymers.

In a report from NIVA, the conclusion is that respectively 99,5% and 99,8% of polyDADMAC, which is the active agent in LT 38, was transmitted to solids with respectively 32 and 56 times higher than normal concentration used in the process, [NIVA, 2012]. It is therefore reasonable to assume that 99 % or more of the polyDADMAC will be bounded to the particles. Polyacrylamide which is the active agent in Magnafloc 10 will also be bounded to particles due to flocculation, [SydvarangerGruveAS, 2012].

The properties of these three chemicals imply interactions between the active agent and particles in suspension. The reaction will cause flocculation and the particles will settle. When the chemicals are bound to the particles, they will no longer be reactive. When the sludge is discharged to the sea, the particles will settle on the seafloor. Thus the only exposure path way will be through direct ingestion of the sediments as a source of nutrient, [Hermansen, 2015]. None of the chemicals are biologically available based on the properties of the structure. This implies that exposed seafloor organisms in the disposal area will not accumulate polyDADMAC, anionic polyacrylamide or cationic polyacrylamide. Bioaccumulation further in the food chain will not occur.

Despite the fact that a potential negative influence from the chemical cannot be excluded, this influence will be limited to a small geographical area over a given interval of time. Polyacrylamide which is the active agent in Magnafloc 10 and Zetag 8187 is a long polymer where the degradability is slow. Polyacrylamide is considered as persistent.

Both Zetag 8187 and LT 38 are classified as acute hazardous to aquatic organisms when tested in clean water, due to their cationic charge. The toxic effect in an aquatic environment is caused by a reaction between the fish gills causing a reduction in oxygen intake. Absorption of the chemical substance through mucous membranes or other membranes is less likely to occur. It is important to notice that this was proven in clean water where the chemicals had not been exposed to particles thus not bounded, flocculated and settled. In a natural environment this acute toxicity will be rapidly eliminated by adsorption onto suspended solids and reaction with humic acids and other substances in solution, [SydvarangerGruveAS, 2014a]. Also by rapid hydrolyses, in the case of Zetag 8187. This implies that the respective application does not bear any risk to aquatic organisms, when misused in terms of overdosing is excluded.

At the disposal area there is a low density of living organisms due to the continuously sediment deposition. Organisms that will be affected by the chemicals disposed in the area will only be organisms that live or are nourished by the seafloor sediments in the disposal area. Some of these organisms are crabs and turbot which both bury and find food in the sediment, and also a special type of worm, which lives in the top of the sediments at the seafloor and down to 20 meters, [SydvarangerGruveAS, 2014a].

NIVA have done several studies based on how the current chemicals added in the water treatment impact the sea life in the fjord where the disposal area is located. The results are that no significant impact on crabs, turbot or crustaceans are observed at any combination of polyDADMAC (LT 38) or polyacrylamide (Magnafloc 10) nor with a combination of these two either at any concentrations, [SydvarangerGruveAS, 2014a].

With respect to LT 38 there is not observed any toxic effects due to disposal discharge into the sea. The tests also indicate that degradation does not take place, or occur so slowly that not enough potential toxic decomposition products are formed to impact the environment, [SydvarangerGruveAS, 2014a]. No reports or studies analyzed are based on Zetag 8187's environmental impact, with respect to usage in water treatment processes, with discharge to the sea. However the supplier confirm that the chemical does not contain any compounds nor is it produced by using raw materials, which are characterized as endocrine disruptors, [Bjurling, 2015]. It is not classified as environmentally hazardous according to the EU directive, and degradability in the resulting waste water sludge, is a subject of current research, initiated and performed by the European Polyelectrolyte Producers Group. In Germany the flocculent is legal and follows individual application conditions outlined in the respective legislations, and used in waste water treatment. The resulting sludge is even used in agriculture, [Bjurling, 2015].

From the data provided in the Zetag 8187 data sheet and the knowledge we have on this product, Zetag 8187 was evaluated to be comparable to, or have similar environmental performance as Magnafloc 10. The same applied to the work environment and occupational health. Based on the available data of Zetag 8187 regarding health, safety and environmental properties it was evaluated to be comparable, or better than LT38, thus Zetag 8187 would be a suitable candidate for substitution of both LT38 and Maganfloc 10 or LT38 alone.

Chapter 7

Discussion and Evaluation of Results

It is important to discuss the impacting factors in order to evaluate the method followed during experiments, and understand the reasoning for conclusions made during testing. The results and analysis will be discussed in this chapter and argumentation for different suggestions and recommendations will be given. Suggestions for further steps that should be done during a follow up of the research will also be presented.

7.1 Method

The chemicals were delivered by post. The chemicals from Kemira had to be tested with the process water sample from the second screening, due to arrival after the first screening was performed. If the tests within a screening were not done with the same process water samples, it may be difficult to compare them, but due to poor test results which left no doubt despite a different test sample, the chemicals were not considered for further screening.

The chemicals were mixed to a concentration of 0, 1 %. The powder products were weighted on a weight with four decimals and variations under 0,009 grams were accepted; the variance had negligible effect on the results. The liquid products were measured with a measuring syringe of 1 ml, to get as accurate dosage as possible. Both the syringe and the container for the powder products were flushed after the products were added the solution, and the flush water was also added to the solution to assure that no chemical was left in the container. The water used for flushing cause a small dilution of the sample, but this impact was not significant and classified as negligible.

The viscosity varied between the chemical solutions and it was sometimes difficult to get the solutions homogenous with the equipment used, as the solution containers were small. This may have had an effect on the concentrations because liquid solution with a higher viscosity would sink to the bottom of the container. The dosing syringe would only reach the middle of the container, thus possible causing an un-accurate dosage due to compilation of concentration at the bottom. If this was the case, the test sample would not be added the concentration of chemicals given, and the results would be of a poorer character than if the concentrations were homogenous. If the syringe reached the compilation of concentration at the bottom, the reaction could be better than the actual reaction at the given concentration, due to a higher concentration added. The chemical concentrations with high viscosity could be diluted even more to decrease the influence of viscosity, but the impact was evaluated to be negligible, as the viscosity did not reach a point where this was seen as a problem with high impact.

Alkalinity

Alkalinity is the waters capability to neutralize acid. It is a measure of how much acid is required to lower the pH to a specific level. The process water in the plant has a stable pH with a value between 8, 5 and 9, 5. Alkalinity gives an indication of the waters capacity to resist changes in pH, that will make the water more acidic. The chemicals used in water treatment usually has a pH range where they have optimal efficiency, it is therefore important to know the alkalinity of the water to see how resistant the pH is to different changes. In nature the water's alkalinity is important in order to resist pH changes, due to for example acid rain. Because the discharge of the thickener is disposed in the sea, which has a high alkalinity, the alkalinity only has to be reviled due to properties of the water treatment. The total alkalinity was measured to be 88mg/L, [Appendix 2]. This is a moderate value, which indicates that the process water is not sensitive to small changes within the content of acid.

Sampling

The process water was sampled in 5 liters containers. The number of containers depended on the amount of sample needed for the given test. The sample was collected with small ladles that had a small opening and increased in size downwards. A huge amount of the samples were collected from the primary magnet separators, while the rest was collected from the secondary magnet separators. The samples were collected in a way that made the sludge similar to the inlet of the thickener. Segregation could easily occur when sampling, due to a rough sludge with many particles of different size. Segregation would make the samples denser than originally, leading to comparison of test results based on the assumption that the sludge had the same properties, which would be misleading. It was important that it was the same relationship between collecting point in each container, as the internal samples were not mixed together, but treated seperately.

The chemicals react different on particles of different size and that was why it was important, when comparing test results, that the tests had the same properties, or else the differences within the sludge sample had to be considered. Also an estimation of the impact had to be established in addition to the different impacting factors already existing. Cilas scanning was done in order to see some of these differences. The Cilas scanning gave an indication of particle size. When looking at test results within the same test this would not be of significant interest, but when comparing test results from different samples this would be an important factor. The particle size may help to explain and understand why tests performed with the same method, may have different results. The Cilas scanning done with the process water samples, used at the different tests, showed similar and comparable particle size distribution, indicating that the variance and impacting factor in these tests are negligible, [Appendix 1].

The percentage of solids was also important for the same purpose as particle size analyzes, to determine the degree of influencing factors within the same testing method, but with different samples. It was difficult to determine the grade of impact of factors within a water sample. The degree of influence will always change as the properties of the process water changes, but it is important to understand how the chemicals react regarding variations within the properties to be able to adapt and optimize the water treatment as time goes by. By recording these properties for both the cilas scanning and the solid content for different tests it will be possible to go back and do similar tests with process water with different properties, and still be able to compare the results due to known impacting properties. The input to the thickener changes all the time and it is more important to be able to adapt to changes in the process, than striving for a sampling of process water within a given standard. This will also give a better simulation of the process and the test results will be more reliable as it is a closer simulation of the plant.

7.2 Process Data

The process data was collected of the same reason as the percentage of solids and particle size analyzes. It gave an impression of the status of the process and for different variations gave the most likely reason for impact and influence. This was to be able to compare test results performed with different samples. It was important to consider these data with care. Despite similar process data, inflow properties of the thickener may vary due to other small differentiations, which were not included in the process data. A clogged pipe is an example that may not be detected at first or mentioned in the status of the plant, but this may have a huge impact of the sludge. The daily reports are based on an average during a time interval of 24 hours, and huge deviations within a small time interval may be ignored. Many hours may also pass before the ore railed reaches the primary mill, due to full bins. Despite the uncertainties these data were helpful when interpreting different results and trying to understand variations of operability. The percentage of iron ore in the mill feed was obtained from these reports, [Appendix 10].

It was important to consider the operating conditions when testing chemicals. The operating conditions can gave an indication if the conditions were recommended for testing or not. The chemical dosage in the plant can give indications of testing environment. If there was a high use of chemicals, the tests would be easier to compare than if the chemical concentration was low. A low chemical concentration of coagulant could indicate that the coagulant had no or ineffective reaction, or that the plant already operated effectivly enough without or with very low concentrations. If the turbidity and the chemical dosage at the plant were high, it could indicate a good testing environment, due to indications of an inefficient water treatment. If the properties of the process water is challenging it is easier to separate between efficient chemicals and inefficient chemicals.

Many factors were more helpful to consider together than alone. Tonnage input at the mill, turbidity and geology specifications of feed, were example of factors that had to be considered together when drawing conclusions. If the input at the mill had low iron content and the tonnage was high, this could influence the load at the thickener to increase. A thickener with a high load would in this case give a good testing environment.

In general, if the iron content was high, the load on the thickener should be lower than if the iron content was low, assuming the same mill feed. An exception arised when the process plant received a special high-grade iron ore, which was causing turbidity problems for the system. The process water treatment had poor effect on this type of geology and it did not take long before the thickener had a high turbidity and the plant had to decrease its production sufficiently. The reason for this is unknown, but Sydvaranger Gruve AS has taken precautions to avoid this type of decreased production. When this type of ore occurs in the mine, the operators will blend it with another type before it is sent by rail to the separation plant.

The operating condition of the plant was important to notice when considering if testing should be performed under the given conditions. It was important to be able to adapt or take in to account unusual operating conditions during the time when the process water samples was planned to be collected. For example if the primary mill had been shut down for a while it is important to wait with water sampling until the plant has stabilized. Also if for instance a secondary magnet separator had been adjusted wrong or had a failure without the feed being closed, there would be a lot of iron content in the samples, causing an unrealistic water sample. These are only minor elements that may affect the samples quite a lot, and this is the reason why it is so important to consider operating conditions of the plant when sampling the process water.

Daily reports
The daily reports were helpful when comparing the conditions the testing were performed under. Since some of the railed rock may lie in the silos for some days before they reach the mill, it is important to remember that the specifications of the geology railed may not always be consistent with the geology specifications of the feed on the mill.

7.3 First Screening

The chemicals tested in this thesis were roughly screened through the first screening. The test was roughly done and the method used was not as accurate and precise as the methods used in the second and third screening. The results may have had more variation than the other screenings resulting, giving a higher risk of omitting and excluding chemicals with a potential reaction. If the method used during the second and third screening was applied for the first screening, the testing would be very time consuming and have had unnecessary high level of accuracy. If a more precise method was used during the first screening more samples would be needed and the first screening would have to be divided into several sections done with different process water samples.

A water sample that was more than 12 hours old was not used. If the water sample was old, its properties like pH, temperature and particle surface properties could have started changing and the suspended particles would be settled into a packed bed, making it less comparable to the suspension in the thickener. In the process plant, the process water will not be able to change these factors before the water treatment takes place. Doing the tests on a fresh water sample of process water made a better simulation of the actual process.

In the first screening the flocculants were tested first and those evaluated to have significantly good results were tested further with coagulants. This method did not consider the option that flocculent with poor reaction may have had a far more promising reaction with a coagulant, thus rejected this as an option. A flocculent that did not work alone was rejected, resulting in a risk of having rejected potential chemicals that could work even better, together with a coagulant, than those not rejected.

The different combinations of chemicals were not combined across the different suppliers. Common and practical principles of chemical and service packages consists of the agreement that if several chemicals are needed they are all bought from the same supplier. This assumption excluded the possibility of potential effective combinations of chemicals if the type of supplier was ignored. This assumption also excluded results and combinations of chemicals that would be difficult to combine, due to lack of expertise and service from the suppliers regarding the combination of the chemicals and their behavior in water treatment. The assumption excluded a possible good outcome, but at the same time excluded a combination of chemicals that would be difficult to handle.

The method used made it hard to classify the settling rate due to the plastic containers used. This resulted in a roughly classified settling rate divided in three categories: bad, medium and good. In this screening the main focus were at the reactions and the water phases, and these categories influenced the decisions wether to include the chemicals to the next screening or not.

7.4 Second Screening

The second screening was done with process water sample in 500 ml cylinders. These cylinders were narrow and this decreased the inaccuracy when measuring reactions with a high settling rate as the water phase decreased relatively fast. In reactions with high settling rates creating difficulties with measuring, only every other measuring point was recorded to limit the inaccuracy.

Similar to the first screening, the second screening used the same process water sample as long as the added concentrations allowed it without disturbing the order of addition: coagulant first, then flocculent. This implied that in the tests where only flocculent was tested at 1, 3 and 5 ppm only one cylinder with the same sample was used. Tests with a fixed concentration of coagulant and varying concentrations of flocculent also used the same process water sample. The reuse of samples was based on the assumption that that previous flocculation and settling, had no effect in the result as long as the suspension was stirred into a homogenous solution and reused. This was proven to be a wrong assumption in the third screening.

Those tests with water phase so contaminated of particles that the turbidity equipment was unable to read were not diluted and measured, due to the results irrelevance of the results, due to high values. The floc size and the compaction were not measured with anything else than by observation, this made it difficult to classify the results, and a simplified classification was used, including small/poor, medium/medium, and big/good. The hardness and strength of flocs were not measured.

The graphs presented in the second screening all had the same scale, despite excluding some of the points thus making them easier to compare. The scale was evaluated to exclude the points that were irrelevant for further evaluation, but still presented the trend of most of the chemicals, and at the same time pointed out differences without magnifying the graphs to display a limited area.

When comparing the graphs presented in the second screening, Zetag 8187 is the flocculent that stands out. The flocculent had a good reaction with both the coagulants and alone. The results seemed to imply that the flocculent worked better combined with a coagulant, since the turbidity was lower at a concentration of 0,5 ppm coagulant and 3 ppm flocculent, than with 5 ppm of only flocculent. Both the flocculent and coagulants tested are positively charged, and this was not a combination that would be highly recommended to test based on theory, since they are assumed to repel each others charge, but from the test results this may not seem to be the case.

The settling rate had a vide span, but at relatively high concentrations it seemed to be fairly good, but it still was significantly different from Magnafloc 10 and LT 38's settling rate. The compaction was poor at low concentrations, but improved with increasing concentrations.

The turbidity at these tests were significantly lower than compared to other tests, and these arguments together made up the summary of evaluation which was the base for the decision of bringing Zetag 8187, LT 32 and LT 37 for further testing in the third screening.

7.5 Third Screening

In the third screening it was used a cylinder that contained a volume of 2000 ml, which gave a more precise and accurate result since the reaction would occur in a larger environment, which would improve the simulation of the water treatment in the process plant. The closer the testing environment is to the real-case environment, the closer the test results will be the real case test results. A cylinder of 2000 ml, gave an environment closer to the plants thickener, than a cylinder of 500 ml. Using a 2000 ml cylinder instead of a 500 ml cylinder during the second screening, would have been time consuming and required process water samples. This would imply several factors regarding different process data to consider when comparing the test results. Due to these impacts the 2000 ml cylinder was not considered as optimal for the second screening.

The floc size was only described by observation, and the compaction was denoted after a given time of 2 minutes.

LT 38 was not included as an option of combination with Zetag 8187 in the first screening, as the results with the other coagulants were better. LT 38 has very similar properties as LT 32 and LT 37 and is therefore expected to have similar reactions. According to previous reports LT 38 is more environmental friendly than LT 32 and LT 37, implying higher relevance for usage in water treatment, [Hermansen, 2015]. Sydvaranger Gruve AS already uses this coagulant; they have knowledge about it, including the equipment and permissions for handling this chemical.

The first screening included some uncertainties that may have affected the results for the combination of Zetag 8187 and LT 38 in a negative way and concealed that the results were better than observed and closer to the the combination of Zetag 8187 and LT 37/LT 32. Another thing that was remarkable was that within the combination of Zetag 8187 and LT 38 the turbidity actually only decreased from 816 to 800 with a difference of concentration of 2 ppm. This implied that the turbidity stagnates due to lack of potential of chemicals, or due to the properties of the sludge. Since both the flocculent and coagulant dosage was increased this implies that none of them had a significant impact of decreasing the turbidity. This contradicts to the previous tests with both LT 38 and Zetag 8187, which imply that the sludge was the reason for the slow decrease in turbidity. The sludge was drawn from the same process water samples as for the other tests done in the first screening, where both increasing concentration of Zetag 8187 or increasing concentration of the combination of Magnafloc 10 and LT 38, had a significant effect on the turbidity. Thus indicated enough doubt to this single test result, to discard the result and approve the coagulant LT 38 as accepted for further testing in combination with Zetag 8187 in the third screening, despite its exclusion in the first screening, thus Zetag 8187 and LT38 was an approved combination.

Magnafloc 10 was tested in the third screening both alone and in combination with LT 38, due to the requirement of comparison of the yielding water treatment. The tests were done in a different order than they were presented, but in order to make the comprehensive tests coherent and give the presentation an overall improved flow, the tests with the flocculants in combination with coagulants, were presented before the tests with only flocculants and their coinciding different methods were presented.

From the test results from the combination of flocculants and coagulants, it is shown that the combination of Zetag 8187 and LT 37 or LT 38 had better results regarding both turbidity and settling rate, excluding LT 32 for further consideration. The combination of Magnafloc 10 and LT 38 had a much faster settling rate than the combinations that includes Zetag 8187, but Magnafloc 10 and LT 38 were not comparable to Zetag 8187 and LT38/LT37's low turbidity. Zetag 8187 and LT 38 was very similar in reaction to Zetag 8187 and LT 37. Despite the fact that the combination of Zetag 8187 and LT 37 had an identifiable trend, the difference between the turbidities was insignificant.

Comparing the tests where only flocculants were used prove that Magnafloc 10 had a significant higher settling rate than Zetag 8187 at low concentrations. Both of the reactions had big flocs at higher concentrations, but Magnafloc 10 had a higher compaction of the settled particles than Zetag 8187. Zetag 8187's turbidity decreased far more than Magnafloc 10's turbidity and these were all complex factors that had to be considered further in order to make a decision of subject for potential full scale testing.

Figure 4.21, which illustrates the turbidity in the range of concentrations, prove that the effect of turbidity, by overdosing Magnafloc 10,4 is far more than overdosing by Zetag 8187. Magnafloc 10's turbidity decreased at lower concentrations than Zetag 8187. It may be difficult to discover a small increase in turbidity due to overdosing, thus resulting in water phase containing chemicals and an unnecessary increase of consumption, but this can be avoided by using equipment that measures charge in the water phase.

During the testing some remarkable factors, that impacted the results were revealed. The method used implied that some of the tests were done with a suspension and chemicals that already had reacted and settled. Three tests would share the same suspension if the concentrations added first allowed the coagulant to be added first, without any flocculent in the suspension. Every third test the suspension tested would be new, not containing any chemicals. This seemed to impact the results in both directions depending on the chemicals tested.

Figure 4.24 prove that the reaction by Magnafloc 10 favors settling between additions, which was the case in two of three tests, using only flocculent. The settling rates had no significant changes. Figure 4.25 prove that Zetag 8187 favors no settling between additions which was the case in one of three tests using only flocculent. Both the turbidity and the settling rate had a significant change. If we look at Figure 4.21 we see a small peak at the reaction of Magnafloc 10 at a concentration of approximately 8 ppm. This peak was probably caused by a new sample and gave a small peak because the test before had settled two times before the last addition that gave 6 ppm, and the favored method decreased the turbidity. This could indicate that the flocs created by Zetag 8187 had a lower strength than those created by Magnafloc 10. This was relative to each other, and did not imply that they were not strong enough for the water treatment process. Another important factor to look at was that the method without settling between additions, is the method that simulated the plants water treatment system best, as no other settling occured before discharge in the thickener.

Figure 4.26 illustrates another difference in results when changing method. If the concentration was added in several steps without settling between, then the results would have been even better, than if the concentrations were added all at once. As the water treatment is performed today, this method could easily be applied at the plant if only one chemical was used in the water treatment process. The method that included adding the chemical twice, could be implemented by injecting some flocculent where the coagulant is added now, and then add the rest in the thickener where the flocculent is added.

7.6 Number of Chemicals

By using only one chemical instead of two, a significant amount of human errors, regarding dosing principles, will be reduced. If two chemicals are used, nine possible decisions regarding dosing will be possible. Leave the concentrations unchanged of both chemicals, increase or decrease the coagulant concentration while the flocculent concentration is fixed, or the opposite, increase or decrease the flocculent concentration while the coagulant concentration is fixed. Increase or decrease both concentrations. Or in addition to these, decrease the coagulant and increase the flocculent or opposite, increase the coagulant and decrease the flocculent.

By using only one chemical there is only three options: decrease, increase or leave the concentration unchanged. No expertise on behavior of chemicals relative to each other is needed, but this may also limit the options in case of water treatment problems.

7.7 Small-scale Tests versus Big-scale Tests

Usually tests done at the lab gets much better results than big-scale tests, but in the case of chemical testing regarding water treatment at Sydvaranger Gruve AS, this have shown to be the opposite. The chemicals actually have proved themselves better in the water treatment process at the plant under previous tests, than at the laboratory small-scale tests, [Nilsen, 2015]. The settling rate of Zetag 8187 was slower than the one for Magnafloc 10, but the settling rate have to be seen relative to the thickener and this is hard to determine without including a full-scale test.

7.8 Recommendations, Increasing Efficiency and Improving Operability

Increase of production will require more process water, if new chemicals makes the treatment stage more efficient and increases its reliability, the thickener may not need a costly expansion or an additional construction.

An online measuring of turbidity will also help monitoring the water treatment and decrease the consumption of chemicals as, the concentration will be adjusted without delay when the turbidity decreases or increases. This will cause a faster reaction to changes and a more stable quality of the reused process water.

The coagulant, LT38, that Sydvaranger Gruve AS uses in their water treatment process is highly cationic, their process water has suspended particles that is negatively charged, thus the coagulant neutralize the charge. Magnafloc 10 that is a slightly anionic acrylamide based flocculant, then floc the particles by bridging into larger flocs that rapidly settles, [Ravina, 1993].

It would be expected that cationic polymers would work efficient in water with suspension of negatively charged particles, since the cationic charge would absorb them. This is true for neutralization purposes and the polymer would attract to the particle surface, but this is not always true for bridging mechanisms. Bridging is preferred by chemical groups that have a good absorption characteristic. Amide groups have these properties and the majority of commercially available polyelectrolytes are anionic, since these tend to be less expensive and have a higher molecular weight than cationic polyelectrolytes, [Wills, 2006]. Despite this, BASF managed to develop a relatively new product, only a year old, which contains an amide groun and have a relatively high molecular weight as well as high cationic charge, [Bjurling, 2015]. This is Zetag 8187. Long chain, high molecular weight, cationic polyelectrolytes operates through charge neutralizing in addition to bridging and this is the case with Zetag 8187 and Sydvaranger Gruve AS's process water, which presents promising results.

By decreasing the turbidity of the reused process water the final iron ore product will increase its purity due to less fines in circulation and improved separation mechanism. Further tests with different process water samples should be done when different types of ore are processed. This will give an indication of how the chemical resists variations of properties in the process water. If this is done and the results of the tests are positive, a huge scale test will have a decreased risk of failure.

Another thing that might be worth testing is a combination of Zetag 8187 and Magnafloc 10. The cationic polymer should be added first and neutralize the charge of the colloids as well as forming microflocs. The slightly anionic polymer should then be added to bridge the flocs into larger flocs, which may result in faster settling, [Ravina, 1993]. This should be examined in order to see if it is possible to increase the settling rate without compromising the low value of turbidity.

If Zetag 8187 is going to be tested at the plant, it is important that the blending and maturation tank is washed if to be used due to different charge between Magnafloc 10 and Zetag 8187, [Bjurling, 2015].

If a pilot mixing plant is used instead this will eliminate the downtime due to washing and it will also increase the flexibility of the test. If the plant receives a blend of ore appropriate for testing, they can change the dosing mechanism without shutting down the water treatment due to washing of the maturation/blending tank. If the chemicals do not work on the given blend, it is possible to change back to the original chemicals. This will decrease the risk of downtime due to testing and also eliminate the washing factor which may be time consuming and require a preliminary dosing mechanism as the tank is being washed.

7.9 Quality Control and Risk Assessment

The quality control indicates that the method used is reliable, but has some variation regarding turbidity, these variations were relatively small, and the turbidity may still be used as a guideline regarding water phase. The risk assessment was based on a qualified interpretation of the data sheets, environmental reports based on two of the chemicals evaluated and statements of the third one made by the supplier. Zetag 8187 was evaluated as a chemical with potential to substitute Magnafloc 10 and LT 38, based on environmental aspects. Further studies and evaluations are recommended before concluding with this evaluation.

Chapter 8

Conclusion

The tests have shown huge variations in reactions and efficiency within the different chemicals tested. It seems that a strongly cationic flocculent with a high molecular weight, may give a clearer water phase with a lower turbidity, with today's process water properties, than a slightly anionic flocculent, in combination with a strongly cationic coagulant with a medium molecular weight. The results have shown that compared to the reference chemicals used in the water treatment today, other combinations of chemicals can improve the treatment slightly, if not significant. Despite proving good results in small-scale tests, a big scale test should be carried out to verify the results shown in the thesis, before any decisions are made regarding changing of the water treatment. Repeatability of results are not given due to a lot of different influencing factors in a big-scale water treatment process, thus big-scale tests should be performed before further conclusions are drawn.

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Appendix 1

This appendix contains particle size distribution from Cilas scanning obtained from process water samples used for first, second and third screening.

