Pulp and Performance Chemicals

Hydrogen peroxide

Product information manual

AkzoNobel

Table of contents

Introduction

Hydrogen peroxide (H_2O_2) is a powerful oxidizing agent which is relatively easy to handle in the concentrations that are produced and sold by AkzoNobel Pulp and Performance Chemicals. When handled correctly the risks are minimized. However, like many other oxidizing chemicals, if handled incorrectly hydrogen peroxide can pose a serious hazard to human health, safety and the environment. Knowledge about its properties and safe handling is therefore essential.

This manual contains important information on hydrogen peroxide and its safe handling; it has been compiled based on the experience gained from many years of producing and handling hydrogen peroxide; incorporating international regulations governing hydrogen peroxide storage, handling and transportation. CEFIC's Bulk Storage Guideline for Hydrogen peroxide (March 2012) has also been used as a reference.

Please do not hesitate to contact AkzoNobel Pulp and Performance Chemicals for advice and instructions concerning the handling of hydrogen peroxide (http://www.akzonobel.com/eka/contact_us/ppc_locations/).

Applications

Hydrogen peroxide has relatively strong oxidizing properties, but nevertheless is a chemical that is relatively easy to handle as long as strict safety principles are known and respected by all. The two by-products of the decomposition of hydrogen peroxide, water and oxygen, are harmless from an environmental standpoint. These properties combined with a growing environmental awareness in the past few decades have contributed to making hydrogen peroxide a very important and widely-used industrial product.

The pulp and paper industry uses hydrogen peroxide as a bleaching agent. Pulp mills employ it to bleach different kinds of mechanical and chemimechanical pulps; stone groundwood (SGW) pulp, thermomechanical pulp (TMP) and chemithermomechanical pulp (CTMP) processes produce high-yield pulps with very good properties and higher brightness/whiteness when hydrogen peroxide is used.

Following the abandonment of chlorine as a bleaching agent due to environmental considerations, two technologies were developed. The first is **Elemental Chlorine Free (ECF)** and the second is **Total Chlorine Free (TCF)**. The distinguishing factor between the two processes is the use of chlorine dioxide, which is used in ECF but not TCF. To compensate for the lack of chlorine dioxide in TCF bleaching, higher dosages of hydrogen peroxide is used and ozone is sometimes added to the bleaching sequence. In 2012, ECF pulp constituted 93% of the world share of bleached chemical pulp. TCF, although decreasing slightly in market share, has remained at approximately 5% of the bleached chemical pulp market.

Hydrogen peroxide acts as a reducing agent when producing chlorine dioxide via the AkzoNobel SVP-HP® and HP-A® processes. Chlorine dioxide is the pulp bleaching agent used in the ECF (Elemental Chlorine-Free) process.

In the chemical industry hydrogen peroxide plays a major part in both inorganic and organic applications. Examples are manufacturing of percarbonates, perborate, a wide variety of organic peroxides and in recent years propylene oxide.

Hydrogen peroxide is a mainstay in surface treatment within the metals industry. It is used for etching, polishing and cleaning, plus it eliminates nitrogen oxide gases (NOx) in connection with nitric acid-based pickling operations. The gentle effectiveness and harmless by-products of hydrogen peroxide have made it a natural for bleaching textiles, paracite control in aquaculture, treating industrial and municipal wastewater, removing such undesirable compounds as hydrogen sulfide, cyanides, hypochlorite, phenols and various oxygen-demanding organic compounds. Its bactericidal properties make it useful in various water and food disinfection applications, as well.

Product grades

AkzoNobel distributes hydrogen peroxide in aqueous solutions in a number of different grades using the product name Eka HP.

Typical commercial concentrations are 35%, equivalent to about 400 g/l hydrogen peroxide; 50%, equivalent to about 600 g/l hydrogen peroxide and 70%, equivalent to about 900 g/l hydrogen peroxide.

Product grades and concentrations vary by market; all alternatives are not globally available. **If you need assistance in deciding which grade is right for your operation, please contact your AkzoNobel Representative for more information.**

Technical data and physical properties

Please refer to the CURRENT hydrogen peroxide SDS for the CURRENT regulatory information about its physical properties. Your AkzoNobel representative will be able to provide you with this document.

Hydrogen peroxide is a clear, colorless liquid. It is used solely in the form of an aqueous solution and can be mixed with water in any proportions. The chemical is odorless at low concentrations. At high concentrations it has a slightly pungent smell.

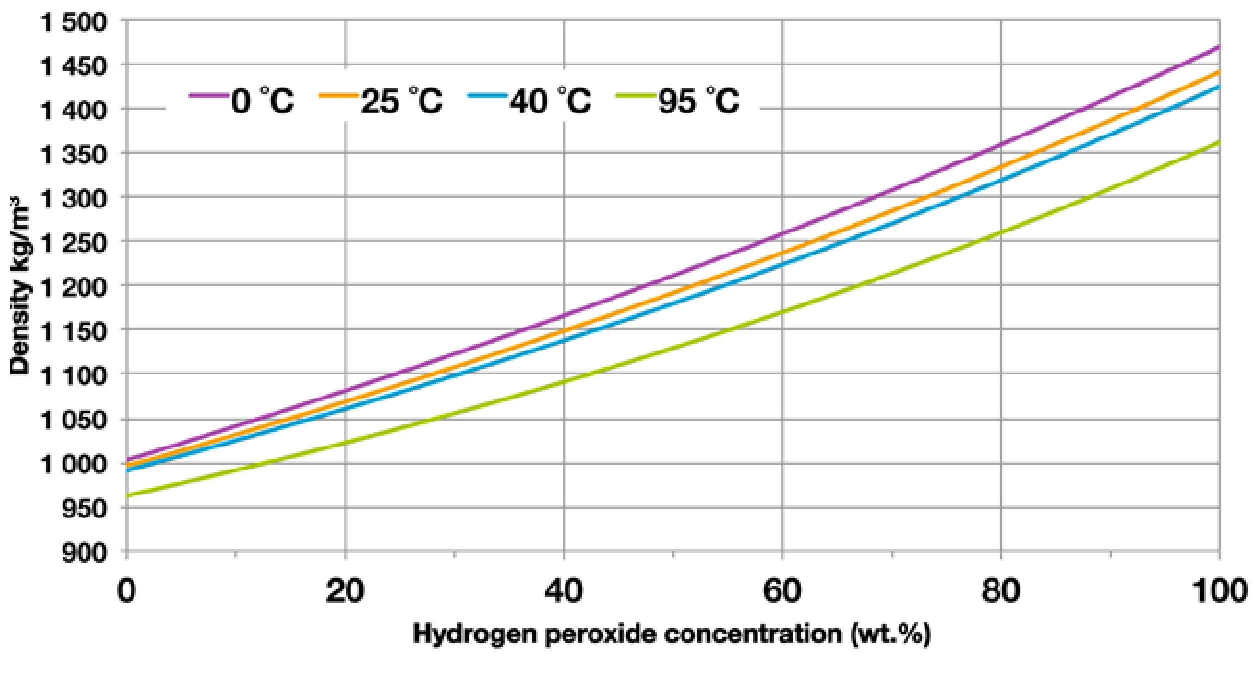
Chemical properties data

Chemical Formula: H_2O_2 Molar Mass: 34.016g