PARTICLE SIZE DISTRIBUTION

CILAS 990 Liquid

Range : 0.20 µm - 500.00 µm / 70 Classes

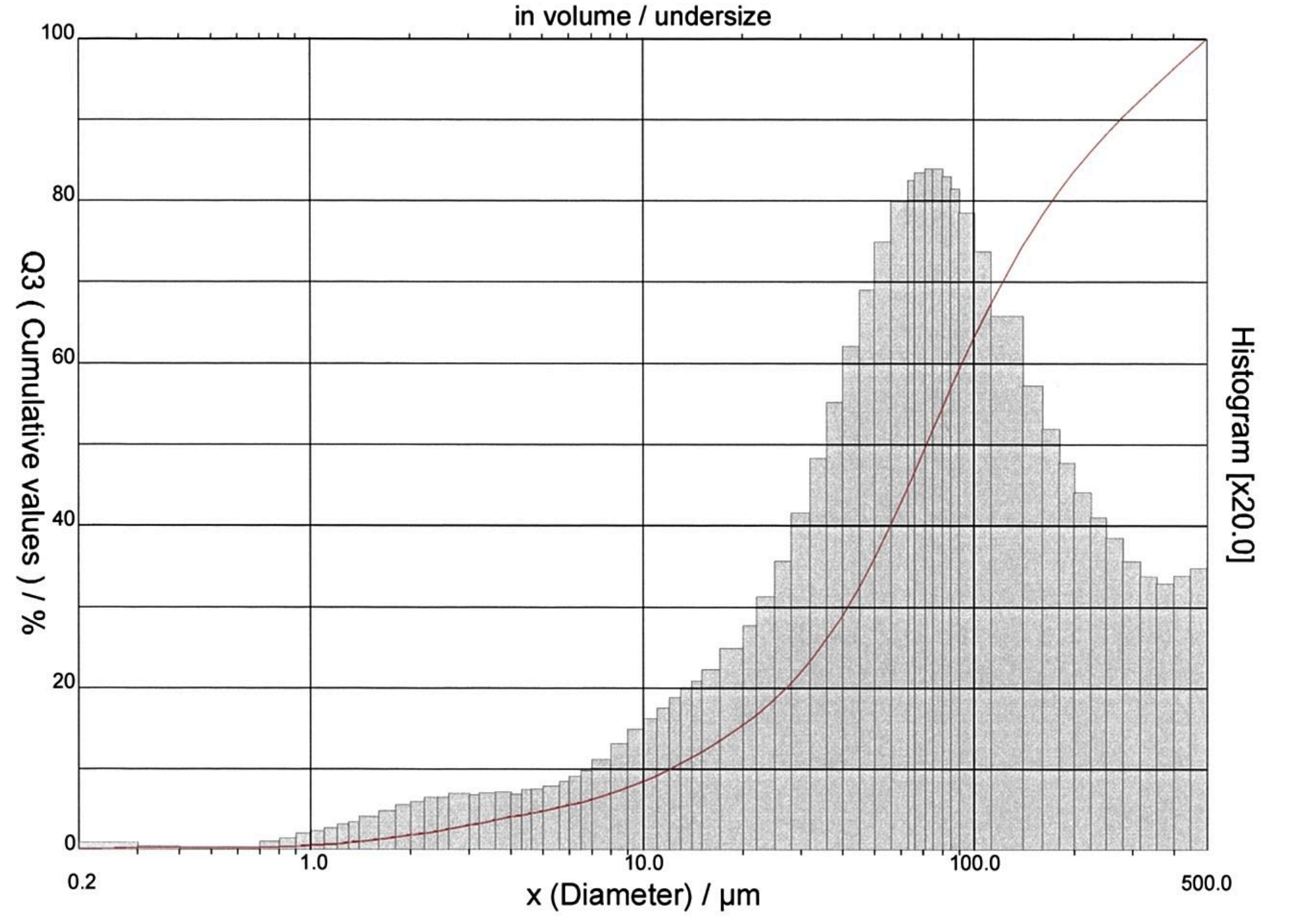
Sample ref.	: 25/09 N/S
Sample Name	: Tail
Sample type	: DAILY
Comments	: 1. Screening 11.03.2015
Liquid	:
Dispersing agent	:
Operator	: Ida Katrine
Company	:
Location	:
Date : 17.04.2015	Time : 11:55:57
Index meas.	: 9993
Database name	: CilasDB1

Ultrasounds	: 60 s
Obscuration	: 16 %
Diameter at 10%	: 11.97 µm
Diameter at 50%	: 71.65 µm
Diameter at 80%	: 171.80 µm
Fraunhofer	
Density/Factor	----------
Specific surface	----------
Automatic dilution	: No / No
Meas./Rins.	: 60s/60s/4
SOP name	: DAILY SAMPLES

Customer defined classes — in volume / undersize

x	45.00	53.00	75.00	106.0	150.0	212.0	300.0
Q3	32.52	38.15	51.87	65.39	76.45	84.90	91.58

x : diameter / µm   Q3 : cumulative value / %   q3 : density distribution



Serial nb : 3174 | Ref : 2.r242.m0.88A1818/7.00/9993/m87.12.20.40.1Fh.20.20.40.Bh/Q-.0.0.0.0//600.0.15.g10.0.9.10.1.10.P4500.1.10.N.0/V 9.29/635

PARTICLE SIZE DISTRIBUTION
CILAS 990 Liquid

Range : 0.20 µm - 500.00 µm / 70 Classes

Sample ref.	: 25/09 N/S
Sample Name	: Tail
Sample type	: DAILY
Comments	: 1. Screening 11.03.2015
Liquid	:
Dispersing agent	:
Operator	: Ida Katrine
Company	:
Location	:
Date : 17.04.2015	Time : 11:55:57
Index meas.	: 9993
Database name	: CilasDB1

Ultrasounds	: 60	s
Obscuration	: 16 %	
Diameter at 10%	: 11.97	µm
Diameter at 50%	: 71.65	µm
Diameter at 80%	: 171.80	µm
Fraunhofer		
Density/Factor	----------	
Specific surface	----------	
Automatic dilution	: No / No	
Meas./Rins.	: 60s/60s/4	
SOP name	: DAILY SAMPLES	

Standards classes in volume / undersize

x	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10
Q3	0.17	0.32	0.37	0.37	0.37	0.37	0.43	0.51	0.61	0.71
q3	0.02	0.04	0.02	0.00	0.00	0.00	0.05	0.07	0.10	0.11
x	1.20	1.30	1.40	1.60	1.80	2.00	2.20	2.40	2.60	3.00
Q3	0.82	0.94	1.06	1.32	1.59	1.87	2.14	2.41	2.66	3.14
q3	0.13	0.15	0.17	0.20	0.23	0.27	0.29	0.32	0.32	0.34
x	3.20	3.60	4.00	4.30	4.60	5.00	5.60	6.00	6.50	7.00
Q3	3.35	3.75	4.11	4.35	4.59	4.89	5.32	5.60	5.95	6.30
q3	0.33	0.35	0.35	0.34	0.36	0.37	0.39	0.42	0.45	0.48
x	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	17.00	20.00
Q3	7.02	7.77	8.53	9.28	10.02	10.75	11.47	12.17	13.52	15.48
q3	0.55	0.65	0.74	0.81	0.87	0.93	0.99	1.04	1.10	1.23
x	22.00	25.00	28.00	32.00	36.00	40.00	45.00	50.00	56.00	63.00
Q3	16.76	18.70	20.66	23.36	26.13	28.96	32.52	36.06	40.20	44.79
q3	1.38	1.55	1.77	2.07	2.41	2.75	3.09	3.44	3.74	3.99
x	66.00	71.00	75.00	80.00	85.00	90.00	100.0	112.0	140.0	160.0
Q3	46.66	49.63	51.87	54.51	56.96	59.23	63.26	67.33	74.48	78.20
q3	4.12	4.16	4.18	4.19	4.14	4.07	3.92	3.68	3.28	2.85
x	180.0	200.0	224.0	250.0	280.0	315.0	355.0	400.0	450.0	500.0
Q3	81.18	83.63	86.06	88.25	90.37	92.41	94.37	96.28	98.22	100.00
q3	2.59	2.38	2.20	2.04	1.92	1.77	1.68	1.64	1.69	1.73

x : diameter / µm Q3 : cumulative value / % q3 : density distribution

Serial nb : 3174 | Ref : 2.r242.m0.88A1818/7.00/9993/m87.12.20.40.1Fh.20.20.40.Bh/Q-.0.0.0.0//600.0.15.g10.0.9.10.1.10.P4500.1.10.N.0/V 9.29/635

PARTICLE SIZE DISTRIBUTION
CILAS 990 Liquid

Range : 0.20 µm - 500.00 µm / 70 Classes

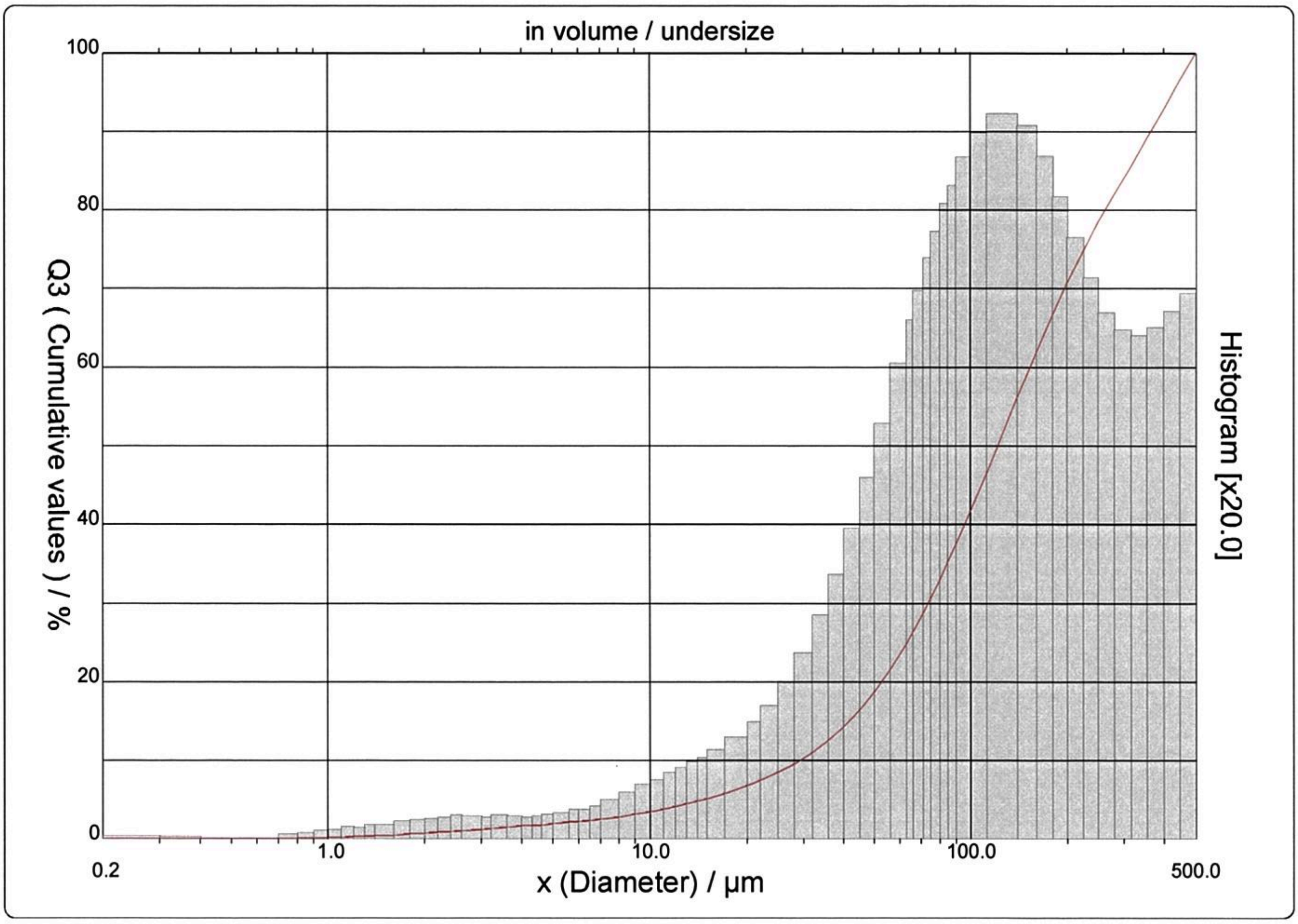
Sample ref.	: 25/09 N/S
Sample Name	: Tail
Sample type	: DAILY
Comments	: 2. Screening 15.03.2015
Liquid	:
Dispersing agent	:
Operator	: Ida Katrine
Company	:
Location	:
Date : 17.04.2015	Time : 12:11:18
Index meas.	: 9994
Database name	: CilasDB1

Ultrasounds	: 60	s
Obscuration	: 16 %	
Diameter at 10%	: 29.11	µm
Diameter at 50%	: 121.29	µm
Diameter at 80%	: 262.31	µm
Fraunhofer		
Density/Factor	----------	
Specific surface	----------	
Automatic dilution	: No / No	
Meas./Rins.	: 60s/60s/4	
SOP name	: DAILY SAMPLES	

Customer defined classes — in volume / undersize

x	45.00	53.00	75.00	106.0	150.0	212.0	300.0
Q3	16.46	20.13	30.61	44.21	59.17	72.87	84.16

x : diameter / µm Q3 : cumulative value / % q3 : density distribution



Serial nb : 3174 | Ref : 2.r242.m0.88A1818/7.00/9994/m87.12.20.40.1Fh.20.20.40.Bh/Q-.0.0.0.0//600.0.15.g10.0.9.10.1.10.P4500.1.10.N.0/V 9.29/635

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Diameter at 80%	: 262.31 µm
Fraunhofer	
Density/Factor	----------
Specific surface	----------
Automatic dilution	: No / No
Meas./Rins.	: 60s/60s/4
SOP name	: DAILY SAMPLES

Standards classes in volume / undersize

x	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10
Q3	0.00	0.06	0.09	0.09	0.09	0.09	0.12	0.16	0.21	0.26
q3	0.00	0.02	0.01	0.00	0.00	0.00	0.02	0.04	0.05	0.06
x	1.20	1.30	1.40	1.60	1.80	2.00	2.20	2.40	2.60	3.00
Q3	0.32	0.37	0.43	0.54	0.66	0.78	0.89	1.00	1.11	1.30
q3	0.07	0.07	0.09	0.09	0.11	0.12	0.12	0.13	0.15	0.14
x	3.20	3.60	4.00	4.30	4.60	5.00	5.60	6.00	6.50	7.00
Q3	1.38	1.54	1.68	1.77	1.86	1.98	2.15	2.27	2.41	2.55
q3	0.13	0.14	0.14	0.13	0.14	0.15	0.16	0.18	0.19	0.20
x	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	17.00	20.00
Q3	2.86	3.18	3.52	3.85	4.19	4.53	4.87	5.20	5.86	6.84
q3	0.25	0.29	0.34	0.37	0.42	0.45	0.49	0.51	0.56	0.64
x	22.00	25.00	28.00	32.00	36.00	40.00	45.00	50.00	56.00	63.00
Q3	7.50	8.51	9.57	11.05	12.62	14.28	16.46	18.73	21.54	24.88
q3	0.74	0.84	0.99	1.18	1.42	1.68	1.97	2.29	2.64	3.02
x	66.00	71.00	75.00	80.00	85.00	90.00	100.0	112.0	140.0	160.0
Q3	26.32	28.71	30.61	32.95	35.25	37.48	41.77	46.55	56.21	61.90
q3	3.29	3.48	3.69	3.86	4.03	4.15	4.33	4.49	4.60	4.53
x	180.0	200.0	224.0	250.0	280.0	315.0	355.0	400.0	450.0	500.0
Q3	66.70	70.74	74.81	78.49	82.05	85.63	89.22	92.86	96.57	100.00
q3	4.33	4.08	3.82	3.56	3.34	3.23	3.19	3.24	3.35	3.46

x : diameter / µm Q3 : cumulative value / % q3 : density distribution

Serial nb : 3174 | Ref : 2.r242.m0.88A1818/7.00/9994/m87.12.20.40.1Fh.20.20.40.Bh/Q-.0.0.0.0//600.0.15.g10.0.9.10.1.10.P4500.1.10.N.0/V 9.29/635

PARTICLE SIZE DISTRIBUTION

CILAS 990 Liquid

Range : 0.20 µm - 500.00 µm / 70 Classes

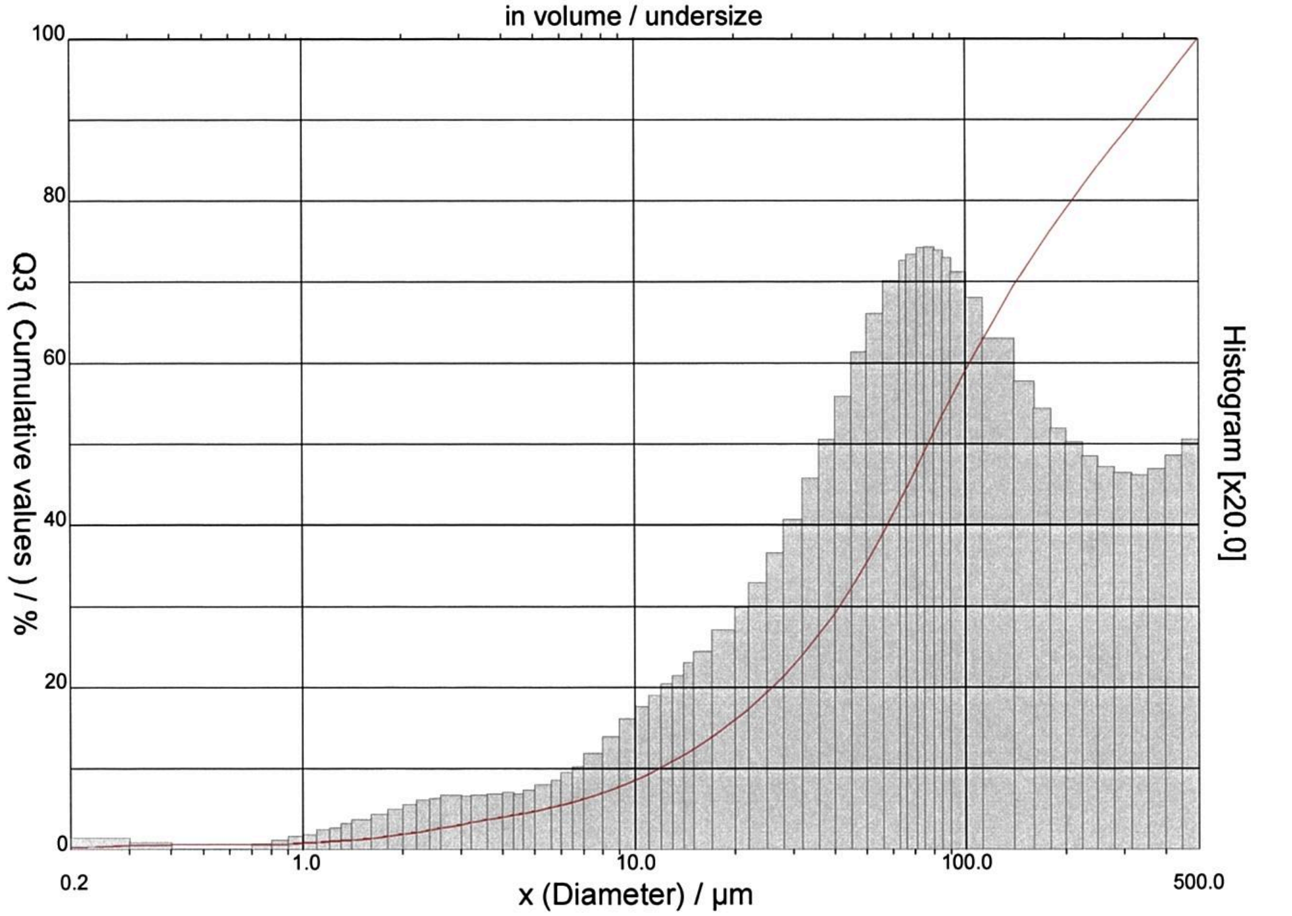
Sample ref.	: 25/09 N/S
Sample Name	: Tail
Sample type	: DAILY
Comments	: 3.Screening.no1. 20.03.15
Liquid	:
Dispersing agent	:
Operator	: Ida Katrine
Company	:
Location	:
Date : 17.04.2015	Time : 12:22:33
Index meas.	: 9995
Database name	: CilasDB1

Ultrasounds	: 60 s
Obscuration	: 15 %
Diameter at 10%	: 11.76 µm
Diameter at 50%	: 77.00 µm
Diameter at 80%	: 209.08 µm
Fraunhofer	
Density/Factor	----------
Specific surface	----------
Automatic dilution	: No / No
Meas./Rins.	: 60s/60s/4
SOP name	: DAILY SAMPLES

Customer defined classes — in volume / undersize

x	45.00	53.00	75.00	106.0	150.0	212.0	300.0
Q3	32.27	37.18	49.06	61.03	71.48	80.35	88.31

x : diameter / µm Q3 : cumulative value / % q3 : density distribution



Serial nb : 3174 | Ref : 2.r242.m0.88A1818/7.00/9995/m87.12.20.40.1Fh.20.20.40.Bh/Q-.0.0.0.0//600.0.15.g10.0.9.10.1.10.P4500.1.10.N.0/V 9.29/635

PARTICLE SIZE DISTRIBUTION

CILAS 990 Liquid

Range : 0.20 µm - 500.00 µm / 70 Classes

Sample ref.	: 25/09 N/S	Ultrasounds	: 60 s
Sample Name	: Tail	Obscuration	: 15 %
Sample type	: DAILY	Diameter at 10%	: 11.76 µm
Comments	: 3.Screening.no1. 20.03.15	Diameter at 50%	: 77.00 µm
Liquid	:	Diameter at 80%	: 209.08 µm
Dispersing agent	:	Fraunhofer	
Operator	: Ida Katrine	Density/Factor	----------
Company	:	Specific surface	----------
Location	:	Automatic dilution	: No / No
Date : 17.04.2015	Time : 12:22:33	Meas./Rins.	: 60s/60s/4
Index meas.	: 9995	SOP name	: DAILY SAMPLES
Database name	: CilasDB1		

Standards classes in volume / undersize

x	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10
Q3	0.31	0.57	0.68	0.68	0.68	0.68	0.72	0.78	0.86	0.94
q3	0.04	0.07	0.04	0.00	0.00	0.00	0.03	0.05	0.08	0.09
x	1.20	1.30	1.40	1.60	1.80	2.00	2.20	2.40	2.60	3.00
Q3	1.04	1.14	1.25	1.48	1.72	1.97	2.22	2.47	2.71	3.16
q3	0.12	0.13	0.15	0.18	0.21	0.25	0.27	0.30	0.31	0.33
x	3.20	3.60	4.00	4.30	4.60	5.00	5.60	6.00	6.50	7.00
Q3	3.36	3.73	4.07	4.31	4.53	4.82	5.25	5.53	5.89	6.25
q3	0.32	0.33	0.34	0.35	0.34	0.36	0.39	0.42	0.47	0.51
x	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	17.00	20.00
Q3	7.00	7.78	8.59	9.39	10.18	10.96	11.72	12.48	13.94	16.04
q3	0.58	0.69	0.80	0.87	0.94	1.01	1.07	1.15	1.21	1.34
x	22.00	25.00	28.00	32.00	36.00	40.00	45.00	50.00	56.00	63.00
Q3	17.40	19.41	21.39	23.99	26.57	29.12	32.27	35.37	38.96	42.92
q3	1.48	1.64	1.82	2.03	2.28	2.52	2.78	3.06	3.30	3.50
x	66.00	71.00	75.00	80.00	85.00	90.00	100.0	112.0	140.0	160.0
Q3	44.54	47.11	49.06	51.36	53.51	55.51	59.11	62.81	69.55	73.24
q3	3.62	3.66	3.70	3.71	3.69	3.64	3.56	3.40	3.14	2.88
x	180.0	200.0	224.0	250.0	280.0	315.0	355.0	400.0	450.0	500.0
Q3	76.31	78.93	81.66	84.21	86.77	89.39	92.03	94.71	97.45	100.00
q3	2.71	2.59	2.51	2.42	2.35	2.31	2.30	2.34	2.42	2.52

x : diameter / µm Q3 : cumulative value / % q3 : density distribution

Serial nb : 3174 | Ref : 2.r242.m0.88A1818/7.00/9995/m87.12.20.40.1Fh.20.20.40.Bh/Q-.0.0.0.0//600.0.15.g10.0.9.10.1.10.P4500.1.10.N.0/V 9.29/635

PARTICLE SIZE DISTRIBUTION

CILAS 990 Liquid

Range : 0.20 µm - 500.00 µm / 70 Classes

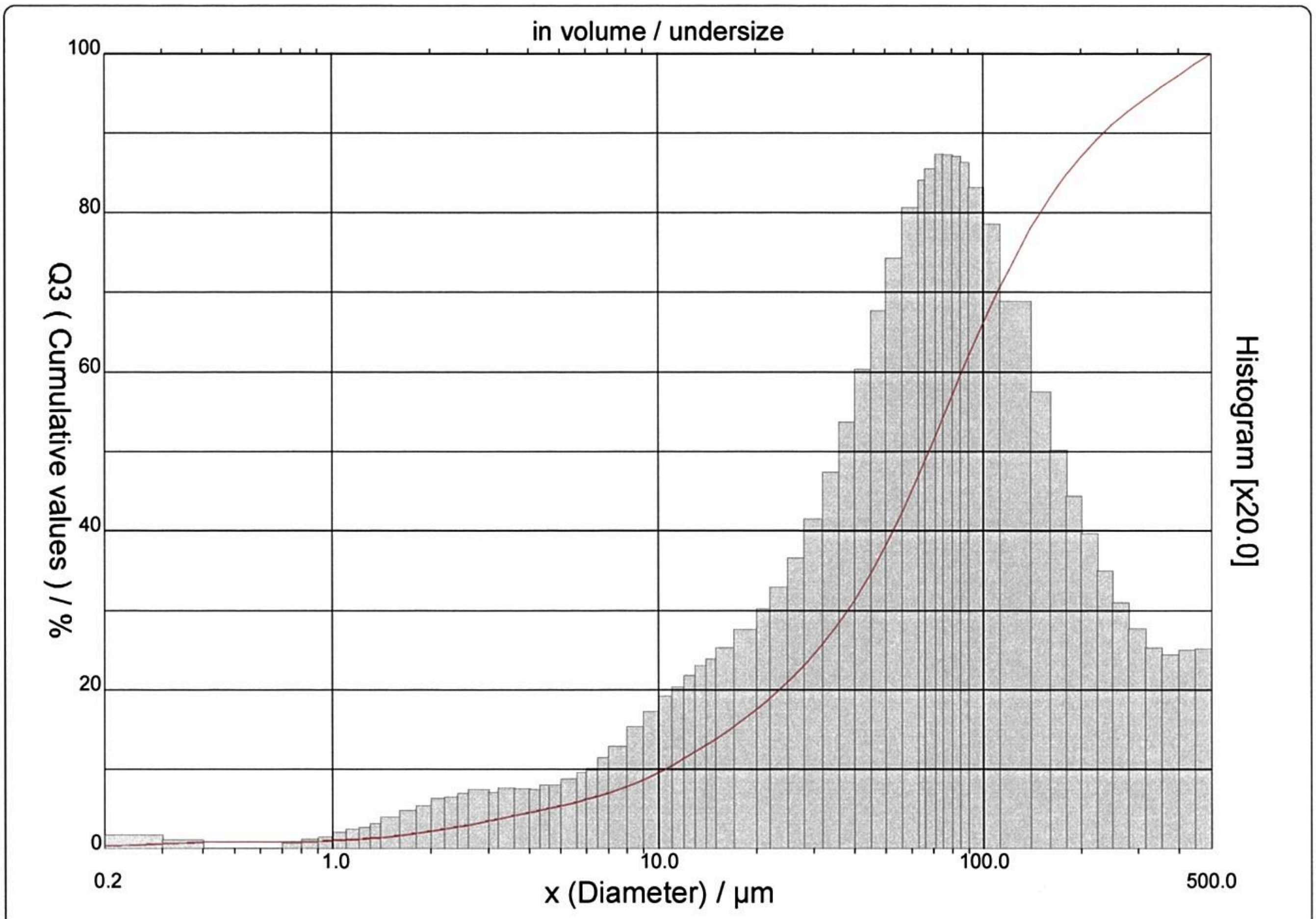
Sample ref.	: 25/09 N/S
Sample Name	: Tail
Sample type	: DAILY
Comments	: 3.Screening.no2. 23.03.15
Liquid	:
Dispersing agent	:
Operator	: Ida Katrine
Company	:
Location	:
Date : 17.04.2015	Time : 12:33:08
Index meas.	: 9996
Database name	: CilasDB1

Ultrasounds	: 60	s
Obscuration	: 15 %	
Diameter at 10%	: 10.39	µm
Diameter at 50%	: 67.84	µm
Diameter at 80%	: 149.69	µm
Fraunhofer		
Density/Factor	----------	
Specific surface	----------	
Automatic dilution	: No / No	
Meas./Rins.	: 60s/60s/4	
SOP name	: DAILY SAMPLES	

Customer defined classes — in volume / undersize

x	45.00	53.00	75.00	106.0	150.0	212.0	300.0
Q3	34.71	40.26	54.24	68.53	80.13	88.19	93.75

x : diameter / µm Q3 : cumulative value / % q3 : density distribution



Serial nb : 3174 | Ref : 2.r242.m0.88A1818/7.00/9996/m87.12.20.40.1Fh.20.20.40.Bh/Q-.0.0.0.0//600.0.15.g10.0.9.10.1.10.P4500.1.10.N.0/V 9.29/635

PARTICLE SIZE DISTRIBUTION

CILAS 990 Liquid

Range : 0.20 µm - 500.00 µm / 70 Classes

Sample ref.	: 25/09 N/S
Sample Name	: Tail
Sample type	: DAILY
Comments	: 3.Screening.no2. 23.03.15
Liquid	:
Dispersing agent	:
Operator	: Ida Katrine
Company	:
Location	:
Date : 17.04.2015	Time : 12:33:08
Index meas.	: 9996
Database name	: CilasDB1

Ultrasounds	: 60 s
Obscuration	: 15 %
Diameter at 10%	: 10.39 µm
Diameter at 50%	: 67.84 µm
Diameter at 80%	: 149.69 µm
Fraunhofer	
Density/Factor	----------
Specific surface	----------
Automatic dilution	: No / No
Meas./Rins.	: 60s/60s/4
SOP name	: DAILY SAMPLES

Standards classes in volume / undersize

x	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10
Q3	0.41	0.74	0.88	0.88	0.88	0.88	0.92	0.98	1.05	1.14
q3	0.05	0.08	0.05	0.00	0.00	0.00	0.03	0.05	0.07	0.10
x	1.20	1.30	1.40	1.60	1.80	2.00	2.20	2.40	2.60	3.00
Q3	1.24	1.34	1.45	1.70	1.97	2.24	2.53	2.80	3.07	3.58
q3	0.12	0.13	0.15	0.19	0.23	0.26	0.31	0.32	0.34	0.36
x	3.20	3.60	4.00	4.30	4.60	5.00	5.60	6.00	6.50	7.00
Q3	3.80	4.23	4.61	4.87	5.13	5.45	5.93	6.25	6.64	7.05
q3	0.35	0.37	0.37	0.37	0.39	0.39	0.43	0.47	0.50	0.57
x	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	17.00	20.00
Q3	7.88	8.76	9.64	10.53	11.39	12.24	13.07	13.87	15.41	17.59
q3	0.63	0.76	0.85	0.95	1.01	1.08	1.14	1.18	1.26	1.37
x	22.00	25.00	28.00	32.00	36.00	40.00	45.00	50.00	56.00	63.00
Q3	18.99	21.04	23.06	25.76	28.48	31.24	34.71	38.19	42.30	46.94
q3	1.50	1.64	1.82	2.07	2.36	2.68	3.01	3.37	3.70	4.02
x	66.00	71.00	75.00	80.00	85.00	90.00	100.0	112.0	140.0	160.0
Q3	48.85	51.90	54.24	56.99	59.57	61.98	66.26	70.61	78.12	81.87
q3	4.19	4.27	4.36	4.35	4.35	4.31	4.15	3.92	3.44	2.87
x	180.0	200.0	224.0	250.0	280.0	315.0	355.0	400.0	450.0	500.0
Q3	84.75	87.03	89.22	91.09	92.80	94.39	95.86	97.28	98.71	100.00
q3	2.50	2.21	1.97	1.74	1.54	1.38	1.26	1.22	1.24	1.25

x : diameter / µm Q3 : cumulative value / % q3 : density distribution

Serial nb : 3174 | Ref : 2.r242.m0.88A1818/7.00/9996/m87.12.20.40.1Fh.20.20.40.Bh/Q-.0.0.0.0//600.0.15.g10.0.9.10.1.10.P4500.1.10.N.0/V 9.29/635

Appendix 2

This appendix contains the analysis results from a water sample sampled from the overflow at the thickener March 23. 2015. The turbidity of the overflow was 730 (NTU) at this time. A laboratory located in Leiden in the Netherlands hired by Nalco analyzed the sample. The filter used was a 0,45 μm (micrometer) filter (ICO-F).

Customer Analytical Services
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NALCO
An Ecolab Company

Final - Report Number: 1399470
SYDVARANGER GRUVE AS
KIRKENES 20 9915 NORWAY
Sold To: 0500069304 **Ship To**:
Representative: SIGRID LARSEN

Sample Number	EW066063
Date Sampled	23-Mar-2015 12:00
Date Received	30-Mar-2015
Date Completed	2-Apr-2015
Date Authorized	8-Apr-2015

Analytical Report

This sample was analyzed as received, the results being as follows:

Sampling point: Overflow thickener

Water

Cations - Metals Test Method: AMW0013	**Filtered**	**Total**
Aluminum (Al)	0.24 mg/L	15 mg/L
Antimony (Sb)	<0.05 mg/L	<0.05 mg/L
Barium (Ba)	<0.05 mg/L	0.08 mg/L
Boron (B)	<0.5 mg/L	<0.5 mg/L
Cadmium (Cd)	<0.01 mg/L	<0.01 mg/L
Calcium (Ca)	4.4 mg/L	16 mg/L
Calcium (CaCO3)	11 mg/L	41 mg/L
Chromium (Cr)	<0.01 mg/L	0.03 mg/L
Copper (Cu)	<0.01 mg/L	0.02 mg/L
Iron (Fe)	0.33 mg/L	48 mg/L
Lead (Pb)	<0.01 mg/L	<0.01 mg/L
Lithium (Li)	<0.1 mg/L	<0.1 mg/L
Magnesium (Mg)	2.0 mg/L	15 mg/L
Magnesium (CaCO3)	8.2 mg/L	61 mg/L
Manganese (Mn)	<0.01 mg/L	0.90 mg/L
Molybdenum (Mo)	<0.05 mg/L	<0.05 mg/L
Nickel (Ni)	<0.01 mg/L	0.02 mg/L
Potassium (K)	10 mg/L	14 mg/L
Silicon (Si)	4.4 mg/L	45 mg/L
Silica (SiO2)	9.4 mg/L	96 mg/L
Sodium (Na)	32 mg/L	35 mg/L
Sodium (CaCO3)	70 mg/L	75 mg/L
Strontium (Sr)	<0.1 mg/L	<0.1 mg/L
Vanadium (V)	<0.05 mg/L	<0.05 mg/L
Zinc (Zn)	<0.02 mg/L	0.07 mg/L
Total Hardness (CaCO3)	19 mg/L	100 mg/L

Anions Test Method: AMW0002	**Filtered**
Chloride (Cl)	15 mg/L
Nitrite (NO2)	<0.5 mg/L
Bromide (Br)	<0.5 mg/L
Nitrate (NO3)	7.3 mg/L
Sulfate (SO4)	10 mg/L

COMPANY WITH
QUALITY SYSTEM
CERTIFIED BY DNV
= ISO 9001:2008 =

Authorized by Arjan Kraak
Group Leader

Customer Analytical Services
P.O. Box 627 2300 AP Leiden
Phone: +31715241100 Email: customeranalyticalservices@nalco.com

NALCO
An Ecolab Company

Final - Report Number: 1399470
SYDVARANGER GRUVE AS
KIRKENES 20 9915 NORWAY
Sold To: 0500069304 **Ship To**:
Representative: SIGRID LARSEN

Sample Number	EW066063
Date Sampled	23-Mar-2015 12:00
Date Received	30-Mar-2015
Date Completed	2-Apr-2015
Date Authorized	8-Apr-2015

Analytical Report

This sample was analyzed as received, the results being as follows:

Sampling point: Overflow thickener

Alkalinity **Test Method: AMW0111**	**Total**
Total Alkalinity ($CaCO_3$)	88 mg/L
Phenolphthalein Alkalinity ($CaCO_3$)	14 mg/L
Bicarbonate ($CaCO_3$)	60 mg/L
Carbonate ($CaCO_3$)	28 mg/L

Other Analytes **Test Method: AMW0111**	**Total**
Conductivity at 25°C	220 µS/cm
pH @ 25°C	9.3 pH Units

COMPANY WITH QUALITY SYSTEM CERTIFIED BY DNV
= ISO 9001:2008 =

Authorized by Arjan Kraak
Group Leader

Appendix 3

This appendix contains a list of the chemicals and their properties tested in this study.

Name:	Supplier:	Powder/liquid:	Molecular weight:	Molecular charge:	Type:
UNIFLOC PDM	Aquatech4you	Liquid	Very high	100 % cationic charge	Coagulant
UNIFLOC OAE 300	Aquatech4you	Liquid	High	30 % anionic charge	Flocculant
UNIFLOC PDMG 25	Aquatech4you	Liquid	Low	100 % cationic charge	Coagulant
UNIFLOC A 300	Aquatech4you	Powder	Very high	30 % anionic charge	Flocculant
UNIFLOC PDMG 90	Aquatech4you	Powder	Low	100 % cationic charge	Coagulant
UNIFLOC OCE 1000	Aquatech4you	Liquid	High	100 % cationic charge	Flocculant
PIX-105	Kemira	Liquid	Low	Anionic charge	PAC - inorganic coagulant
SUPERFLOC A-100	Kemira	Powder	High	10 % anionic charge	Flocculant
SUPERFLOC A-100 HMW	Kemira	Powder	Very high	10 % anionic charge	Flocculant
SUPERFLOC N-300	Kemira	Powder	High	Nonionic	Flocculant
SUPERFLOC N-100	Kemira	Powder	High	Nonionic	Flocculant
71605	Nalco	Liquid	Very high	30 % anionic charge	Flocculant
GR 204	Nalco	Liquid	medium/high	65 % cationic charge	Flocculant
71408	Nalco	Liquid	High	25-30 % cationic charge	Flocculant
9916	Nalco	Powder	High	70 % cationic charge	Flocculant
71771	Nalco	Powder	medium/high	Nonionic	Flocculant
74695	Nalco	Liquid	Low	100 % cationic charge	Coagulant
Zetag 4120	BASF	Powder	Very high	20 % anion charge	Flocculant
Zetag 8187	BASF	Powder	Very high	80 % cation charge	Flocculant
Magnafloc LT32	BASF	Liquid	Very low	100 % cation charge	Coagulant
Magnafloc LT37	BASF	Liquid	Low	100 % cation charge	Coagulant
Magnafloc 10 / Zetag 4100	BASF	Powder	High	8 % anion charge	Flocculant
Magnafloc 338/Zetag 4105	BASF	Powder	Very high	9 % anionic charge	Flocculant
Magnafloc 3105	BASF	Powder	High	18 % anionic charge	Flocculant
Magnafloc LT 38	BASF	Liquid	Low/medium	100 % cationic charge	Coagulant
Zetag 9016	BASF	Liquid	Very high	60 % cationic charge	Flocculant
Zetag 9018	BASF	Liquid	Very high	80 % cationic charge	Flocculant
Ekoflock 91	BASF	Liquid	Very low	100 % cationic charge	PAC - inorganic coagulant
FL 7226	Clariant	Liquid	Medium/high	48 % anionic charge	Flocculant
FL 39939	Clariant	Powder	Very high	32 % anionic charge	Flocculant

Appendix 4

This appendix contains results from the first screening including descriptions, data, graphs and process data.

Date:	11.03.2015
Test number:	**1. Screening**
MF10 feed concentration:	1,9 m^3/h
LT38 feed concentration:	0 L/h
NTU from overflow at thickener:	511
Time:	19:00
Feed on the mill (tons):	650
Status at the facility:	Cannot increase the feed to the primary mill due to problems at the thickener, the iron % is low, this gives the thickener a lot of particles, the discharge from the thickener is limited.
Mill feeds % of iron magnetite:	19,00
% solids in test sample (weight %):	25,85
pH of sample:	9,13
Tailings flow from the thickener:	441 m^3/h
Tailngs density from the thickener	473 tons/h

	0,4 ml of 1000 ppm solution added in 400 ml sample gives 1 ppm in watersample:						
Name:	**Watersample volume (ml):**	**Weight (grams):**	**Settling description:**	**Floc size:**	**Compaction:**	**Waterphase description:**	**NTU (measured after 1 minute):**
UNIFLOC OCE 1000	400	488	bad settling	small	poor	no clear water phase	no reading
UNIFLOC OAE 300	400	482	bad settling	small	poor	no clear water phase	no reading
UNIFLOC A 300	400	477	medium settling	medium	poor	medium clear water phase, some fines	598
SUPERFLOC A-100	400	491	bad settling	small	poor	no clear water phase	no reading
SUPERFLOC A-100 HMW	400	497	bad settling	small	poor	no clear water phase	no reading
SUPERFLOC N-300	400	483	bad settling	small	poor	no clear water phase	no reading
SUPERFLOC N-100	400	489	bad settling	small	poor	no clear water phase	no reading
71605	400	500	bad settling	small	poor	no clear water phase	no reading
GR 204	400	476	bad settling	small	poor	no clear water phase	no reading
71408	400	496	bad settling	small	poor	no clear water phase	no reading
9916	400	474	bad settling	small	poor	no clear water phase	no reading
71771	400	497	bad settling	small	poor	no clear water phase	no reading
Zetag 4120	400	504	bad settling	small	poor	no clear water phase	no reading
Zetag 8187	400	474	bad settling	small	poor	no clear water phase	no reading
Magnafloc 10 / Zetag 4100	400	509	bad settling	small	poor	no clear water phase	no reading
Magnafloc 338/Zetag 4105	400	478	bad settling	small	poor	no clear water phase	no reading
Magnafloc 3105	400	483	bad settling	small	poor	no clear water phase	no reading
Zetag 9016	400	475	bad settling	small	poor	no clear water phase	no reading
Zetag 9018	400	501	bad settling	small	poor	no clear water phase	no reading
FL 33939	400	505	bad settling	small	poor	no clear water phase	no reading
FL 7226	400	500	bad settling	small	poor	no clear water phase	no reading

	1,2 ml of 1000 ppm solution added in 400 ml sample gives 3 ppm in watersample:						
Name:	Watersample volume (ml):	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC OCE 1000	400	488	bad settling	small	poor	no clear water phase	no reading
UNIFLOC OAE 300	400	482	bad settling	small	poor	no clear water phase	no reading
UNIFLOC A 300	400	477	good settling	medium	medium	medium clear water phase, some fines	531
SUPERFLOC A-100	400	491	medium settling	medium	medium	medium clear water phase, some fines	890
SUPERFLOC A-100 HMW	400	497	good settling	medium	medium	medium clear water phase, some fines	831
SUPERFLOC N-300	400	483	good settling	small	medium	medium clear water phase, some fines	914
SUPERFLOC N-100	400	489	medium settling	small	medium	medium clear water phase, some fines	927
71605	400	500	bad settling	small	poor	no clear water phase	no reading
GR 204	400	476	bad settling	small	poor	no clear water phase	no reading
71408	400	496	bad settling	small	poor	no clear water phase	no reading
9916	400	474	medium settling	small	medium	medium clear water phase, some fines	791
71771	400	497	medium settling	small	medium	medium clear water phase, some fines	884
Zetag 4120	400	504	medium settling	small	medium	medium clear water phase, some fines	888
Zetag 8187	400	474	medium settling	small	poor	medium clear water phase, some fines	853
Magnafloc 10 / Zetag 4100	400	509	good settling	medium	medium	medium clear water phase, some fines	952
Magnafloc 338/Zetag 4105	400	478	good settling	medium	medium	medium clear water phase, some fines	868
Magnafloc 3105	400	483	good settling	medium	medium	medium clear water phase, some fines	928
Zetag 9016	400	475	bad settling	small	poor	no clear water phase	no reading
Zetag 9018	400	501	bad settling	small	poor	no clear water phase	no reading
FL 33939	400	505	bad settling	small	poor	no clear water phase	no reading
FL 7226	400	500	bad settling	small	poor	no clear water phase	no reading

	2 ml of 1000 ppm solution added in 400 ml sample gives 5 ppm in watersample:						
Name:	Watersample volume (ml):	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC OCE 1000	400	488	medium settling	small	poor	medium clear water phase, some fines	670
UNIFLOC OAE 300	400	482	bad settling	small	poor	no clear water phase	no reading
UNIFLOC A 300	400	477	fast settling	medium	medium	clear water, some fines	294
SUPERFLOC A-100	400	491	medium settling	medium	medium	medium clear water phase, some fines	506
SUPERFLOC A-100 HMW	400	497	good settling	medium	medium	medium clear water phase, some fines	497
SUPERFLOC N-300	400	483	good settling	medium	medium	medium clear water phase, some fines	404
SUPERFLOC N-100	400	489	good settling	medium	medium	medium clear water phase, some fines	478
71605	400	500	medium settling	small	poor	no clear water phase	no reading
GR 204	400	476	medium settling	small	poor	no clear water phase	no reading
71408	400	496	medium settling	small	poor	no clear water phase	no reading
9916	400	474	good settling	medium	medium	clear water	81,7
71771	400	497	good settling	medium	medium	clear water, some fines	218
Zetag 4120	400	504	medium settling	medium	medium	medium clear water phase, some fines	815
Zetag 8187	400	474	medium settling	medium	medium	clear water	133
Magnafloc 10 / Zetag 4100	400	509	good settling	big	medium	clear water, some fines	279
Magnafloc 338/Zetag 4105	400	478	good settling	medium	medium	medium clear water phase, some fines	383
Magnafloc 3105	400	483	good settling	medium	medium	medium clear water phase, some fines	645
Zetag 9016	400	475	bad settling	small	poor	no clear water phase	no reading
Zetag 9018	400	501	bad settling	small	poor	no clear water phase	no reading
FL 33939	400	505	medium settling	small	poor	medium clear water phase, some fines	536
FL 7226	400	500	bad settling	small	poor	no clear water phase	no reading

	0,1 ml of 1000 ppm solution coagulant and 0,3 ml of 1000 ppm solution flocculant added in 400 ml sample gives 0,25 ppm + 0,75 ppm in watersample:						
Name (coagulant+flocculant):	Watersample volume (ml):	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC PDMG 25 + UNIFLOC A 300	400	478	bad settling	small	poor	bad	no reading
UNIFLOC PDM + UNIFLOC A 300	400	493	bad settling	small	poor	bad	no reading
UNIFLOC PDMG 90 + UNIFLOC A 300	400	483	bad settling	small	poor	bad	no reading
PIX-105 + SUPERFLOC A-100 HMW	400	476	bad settling	small	poor	bad	no reading
PIX-105 + SUPERFLOC N-300	400	489	bad settling	small	poor	bad	no reading
PIX-105 + SUPERFLOC N-100	400	505	bad settling	small	poor	bad	no reading
74695 + 9916	400	486	bad settling	small	poor	bad	no reading
74695 + 71771	400	472	bad settling	small	poor	bad	no reading
Magnafloc LT32 + Zetag 8187	400	489	bad settling	small	poor	bad	no reading
Magnafloc LT32 + Magnafloc 10 / Zetag 4100	400	470	bad settling	small	poor	bad	no reading
Magnafloc LT32 + Magnafloc 338/Zetag 4105	400	477	bad settling	small	poor	bad	no reading
Magnafloc LT37 + Zetag 8187	400	482	bad settling	small	poor	bad	no reading
Magnafloc LT37 + Magnafloc 10 / Zetag 4100	400	477	bad settling	small	poor	bad	no reading
Magnafloc LT37 + Magnafloc 338/Zetag 4105	400	483	bad settling	small	poor	bad	no reading
Magnafloc LT 38 + Zetag 8187	400	478	bad settling	small	poor	bad	no reading
Magnafloc LT 38 + Magnafloc 10 / Zetag 4100	400	488	bad settling	small	poor	bad	no reading
Magnafloc LT 38 + Magnafloc 338/Zetag 4105	400	475	bad settling	small	poor	bad	no reading
Ekoflock 91 + Zetag 8187	-	-	-	-	-	-	-
Ekoflock 91 + Magnafloc 10 / Zetag 4100	-	-	-	-	-	-	-
Ekoflock 91 + Magnafloc 338/Zetag 4105	-	-	-	-	-	-	-

	0,3 ml of 1000 ppm solution coagulant and 0,9 ml of 1000 ppm solution flocculant added in 400 ml sample gives 0,5 ppm + 2,25 ppm in watersample:						
Name (coagulant+flocculant):	Watersample volume (ml):	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC PDMG 25 + UNIFLOC A 300	400	506	medium settling	medium	meidum	medium clear water phase, some fines	908
UNIFLOC PDM + UNIFLOC A 300	400	520	medium settling	medium	meidum	medium clear water phase, some fines	865
UNIFLOC PDMG 90 + UNIFLOC A 300	400	495	medium settling	medium	meidum	medium clear water phase, some fines	908
PIX-105 + SUPERFLOC A-100 HMW	400	481	medium settling	medium	meidum	medium clear water phase, some fines	792
PIX-105 + SUPERFLOC N-300	400	496	medium settling	medium	meidum	no clear water phase	no reading
PIX-105 + SUPERFLOC N-100	400	505	medium settling	medium	meidum	no clear water phase	no reading
74695 + 9916	400	478	medium settling	small	meidum	medium clear water phase, some fines	860
74695 + 71771	400	480	medium settling	small	meidum	medium clear water phase, some fines	869
Magnafloc LT32 + Zetag 8187	400	496	medium settling	small	meidum	medium clear water phase, some fines	870
Magnafloc LT32 + Magnafloc 10 / Zetag 4100	400	474	good settling	small	meidum	medium clear water phase, some fines	733
Magnafloc LT32 + Magnafloc 338/Zetag 4105	400	502	medium settling	small	meidum	medium clear water phase, some fines	500
Magnafloc LT37 + Zetag 8187	400	473	medium settling	small	poor	no clear water phase	no reading
Magnafloc LT37 + Magnafloc 10 / Zetag 4100	400	474	medium settling	small	meidum	medium clear water phase, some fines	784
Magnafloc LT37 + Magnafloc 338/Zetag 4105	400	491	good settling	medium	meidum	medium clear water phase, some fines	839
Magnafloc LT 38 + Zetag 8187	400	482	medium settling	small	meidum	medium clear water phase, some fines	816
Magnafloc LT 38 + Magnafloc 10 / Zetag 4100	400	471	medium settling	medium	meidum	no clear water phase	no reading
Magnafloc LT 38 + Magnafloc 338/Zetag 4105	400	483	medium settling	medium	meidum	medium clear water phase, some fines	711
Ekoflock 91 + Zetag 8187	-	-	-	-	-	-	-
Ekoflock 91 + Magnafloc 10 / Zetag 4100	-	-	-	-	-	-	-
Ekoflock 91 + Magnafloc 338/Zetag 4105	-	-	-	-	-	-	-

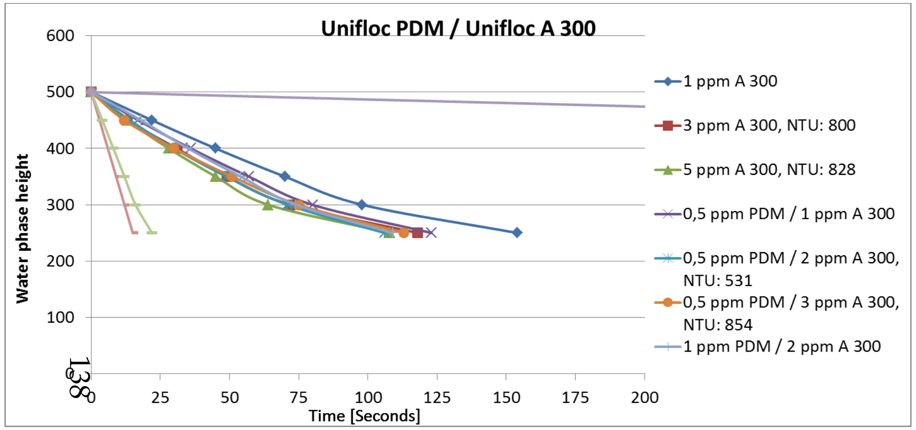
	0,5 ml of 1000 ppm solution coagulant and 1,5 ml of 1000 ppm solution flocculant added in 400 ml sample gives 1,25 ppm + 3,75 ppm in watersample:						
Name (coagulant+flocculant):	Watersample volume (ml):	Weight (grams):	Settling description:	Floc size:	Compaction:	Waterphase description:	NTU (measured after 1 minute):
UNIFLOC PDMG 25 + UNIFLOC A 300	400	477	medium settling	medium	medium	medium clear water phase, some fines	553
UNIFLOC PDM + UNIFLOC A 300	400	490	medium settling	medium	medium	medium clear water phase, some fines	485
UNIFLOC PDMG 90 + UNIFLOC A 300	400	470	medium settling	medium	medium	medium clear water phase, some fines	558
PIX-105 + SUPERFLOC A-100 HMW	400	476	medium settling	medium	medium	medium clear water phase, some fines	752
PIX-105 + SUPERFLOC N-300	400	467	bad settling	small	poor	medium clear water phase, some fines	887
PIX-105 + SUPERFLOC N-100	400	499	medium settling	medium	medium	medium clear water phase, some fines	893
74695 + 9916	400	473	medium settling	small	medium	medium clear water phase, some fines	687
74695 + 71771	400	480	medium settling	small	medium	medium clear water phase, some fines	698
Magnafloc LT32 + Zetag 8187	400	471	medium settling	small	medium	clear water, some fines	325
Magnafloc LT32 + Magnafloc 10 / Zetag 4100	400	474	good settling	medium	medium	clear water, some fines	249
Magnafloc LT32 + Magnafloc 338/Zetag 4105	400	481	medium settling	medium	medium	medium clear water phase, some fines	447
Magnafloc LT37 + Zetag 8187	400	471	medium settling	medium	medium	medium clear water phase, some fines	260
Magnafloc LT37 + Magnafloc 10 / Zetag 4100	400	475	medium settling	medium	medium	clear water, some fines	240
Magnafloc LT37 + Magnafloc 338/Zetag 4105	400	474	medium settling	medium	medium	medium clear water phase, some fines	613
Magnafloc LT 38 + Zetag 8187	400	475	medium settling	medium	medium	medium clear water phase, some fines	800
Magnafloc LT 38 + Magnafloc 10 / Zetag 4100	400	474	medium settling	small	medium	clear water, some fines	319
Magnafloc LT 38 + Magnafloc 338/Zetag 4105	400	476	good settling	medium	good	clear water, some fines	193
Ekoflock 91 + Zetag 8187	400	472	bad settling	small	poor	no clear water phase	no reading
Ekoflock 91 + Magnafloc 10 / Zetag 4100	400	487	medium settling	medium	medium	medium clear water phase, some fines	809
Ekoflock 91 + Magnafloc 338/Zetag 4105	400	478	medium settling	medium	medium	medium clear water phase, some fines	766

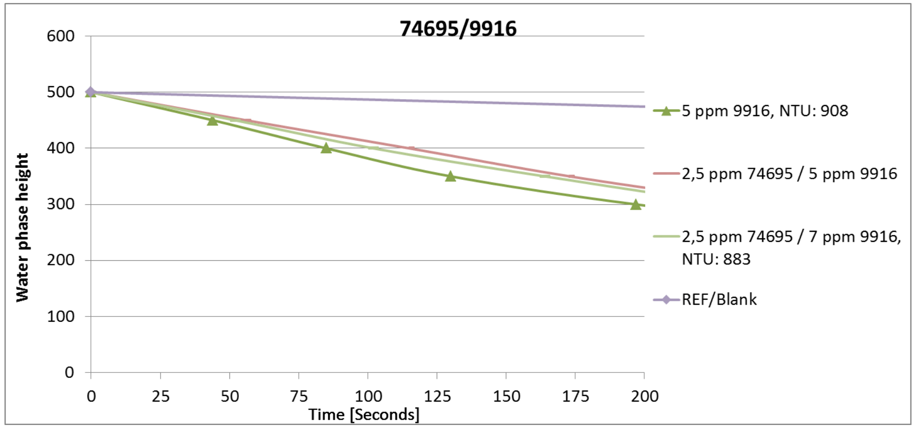
Appendix 5

This appendix contains results from the second screening including descriptions, data, graphs and process data.

Products:	Concentration:	Settling description:	Floc size:	Compaction:	Waterphase + NTU (after 3 min):	Settling height(ml) after 3 minutes:
REF/Blank	0 ppm	no reaction	Very small	bad	No reading	-
Unifloc A 300	1 ppm	bad	very small	bad	No reading	200
Unifloc A 300	3 ppm	ok reaction	small	bad	800	220
Unifloc A 300	5 ppm	ok reaction	small	bad	828	230
Unifloc PDM/UNIFLOC A 300	0,5 ppm / 1 ppm	ok reaction	small	bad	No reading	220
Unifloc PDM/UNIFLOC A 300	0,5 ppm / 2 ppm	ok reaction	moderate	moderate	531	220
Unifloc PDM/UNIFLOC A 300	0,5 ppm / 3 ppm	ok reaction	big	moderate	854	220
Unifloc PDM/UNIFLOC A 300	1 ppm / 2 ppm	ok reaction	big	moderate	No reading	195
Unifloc PDM/UNIFLOC A 300	2,5 ppm / 5 ppm	ok reaction	big	moderate	899	195
Unifloc PDM/UNIFLOC A 300	2,5 ppm / 7 ppm	ok reaction	big	moderate	735	195
9916	1 ppm	no reaction	very small	bad	No reading	-
9916	3 ppm	no reaction	very small	bad	No reading	-
9916	5 ppm	bad	small	bad	908	-
74695/9916	0,5 ppm / 1 ppm	no reaction	small	bad	No reading	-
74695/9916	0,5 ppm / 2 ppm	no reaction	very small	bad	No reading	-
74695/9916	0,5 ppm / 3 ppm	no reaction	very small	bad	No reading	-
74695/9916	1 ppm / 2 ppm	no reaction	very small	bad	No reading	-
74695/9916	2,5 ppm / 5 ppm	very slow	small	moderate	No reading	-
74695/9916	2,5 ppm / 7 ppm	slow	medium	moderate	883	330
71771	1 ppm	no reaction	very small	bad	No reading	-
71771	3 ppm	bad reaction	very small	bad	No reading	-
71771	5 ppm	ok reaction	small	bad	822	-
74695/71771	0,5 ppm / 1 ppm	no reaction	small	moderate	No reading	195
74695/71771	0,5 ppm / 2 ppm	no reaction	small	moderate	No reading	-
74695/71771	0,5 ppm / 3 ppm	bad reaction	small	moderate	No reading	-
74695/71771	1 ppm / 2 ppm	ok reaction	small	good	505	215
74695/71771	2,5 ppm / 5 ppm	ok reaction	medium	moderate	No reading	-
74695/71771	2,5 ppm / 7 ppm	ok reaction	medium	good	910	220
8187	1 ppm	no reaction	very small	bad	No reading	-
8187	3 ppm	bad reaction	very small	bad	No reading	-
8187	5 ppm	ok reaction	small	moderate	837	280
LT32/8187	0,5 ppm / 1 ppm	no reaction	very small	bad	No reading	-
LT32/8187	0,5 ppm / 2 ppm	no reaction	very small	bad	No reading	-
LT32/8187	0,5 ppm / 3 ppm	ok reaction	small	moderate	503	260
LT32/8187	1 ppm / 2 ppm	bad reaction	small	bad	No reading	-
LT32/8187	2,5 ppm / 5 ppm	ok reaction	medium	moderate	615	215
LT32/8187	2,5 ppm / 7 ppm	good reaction	medium	good	23,3	210
LT 37/Zetag 8187	0,5 ppm / 1 ppm	no reaction	very small	bad	No reading	-
LT 37/Zetag 8187	0,5 ppm / 2 ppm	no reaction	very small	bad	No reading	-
LT 37/Zetag 8187	0,5 ppm / 3 ppm	ok reaction	small	moderate	551	285
LT 37/Zetag 8187	1 ppm / 2 ppm	no reaction	very small	bad	No reading	-
LT 37/Zetag 8187	2,5 ppm / 5 ppm	good reaction	medium	good	123	200
LT 37/Zetag 8187	2,5 ppm / 7 ppm	good reaction	medium	good	28,5	235
MF10	1 ppm	no reaction	very small	bad	No reading	-
MF10	3 ppm	bad reaction	very small	moderate	No reading	290
MF10	5 ppm	ok reaction	small	good	904	190
LT32/MF10	0,5 ppm / 1 ppm	no reaction	very small	bad	No reading	-
LT32/MF10	0,5 ppm / 2 ppm	no reaction	very small	moderate	No reading	180
LT32/MF10	0,5 ppm / 3 ppm	ok reaction	small	good	449	180
LT32/MF10	1 ppm / 2 ppm	no reaction	very small	bad	No reading	-
LT32/MF10	2,5 ppm / 5 ppm	ok reaction	medium	moderate	901	180
LT32/MF10	2,5 ppm / 7 ppm	ok reaction	medium	good	670	175
LT37/MF10	0,5 ppm / 1 ppm	no reaction	very small	bad	No reading	-
LT37/MF10	0,5 ppm / 2 ppm	bad reaction	small	moderate	No reading	200
LT37/MF10	0,5 ppm / 3 ppm	bad reaction	small	moderate	No reading	205
LT37/MF10	1 ppm / 2 ppm	bad reaction	small	moderate	No reading	220
LT37/MF10	2,5 ppm / 5 ppm	ok reaction	medium	moderate	954	225
LT37/MF10	2,5 ppm / 7 ppm	ok reaction	medium	good	600	205
LT38/MF10	0,5 ppm / 1 ppm	no reaction	very small	bad	No reading	-
LT38/MF10	0,5 ppm / 2 ppm	bad reaction	small	moderate	No reading	195
LT38/MF10	0,5 ppm / 3 ppm	bad reaction	small	moderate	No reading	195
LT38/MF10	1 ppm / 2 ppm	bad reaction	small	moderate	No reading	165
LT38/MF10	2,5 ppm / 5 ppm	ok reaction	medium	good	938	200
LT38/MF10	2,5 ppm / 7 ppm	ok reaction	medium	good	636	195
MF338	1 ppm	no reaction	very small	bad	No reading	-
MF338	3 ppm	bad reaction	small	moderate	No reading	175
MF338	5 ppm	ok reaction	small	good	929	175
LT38/MF338	0,5 ppm / 1 ppm	bad reaction	small	bad	No reading	-
LT38/MF338	0,5 ppm / 2 ppm	bad reaction	small	moderate	No reading	190
LT38/MF338	0,5 ppm / 3 ppm	ok reaction	small	good	576	190
LT38/MF338	1 ppm / 2 ppm	bad reaction	small	moderate	No reading	200
LT38/MF338	2,5 ppm / 5 ppm	ok reaction	Medium flocs	good	763	185
LT38/MF338	2,5 ppm / 7 ppm	ok reaction	Medium flocs	good	522	180
N-300	1 ppm	no reaction	very small	bad	No reading	-
N-300	3 ppm	bad reaction	small	moderate	No reading	195
N-300	5 ppm	bad reaction	small	moderate	No reading	195
PIX-105/N-300	20 ppm/5 ppm	good reaction	Medium flocs	good	50,3	280

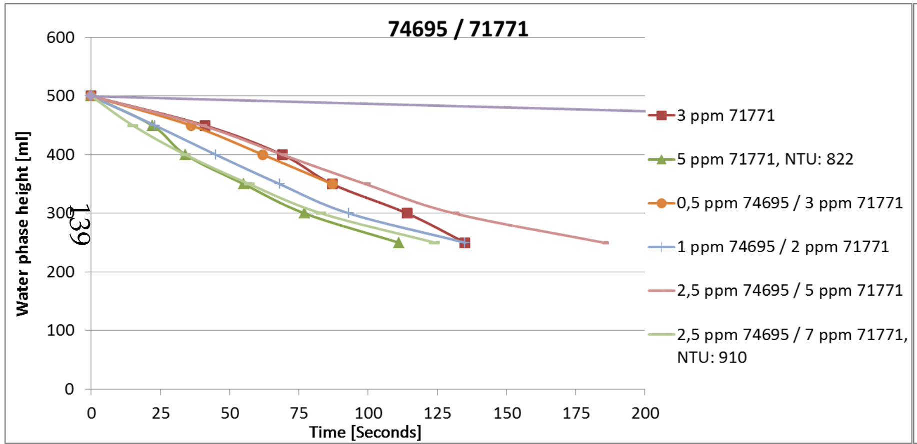
Product:		REF/Blank	Unifloc A 300	Unifloc A 300	Unifloc A 300	Unifloc A 300/Unifloc PDM	Unifloc A 300/Unifloc PDM	Unifloc A 300/Unifloc PDM	Unifloc A 300/Unifloc PDM	Unifloc A 300/Unifloc PDM	Unifloc A 300/Unifloc PDM
Dosage ppm/vol:		0	1 ppm	3 ppm	5 ppm	0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0	0	0	0	0
23,4	450	360	22	13	13	17	14	12	18	3	4
20,8	400	490	45	31	28	36	30	30	35	6	8
18,2	350		70	49	45	57	49	51	54	9	12
15,6	300		98	72	64	80	71	75	74	12	16
13	250		154	118	108	123	106	113	109	15	22
10,4	200										
Turbidity after3 minutes (NTU) :		no reading	no reading	800	828	no reading	531	854	no reading	899	735

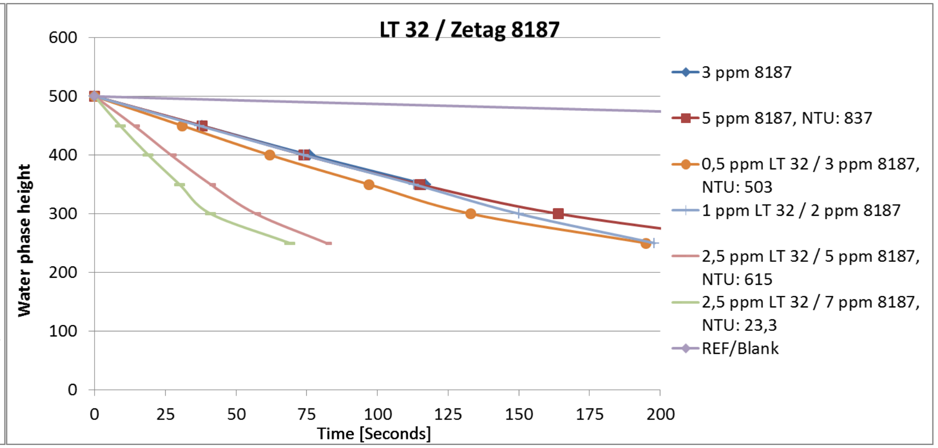




Product:		9916	9916	9916	74695/9916	74695/9916	74695/9916	74695/9916	74695/9916	74695/9916
Dosage ppm/vol:		1 ppm	3 ppm	5 ppm	0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0	0	0	0
23,4	450	no reaction	1,2	44	no reaction	67	46	62	56	52
20,8	400		no reaction	85		no reaction	No reaction	No reaction	115	102
18,2	350			130					173	164
15,6	300			197					241	234
13	250			287					300	329
10,4	200									
Turbidity after3 minutes (NTU) :		no reading	no reading	908	no reading	no reading	no reading	no reading	no reading	883

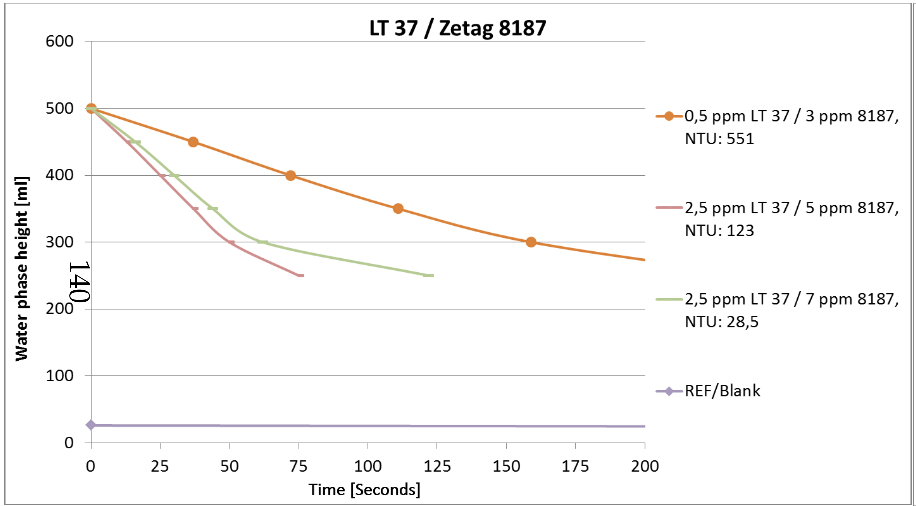
Product:		71771	71771	71771	74695/71771	74695/71771	74695/71771	74695/71771	74695/71771	74695/71771
Dosage ppm/vol:		1 ppm	3 ppm	5 ppm	0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0	0	0	0
23,4	450	no reaction	41	22	no reaction	48	36	23	40	15
20,8	400		69	34		no reaction	62	45	69	34
18,2	350		87	55			87	68	99	57
15,6	300		114	77				93	131	83
13	250		135	111				135	185	124
10,4	200									
Turbidity after3 minutes (NTU) :		no reading	no reading	822	no reading	no reading	no reading	505	no reading	910

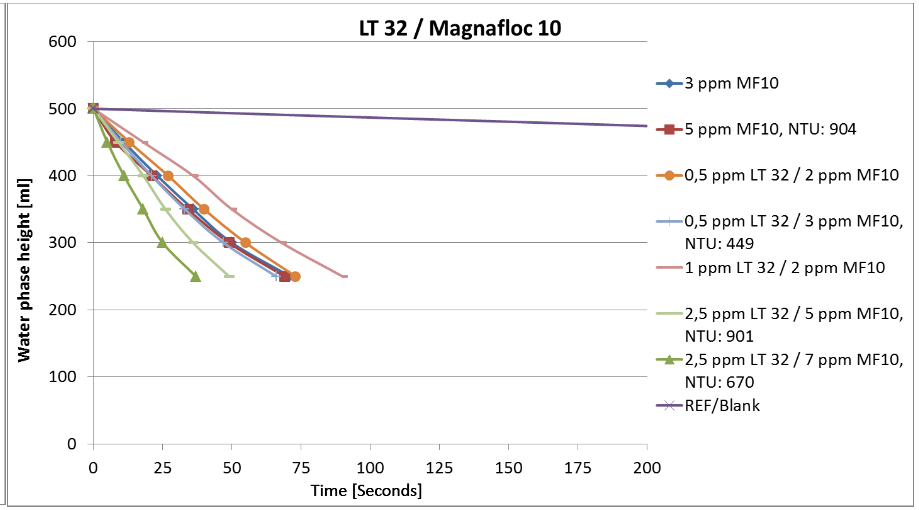




Product:		Zetag 8187	Zetag 8187	Zetag 8187	LT 32/Zetag 8187	LT 32/Zetag 8187	LT 32/Zetag 8187	LT 32/Zetag 8187	LT 32/Zetag 8187	LT 32/Zetag 8187
Dosage ppm/vol:		1 ppm	3 ppm	5 ppm	0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0	0	0	0
23,4	450	61	38	38	81	48	31	37	14	9
20,8	400	no reaction	76	74		93	62	74	27	19
18,2	350		117	115	no reaction	no reaction	97	113	41	30
15,6	300			164			133	150	57	41
13	250			240			195	198	82	69
10,4	200									
Turbidity after3 minutes (NTU) :		no reading	no reading	837	no reading	no reading	503	no reading	615	23,3

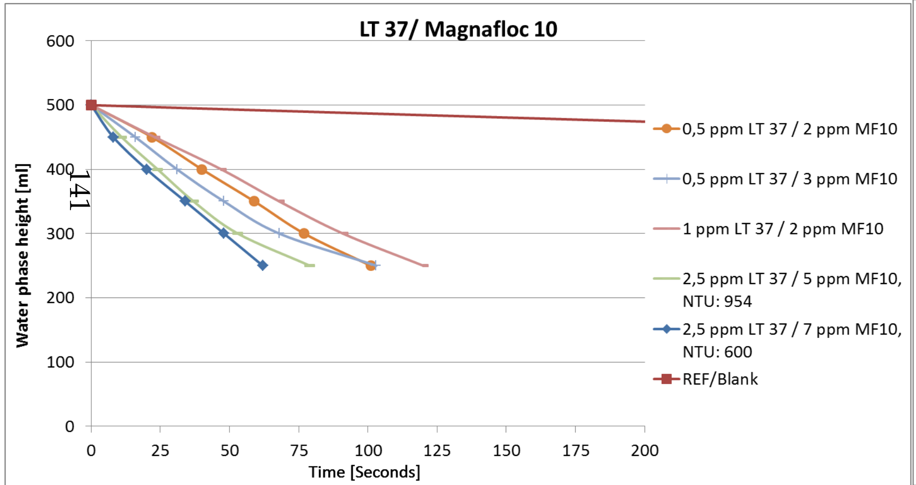
Product:		LT 37/Zetag 8187	LT 37/Zetag 8187	LT 37/Zetag 8187	LT 37/Zetag 8187	LT 37/Zetag 8187	LT 37/Zetag 8187
Dosage ppm/vol:		0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0
23,4	450	76	50	37	49	13	16
20,8	400	no reaction	94	72	95	25	30
18,2	350		no reaction	111	no reaction	37	44
15,6	300			159		50	62
13	250			240		75	122
10,4	200						
Turbidity after3 minutes (NTU) :		no reading	no reading	551	no reading	123	28,5

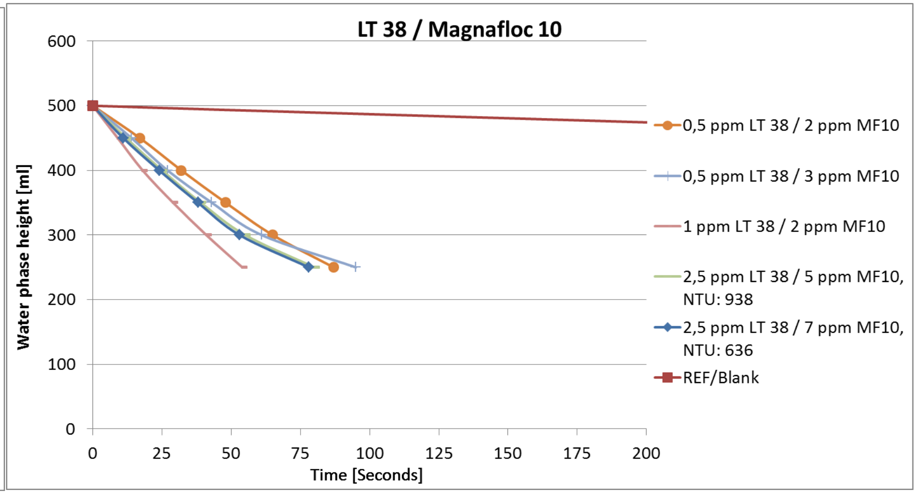




Product:		MF10	MF10	MF10	LT32/MF10	LT32/MF10	LT32/MF10	LT32/MF10	LT32/MF10	LT32/MF10
Dosage ppm/vol:		1 ppm	3 ppm	5 ppm	0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0	0	0	0
23,4	450	52	11	8	58	13	10	18	9	5
20,8	400	no reaction	23	21	no reaction	27	21	36	18	11
18,2	350		36	34		40	33	50	26	18
15,6	300		50	49		55	47	68	36	25
13	250		71	69		73	66	90	49	37
10,4	200									
Turbidity after3 minutes (NTU) :		no reading	no reading	904	no reading	no reading	449	no reading	901	670

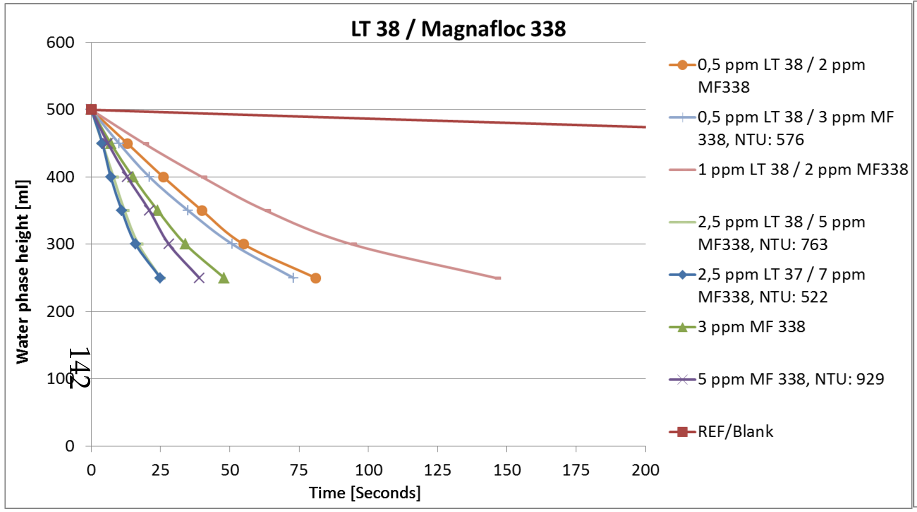
Product:		LT37/MF10	LT37/MF10	LT37/MF10	LT37/MF10	LT37/MF10	LT37/MF10
Dosage ppm/vol:		0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0
23,4	450	58	22	16	23	11	8
20,8	400		40	31	47	24	20
18,2	350		59	48	68	37	34
15,6	300		77	68	91	53	48
13	250		101	103	120	79	62
10,4	200						
Turbidity after3 minutes (NTU) :		no reading	no reading	no reading	no reading	NTU:954	NTU: 600

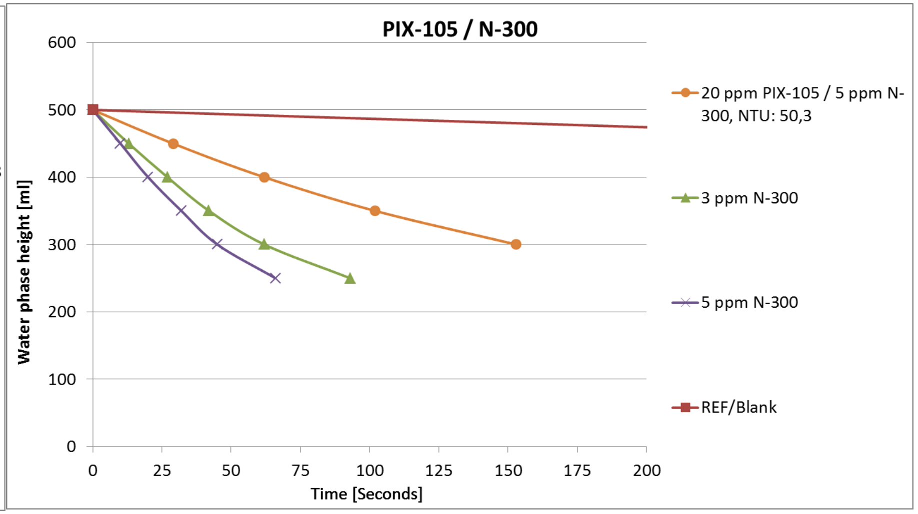




Product:		LT38/MF10	LT38/MF10	LT38/MF10	LT38/MF10	LT38/MF10	LT38/MF10
Dosage ppm/vol:		0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0
23,4	450	44	17	14	9	12	11
20,8	400	no reaction	32	27	18	25	24
18,2	350		48	43	29	39	38
15,6	300		65	61	41	55	53
13	250		87	95	54	80	78
10,4	200						
Turbidity after3 minutes (NTU) :		no reading	no reading	no reading	No reading	938	636

Product:		MF338	MF338	MF338	LT38/MF338	LT38/MF338	LT38/MF338	LT38/MF338	LT38/MF338	LT38/MF338
Dosage ppm/vol:		1 ppm	3 ppm	5 ppm	0,5 ppm/1 ppm	0,5 ppm/2 ppm	0,5 ppm/3 ppm	1 ppm/2ppm	2,5 ppm/5 ppm	2,5 ppm/7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
26	500	0	0	0	0	0	0	0	0	0
23,4	450	43	7	6	23	13	10	19	4	4
20,8	400	no reaction	15	13	42	26	21	40	8	7
18,2	350		24	21		40	35	63	12	11
15,6	300		34	28		55	51	94	17	16
13	250		48	39		81	73	146	25	25
10,4	200									
Turbidity after3 minutes (NTU) :		no reading	no reading	929	no reading	no reading	576	no reading	763	522





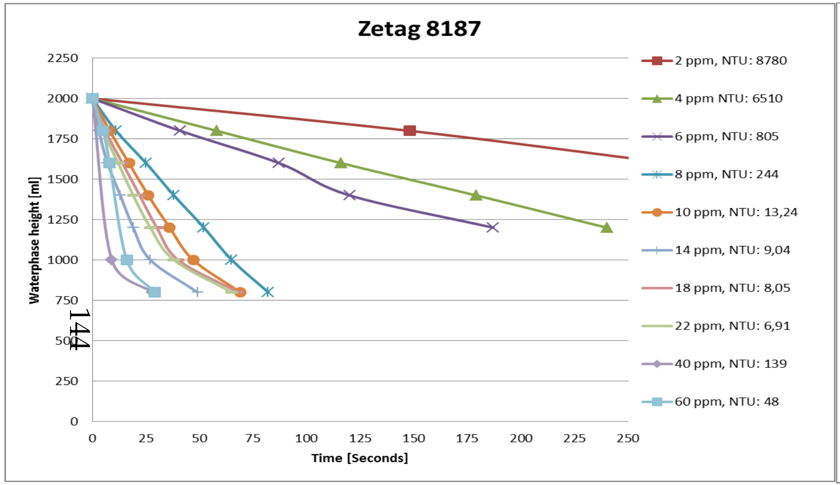
Product:		N-300	N-300	N-300	PIX-105/N-300
Dosage ppm/vol:		1 ppm	3 ppm	5 ppm	20ppm / 5 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec
26	500	0	0	0	0
23,4	450	15	13	10	29
20,8	400	no reaction	27	20	62
18,2	350		42	32	102
15,6	300		62	45	153
13	250		93	66	
10,4	200				
7,8	150				
5,2	100				
2,6	50				
0	0				
Turbidity after3 minutes (NTU) :		no reading	no reading	no reading	50,3

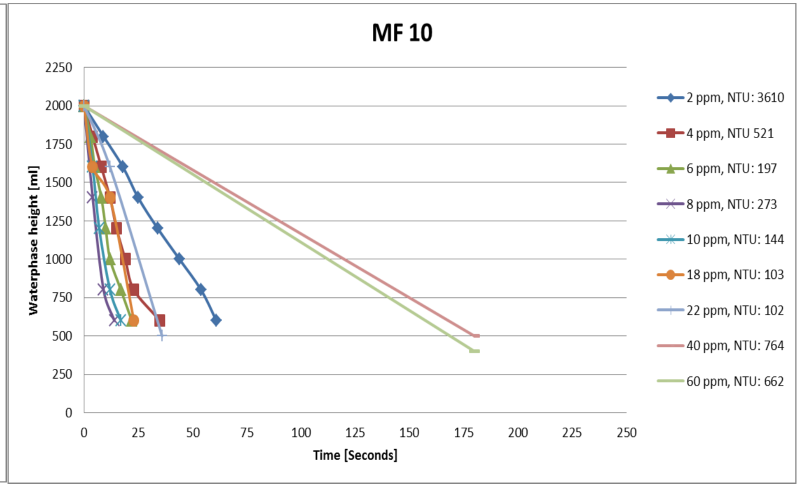
Date:	15.03.2015
Test number:	2. Screening
MF10 feed concentration:	2,1 m^3/h
LT38 feed concentration:	1 L/h
NTU from overflow at thickener:	675
Time:	14:30
Feed on the mill (tons):	600
Status at the facility:	The mine stuggulling with delivrability of rock due to shutdown of a blasting area and problems with OK 01, an excavator.
Mill feeds % of iron magnetite:	23,60
% solids in test sample (weight %):	26,37
pH of sample:	9,0
Tailings flow from the thickener:	19,0
Tailngs density from the thickener	415 m^3/h
Tailngs density from the thickener	446 tons/h

Appendix 6

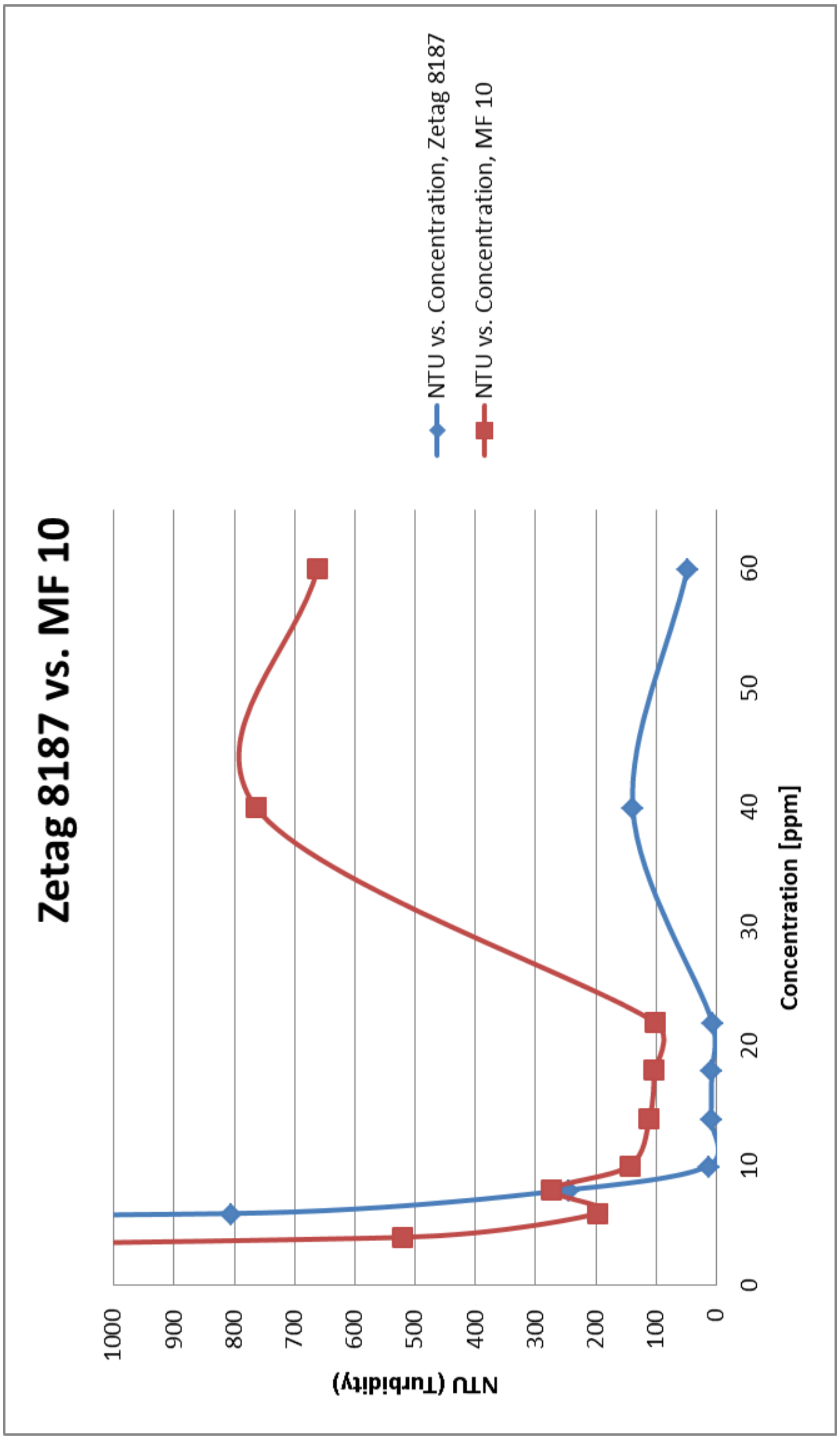
This appendix contains results from the third screening including data, graphs and process data.

Product:		Zetag 8187									
Dosage ppm:		2 ppm	4 ppm	6 ppm	8 ppm	10 ppm	14 ppm	18 ppm	22 ppm	40 ppm	60 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
40	2000	0	0	0	0	0	0	0	0	0	0
36	1800	148	58	41	11	8	3	6	5		5
32	1600	269	116	87	25	17	7	14	12		8
28	1400		179	120	38	26	13	22	19		
24	1200		240	187	52	36	19	30	27		
20	1000				65	47	27	40	38	9	16
16	800				82	69	49	68	65	28	29
12	600										
8	400										
4	200										
0	0										
Settling height after 3 min:		-	-	-	600	590	600	600	610	690	640
Turbidity NTU after 2 min:		8780	6510	805	244	13,24	9,04	8,05	6,91	139	48



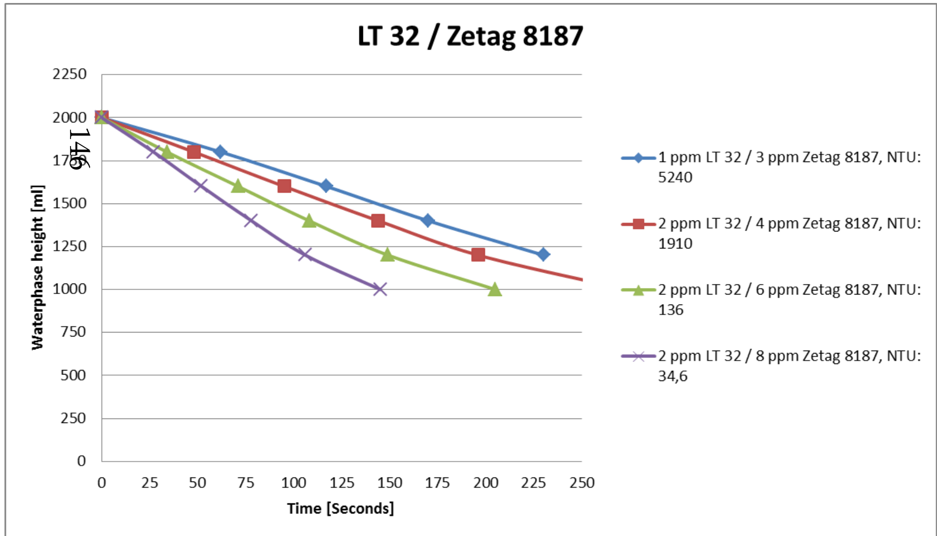


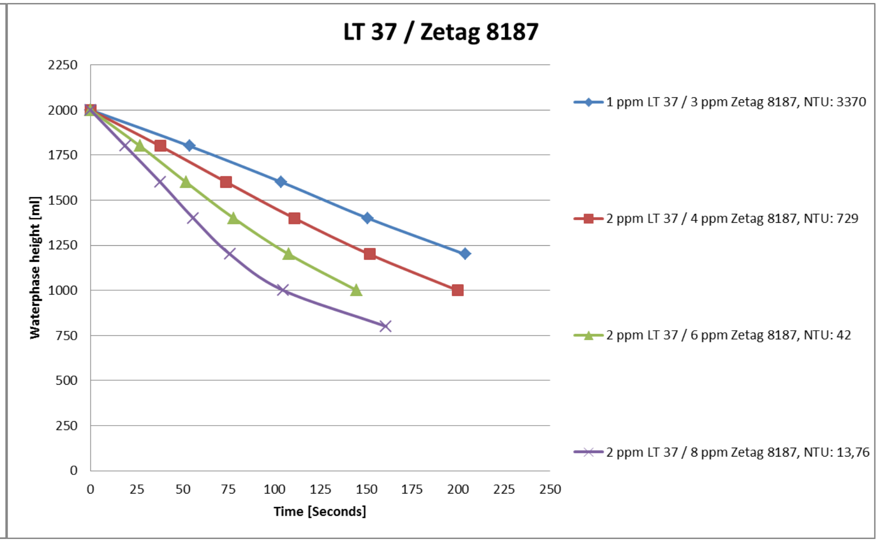
Product:		MF 10									
Dosage ppm:		2 ppm	4 ppm	6 ppm	8 ppm	10 ppm	14 ppm	18 ppm	22 ppm	40 ppm	60 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
40	2000	0	0	0	0	0	0	0	0	0	0
36	1800	9	4	3			3				
32	1600	18	8	5		4		4	12		
28	1400	25	12	8	4		7	12			
24	1200	34	15	10		7					
20	1000	44	19	12			13				
16	800	54	23	17	9	12					
12	600	61	35	22	14	17	20	23			
10	500										180
8	400								36	180	
4	200										
0	0										
Settling height after 3 min:		440	420	420	430	420	430	430	410	500	410
Turbidity NTU after 2 min:		3610	521	197	273	144	111	103	102	764	662


Zetag 8187 vs. MF 10
NTU (Turbidity)
Concentration [ppm]
NTU vs. Concentration, Zetag 8187
NTU vs. Concentration, MF 10
0
100
200
300
400
500
600
700
800
900
1000
0
10
20
30
40
50
60

Product:		LT 32 / Zetag 8187			
Dosage ppm:		1 ppm / 3 ppm	2 ppm / 4 ppm	2 ppm /6 ppm	2 ppm /8 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec
40	2000	0	0	0	0
36	1800	62	48	34	27
32	1600	117	95	71	52
28	1400	170	144	108	78
24	1200	230	196	149	106
20	1000		273	205	145
16	800				
12	600				
8	400				
4	200				
0	0				
Settling height after 3 min:		1380	1300	1090	890
Turbidity NTU after 2 min:		5240	1910	136	34,6

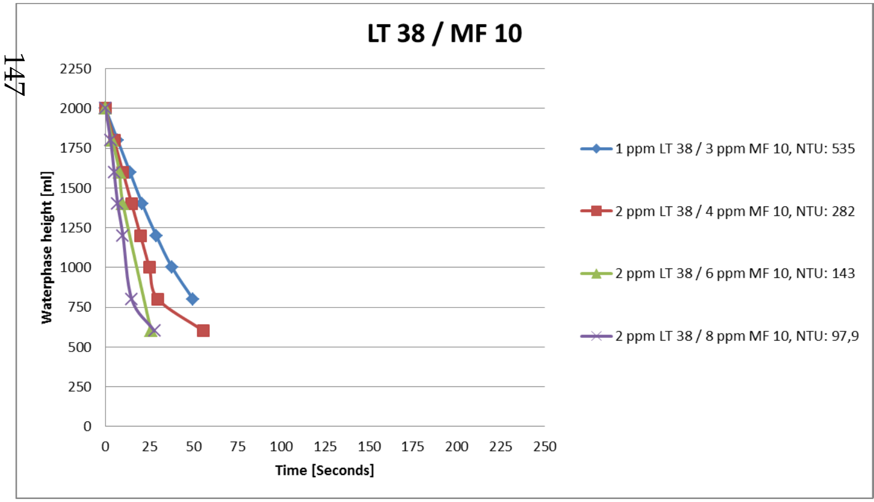
Product:		LT 37 / Zetag 8187			
Dosage ppm:		1 ppm / 3 ppm	2 ppm / 4 ppm	2 ppm /6 ppm	2 ppm /8 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec
40	2000	0	0	0	0
36	1800	54	38	27	19
32	1600	104	74	52	38
28	1400	151	111	78	56
24	1200	204	152	108	76
20	1000		200	145	105
16	800				161
12	600				
8	400				
4	200				
0	0				
Settling height after 3 min:		1290	1090	865	790
Turbidity NTU after 2 min:		3370	729	42	13,76

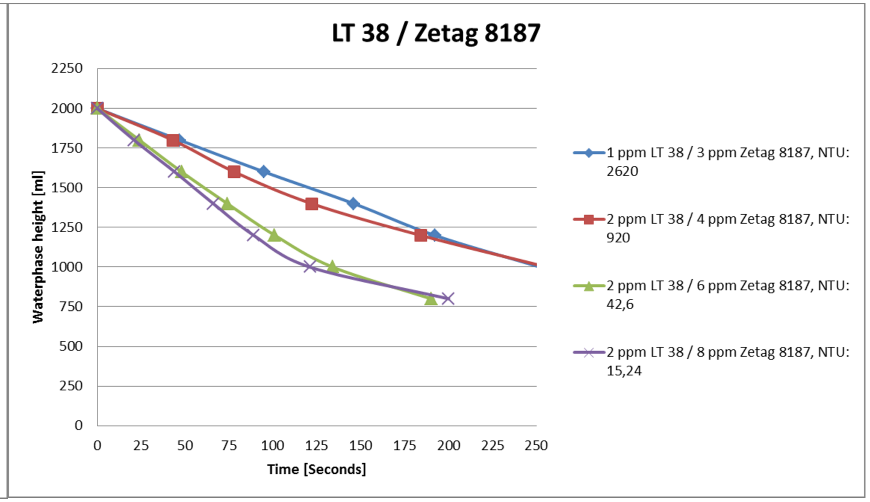




Product:		LT38/MF10			
Dosage ppm:		1 ppm / 3 ppm	2 ppm / 4 ppm	2 ppm /6 ppm	2 ppm /8 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec
40	2000	0	0	0	0
36	1800	7	5	4	3
32	1600	14	10	8	5
28	1400	21	15	10	7
24	1200	29	20		10
20	1000	38	25		
16	800	50	30		15
12	600		56	26	28
8	400				
4	200				
0	0				
Settling height after 3 min:		520	510	440	445
Turbidity NTU after 2 min:		535	282	143	97,9

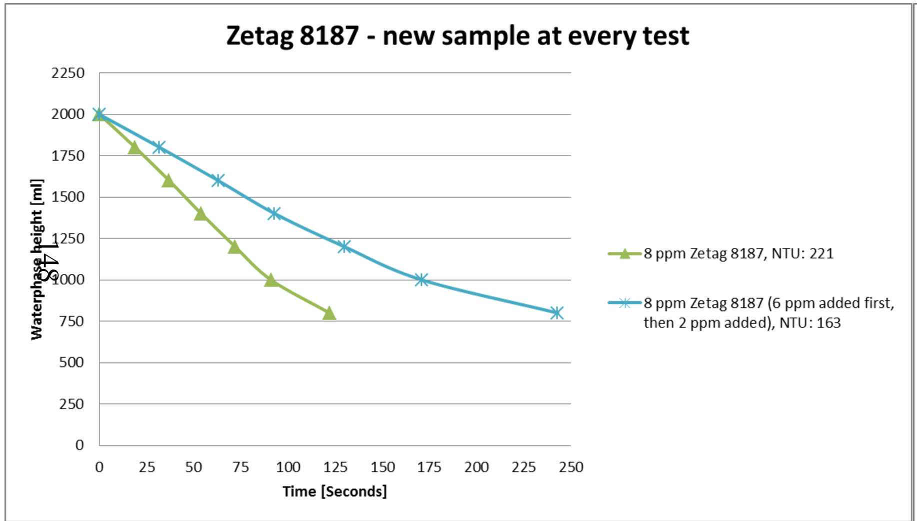
Product:		LT38/8187			
Dosage ppm:		1 ppm / 3 ppm	2 ppm / 4 ppm	2 ppm /6 ppm	2 ppm /8 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec
40	2000	0	0	0	0
36	1800	47	43	24	21
32	1600	95	78	48	44
28	1400	146	122	74	66
24	1200	192	184	101	89
20	1000	252	256	134	121
16	800			190	200
12	600				
8	400				
4	200				
0	0				
Settling height after 3 min:		-	-	820	820
Turbidity NTU after 2 min:		2620	920	42,6	15,24

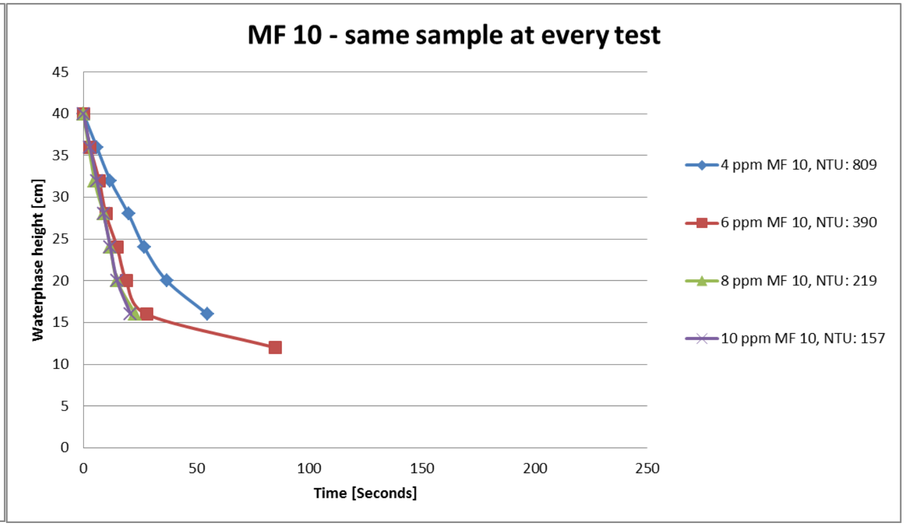




Product:		8187			
Method:		New sample at every test			
Dosage ppm:		4 ppm	6 ppm	8 ppm	10 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec
40	2000	0	0	0	0
36	1800	62	43	19	19
32	1600	115	84	37	36
28	1400	166	127	54	53
24	1200	230	168	72	72
20	1000		220	91	96
16	800			122	149
12	600				
8	400				
4	200				
0	0				
Settling height after 3 min:		-	1160	680	745
Turbidity NTU after 2 min:		6770	2520	221	70,7

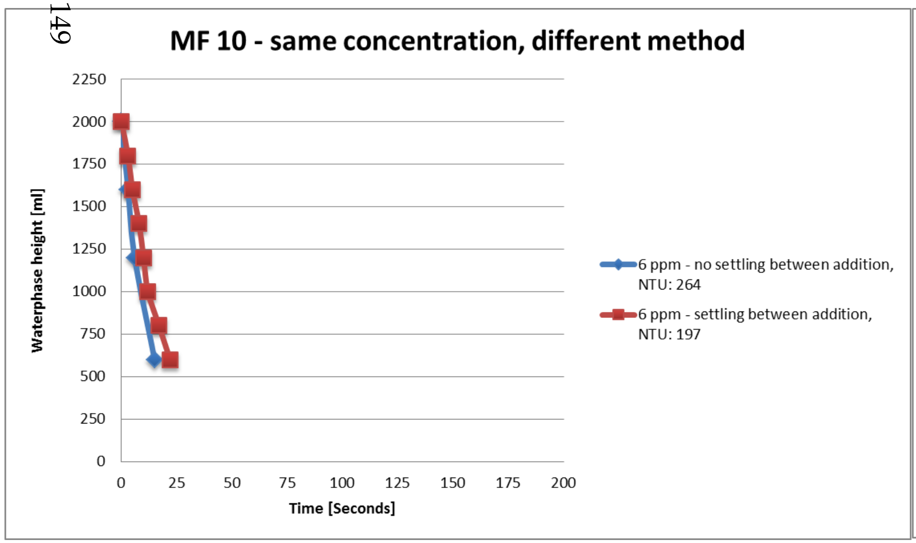
Product:		MF 10			
Method:		Same samle at every test			
Dosage ppm:		4 ppm	6 ppm	8 ppm	10 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec
40	2000	0	0	0	0
36	1800	6	3		3
32	1600	12	7	5	6
28	1400	20	10	9	9
24	1200	27	15	12	12
20	1000	37	19	15	15
16	800	55	28	23	21
12	600		85		
8	400				
4	200				
0	0				
Settling height after 3 min:		580	530	540	520
Turbidity NTU after 2 min:		809	390	219	157

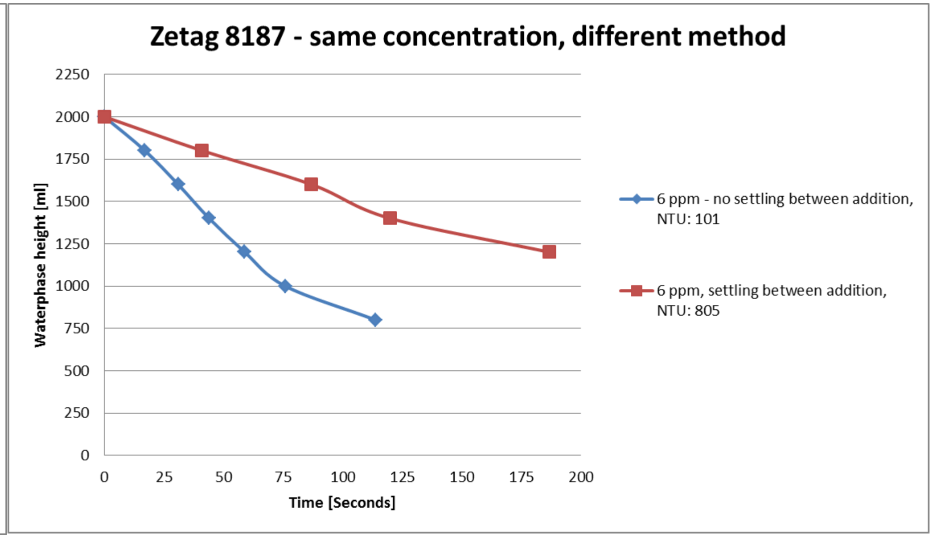




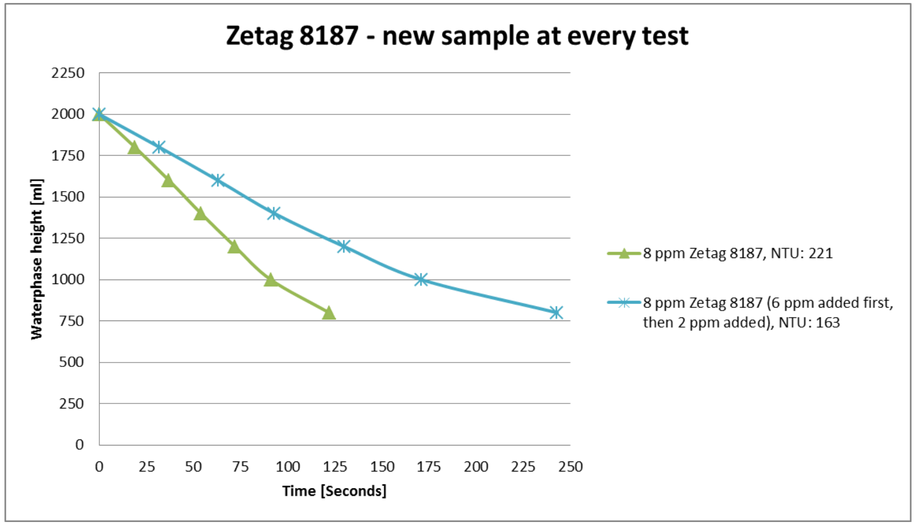
Product:		MF 10	
Dosage ppm:		6 ppm	6 ppm
With settling between dosage:		Yes	No
Distance cm:	Distance ml:	Sec	Sec
40	2000	0	0
36	1800	3	
32	1600	5	3
28	1400	8	
24	1200	10	6
20	1000	12	
16	800	17	
12	600	22	15
8	400		
4	200		
0	0		
Settling height after 3 min:		420	420
Turbidity NTU after 2 min:		197	264

Product:		Zetag 8187	
Dosage ppm:		6 ppm	6 ppm
With settling between dosage:		Yes	No
Distance cm:	Distance ml:	Sec	Sec
40	2000	0	0
36	1800	41	17
32	1600	87	31
28	1400	120	44
24	1200	187	59
20	1000		76
16	800		114
12	600		
8	400		
4	200		
0	0		
Settling height after 3 min:		-	690
Turbidity NTU after 2 min:		805	101





Product:		8187	
Dosage ppm:		8 ppm	6 ppm + 2 ppm
Divided dosage:		No	Yes
Distance cm:	Distance ml:	Sec	Sec
40	2000	0	0
36	1800	19	32
32	1600	37	63
28	1400	54	93
24	1200	72	130
20	1000	91	171
16	800	122	243
12	600		
8	400		
4	200		
0	0		
Settling height after 3 min:		680	-
Turbidity NTU after 2 min:		221	163



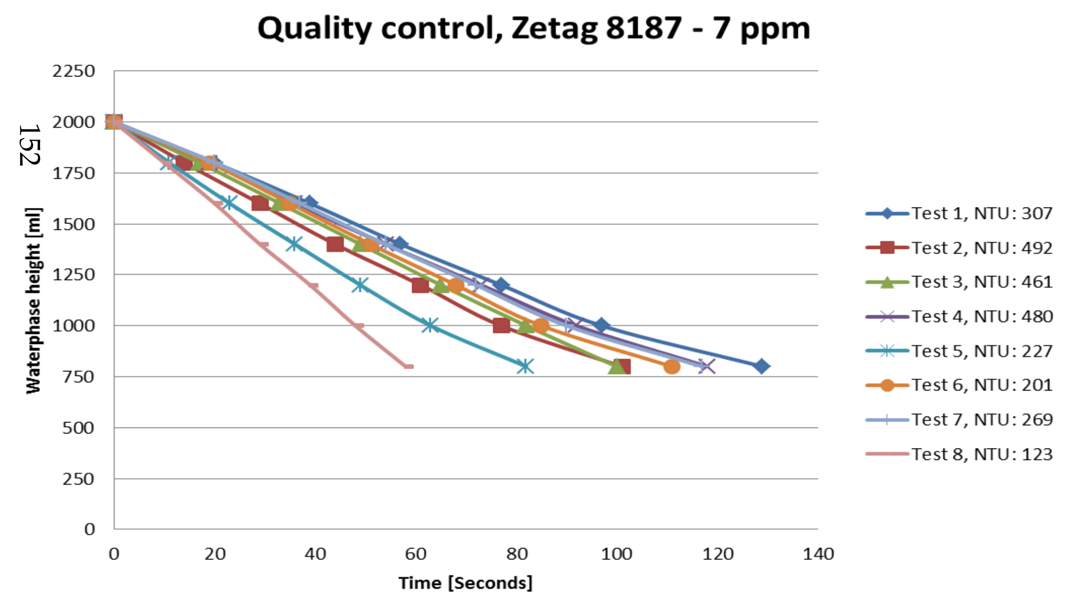
Date:	20.03.2015
Test number:	3. Screening number 1:
MF10 feed concentration:	2,2 m^3/h
LT38 feed concentration:	5 L/h
NTU from overflow at thickener:	650
Time:	17:00
Feed on the mill (tons):	Decreased from 700 to 650
Status at the facility:	Low production due to Bjørnevatn is not able to deliver.
Mill feeds % of iron magnetite:	24,60
% solids in test sample (weight %):	27,13
pH of sample:	8,97
Tailings flow from the thickener:	18,8
Tailngs density from the thickener	440 m^3/h
Tailngs density from the thickener	451 tons/h

Date:	23.03.2015
Test number:	3. Screening number 2:
MF10 feed concentration:	2,3 m^3/h
LT38 feed concentration:	4 L/h
NTU from overflow at thickener:	611
Time:	18:00
Feed on the mill (tons):	600
Status at the facility:	Mill 6 stopped due to grease problems.
Mill feeds % of iron magnetite:	24,20
% solids in test sample (weight %):	22,02
pH of sample:	9,12
Tailings flow from the thickener:	16,9
Tailngs density from the thickener	456 m^3/h
Tailngs density from the thickener	458 tons/h

Appendix 7

This appendix contains the results from the quality control including data, graphs and process data.

Product:		8187							
Dosage ppm:		7 ppm	7 ppm	7 ppm	7 ppm	7 ppm	7 ppm	7 ppm	7 ppm
Distance cm:	Distance ml:	Sec	Sec	Sec	Sec	Sec	Sec	Sec	Sec
40	2000	0	0	0	0	0	0	0	0
36	1800	20	14	17	19	11	19	20	10
32	1600	39	29	33	36	23	35	37	20
28	1400	57	44	49	54	36	51	54	29
24	1200	77	61	65	73	49	68	72	39
20	1000	97	77	82	92	63	85	90	48
16	800	129	101	100	118	82	111	117	58
12	600								
8	400								
4	200								
0	0								
Settling height after 3 min:		690	620	600	660	595	645	660	440
Turbidity NTU after 2 min:		307	492	461	480	227	201	269	123



Date:	19.03.2015
Test number:	**Quality control**
MF10 feed concentration:	2,2 m^3/h
LT38 feed concentration:	4 L/h
NTU from overflow at thickener:	584
Time:	21:00
Feed on the mill (tons):	800
Status at the facility:	Mill 7 have had some down time due to maintenance. Outlet from primary magsep 4 and 5 was clogged so the process water sample was replaced with outled from primary magsep 1 and 2, this is more or less comparable material.
Mill feeds % of iron magnetite:	23,70
% solids in test sample (weight %):	16,93
pH of sample:	9,28
Tailings flow from the thickener:	19,1
Tailngs density from the thickener	407 m^3/h
Tailngs density from the thickener	441 tons/h

Appendix 8

This appendix contains chemical data sheets of the chemicals: Magnafloc 10, Magnafloc LT 38 and Zetag 8187. The chemical data sheets are obtained from the supplier, BASF.

Sikkerhetsdatablad

BTC Europe Sikkerhetsdatablad i henhold til forordning (EF) nr. 1907/2006 med senere endringer.
Dato / oppdatert: 30.10.2014 Utgave: 5.0
Produkt: **Magnafloc® 10**

(ID nr. 50112050/SDS_GEN_NO/NO)
Trykkdato 01.11.2014

PUNKT 1: Identifikasjon av stoffet/stoffblandingen og selskapet/foretaket

1.1. Produktidentifikator

Magnafloc® 10

Produktregistreringsnummer: 160397

1.2. Relevante identifiserte anvendelser for stoffet eller blandingen samt anvendelser som frarådes

Relevante identifiserte anvendelser: flokkuleringsmiddel

1.3. Nærmere opplysninger om leverandøren av sikkerhetsdatabladet

Firma:
BTC Europe GmbH
Rheinpromenade 1
40789 Monheim, Germany

Kontaktadresse:
BTC Europe GmbH
Rheinpromenade 1
40789 Monheim, Germany
Branch:
BTC Europe GmbH
Industriestr. 20
91593 Burgbernheim

Telefon: +49 2173 3347-0
E-mail adresse: btc-productsafety@btc-europe.com

1.4. Nødnummer

Giftinformasjonen +47 22 59 13 00, 24-timers service 7 dager i uken
International emergency number:
Telefon: +49 180 2273-112

PUNKT 2: Fareidentifikasjon

2.1. Klassifisering av stoffet eller blandingen

I henhold til Forordning (EF) Nr. 1272/2008 [CLP]

Produktet er ikke klassifiseringspliktig i henhold til GHS kriteriene.

I henhold til direktiv 67/548/EØF eller 1999/45/EF

Mulige farer:
Kan forårsake en viss øyeirritasjon som bør opphøre etter at produkteter fjernet.
Kan forårsake en viss irritasjon av luftveiene ved innånding av støv.
Ved lengere påvirkning av produktet er hudirritasjoner mulig.
Denne typen produkt har en tendens til å danne støv hvis det håndteres hardhendt. Det brenner ikke lett, men som for så mange organiske pulvere kan det dannes brennbare støvskyer i luft
Svært glatt når det er vått.

2.2. Merkningselementer

Globally Harmonized System, EU (GHS)

Produktet er ikke merkepliktig i henhold til GHS kriteriene.

I henhold til Forordning (EF) Nr. 1272/2008 [CLP]

Fareutløser(e): AKRYLAMID

I henhold til direktiv 67/548/EØF eller 1999/45/EF

Direktiv 1999/45/EØF ('Preparatdirektivet')

Produktet er ikke merkepliktig i hht EU-direktiver.

Produktet har lik klassifisering i Norge som i EU.

Fareutløser(e): AKRYLAMID

2.3. Andre farer

I henhold til Forordning (EF) Nr. 1272/2008 [CLP]

Hvis relevant er det gitt informasjon i denne seksjonen om andre farer, som ikke resulterer i klassifisering, men som kan bidra til de overordnede farene av stoffet eller blandingen.

PUNKT 3: Sammensetning/opplysninger om bestanddeler

3.1. Stoffer

Ikke relevant.

3.2. Blandinger

Kjemisk karakterisering

polyakrylamid, anionisk

PUNKT 4: Førstehjelpstiltak

4.1. Beskrivelse av førstehjelpstiltak

Tilsølte klær fjernes.

Ved innånding:
Ved ubehag etter innånding av støv: friskluft, legehjelp.

Ved hudkontakt:
Vask grundig med såpe og vann.

Ved kontakt med øynene:
Skyll grundig med åpne øyelokk i minst 15 minutter under rennende vann.

Ved svelging:
Skyll munnen og drikk deretter rikelig med vann. Kontroller åndedrett og puls. Plasser offeret i stabilt sideleie, tildekk og holde vedkommende varm. Løsne tettsittende klær som snipp, slips, belte eller bukselinning. Søk medisinsk hjelp. Fremkall aldri brekninger eller gi noe oralt, dersom den tilskadekommende er uten bevissthet eller har krampeanfall.

Ikke fremkall brekninger uten at det er gitt beskjed om dette fra Giftinformasjonssentralen eller av lege.

4.2. Viktigste symptomer og virkninger, både akutte og forsinkede

Symptomer: De viktigste kjente symptomer og effekter er beskrevet i merkingen (se seksjon 2) og/eller i seksjon 11., Andre kjente symptomer og effekter er sålangt ikke kjent.

4.3. Angivelse av om øyeblikkelig legehjelp og spesialbehandling er nødvendig

Behandling: Symptomatisk behandling (dekontaminering, vitalefunksjoner), ingen spesifikk motgift kjent.

PUNKT 5: Brannslokkingstiltak

5.1. Slokkingsmidler

Egnede brannslokningsmidler:
pulver, skum

Av sikkerhetsgrunner uegnede brannslokningsmidler:

vannstråle

Tilleggsinformasjon:
Hvis det brukes vann, holdes fotgjengere og kjøretøy vekk fra områder hvor det er fare for glatt overflate/sklifare.

5.2. Spesielle farer i forbindelse med stoffet eller blandingen

karbonoksider, nitrogenoksider
Nevnte stoffer/stoffgrupper kan frigjøres ved brann. Svært glatt når det er vått.

5.3. Anvisninger for brannmannskap

Særskilt verneutstyr:
Bruk luftforsynt åndedrettsvern.

Andre opplysninger:
Risikoen avhenger av de stoffer som brenner og av brannforholdene. Forurenset slokningsvann må destrueres i overensstemmelse med lokale forskrifter.

PUNKT 6: Tiltak ved utilsiktede utslipp

6.1. Personlige sikkerhetstiltak, personlig verneutstyr og nødprosedyrer

Bruk personlige verneklær.

6.2. Miljøverntiltak

Må ikke slippes ut til kloakksystem/overflatevann/grunnvann.

6.3. Metoder og utstyr for inndemming og opprensning

Ved små mengder: Tas opp med egnet utstyr og destrueres.
Ved store mengder: Tas opp med støvbindende materiale og destrueres.
Produktsøl som blir vått eller sølt vandig løsning utgjør en fare fordi det blir glatt. Unngå støvutvikling.

6.4. Henvisning til andre punkter

Informasjon om eksponeringskontroll/personlig verneutstyr og forhold vedrørende avfallsbehandling finnes i seksjon 8 og 13.

PUNKT 7: Håndtering og lagring

7.1. Forholdsregler for sikker håndtering

Ved omfylling av større mengder uten avtrekksanlegg: bruk åndedrettsvern. Må behandles i henhold til alle forskrifter vedrørende industriell hygiene og sikkerhetstiltak. Med vann dannes sklifarlige belegg.

7.2. Betingelser for sikker oppbevaring, herunder eventuell uforenelighet

Ytterligere informasjoner til lagerbetingelsene: Lagres kjølig og tørt i uåpnet originalemballasje.
Unngå våte eller fuktige forhold, ekstreme temperaturer og antennelseskilder.

Lagerstabilitet:
Unngå ekstrem varme.

7.3. Særlig(e) bruksområde(r)

For de aktuelle identifiserte bruksområdene oppført i seksjon 1 må man ta hensyn til de rådene som er nevnt i seksjon 7.

PUNKT 8: Eksponeringskontroll/personlig beskyttelse

8.1. Kontrolparametre

Komponenter med arbeidsplassrelaterte grenseverdier

Sjenerende støv, respirabelt støv
TLV 10 mg/m3 (Administrative normer), Total støv
TLV 5 mg/m3 (Administrative normer), respirabelt støv
Sjenerende støv, totalstøv
TLV 10 mg/m3 (Administrative normer), Total støv

79-06-1: akrylamid
TLV 0,03 mg/m3 (Administrative normer)
Hudeffekt (Administrative normer)
Stoffet kan opptaes via huden.

8.2. Eksponeringskontroll

Personlig verneutstyr

Åndedrettsvern:
Egnet åndedrettsvern ved lavere konsentrasjoner eller innvirkning over kort tid: Partikkelfilter med middels tilbakeholdelsesevne for faste og væskeformige partikler (f.eks. EN 143 eller 149, type P2 eller FFP2).

Håndbeskyttelse:
Kjemikaliebestandige vernehansker (EN 374)
Egnede materialer også ved langvarig, direkte kontakt (Anbefalt: Beskyttelsesindeks 6, svarende til > 480 minutters gjennomtregningstid etter EN 374):
f.eks. nitrilgummi (0,4 mm), kloroprengummi (0,5 mm), polyvinylklorid (0,7 mm) og andre
Tilleggsnotis: Spesifikasjonene er basert på tester, litteraturdata og informasjon fra hanskeprodusenter eller er utledet fra lignende substanser ved analogiske slutninger. På grunn av mange påvirkningsfaktorer (f.eks. temperatur), må man ta hensyn til at den daglige anvendelsestid for en kjemikaliebeskyttende hansker kan være betydelig kortere enn de permeasjonstider funnet i tester.
På grunn av stort typemangfold skal produsentenes bruksanvisninger følges.

Øyevern:
Vernebriller med sidebeskyttelse (vernebriller) (EN 166)

Verneklær:
lette beskyttelsesklær

Generelle beskyttelses- og hygienetiltak
Må behandles i henhold til alle forskrifter vedrørende industriell hygiene og sikkerhetstiltak. Sørg for skikkelig ventilasjon. Det anbefales å bruke tett arbeidstøy.

PUNKT 9: Fysiske og kjemiske egenskaper

9.1. Opplysninger om grunnleggende fysiske og kjemiske egenskaper

Form:	pulver	
Farge:	off-white	
Lukt:	luktfri	
luktgrense:	Ingen relevant informasjon tilgjengelig.	
pH-verdi:	6 - 8 (10 g/l) Produktet har ikke blitt testet. Utsagnet er avledet fra stoffer/produkter med lignende struktur eller sammensetning.	
Smeltepunkt:	Stoffet / produktet dekomponerer, derfor ikke bestembar.	
Kokepunkt:	ikke anvendelig	
Flammepunkt:	ikke anvendelig	
Fordampningshastighet:	Produktet er et ikke-flyktig fast stoff.	
Antennelighet:	antenner ikke	
Damptrykk:	Produktet er ikke testet.	
Løselighet i vann:	Danne en viskøs løsning.	
Fordelingskoeffisient n-oktanol/vann (log Kow):	Studier er på vitenskapelig bakgrunn ikke nødvendige.	
Selvantennelighet:	ikke selvantennelig	
Viskositet, dynamisk:	25 - 49 mPa.s (0,5 %(m), 25 °C, 300 1/s)	(DIN 53019)
eksplosjonsfare:	ikke eksplosiv	
Brannfremmende egenskaper:	ikke brannfremmende	

9.2. Andre opplysninger

Selvoppvarmingsevne: Dette stoffet har ingen evne til selvoppheting.

Løs vekt: ca. 700 kg/m3

Andre opplysninger:
Om nødvendig er andre fysiske og kjemiske egenskaper angitt i denne seksjonen.

PUNKT 10: Stabilitet og reaktivitet

10.1. Reaktivitet

Ingen farlige reaksjoner om forskrifter/henvisninger for lagring og håntering overholdes.

Korrosjon på metall: Ikke korrosiv overfor metall.

10.2. Kjemisk stabilitet

Produktet er stabilt dersom forksriftene/henvisningene for lagring og håndterking følges.

10.3. Risiko for farlige reaksjoner

Produktet er i levert form ikke støveksplosjonsfarlig men dannelse av fint støv kan føre til støveksplosjon.

10.4. Forhold som skal unngås

Unngå ekstreme temperaturer. Unngå fuktighet.

10.5. Materialer som skal unngås

Stoffer som må unngåes:
sterke syre, sterke baser, sterke oksidasjonsmidler

10.6. Farlige nedbrytingsprodukter

Ingen farlige nedbrytningsprodukter ved forskriftsmessig oppbevaring og håndtering.

PUNKT 11: Toksikologiske opplysninger

11.1. Opplysninger om toksikologiske virkninger

Akutt toksisitet

Eksperimentelle/beregnede data:
LD50 rotte (oral): > 5.000 mg/kg (OECD Guideline 401)

Irritasjon

Eksperimentelle/beregnede data:

Hudetsing/hudirritasjon kanin: ikke irriterende (OECD Guideline 404)

Alvorlig øyeskade/øyeirritasjon kanin: ikke irriterende

Sensibilisering ved innånding/hudsensibilisering

Vurdering av sensibilitet:
Basert på ingrediensene er det ingen mistanke om sensibiliserende virkning.

Kimcellemutagenisitet

Vurdering av mutagenitet:
Basert på ingrediensene er det ingen mistanke om mutagen virkning.

Cancerogenitet

Vurdering av karsinogenitet:
All informasjon som kan vurderes, gir ingen indikasjon på kreftfremkallende virkning.

reproduksjonstoksisitet

Vurdering av reproduksjonstoksisitet:
Basert på ingrediensene er det ingen mistanke om toksikologisk virkning på reproduksjon.

Utviklingstoksisitet

Vurdering av teratogenitet:
Basert på innholdsstoffene er det ingen mistanke om teratogen effekt.

Toksisitet ved gjentatt dosering og spesifikk målorgantoksisitet (gjentatt eksponering)

Vurdering av toksisitet ved gjentatt dose:
Så lenge produktet håndteres på en hensiktsmessig måte og benyttes som foreskrevet, har produktet etter våre erfaringer og informasjoner ingen negativ virkning på helsen. Produktet er ikke testet. Uttalelsene er utledet på grunnlag av enkeltkomponenters egenskaper.

Aspirasjonsfare

Ingen fare forventet ved innånding.

Øvrige informasjoner til toksisitet

Produktet er ikke blitt testet. Opplysningene angående toksikologi er avledet fra produkter med liknende struktur eller sammensetning.

PUNKT 12: Økologiske opplysninger

12.1. Toksisitet

Fisketoksisitet:
LC50 (96 h) > 100 mg/l, Oncorhynchus mykiss (statisk)
(under forhold for metoden "static renewal" i nærvær av huminsyre)

Akvatiske virvelløse dyr:
LC50 (48 h) > 100 mg/l, Daphnia magna

12.2. Persistens og nedbrytbarhet

Vurdering av bionedbrytbarhet og eliminasjon (H_2O):
biologisk ikke lett nedbrytbar (i henhold til OECD-kriterier)

12.3. Bioakkumuleringspotensial

Vurdering bioakkumulasjonspotensial:
På basis av strukturelle egenskaper er polymeren ikke biotilgjengelig. Akkumulering i organismer forventes ikke.

12.4. Mobilitet i jord

Informasjon om: 2-Propenoic acid, sodium salt, polymer with 2-propenamide
Vurdering av transport mellom miljøområder:
Adsorpsjon i jord: Adsorpsjon til faste jordpartikler kan forventes.

12.5. Resultater av PBT- og vPvB-vurdering

I henhold til vedlegg XIII av Forordning (EF) Nr. 1907/2006 om registrering, vurdering, godkjenning og begrensning av kjemikalier (REACH): Produktet inneholder ingen stoffer, som oppfyller PBT-kriteriene (persistent/bioakkumulerende/toksisk) eller vPvB-kriteriene (veldig persistente/veldig bioakkumulerende).

12.6. Andre skadevirkninger

Produktet inneholder ingen stoffer, som er listet opp i vedlegg I i Forordning (EF) Nr. 2037/2000 om stoffer som bryter ned ozonlaget.

12.7. Tilleggsinformasjon

Øvrige økotoksikologiske henvisninger:
Produktet er ikke testet. Opplysningene om økotoksikologi er avledet fra produkter med liknende struktur eller sammensetning.

PUNKT 13: Instrukser ved disponering

13.1. Metoder til avfallsbehandling

Må avfallshåndteres i hht. de lokale bestemmelser, f.eks. i egnet deponi eller egnet forbrenningsanlegg.

Forurenset emballasje:
Emballasje som ikke kan rengjøres, må avfallshåndteres som stoffet.
Ikke kontaminert emballasje kan gå til gjenbruk.

PUNKT 14: Transportopplysninger

Landtransport

ADR

	Ikke farlig gods i henhold til transportforskriftene
FN-nummer:	Ikke relevant.
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.
Transportfareklasse(r):	Ikke relevant.
Emballasjegruppe:	Ikke relevant.
Miljøfarer:	Ikke relevant.
Særlige forsiktighetsregler ved bruk	Ikke kjent.

RID

	Ikke farlig gods i henhold til transportforskriftene
FN-nummer:	Ikke relevant.
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.
Transportfareklasse(r):	Ikke relevant.
Emballasjegruppe:	Ikke relevant.
Miljøfarer:	Ikke relevant.
Særlige forsiktighetsregler ved bruk	Ikke kjent.

Innenriks sjøtransport
ADN

	Ikke farlig gods i henhold til transportforskriftene
FN-nummer:	Ikke relevant.
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.
Transportfareklasse(r):	Ikke relevant.
Emballasjegruppe:	Ikke relevant.
Miljøfarer:	Ikke relevant.
Særlige forsiktighetsregler ved bruk	Ikke kjent.
Transport i tankskip på innlandsvannveier:	Ikke evaluert

Sjøtransport		**Sea transport**	
IMDG		IMDG	
Ikke farlig gods i henhold til transportforskriftene			
FN-nummer:	Ikke relevant.	UN number:	Not applicable
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.	UN proper shipping name:	Not applicable
Transportfareklasse(r):	Ikke relevant.	Transport hazard class(es):	Not applicable
Emballasjegruppe:	Ikke relevant.	Packing group:	Not applicable
Miljøfarer:	Ikke relevant.	Environmental hazards:	Not applicable
Særlige forsiktighetsregler ved bruk	Ikke kjent.	Special precautions for user	None known

Flytransport		**Air transport**	
IATA/ICAO		IATA/ICAO	
Ikke farlig gods i henhold til transportforskriftene			
FN-nummer:	Ikke relevant.	UN number:	Not applicable
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.	UN proper shipping name:	Not applicable
Transportfareklasse(r):	Ikke relevant.	Transport hazard class(es):	Not applicable
Emballasjegruppe:	Ikke relevant.	Packing group:	Not applicable
Miljøfarer:	Ikke relevant.	Environmental hazards:	Not applicable
Særlige forsiktighetsregler ved bruk	Ikke kjent.	Special precautions for user	None known

14.1. FN-nummer
Se tilsvarende oppføringer for "FN-nummer" i de respektive forskrifter i tabellene over.

14.2. FN-forsendelsesbetegnelse (UN proper shipping name)
Se tilsvarende oppføringer for "FN-forsendelsesbetegnelse" i de respektive forskrifter i tabellene over.

14.3. Transportfareklasse(r)
Se tilsvarende oppføringer for "Transportfareklasse(r)" i de respektive forskrifter i tabellene over.

14.4. Emballasjegruppe

Se tilsvarende oppføringer for "Emballasjegruppe" i de respektive forskrifter i tabellene over.

14.5. Miljøfarer

Se tilsvarende oppføringer for "Miljøfarer" i de respektive forskrifter i tabellene over.

14.6. Særlige forsiktighetsregler ved bruk

Se tilsvarende oppføringer for "Særlige forsiktighetsregler ved bruk" i de respektive forskrifter i tabellene over.

14.7. Bulktransport i henhold til vedlegg II i MARPOL 73/78 og IBC-koden

Forordning:	Ikke evaluert
Transport tillatt:	Ikke evaluert
Forurensningsnavn:	Ikke evaluert
Forurensningskategori:	Ikke evaluert
Skipstype:	Ikke evaluert

Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code

Regulation:	Not evaluated
Shipment approved:	Not evaluated
Pollution name:	Not evaluated
Pollution category:	Not evaluated
Ship Type:	Not evaluated

PUNKT 15: Regelverksmessige opplysninger

15.1. Spesielle bestemmelser/spesiell lovgivning for stoffet eller blandingen med hensyn til sikkerhet, helse og miljø

Hvis ytteligere lovgivning er gjeldende, som ikke allerede er oppført andre steder i dette sikkerhetsdatabladet, vil det være beskrevet i dette underpunktet.

FOR 2002-07-16 nr 1139: Forskrift om klassifisering, merking mv. av farlige kjemikalier. (Norge)
Administrative normer for forurensning i arbeidsatmosfære. (Norge)
FOR 2001-04-30 nr 443: Forskrift om vern mot eksponering for kjemikalier på arbeidsplassen (kjemikalieforskriften). (Norge)

PUNKT 16: Andre opplysninger

Vurdering av fareklassene i henhold til UN GHS-kriterium (siste versjon)

Hvis De har spørsmål angående dette sikkerhetsdatablad, dets innhold eller andre produktsikkerhetsrelevante spørsmål, bes de om å skrive til følgende e-mail adresse: btc-productsafety@btc-europe.com

Informasjonen i dette sikkerhetsdatabladet er basert på vår nåværende kunnskap og erfaring, og beskriver produktet kun med hensyn til kravene til sikkerhet. Informasjonen skal ikke anses som en beskrivelse av produktets egenskaper (produktspesifikasjon). En avtalt egenskap eller produktets kvalifikasjon for et konkret applikasjonsformål kan ikke utledes fra våre oppgaver i sikkerhetsdatabladet. Det er ansvaret til mottaker av produktet å observere mulige eiendomsrettigheter samt gjeldende lover og forskrifter.

Loddrette streker i venstre marg henviser til endringer i forhold til foregående versjon.

Sikkerhetsdatablad

BASF Sikkerhetsdatablad i henhold til forordning (EG) Nr. 1907/2006
Dato / oppdatert: 26.01.2012 Utgave: 2.0
Produkt: **MAGNAFLOC® LT38**
(ID nr. 30478997/SDS_GEN_NO/NO)
Trykkdato 27.01.2012

1. Identifikasjon av stoffet/stoffblandingen og selskapet/foretaket

Produktidentifikator

MAGNAFLOC® LT38

Relevante identifiserte anvendelser for stoffet eller blandingen samt anvendelser som frarådes

Relevante identifiserte anvendelser: Koagulant

Nærmere opplysninger om leverandøren av sikkerhetsdatabladet

Firma:
BASF SE
67056 Ludwigshafen
GERMANY

Kontaktadresse:
BASF AS
Postboks 233
1372 Asker
NORWAY

Telefon: +47 66 792-100
E-mail adresse: product-safety-north@basf.com

Nødnummer

Giftinformasjonen +47 22 59 13 00, 24-hour service 7 days a week
International emergency number:
Telefon: +49 180 2273-112

2. Fareidentifikasjon

Merkningselementer

Globally Harmonized System, EU (GHS)

Faresetninger:
H412 Skadelig, med langtidsvirkning, for liv i vann.

Sikkerhetssetninger (forebygging):

P273	Unngå utslipp til miljøet.

Sikkerhetssetninger (disponering):

P501	Innhold/beholder leveres til et sted for skadelig eller spesielt avfall.

I henhold til direktiv 67/548/EØF eller 1999/45/EF

R-setning(er)

R52/53	Skadelig for vannlevende organismer: kan forårsake uønskede langtidsvirkninger i vannmiljøet.

S-setning(er)

S61	Unngå utslipp til miljøet. Se produktdatablad for ytterligere informasjon.

Klassifisering påkrevd i henhold til EU.

Produktet har lik klassifisering i Norge som i EU.

Klassifisering av stoffet eller blandingen

I henhold til Forordning (EF) Nr. 1272/2008 [CLP]

Aquatic Chronic 3

I henhold til direktiv 67/548/EØF eller 1999/45/EF

Mulige farer:
Skadelig for vannlevende organismer: kan forårsake uønskede langtidsvirkninger i vannmiljøet.
Kan forårsake en viss øyeirritasjon som bør opphøre etter at produkteter fjernet.
Ved lengere påvirkning av produktet er hudirritasjoner mulig.
Svært glatt når det er vått.

For klassifiseringer ikke skrevet ut i sin helhet i denne seksjon finnes den fullstendige teksten i seksjon 16.

Andre farer

I henhold til Forordning (EF) Nr. 1272/2008 [CLP]

Hvis relevant er det gitt informasjon i denne seksjonen om andre farer, som ikke resulterer i klassifisering, men som kan bidra til de overordnede farene av stoffet eller blandingen.

3. Sammensetning/opplysninger om bestanddeler

Blandinger

Kjemisk karakterisering

Vandig løsning på basis: homopolymer, kationisk

Vandig løsning på basis: homopolymer, kationisk

Fareutløsere (GHS)
I henhold til Forordning (EF) Nr. 1272/2008

2-Propen-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride, homopolymer

Innhold (W/W): >= 10 % - <= 50 %	Aquatic Chronic 3
CAS-nummer: 26062-79-3	H412

Fareutløsere
i henhold til Direktiv 1999/45/EF

2-Propen-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride, homopolymer
Innhold (W/W): >= 10 % - <= 50 %
CAS-nummer: 26062-79-3
R-setning(er): 52/53

For klassifiseringer ikke skrevet ut i sin helhet i denne seksjon, herunder angivelse av fare, faresymboler, R-setninger, og faresetninger, er hele teksten oppført i seksjon 16.

4. Førstehjelpstiltak

Beskrivelse av førstehjelpstiltak

Tilsølte klær fjernes.

Ved innånding:
Ved ubehag etter innånding av damp/sprøytetåke: Friskluft, legehjelp.

Ved hudkontakt:
Vask grundig med såpe og vann.

Ved kontakt med øynene:
Skyll grundig med åpne øyelokk i minst 15 minutter under rennende vann.

Ved svelging:
Skyll munnen og drikk deretter rikelig med vann.

Ikke fremkall brekninger uten at det er gitt beskjed om dette fra Giftinformasjonssentralen eller av lege.

Viktigste symptomer og virkninger, både akutte og forsinkede

Symptomer: De viktigste kjente symptomer og effekter er beskrevet i merkingen (se seksjon 2) og/eller i seksjon 11., Andre kjente symptomer og effekter er sålangt ikke kjent.

Angivelse av om øyeblikkelig legehjelp og spesialbehandling er nødvendig

Behandling: Symptomatisk behandling (dekontaminering, vitalefunksjoner), ingen spesifikk motgift kjent.

5. Brannslokkingstiltak

Slokkingsmidler

Egnede brannslokningsmidler:
vanntåke, pulver, skum

Tilleggsinformasjon:
Hvis det brukes vann, holdes fotgjengere og kjøretøy vekk fra områder hvor det er fare for glatt overflate/sklifare.

Spesielle farer i forbindelse med stoffet eller blandingen

giftige gasser/damper, karbonoksider, nitrogenoksider
Utvikling/fremkalling av røyk/tåke. Nevnte stoffer/stoffgrupper kan frigjøres ved brann. Unngå utslipp av forurenset vann til jord, avløp og overflatevann. Ta nødvendige forholdsregler for å holde tilbake slukningsvann. Kontaminert slukningsvann og mark behandles i henhold til lokale forskrifter.

Anvisninger for brannmannskap

Særskilt verneutstyr:
Bruk selvforsynt åndedrettsvern og beskyttelsesklær.

Andre opplysninger:
Forurenset slokningsvann må destrueres i overensstemmelse med lokale forskrifter.

6. Tiltak ved utilsiktede utslipp

Stor fare for glatt gulv/sklifare ved tilsøling/lekking av produktet.

Personlige sikkerhetstiltak, personlig verneutstyr og nødprosedyrer

Bruk personlige verneklær.

Miljøverntiltak

Hold tilbake forurenset vann/brannslukningsvann. Må ikke slippes ut til kloakksystem/overflatevann/grunnvann.

Metoder og utstyr for inndemming og opprensning

Ved store mengder: Pumpes bort.
For rester: Tas opp med egnede væskebindende materialer. Materiale som er tatt opp går til forskriftsmessig avfallsbehandling.

Henvisning til andre punkter

Informasjon om eksponeringskontroll/personlig verneutstyr og forhold vedrørende avfallsbehandling finnes i seksjon 8 og 13.

7. Håndtering og lagring

Forholdsregler for sikker håndtering

Ved sakkyndig bruk er ingen spesielle forholdsregler påkrevet.

Brann- og eksplosjonsbeskyttelse:
Ingen spesielle forholdsregler er påkrevet.

Betingelser for sikker oppbevaring, herunder eventuell uforenelighet

Ytterligere informasjoner til lagerbetingelsene: Emballasjen oppbevares godt lukket på et kjølig sted. Unngå ekstreme temperaturer, spesielt frost og kulde

Lagerstabilitet:
Lagringstemperatur: > 0 °C

Unngå frysning.

Særlig(e) bruksområde(r)

For de aktuelle identifiserte bruksområdene oppført i seksjon 1 må man ta hensyn til de rådene som er nevnt i seksjon 7.

8. Eksponeringskontroll/personlig beskyttelse

Kontrolparametre

Komponenter med arbeidsplassrelaterte grenseverdier

Ingen yrkesrelaterte grenseverdier kjent.

Eksponeringskontroll

Personlig verneutstyr

Åndedrettsvern:
Åndedrettsvern ved utilstrekkelig ventilasjon.

Håndbeskyttelse:
Kjemikaliebestandige vernehansker (EN 374)
Egnede materialer også ved langvarig, direkte kontakt (Anbefalt: Beskyttelsesindeks 6, svarende til > 480 minutters gjennomtregningstid etter EN 374):
f.eks. nitrilgummi (0,4 mm), kloroprengummi (0,5 mm), polyvinylklorid (0,7 mm) og andre
Tilleggsnotis: Spesifikasjonene er basert på tester, litteraturdata og informasjon fra hanskeprodusenter eller er utledet fra lignende substanser ved analogiske slutninger. På grunn av mange påvirkningsfaktorer (f.eks. temperatur), må man ta hensyn til at den daglige anvendelsestid for en kjemikaliebeskyttende hansker kan være betydelig kortere enn de permeasjonstider funnet i tester. På grunn av stort typemangfold skal produsentenes bruksanvisninger følges.

Øyevern:
Vernebriller med sidebeskyttelse (vernebriller) (EN 166)

Verneklær:
lette beskyttelsesklær

Generelle beskyttelses- og hygienetiltak

Må behandles i henhold til alle forskrifter vedrørende industriell hygiene og sikkerhetstiltak. Det anbefales å bruke tett arbeidstøy.

9. Fysisk og kjemiske egenskaper

Opplysninger om grunnleggende fysiske og kjemiske egenskaper

Form:	flytende
Farge:	strågul
Lukt:	aminaktig, lett lukt
pH-verdi:	ca. 5,5
Smeltepunkt:	< 0 °C
Kokepunkt:	> 100 °C
Flammepunkt:	
	På grunn av det høye vanninnholdet er måling av flammepunktet ikke nødvendig.
Damptrykk:	ca. 32 mbar (25 °C)
Tetthet:	ca. 1,1 g/cm3 (20 °C)
Løselighet i vann:	blandbar
Viskositet, dynamisk:	8.000 - 13.000 mPa*s (25 °C)
eksplosjonsfare:	ikke eksplosiv

Andre opplysninger

Blandbarhet med vann:
blandbar
Andre opplysninger:
Om nødvendig er andre fysiske og kjemiske egenskaper angitt i denne seksjonen.

10. Stabilitet og reaktivitet

Reaktivitet
Ingen farlige reaksjoner om forskrifter/henvisninger for lagring og håntering overholdes.

Kjemisk stabilitet
Produktet er stabilt dersom forksriftene/henvisningene for lagring og håndterking følges.

Peroksyder: 0 %
Produktet inneholder ingen peroksyder.

Risiko for farlige reaksjoner
Ingen farlige nedbrytningsprodukter ved forskriftsmessig oppbevaring og håndtering.

Forhold som skal unngås
Unngå temperaturoverskridelser. Unngå frysning.

Materialer som skal unngås

Stoffer som må unngåes:
sterke syre, sterke baser, sterke oksidasjonsmidler

Farlige nedbrytingsprodukter

Ingen farlige nedbrytningsprodukter ved forskriftsmessig oppbevaring og håndtering.

11. Toksikologiske opplysninger

Opplysninger om toksikologiske virkninger

Akutt toksisitet

Eksperimentelle/beregnede data:
LD50 rotte (oral): > 5.000 mg/kg

Irritasjon

Eksperimentelle/beregnede data:
Hudetsing/hudirritasjon kanin: ikke irriterende (OECD Guideline 404)

Alvorlig øyeskade/øyeirritasjon kanin: ikke irriterende (OECD Guideline 405)

Øvrige informasjoner til toksisitet

Produktet er ikke blitt testet. Opplysningene angående toksikologi er avledet fra produkter med liknende struktur eller sammensetning.

12. Økologiske opplysninger

Toksisitet

Vurdering av akvatisk toksisitet:
Akutt skadelig for vannorganismer. Kan forårsake uønskede langtidsvirkninger i vannmiljøet.
Produktet er ikke testet. Opplysningene er avledet fra produkter med lignende struktur eller sammensetning.

Fisketoksisitet:
LC50 (96 h) 10 - 100 mg/l

Akvatiske virvelløse dyr:
EC50 (48 h) 10 - 100 mg/l, Daphnia magna

Persistens og nedbrytbarhet

Opplysninger om eliminerbarhet:
biologisk ikke lett nedbrytbar (i henhold til OECD-kriterier)

Bioakkumuleringspotensial

Bioakkumuleringspotensiale:
På basis av strukturelle egenskaper er polymeren ikke biotilgjengelig. Akkumulering i organismer forventes ikke.

Mobilitet i jord (og andre delområder hvis tilgjengelige)

Informasjon om: 2-Propen-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride, homopolymer
Vurdering av transport mellom miljøområder:
Adsorpsjon til faste jordpartikler kan forventes.

Resultater av PBT- og vPvB-vurdering

I henhold til vedlegg XIII av Forordning (EF) Nr. 1907/2006 om registrering, vurdering, godkjenning og begrensning av kjemikalier (REACH): Produktet inneholder ingen stoffer, som oppfyller PBT-kriteriene (persistent/bioakkumulerende/toksisk) eller vPvB-kriteriene (veldig persistente/veldig bioakkumulerende).

13. Instrukser ved disponering

Metoder til avfallsbehandling

Må avfallshåndteres i hht. de lokale bestemmelser, f.eks. i egnet deponi eller egnet forbrenningsanlegg.

Forurenset emballasje:
Ikke kontaminert emballasje kan gå til gjenbruk.
Emballasje som ikke kan rengjøres, må avfallshåndteres som stoffet.

14. Transportopplysninger

Landtransport

ADR

Ikke farlig gods i henhold til transportforskriftene

RID

Ikke farlig gods i henhold til transportforskriftene

Innenriks sjøtransport
ADN

Ikke farlig gods i henhold til transportforskriftene

Sjøtransport
IMDG
Ikke farlig gods i henhold til transportforskriftene

Sea transport
IMDG
Not classified as a dangerous good under transport regulations

Flytransport
IATA/ICAO
Ikke farlig gods i henhold til transportforskriftene

Air transport
IATA/ICAO
Not classified as a dangerous good under transport regulations

15. Regelverksmessige opplysninger

Spesielle bestemmelser/spesiell lovgivning for stoffet eller blandingen med hensyn til sikkerhet, helse og miljø

Hvis ytteligere lovgivning er gjeldende, som ikke allerede er oppført andre steder i dette sikkerhetsdatabladet, vil det være beskrevet i dette underpunktet.

FOR 2002-07-16 nr 1139: Forskrift om klassifisering, merking mv. av farlige kjemikalier. (Norge)
Administrative normer for forurensning i arbeidsatmosfære. (Norge)
FOR 2004-06-01 nr 930: Forskrift om gjenvinning og behandling av avfall (avfallsforskriften). (Norge)
FOR 2001-04-30 nr 443: Forskrift om vern mot eksponering for kjemikalier på arbeidsplassen (kjemikalieforskriften). (Norge)

Kjemikaliesikkerhetsvurdering

Kjemisk sikkerhetsvurdering ennå ikke utført på grunn av registreringsfrister

16. Andre opplysninger

Grunnet sammenslåingen av CIBA og BASF gruppen er alle sikkerhetsdatablader blitt revurdert på basis av konsolidert informasjon. Dette kan ha resultert i endringer i databladene. I tilfelle av spørsmål til slike endringer så kontakt oss vennligst via den adresse som er nevnt i seksjon 1.

Full tekst av klassifiseringene, inkludert angivelse av fare, faresymboler, R-setninger, og faresetninger dersom nevnt i seksjon 2 eller 3:

52/53	Skadelig for vannlevende organismer: kan forårsake uønskede langtidsvirkninger i vannmiljøet.
Aquatic Chronic	Farlig for vannmiljøet - kronisk
H412	Skadelig, med langtidsvirkning, for liv i vann.

Hvis De har spørsmål angående dette sikkerhetsdatablad, dets innhold eller andre produktsikkerhetsrelevante spørsmål, bes de om å skrive til følgende e-mail adresse:
product-safety-north@basf.com

Informasjonen i dette sikkerhetsdatabladet er basert på vår nåværende kunnskap og erfaring, og beskriver produktet kun med hensyn til kravene til sikkerhet. Informasjonen skal ikke anses som en beskrivelse av produktets egenskaper (produktspesifikasjon). En avtalt egenskap eller produktets kvalifikasjon for et konkret applikasjonsformål kan ikke utledes fra våre oppgaver i sikkerhetsdatabladet. Det er ansvaret til mottaker av produktet å observere mulige eiendomsrettigheter samt gjeldende lover og forskrifter.

Loddrette streker i venstre marg henviser til endringer i forhold til foregående versjon.

Sikkerhetsdatablad

BASF Sikkerhetsdatablad i henhold til forordning (EF) nr. 1907/2006 med senere endringer.
Dato / oppdatert: 12.11.2014 Utgave: 2.0
Produkt: **Zetag® 8187**

(ID nr. 30570106/SDS_GEN_NO/NO)
Trykkdato 13.11.2014

PUNKT 1: Identifikasjon av stoffet/stoffblandingen og selskapet/foretaket

1.1. Produktidentifikator

Zetag® 8187

1.2. Relevante identifiserte anvendelser for stoffet eller blandingen samt anvendelser som frarådes

Relevante identifiserte anvendelser: flokkuleringsmiddel

1.3. Nærmere opplysninger om leverandøren av sikkerhetsdatabladet

Firma:	Kontaktadresse:
BASF SE	BASF AS
67056 Ludwigshafen	Postboks 233
GERMANY	1372 Asker
	NORWAY

Telefon: +47 66 792-100
E-mail adresse: product-safety-north@basf.com

1.4. Nødnummer

Giftinformasjonen +47 22 59 13 00, 24-timers service 7 dager i uken
International emergency number:
Telefon: +49 180 2273-112

PUNKT 2: Fareidentifikasjon

2.1. Klassifisering av stoffet eller blandingen

I henhold til Forordning (EF) Nr. 1272/2008 [CLP]

Produktet er ikke klassifiseringspliktig i henhold til GHS kriteriene.

I henhold til direktiv 67/548/EØF eller 1999/45/EF

Mulige farer:
Kan forårsake en viss øyeirritasjon som bør opphøre etter at produkteter fjernet.
Kan forårsake en viss irritasjon av luftveiene ved innånding av støv.
Ved lengere påvirkning av produktet er hudirritasjoner mulig.
Denne typen produkt har en tendens til å danne støv hvis det håndteres hardhendt. Det brenner ikke lett, men som for så mange organiske pulvere kan det dannes brennbare støvskyer i luft
Svært glatt når det er vått.
Lav akutt LC50/EC50 for akvatiske organismer, men forårsaker ikke langsiktige skadevirkninger på det akvatiske miljøet. Se avsnitt 12 for nærmere informasjon.
Produktet er under bestemte forhold støveksplosjonsfarlig.

2.2. Merkningselementer

Globally Harmonized System, EU (GHS)

Produktet er ikke merkepliktig i henhold til GHS kriteriene.

I henhold til direktiv 67/548/EØF eller 1999/45/EF

Direktiv 1999/45/EØF ('Preparatdirektivet')

Produktet er ikke merkepliktig i hht EU-direktiver.

Produktet har lik klassifisering i Norge som i EU.

2.3. Andre farer

I henhold til Forordning (EF) Nr. 1272/2008 [CLP]

Hvis relevant er det gitt informasjon i denne seksjonen om andre farer, som ikke resulterer i klassifisering, men som kan bidra til de overordnede farene av stoffet eller blandingen.

PUNKT 3: Sammensetning/opplysninger om bestanddeler

3.1. Stoffer

Ikke relevant.

3.2. Blandinger

Kjemisk karakterisering

polyakrylamid

kationisk

Fareutløsere (GHS)
I henhold til Forordning (EF) Nr. 1272/2008

adipinsyre

Innhold (W/W): >= 2 % - <= 6 % CAS-nummer: 124-04-9 EG-nummer: 204-673-3 REACH registreringsnummer: 01-2119457561-38 Indeks-nummer: 607-144-00-9	Eye Dam./Irrit. 2 H319 Avvikende klassifisering i henhold til aktuelle kunnskaper og kriteriene i bilag I til forordning (EF) nr. 1272/2008 Eye Dam./Irrit. 1 H318

Fareutløsere
i henhold til Direktiv 1999/45/EF

adipinsyre

Innhold (W/W): >= 2 % - <= 6 %
CAS-nummer: 124-04-9
EG-nummer: 204-673-3
REACH registreringsnummer: 01-2119457561-38
Indeks-nummer: 607-144-00-9
Faresymbol(er): Xi
R-setning(er): 36

For klassifiseringer ikke skrevet ut i sin helhet i denne seksjon, herunder angivelse av fare, faresymboler, R-setninger, og faresetninger, er hele teksten oppført i seksjon 16.

PUNKT 4: Førstehjelpstiltak

4.1. Beskrivelse av førstehjelpstiltak

Tilsølte klær fjernes.

Ved innånding:
Ved ubehag etter innånding av støv: friskluft, legehjelp.

Ved hudkontakt:
Vask grundig med såpe og vann.

Ved kontakt med øynene:
Skyll grundig med åpne øyelokk i minst 15 minutter under rennende vann.

Ved svelging:
Skyll munnen og drikk deretter rikelig med vann. Kontroller åndedrett og puls. Plasser offeret i stabilt sideleie, tildekk og holde vedkommende varm. Løsne tettsittende klær som snipp, slips, belte eller

bukselinning. Søk medisinsk hjelp. Fremkall aldri brekninger eller gi noe oralt, dersom den tilskadekommende er uten bevissthet eller har krampeanfall.

Ikke fremkall brekninger uten at det er gitt beskjed om dette fra Giftinformasjonssentralen eller av lege.

4.2. Viktigste symptomer og virkninger, både akutte og forsinkede

Symptomer: Ingen betydelige symptomer er forventet på bakgrunn av at produktet ikke er klassifiseringspliktig.

Farer: Ingen fare er forventet under tiltenkt bruk og riktig håndtering.

4.3. Angivelse av om øyeblikkelig legehjelp og spesialbehandling er nødvendig

Behandling: Symptomatisk behandling (dekontaminering, vitalefunksjoner), ingen spesifikk motgift kjent.

PUNKT 5: Brannslokkingstiltak

5.1. Slokkingsmidler

Egnede brannslokningsmidler:
pulver, skum

Av sikkerhetsgrunner uegnede brannslokningsmidler:
vannstråle, karbondioksid

Tilleggsinformasjon:
Hvis det brukes vann, holdes fotgjengere og kjøretøy vekk fra områder hvor det er fare for glatt overflate/sklifare.

5.2. Spesielle farer i forbindelse med stoffet eller blandingen

karbonoksider, nitrogenoksider
Nevnte stoffer/stoffgrupper kan frigjøres ved brann. Svært glatt når det er vått.

5.3. Anvisninger for brannmannskap

Særskilt verneutstyr:
Bruk luftforsynt åndedrettsvern.

Andre opplysninger:
Risikoen avhenger av de stoffer som brenner og av brannforholdene. Forurenset slokningsvann må destrueres i overensstemmelse med lokale forskrifter.

PUNKT 6: Tiltak ved utilsiktede utslipp

6.1. Personlige sikkerhetstiltak, personlig verneutstyr og nødprosedyrer

Bruk personlige verneklær.

6.2. Miljøverntiltak
Må ikke slippes ut til kloakksystem/overflatevann/grunnvann.

6.3. Metoder og utstyr for inndemming og opprensning
Ved små mengder: Tas opp med egnet utstyr og destrueres.
Ved store mengder: Tas opp med støvbindende materiale og destrueres.
Produktsøl som blir vått eller sølt vandig løsning utgjør en fare fordi det blir glatt. Unngå støvutvikling.

6.4. Henvisning til andre punkter
Informasjon om eksponeringskontroll/personlig verneutstyr og forhold vedrørende avfallsbehandling finnes i seksjon 8 og 13.

PUNKT 7: Håndtering og lagring

7.1. Forholdsregler for sikker håndtering
Ved omfylling av større mengder uten avtrekksanlegg: bruk åndedrettsvern. Må behandles i henhold til alle forskrifter vedrørende industriell hygiene og sikkerhetstiltak. Med vann dannes sklifarlige belegg.

7.2. Betingelser for sikker oppbevaring, herunder eventuell uforenelighet
Produktet i uskadet emballasje behøver ikke lagres separat.
Ytterligere informasjoner til lagerbetingelsene: Lagres kjølig og tørt i uåpnet originalemballasje. Unngå våte eller fuktige forhold, ekstreme temperaturer og antennelseskilder.

Lagerstabilitet:
Unngå ekstrem varme.

Beskyttes mot temperaturer under -20 °C
Beskyttes mot temperaturer over 50 °C

7.3. Særlig(e) bruksområde(r)
For de aktuelle identifiserte bruksområdene oppført i seksjon 1 må man ta hensyn til de rådene som er nevnt i seksjon 7.

PUNKT 8: Eksponeringskontroll/personlig beskyttelse

8.1. Kontrolparametre

Komponenter med arbeidsplassrelaterte grenseverdier

Sjenerende støv, respirabelt støv
TLV 10 mg/m3 (Administrative normer), Total støv
TLV 5 mg/m3 (Administrative normer), respirabelt støv
Sjenerende støv, totalstøv
TLV 10 mg/m3 (Administrative normer), Total støv

79-06-1: akrylamid
TLV 0,03 mg/m3 (Administrative normer)
Hudeffekt (Administrative normer)
Stoffet kan opptaes via huden.

8.2. Eksponeringskontroll

Personlig verneutstyr

Åndedrettsvern:
Egnet åndedrettsvern ved lavere konsentrasjoner eller innvirkning over kort tid: Partikkelfilter med middels tilbakeholdelsesevne for faste og væskeformige partikler (f.eks. EN 143 eller 149, type P2 eller FFP2).

Håndbeskyttelse:
Kjemikaliebestandige vernehansker (EN 374)
Egnede materialer også ved langvarig, direkte kontakt (Anbefalt: Beskyttelsesindeks 6, svarende til > 480 minutters gjennomtregningstid etter EN 374):
f.eks. nitrilgummi (0,4 mm), kloroprengummi (0,5 mm), polyvinylklorid (0,7 mm) og andre
Tilleggsnotis: Spesifikasjonene er basert på tester, litteraturdata og informasjon fra hanskeprodusenter eller er utledet fra lignende substanser ved analogiske slutninger. På grunn av mange påvirkningsfaktorer (f.eks. temperatur), må man ta hensyn til at den daglige anvendelsestid for en kjemikaliebeskyttende hansker kan være betydelig kortere enn de permeasjonstider funnet i tester.
På grunn av stort typemangfold skal produsentenes bruksanvisninger følges.

Øyevern:
Vernebriller med sidebeskyttelse (vernebriller) (EN 166)

Verneklær:
lette beskyttelsesklær

Generelle beskyttelses- og hygienetiltak
Må behandles i henhold til alle forskrifter vedrørende industriell hygiene og sikkerhetstiltak. Sørg for skikkelig ventilasjon. Det anbefales å bruke tett arbeidstøy. Ikke spis, drikk, røyk eller bruk snus under arbeid.

PUNKT 9: Fysiske og kjemiske egenskaper

9.1. Opplysninger om grunnleggende fysiske og kjemiske egenskaper

Form:	amorft pulver
Farge:	off-white
Lukt:	nesten luktfri
luktgrense:	Ingen relevant informasjon tilgjengelig.

pH-verdi: 4,6
(1 %(m), 25 °C)
Smeltepunkt: > 250 °C (kapillærrørmetode)
Kokepunkt:
ikke anvendelig
Flammepunkt:
ikke anvendelig
Fordampningshastighet:
Produktet er et ikke-flyktig fast stoff.
Antennelighet: ikke lett antennelig
Nedre eksplosjonsgrense:
For faste stoffer, ikke relevant for klassifisering og merking.
Øvre eksplosjonsgrense:
For faste stoffer, ikke relevant for klassifisering og merking.
Damptrykk:
Produktet er ikke testet.
Løselighet i vann: lett løselig
> 10 g/l
Løslighet (kvalitativt) løsemiddel: polare løsemidler
løselig
Fordelingskoeffisient n-oktanol/vann (log Kow):
Studier er på vitenskapelig bakgrunn ikke nødvendige.
Selvantennelighet: ikke selvantennelig

Termisk nedbrytning: Ingen nedbryting, om forskrifter/henvisninger vedr. lagring og håntering overholdes.
Viskositet, dynamisk:
ikke bestemt
eksplosjonsfare: ikke eksplosiv
Brannfremmende egenskaper: ikke brannfremmende

9.2. Andre opplysninger

Selvoppvarmingsevne: Dette stoffet har ingen evne til selvoppheting.

Løs vekt: 700 kg/m3
Hygroskopi: hygroskopisk
Andre opplysninger:
Om nødvendig er andre fysiske og kjemiske egenskaper angitt i denne seksjonen.

PUNKT 10: Stabilitet og reaktivitet

10.1. Reaktivitet
Ingen farlige reaksjoner om forskrifter/henvisninger for lagring og håntering overholdes.

Korrosjon på metall: Ikke korrosiv overfor metall.

10.2. Kjemisk stabilitet

Produktet er stabilt dersom forksriftene/henvisningene for lagring og håndterking følges.

10.3. Risiko for farlige reaksjoner

Produktet er i levert form ikke støveksplosjonsfarlig men dannelse av fint støv kan føre til støveksplosjon.

10.4. Forhold som skal unngås

Unngå ekstreme temperaturer. Unngå fuktighet.

10.5. Materialer som skal unngås

Stoffer som må unngåes:
sterke syre, sterke baser, sterke oksidasjonsmidler

10.6. Farlige nedbrytingsprodukter

Ingen farlige nedbrytningsprodukter ved forskriftsmessig oppbevaring og håndtering.

PUNKT 11: Toksikologiske opplysninger

11.1. Opplysninger om toksikologiske virkninger

Akutt toksisitet

Eksperimentelle/beregnede data:
LD50 rotte (oral): > 5.000 mg/kg (OECD Guideline 401)

Irritasjon

Eksperimentelle/beregnede data:
Hudetsing/hudirritasjon kanin: ikke irriterende (OECD Guideline 404)

Alvorlig øyeskade/øyeirritasjon kanin: ikke irriterende

Sensibilisering ved innånding/hudsensibilisering

Vurdering av sensibilitet:
Basert på ingrediensene er det ingen mistanke om sensibiliserende virkning.

Kimcellemutagenisitet

Vurdering av mutagenitet:
Basert på ingrediensene er det ingen mistanke om mutagen virkning.

Cancerogenitet

Vurdering av karsinogenitet:
All informasjon som kan vurderes, gir ingen indikasjon på kreftfremkallende virkning.

reproduksjonstoksisitet

Vurdering av reproduksjonstoksisitet:
Basert på ingrediensene er det ingen mistanke om toksikologisk virkning på reproduksjon.

Toksisitet ved gjentatt dosering og spesifikk målorgantoksisitet (gjentatt eksponering)

Vurdering av toksisitet ved gjentatt dose:
Så lenge produktet håndteres på en hensiktsmessig måte og benyttes som foreskrevet, har produktet etter våre erfaringer og informasjoner ingen negativ virkning på helsen. Produktet er ikke testet. Uttalelsene er utledet på grunnlag av enkeltkomponenters egenskaper.

Aspirasjonsfare

Ingen fare forventet ved innånding.

Øvrige informasjoner til toksisitet

Produktet er ikke blitt testet. Opplysningene angående toksikologi er avledet fra produkter med liknende struktur eller sammensetning.

PUNKT 12: Økologiske opplysninger

12.1. Toksisitet

Vurdering av akvatisk toksisitet:
Akutte effekter på akvatiske organismer skyldes fullt ut polymerens kationiske ladning, som nøytraliseres raskt og fullstendig i naturlige vannløp ved irreversibel adsorpsjon på partikler, hydrolyse og oppløst organisk karbon. Fisk- og akvatisk toksisitet nedsettes drastisk gjennom rask irreversibel adsorpsjon på suspendert og/eller løst organisk materie. Hydrolyseproduktene er ikke akkut skadelige for akvatiske organismer. Et stoff med høy kationisk ladningstetthet ble testet. Da den akutte toksisiteten er ladningsavhengig, må tilsvarende stoffer med lavere ladningstetthet forventes å ha en lavere toksisitet.

Fisketoksisitet:
LC50 (96 h) 1 - 10 mg/l, Fisk (statisk)

Akvatiske virvelløse dyr:
EC50 (48 h) 10 - 100 mg/l, dafnier

12.2. Persistens og nedbrytbarhet

Vurdering av bionedbrytbarhet og eliminasjon (H_2O):
biologisk ikke lett nedbrytbar (i henhold til OECD-kriterier)

Informasjon om stabilitet i vann (hydrolyse):
 > 70 % (28 d) (pH-verdi > 6)
Ved kontakt med vann vil stoffet nedbrytes meget rask

12.3. Bioakkumuleringspotensial

Vurdering bioakkumulasjonspotensial:
På basis av strukturelle egenskaper er polymeren ikke biotilgjengelig. Akkumulering i organismer forventes ikke.

12.4. Mobilitet i jord

Informasjon om: Ethanaminium, N,N,N-trimethyl-2-[(1-oxo-2-propenyl)oxy]-, chloride, polymer with 2-propenamide
Vurdering av transport mellom miljøområder:
Adsorpsjon i jord: Adsorpsjon til faste jordpartikler kan forventes.

12.5. Resultater av PBT- og vPvB-vurdering

I henhold til vedlegg XIII av Forordning (EF) Nr. 1907/2006 om registrering, vurdering, godkjenning og begrensning av kjemikalier (REACH): Produktet inneholder ingen stoffer, som oppfyller PBT-kriteriene (persistent/bioakkumulerende/toksisk) eller vPvB-kriteriene (veldig persistente/veldig bioakkumulerende).

12.6. Andre skadevirkninger

Produktet inneholder ingen stoffer, som er listet opp i vedlegg I i Forordning (EF) Nr. 2037/2000 om stoffer som bryter ned ozonlaget.

12.7. Tilleggsinformasjon

Øvrige økotoksikologiske henvisninger:
Produktet har ikke blitt testet. Utsagnet er avledet fra stoffer/produkter med lignende struktur eller sammensetning.

PUNKT 13: Instrukser ved disponering

13.1. Metoder til avfallsbehandling

Fjernes i henhold til nasjonale, regionale og lokale myndigheters forskrifter.

Forurenset emballasje:
Emballasje som ikke kan rengjøres, må avfallshåndteres som stoffet.
Ikke kontaminert emballasje kan gå til gjenbruk.

PUNKT 14: Transportopplysninger

Landtransport

ADR

	Ikke farlig gods i henhold til transportforskriftene
FN-nummer:	Ikke relevant.
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.
Transportfareklasse(r):	Ikke relevant.
Emballasjegruppe:	Ikke relevant.
Miljøfarer:	Ikke relevant.
Særlige forsiktighetsregler ved bruk	Ikke kjent.

RID

	Ikke farlig gods i henhold til transportforskriftene
FN-nummer:	Ikke relevant.
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.
Transportfareklasse(r):	Ikke relevant.
Emballasjegruppe:	Ikke relevant.
Miljøfarer:	Ikke relevant.
Særlige forsiktighetsregler ved bruk	Ikke kjent.

Innenriks sjøtransport
ADN

	Ikke farlig gods i henhold til transportforskriftene
FN-nummer:	Ikke relevant.
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.
Transportfareklasse(r):	Ikke relevant.
Emballasjegruppe:	Ikke relevant.
Miljøfarer:	Ikke relevant.
Særlige forsiktighetsregler ved bruk	Ikke kjent.
Transport i tankskip på innlandsvannveier:	Ikke evaluert

Sjøtransport	**Sea transport**
IMDG	IMDG
Ikke farlig gods i henhold til transportforskriftene	Not classified as a dangerous good under transport regulations

FN-nummer:	Ikke relevant.	UN number:	Not applicable
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.	UN proper shipping name:	Not applicable
Transportfareklasse(r):	Ikke relevant.	Transport hazard class(es):	Not applicable
Emballasjegruppe:	Ikke relevant.	Packing group:	Not applicable
Miljøfarer:	Ikke relevant.	Environmental hazards:	Not applicable
Særlige forsiktighetsregler ved bruk	Ikke kjent.	Special precautions for user	None known

Flytransport / **Air transport**

IATA/ICAO / IATA/ICAO

Ikke farlig gods i henhold til transportforskriftene / Not classified as a dangerous good under transport regulations

FN-nummer:	Ikke relevant.	UN number:	Not applicable
FN-forsendelsesbetegnelse (UN proper shipping name):	Ikke relevant.	UN proper shipping name:	Not applicable
Transportfareklasse(r):	Ikke relevant.	Transport hazard class(es):	Not applicable
Emballasjegruppe:	Ikke relevant.	Packing group:	Not applicable
Miljøfarer:	Ikke relevant.	Environmental hazards:	Not applicable
Særlige forsiktighetsregler ved bruk	Ikke kjent.	Special precautions for user	None known

14.1. FN-nummer
Se tilsvarende oppføringer for "FN-nummer" i de respektive forskrifter i tabellene over.

14.2. FN-forsendelsesbetegnelse (UN proper shipping name)
Se tilsvarende oppføringer for "FN-forsendelsesbetegnelse" i de respektive forskrifter i tabellene over.

14.3. Transportfareklasse(r)
Se tilsvarende oppføringer for "Transportfareklasse(r)" i de respektive forskrifter i tabellene over.

14.4. Emballasjegruppe
Se tilsvarende oppføringer for "Emballasjegruppe" i de respektive forskrifter i tabellene over.

14.5. Miljøfarer
Se tilsvarende oppføringer for "Miljøfarer" i de respektive forskrifter i tabellene over.

14.6. Særlige forsiktighetsregler ved bruk

Se tilsvarende oppføringer for "Særlige forsiktighetsregler ved bruk" i de respektive forskrifter i tabellene over.

14.7. Bulktransport i henhold til vedlegg II i MARPOL 73/78 og IBC-koden

Forordning:	Ikke evaluert
Transport tillatt:	Ikke evaluert
Forurensningsnavn:	Ikke evaluert
Forurensningskategori:	Ikke evaluert
Skipstype:	Ikke evaluert

Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code

Regulation:	Not evaluated
Shipment approved:	Not evaluated
Pollution name:	Not evaluated
Pollution category:	Not evaluated
Ship Type:	Not evaluated

PUNKT 15: Regelverksmessige opplysninger

15.1. Spesielle bestemmelser/spesiell lovgivning for stoffet eller blandingen med hensyn til sikkerhet, helse og miljø

Forbud, restriksjoner og autorisasjoner

Vedlegg XVII til EU-forordning nr.1907/2006: Nummer på liste: 28

FOR 2002-07-16 nr 1139: Forskrift om klassifisering, merking mv. av farlige kjemikalier. (Norge)
Administrative normer for forurensning i arbeidsatmosfære. (Norge)
FOR 2001-04-30 nr 443: Forskrift om vern mot eksponering for kjemikalier på arbeidsplassen (kjemikalieforskriften). (Norge)

Hvis ytteligere lovgivning er gjeldende, som ikke allerede er oppført andre steder i dette sikkerhetsdatabladet, vil det være beskrevet i dette underpunktet.

15.2. Kjemikaliesikkerhetsvurdering

Kjemisk sikkerhetsvurdering ennå ikke utført på grunn av registreringsfrister

PUNKT 16: Andre opplysninger

Vurdering av fareklassene i henhold til UN GHS-kriterium (siste versjon)

Aquatic Acute 2

Full tekst av klassifiseringene, inkludert angivelse av fare, faresymboler, R-setninger, og faresetninger dersom nevnt i seksjon 2 eller 3:

Xi	Irriterende.
36	Irriterer øynene.
Eye Dam./Irrit.	Alvorlig øyeskade eller øyeirritasjon
H319	Gir alvorlig øyeirritasjon.
H318	Gir alvorlig øyeskade.

Hvis De har spørsmål angående dette sikkerhetsdatablad, dets innhold eller andre produktsikkerhetsrelevante spørsmål, bes de om å skrive til følgende e-mail adresse: product-safety-north@basf.com

Informasjonen i dette sikkerhetsdatabladet er basert på vår nåværende kunnskap og erfaring, og beskriver produktet kun med hensyn til kravene til sikkerhet. Informasjonen skal ikke anses som en beskrivelse av produktets egenskaper (produktspesifikasjon). En avtalt egenskap eller produktets kvalifikasjon for et konkret applikasjonsformål kan ikke utledes fra våre oppgaver i sikkerhetsdatabladet. Det er ansvaret til mottaker av produktet å observere mulige eiendomsrettigheter samt gjeldende lover og forskrifter.

Loddrette streker i venstre marg henviser til endringer i forhold til foregående versjon.

Appendix 9

This appendix contains the tables used to calculate correct chemical concentration with respect to concentration of the chemical solution and volume of sample.

Desired dosage	ppm=	5		0,000005		
		kk				
Test sample (ml)	**0,10 %**	**0,20 %**	**0,25 %**	**0,30 %**	**0,40 %**	**0,50 %**
100	0,50 ml	0,25 ml	0,20 ml	0,17 ml	0,13 ml	0,10 ml
150	0,75 ml	0,38 ml	0,30 ml	0,25 ml	0,19 ml	0,15 ml
200	1,00 ml	0,50 ml	0,40 ml	0,33 ml	0,25 ml	0,20 ml
250	1,25 ml	0,63 ml	0,50 ml	0,42 ml	0,31 ml	0,25 ml
300	1,50 ml	0,75 ml	0,60 ml	0,50 ml	0,38 ml	0,30 ml
350	1,75 ml	0,88 ml	0,70 ml	0,58 ml	0,44 ml	0,35 ml
400	2,00 ml	1,00 ml	0,80 ml	0,67 ml	0,50 ml	0,40 ml
450	2,25 ml	1,13 ml	0,90 ml	0,75 ml	0,56 ml	0,45 ml
500	2,50 ml	1,25 ml	1,00 ml	0,83 ml	0,63 ml	0,50 ml
550	2,75 ml	1,38 ml	1,10 ml	0,92 ml	0,69 ml	0,55 ml
600	3,00 ml	1,50 ml	1,20 ml	1,00 ml	0,75 ml	0,60 ml
650	3,25 ml	1,63 ml	1,30 ml	1,08 ml	0,81 ml	0,65 ml
700	3,50 ml	1,75 ml	1,40 ml	1,17 ml	0,88 ml	0,70 ml
750	3,75 ml	1,88 ml	1,50 ml	1,25 ml	0,94 ml	0,75 ml
800	4,00 ml	2,00 ml	1,60 ml	1,33 ml	1,00 ml	0,80 ml
850	4,25 ml	2,13 ml	1,70 ml	1,42 ml	1,06 ml	0,85 ml
900	4,50 ml	2,25 ml	1,80 ml	1,50 ml	1,13 ml	0,90 ml
950	4,75 ml	2,38 ml	1,90 ml	1,58 ml	1,19 ml	0,95 ml
1000	5,00 ml	2,50 ml	2,00 ml	1,67 ml	1,25 ml	1,00 ml
2000	10,00 ml	5,00 ml	4,00 ml	3,33 ml	2,50 ml	2,00 ml

Dosage	ml=	2		0,000002		
Test sample (ml)	**0,10 %**	**0,20 %**	**0,25 %**	**0,30 %**	**0,40 %**	**0,50 %**
100	20,0 ppm	40,0 ppm	50,0 ppm	60,0 ppm	80,0 ppm	100,0 ppm
150	13,3 ppm	26,7 ppm	33,3 ppm	40,0 ppm	53,3 ppm	66,7 ppm
200	10,0 ppm	20,0 ppm	25,0 ppm	30,0 ppm	40,0 ppm	50,0 ppm
250	8,0 ppm	16,0 ppm	20,0 ppm	24,0 ppm	32,0 ppm	40,0 ppm
300	6,7 ppm	13,3 ppm	16,7 ppm	20,0 ppm	26,7 ppm	33,3 ppm
350	5,7 ppm	11,4 ppm	14,3 ppm	17,1 ppm	22,9 ppm	28,6 ppm
400	5,0 ppm	10,0 ppm	12,5 ppm	15,0 ppm	20,0 ppm	25,0 ppm
450	4,4 ppm	8,9 ppm	11,1 ppm	13,3 ppm	17,8 ppm	22,2 ppm
500	4,0 ppm	8,0 ppm	10,0 ppm	12,0 ppm	16,0 ppm	20,0 ppm
550	3,6 ppm	7,3 ppm	9,1 ppm	10,9 ppm	14,5 ppm	18,2 ppm
600	3,3 ppm	6,7 ppm	8,3 ppm	10,0 ppm	13,3 ppm	16,7 ppm
650	3,1 ppm	6,2 ppm	7,7 ppm	9,2 ppm	12,3 ppm	15,4 ppm
700	2,9 ppm	5,7 ppm	7,1 ppm	8,6 ppm	11,4 ppm	14,3 ppm
750	2,7 ppm	5,3 ppm	6,7 ppm	8,0 ppm	10,7 ppm	13,3 ppm
800	2,5 ppm	5,0 ppm	6,3 ppm	7,5 ppm	10,0 ppm	12,5 ppm
850	2,4 ppm	4,7 ppm	5,9 ppm	7,1 ppm	9,4 ppm	11,8 ppm
900	2,2 ppm	4,4 ppm	5,6 ppm	6,7 ppm	8,9 ppm	11,1 ppm
950	2,1 ppm	4,2 ppm	5,3 ppm	6,3 ppm	8,4 ppm	10,5 ppm
1000	2,0 ppm	4,0 ppm	5,0 ppm	6,0 ppm	8,0 ppm	10,0 ppm
2000	1,0 ppm	2,0 ppm	2,5 ppm	3,0 ppm	4,0 ppm	5,0 ppm

Dosage	ml=	12		0,000012		
Test sample (ml)	0,01 %	0,02 %	0,025 %	0,03 %	0,04 %	0,05 %
100	12,000 ppm	24,000 ppm	30,000 ppm	36,000 ppm	48,000 ppm	60,000 ppm
150	8,000 ppm	16,000 ppm	20,000 ppm	24,000 ppm	32,000 ppm	40,000 ppm
200	6,000 ppm	12,000 ppm	15,000 ppm	18,000 ppm	24,000 ppm	30,000 ppm
250	4,800 ppm	9,600 ppm	12,000 ppm	14,400 ppm	19,200 ppm	24,000 ppm
300	4,000 ppm	8,000 ppm	10,000 ppm	12,000 ppm	16,000 ppm	20,000 ppm
350	3,429 ppm	6,857 ppm	8,571 ppm	10,286 ppm	13,714 ppm	17,143 ppm
400	3,000 ppm	6,000 ppm	7,500 ppm	9,000 ppm	12,000 ppm	15,000 ppm
450	2,667 ppm	5,333 ppm	6,667 ppm	8,000 ppm	10,667 ppm	13,333 ppm
500	2,400 ppm	4,800 ppm	6,000 ppm	7,200 ppm	9,600 ppm	12,000 ppm
550	2,182 ppm	4,364 ppm	5,455 ppm	6,545 ppm	8,727 ppm	10,909 ppm
600	2,000 ppm	4,000 ppm	5,000 ppm	6,000 ppm	8,000 ppm	10,000 ppm
650	1,846 ppm	3,692 ppm	4,615 ppm	5,538 ppm	7,385 ppm	9,231 ppm
700	1,714 ppm	3,429 ppm	4,286 ppm	5,143 ppm	6,857 ppm	8,571 ppm
750	1,600 ppm	3,200 ppm	4,000 ppm	4,800 ppm	6,400 ppm	8,000 ppm
800	1,500 ppm	3,000 ppm	3,750 ppm	4,500 ppm	6,000 ppm	7,500 ppm
850	1,412 ppm	2,824 ppm	3,529 ppm	4,235 ppm	5,647 ppm	7,059 ppm
900	1,333 ppm	2,667 ppm	3,333 ppm	4,000 ppm	5,333 ppm	6,667 ppm
950	1,263 ppm	2,526 ppm	3,158 ppm	3,789 ppm	5,053 ppm	6,316 ppm
1000	1,200 ppm	2,400 ppm	3,000 ppm	3,600 ppm	4,800 ppm	6,000 ppm
2000	0,600 ppm	1,200 ppm	1,500 ppm	1,800 ppm	2,400 ppm	3,000 ppm

Desired dosage	ppm=	3		0,000003		
		kk				
Test sample (ml)	0,01 %	0,02 %	0,025 %	0,03 %	0,04 %	0,05 %
100	3,000 ml	1,500 ml	1,200 ml	1,000 ml	0,750 ml	0,600 ml
150	4,500 ml	2,250 ml	1,800 ml	1,500 ml	1,125 ml	0,900 ml
200	6,000 ml	3,000 ml	2,400 ml	2,000 ml	1,500 ml	1,200 ml
250	7,500 ml	3,750 ml	3,000 ml	2,500 ml	1,875 ml	1,500 ml
300	9,000 ml	4,500 ml	3,600 ml	3,000 ml	2,250 ml	1,800 ml
350	10,500 ml	5,250 ml	4,200 ml	3,500 ml	2,625 ml	2,100 ml
400	12,000 ml	6,000 ml	4,800 ml	4,000 ml	3,000 ml	2,400 ml
450	13,500 ml	6,750 ml	5,400 ml	4,500 ml	3,375 ml	2,700 ml
500	15,000 ml	7,500 ml	6,000 ml	5,000 ml	3,750 ml	3,000 ml
550	16,500 ml	8,250 ml	6,600 ml	5,500 ml	4,125 ml	3,300 ml
600	18,000 ml	9,000 ml	7,200 ml	6,000 ml	4,500 ml	3,600 ml
650	19,500 ml	9,750 ml	7,800 ml	6,500 ml	4,875 ml	3,900 ml
700	21,000 ml	10,500 ml	8,400 ml	7,000 ml	5,250 ml	4,200 ml
750	22,500 ml	11,250 ml	9,000 ml	7,500 ml	5,625 ml	4,500 ml
800	24,000 ml	12,000 ml	9,600 ml	8,000 ml	6,000 ml	4,800 ml
850	25,500 ml	12,750 ml	10,200 ml	8,500 ml	6,375 ml	5,100 ml
900	27,000 ml	13,500 ml	10,800 ml	9,000 ml	6,750 ml	5,400 ml
950	28,500 ml	14,250 ml	11,400 ml	9,500 ml	7,125 ml	5,700 ml
1000	30,000 ml	15,000 ml	12,000 ml	10,000 ml	7,500 ml	6,000 ml
2000	60,000 ml	30,000 ml	24,000 ml	20,000 ml	15,000 ml	12,000 ml

Appendix 10

This appendix contains daily reports from the process plant from the dates that the tests were preformed.

1. Screening: 11.03.2015

2. Screening: 15.03.2015

3. Screening number 1: 20.03.2015

3. Screening number 2: 23.03.2015

SYDVARANGER GRUVE - DAILY PRODUCTION REPORT

SVG

Date: 11 March 2015

Rail

Physicals	Today		MTD	MTD Target
Trips	15	no.	95	144
Wagons per train	19	no.		
Calc tonnes	18 525	wet t	117 325	177 463
Cycle time	1,5	hrs		
Total downtime	1,1	hrs		
Bjørnevatn	0,0	hrs		
Kirkenes	1,1	hrs		

Downtime	*Hours*
Full bin	0,83
Brake test	0,25

Fine Crushing

Physicals	Today		MTD	MTD Target
Crushed tonnes	17 819	wet t	120 062	172 139
Avg Crush rate	918	wet tph	786	906
Downtime	4,6	hrs	111,3	74,2
Runtime	81	%	58 %	72 %
Crusher P 80	15,4	mm	9,8	13,0
Emergency bin	8 960	wet t		
Mill bin	1 200	wet t		
Reclaimed Scats	0	wet t	0	0
Mobile Crusher	0	wet t	6 706	5 324
Mobile Crusher P 80	No Sample	mm	0,0	12,0

Downtime	*Hours*
CR05 - Automation is working with the level sensor	1,30
CV14 - Ice	1,05
Inspection/calibration	0,88
CV14 - Metal detect	0,72
CV14 - Photo cell	0,53
CR05 - High level	0,10

Milling

Physicals	Today		MTD	MTD Target
Milled tonnes	16 587	wet t	121 377	177 463
Milling rate	691	wet tph	654	742
Downtime	0,0	hrs	78,4	24,8
Runtime	100	%	70 %	91 %
Mill feed Fe Mag	19,0	%	22,2	28,5

Downtime	*Hours*

Filtration

Physicals	Today		MTD	MTD Target	
Concentrate Filtered	5 794	dry t	42 133	72 500	
VPA daily tonnage	3 535	dry t			
Avg VPA Filtration rate	150	dry tph			
VPA cycles	127	no.			
Iron grade	67,7	%	67,6	>68.0	%
Silica grade	4,82	%	5,04	<5.00	%

Downtime	*Hours*
VPA	0,4
Larox	24,0
Scanmec 1	9,2
Scanmec 2	14,9
Scanmec 3	24,0

	Today	MTD	
Average moisture	7,8	7,9	%
CV-29 moisture	8,5	8,7	%
CV-29A moisture	7,4	7,5	%

Silos

Total Tonnes

	Wet	*Dry*	*Iron*	*Silica*	*Moisture*
Silo 3	40 401	37 159	67,8 %	4,81 %	8,02 %
Silo 4	7 408	6 804	67,9 %	4,68 %	8,16 %
Silo 5	15 165	13 961	67,4 %	5,19 %	7,94 %
Total	62 974	57 925	67,7 %	4,89 %	8,02 %

Shipping

Next shipment	MV Miden Max - 16 March 2015	
Goal		wet t
Loaded		wet t
Tonnes to go		wet t

KPI

			MTD	Target
Mass recovery	33	%	35	42
Fe Mag recovery	97,9	%	96,9	98,5
Mill runtime	100	%	70 %	91 %
LTI free days	64			

Water and Chemicals

	Today	MTD	
Raw water usage	8 370	80 608	m^3
MF10 Usage	7,5	11,7	g/t
LT 38 Usage	0,0	0,3	g/t
Turbidity	455	514	NTU

Daily Targets

Rail			Fine Crushing					Primary Mill			Filtration		VPA
16 133	*90*	*90*	*15 649*	*72*	*906*	*24 000*	*5 000*	*16 133*	*91*	*742*	*6 591*	*303*	*3 479*
18 525	100	95	17 819	81	918	8 960	1 200	16 587	100	691	5 794	241	3 535
wet t	B'vtn	Kirkenes	wet t	Runtime	wet tph	wet t	wet t	wet t	runtime	wet tph	dry t	dry tph	dry t

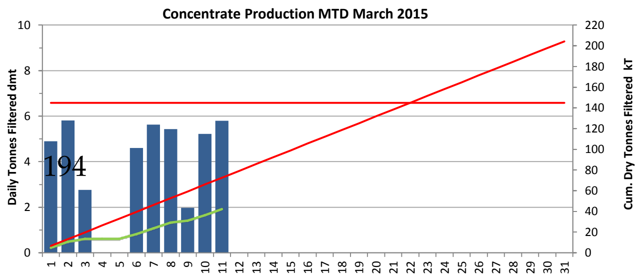
Well Below Target | Close to Target | Achieved Target

Comments

Main reason for fine crusher downtime was ice on CV14 and some adjustment on the level sensor in CR05, other than that we had a stable day with good production.

We increased the primary mill throughput during the whole day, in the end of the nightshift we had 735tph fresh feed.

Month Target	*Still to go*	*Current MTD Position*
204 317	162 184	Behind 30 400 dmt



SYDVARANGER GRUVE - DAILY PRODUCTION REPORT

SVG

Date: 15 March 2015

Rail

Physicals	Today		MTD	MTD Target
Trips	9	no.	135	196
Wagons per train	20	no.		
Calc tonnes	11 700	wet t	168 480	241 995
Cycle time	2,7	hrs		
Total downtime	0,0	hrs		
Bjørnevatn	0,0	hrs		
Kirkenes	0,0	hrs		

Downtime	*Hours*
No report	

Fine Crushing

Physicals	Today		MTD	MTD Target
Crushed tonnes	13 833	wet t	173 511	234 735
Avg Crush rate	791	wet tph	804	906
Downtime	6,5	hrs	144,3	101,2
Runtime	73	%	60 %	72 %
Crusher P 80	13,8	mm	10,0	13,0
Emergency bin	5 600	wet t		
Mill bin	1 200	wet t		
Reclaimed Scats	0	wet t	0	0
Mobile Crusher	0	wet t	6 706	7 260
Mobile Crusher P 80	No Sample	mm	0,0	12,0

Downtime	*Hours*
CV14 - Ice	2,72
No ore - Mine	1,28
CV16 - Underspeed	1,02
CR05 - Low oil flow	0,73
CV14 - Metal detect	0,43
CV15 - Underspeed	0,33

Milling

Physicals	Today		MTD	MTD Target
Milled tonnes	14 795	wet t	175 884	241 995
Milling rate	616	wet tph	662	742
Downtime	0,0	hrs	94,2	33,8
Runtime	100	%	74 %	91 %
Mill feed Fe Mag	23,6	%	22,5	28,5

Downtime	*Hours*

Filtration

Physicals	Today		MTD	MTD Target	
Concentrate Filtered	4 786	dry t	59 585	98 863	
VPA daily tonnage	3 412	dry t			
Avg VPA Filtration rate	145	dry tph			
VPA cycles	127	no.			
Iron grade	67,9	%	67,6	>68.0	%
Silica grade	4,70	%	4,98	<5.00	%

Downtime	*Hours*
VPA	0,5
Larox	24,0
Scanmec 1	0,5
Scanmec 2	19,8
Scanmec 3	24,0

	Today	MTD	
Average moisture	7,8	7,9	%
CV-29 moisture	8,5	8,7	%
CV-29A moisture	7,6	7,5	%

Silos

Total Tonnes

	Wet	*Dry*	*Iron*	*Silica*	*Moisture*
Silo 3	TBA	TBA	TBA	TBA	TBA
Silo 4	TBA	TBA	TBA	TBA	TBA
Silo 5	TBA	TBA	TBA	TBA	TBA
Total					

Shipping

Ship:	MV Miden Max	
Goal	wet t	70 000
Loaded	wet t	26 000
Tonnes to go	wet t	44 000

KPI

			MTD	Target
Mass recovery	35	%	34	42
Fe Mag recovery	96,7	%	96,8	98,5
Mill runtime	100	%	74 %	91 %
LTI free days	68			

Water and Chemicals

	Today	MTD	
Raw water usage	7 995	113 175	m^3
MF10 Usage	12,8	11,2	g/t
LT 38 Usage	1,1	0,3	g/t
Turbidity	725	534	NTU

Daily Targets

	Rail			Fine Crushing					Primary Mill			Filtration		VPA
Target	*16 133*	*90*	*90*	*15 649*	*72*	*906*	*24 000*	*5 000*	*16 133*	*91*	*742*	*6 591*	*303*	*3 479*
Actual	11 700	100	100	13 833	73	791	5 600	1 200	14 795	100	616	4 786	199	3 412
Unit	wet t	B'vtn	Kirkenes	wet t	Runtime	wet tph	wet t	wet t	wet t	runtime	wet tph	dry t	dry tph	dry t

Well Below Target | Close to target | Achieved Target

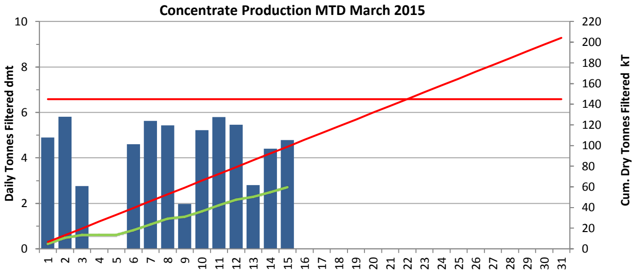
Comments

Ice where the main reason for downtime in the fine crusher.

Mill throughtput is constrained by the low bin levels, at the moment we are running 700tph minus the scats.

Month Target	*Still to go*	*Current MTD Position*
204 317	144 732	Behind 39 300 dmt

Concentrate Production MTD March 2015



SYDVARANGER GRUVE - DAILY PRODUCTION REPORT

SVG

Date: 20 March 2015

Rail

Physicals	Today		MTD	MTD Target
Trips	3	no.	184	261
Wagons per train	15	no.		
Calc tonnes	2 925	wet t	228 865	322 660
Cycle time	1,8	hrs		
Total downtime	18,6	hrs		
Bjørnevatn	10,8	hrs		
Kirkenes	7,8	hrs		

Downtime	Hours
No ore - mine	9,00
Full bin	7,75
Blasting BN hatches	1,83

Fine Crushing

Physicals	Today		MTD	MTD Target
Crushed tonnes	4 663	wet t	227 174	312 980
Avg Crush rate	458	wet tph	790	906
Downtime	13,8	hrs	192,4	134,9
Runtime	42	%	60 %	72 %
Crusher P 80	14,6	mm	10,9	13,0
Emergency bin	0	wet t		
Mill bin	0	wet t		
Reclaimed Scats	0	wet t	0	0
Mobile Crusher	1 441	wet t	18 039	9 680
Mobile Crusher P 80	No Sample	mm	1,2	12,0

Downtime	Hours
CV16 - Replacing gearbox	9,92
No ore - Mine	1,60
Inspection/calibration	1,00
CV14 - Ice	0,45
CV15 - Blocked chute	0,38
CR03 - Blocked chute	0,27
CV13 - Metal detect	0,20

Milling

Physicals	Today		MTD	MTD Target
Milled tonnes	15 678	wet t	245 950	322 660
Milling rate	653	wet tph	665	742
Downtime	0,0	hrs	110,3	45,1
Runtime	100	%	77 %	91 %
Mill feed Fe Mag	24,6	%	22,9	28,5

Downtime	Hours

Filtration

Physicals	Today		MTD	MTD Target	
Concentrate Filtered	5 828	dry t	84 069	131 817	
VPA daily tonnage	3 451	dry t			
Avg VPA Filtration rate	144	dry tph			
VPA cycles	132	no.			
Iron grade	68,0	%	67,8	>68.0	%
Silica grade	4,49	%	4,80	<5.00	%

Downtime	Hours
VPA	0,0
Larox	24,0
Scanmec 1	24,0
Scanmec 2	12,4
Scanmec 3	0,0

	Today	MTD	
Average moisture	8,0	8,0	%
CV-29 moisture	8,8	8,7	%
CV-29A moisture	7,5	7,5	%

Silos

Total Tonnes

	Wet	Dry	Iron	Silica	Moisture
Silo 3	11 854	10 916	67,8 %	4,78 %	7,92 %
Silo 4	5 408	4 977	67,9 %	4,76 %	7,98 %
Silo 5	21 482	19 761	68,1 %	4,41 %	8,01 %
Total	38 745	35 654	68,0 %	4,57 %	7,98 %

Shipping

Next shipment	TBA	
Goal		wet t
Loaded		wet t
Tonnes to go		wet t

KPI

			MTD	Target
Mass recovery	38	%	35	42
Fe Mag recovery	98,4	%	97,0	98,5
Mill runtime	100	%	77 %	91 %
LTI free days	73			

Water and Chemicals

	Today	MTD	
Raw water usage	8 457	156 586	m^3
MF10 Usage	13,1	11,7	g/t
LT 38 Usage	5,1	1,5	g/t
Turbidity	585	570	NTU

Daily Targets

	Rail			Fine Crushing					Primary Mill			Filtration		VPA
Target	16 133	90	90	15 649	72	906	24 000	5 000	16 133	91	742	6 591	303	3 479
Actual	2 925	55	68	4 663	42	458	0	0	15 678	100	653	5 828	243	3 451
Unit	wet t	B'vtn	Kirkenes	wet t	Runtime	wet tph	wet t	wet t	wet t	runtime	wet tph	dry t	dry tph	dry t

Well Below Target | Close to target | Achieved Target

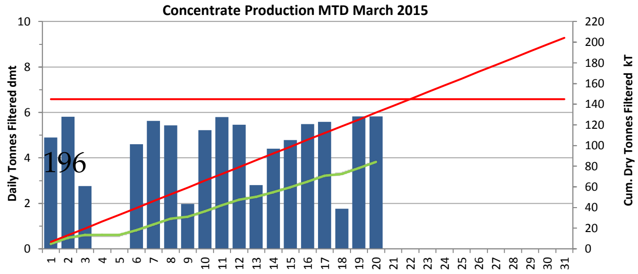
Comments

Due to wet ore we could only run 350-450tph from CV14 and aprox 100-150tph from CV13. Around 07.00 CV16 stopped due to a failure in one of the gearboxes, the replacemnet took aprox 10 hrs.

Mill trhroughput had to be reduce due to bin levels, 05.30 this morning we had to stop the plant due to empty bins.

Month Target	*Still to go*	*Current MTD Position*
204 317	120 248	Behind 47 700 dmt

Concentrate Production MTD March 2015



SYDVARANGER GRUVE - DAILY PRODUCTION REPORT

SVG

Date: 23 March 2015

Rail

Physicals	Today		MTD	MTD Target
Trips	10	no.	205	300
Wagons per train	17	no.		
Calc tonnes	11 050	wet t	251 485	371 059
Cycle time	1,7	hrs		
Total downtime	6,8	hrs		
Bjørnevatn	1,1	hrs		
Kirkenes	5,6	hrs		

Downtime	Hours
Full bin	4,37
Shifting wagons	1,25
Blasting in BN old north (safety)	1,13

Fine Crushing

Physicals	Today		MTD	MTD Target
Crushed tonnes	11 798	wet t	246 075	359 927
Avg Crush rate	718	wet tph	774	906
Downtime	7,6	hrs	234,0	155,1
Runtime	68	%	58 %	72 %
Crusher P 80	13,5	mm	10,7	13,0
Emergency bin	5 600	wet t		
Mill bin	1 500	wet t		
Reclaimed Scats	0	wet t	0	0
Mobile Crusher	1 506	wet t	20 457	11 132
Mobile Crusher P 80	No Sample	mm	1,0	12,0

Downtime	Hours
CR03 - Blockage underneath	2,67
SC03 - Replacing panels	1,65
CV14 - Ice	1,53
CV14 - Metal detect	0,68
CV14 - Photocell	0,50
Inspection/calibration	0,45
CR05 - High level	0,08

Milling

Physicals	Today		MTD	MTD Target
Milled tonnes	14 210	wet t	262 209	371 059
Milling rate	592	wet tph	660	742
Downtime	0,0	hrs	155,0	51,9
Runtime	100	%	72 %	91 %
Mill feed Fe Mag	24,2	%	23,1	28,5

Downtime	Hours

Filtration

Physicals	Today		MTD	MTD Target	
Concentrate Filtered	4 571	dry t	89 572	151 590	
VPA daily tonnage	1 582	dry t			
Avg VPA Filtration rate	79	dry tph			
VPA cycles	57	no.			
Iron grade	67,4	%	67,7	>68.0	%
Silica grade	5,22	%	4,85	<5.00	%

Downtime	Hours
VPA	4,0
Larox	24,0
Scanmec 1	24,0
Scanmec 2	4,2
Scanmec 3	0,3

	Today	MTD	
Average moisture	8,6	8,0	%
CV-29 moisture	8,8	8,7	%
CV-29A moisture	8,2	7,5	%

Silos

Total Tonnes

	Wet	*Dry*	*Iron*	*Silica*	*Moisture*
Silo 3	11 854	10 916	67,8 %	4,78 %	7,92 %
Silo 4	5 408	4 977	67,9 %	4,76 %	7,98 %
Silo 5	27 491	25 266	67,9 %	4,62 %	8,09 %
Total	44 754	41 158	67,9 %	4,68 %	8,03 %

Shipping

Next shipment	MV Conti Spinell - 30th March
Goal	wet t
Loaded	wet t
Tonnes to go	wet t

KPI

			MTD	Target
Mass recovery	34	%	35	42
Fe Mag recovery	97,7	%	96,9	98,5
Mill runtime	100	%	72 %	91 %
LTI free days	76			

Water and Chemicals

	Today	MTD	
Raw water usage	8 430	171 784	m^3
MF10 Usage	13,9	11,8	g/t
LT 38 Usage	3,0	1,6	g/t
Turbidity	566	553	NTU

Daily Targets

Area	Measure	Target	Actual	Status
Rail	wet t	16 133	11 050	Well Below Target
Rail	B'vtn	90	95	Achieved Target
Rail	Kirkenes	90	77	Well Below Target
Fine Crushing	wet t	15 649	11 798	Well Below Target
Fine Crushing	Runtime	72	68	Close to target
Fine Crushing	wet tph	906	718	Well Below Target
Fine Crushing	wet t	24 000	5 600	Well Below Target
Fine Crushing	wet t	5 000	1 500	Well Below Target
Primary Mill	wet t	16 133	14 210	Well Below Target
Primary Mill	runtime	91	100	Achieved Target
Primary Mill	wet tph	742	592	Well Below Target
Filtration	dry t	6 591	4 571	Well Below Target
Filtration	dry tph	303	190	Well Below Target
VPA	dry t	3 479	1 582	Well Below Target

Well Below Target | Close to target | Achieved Target

Comments

Fine crusher downtime was mainly from an incident with SC03, some panels fell of and got stuck underneath CR03. There was also an increased amount of ice lumps on CV14 during the nightshift.

Mill throughput was fixed on 600tph total feed due to low ore bin levels.

Month Target	*Still to go*	*Current MTD Position*
204 317	114 745	Behind 62 000 dmt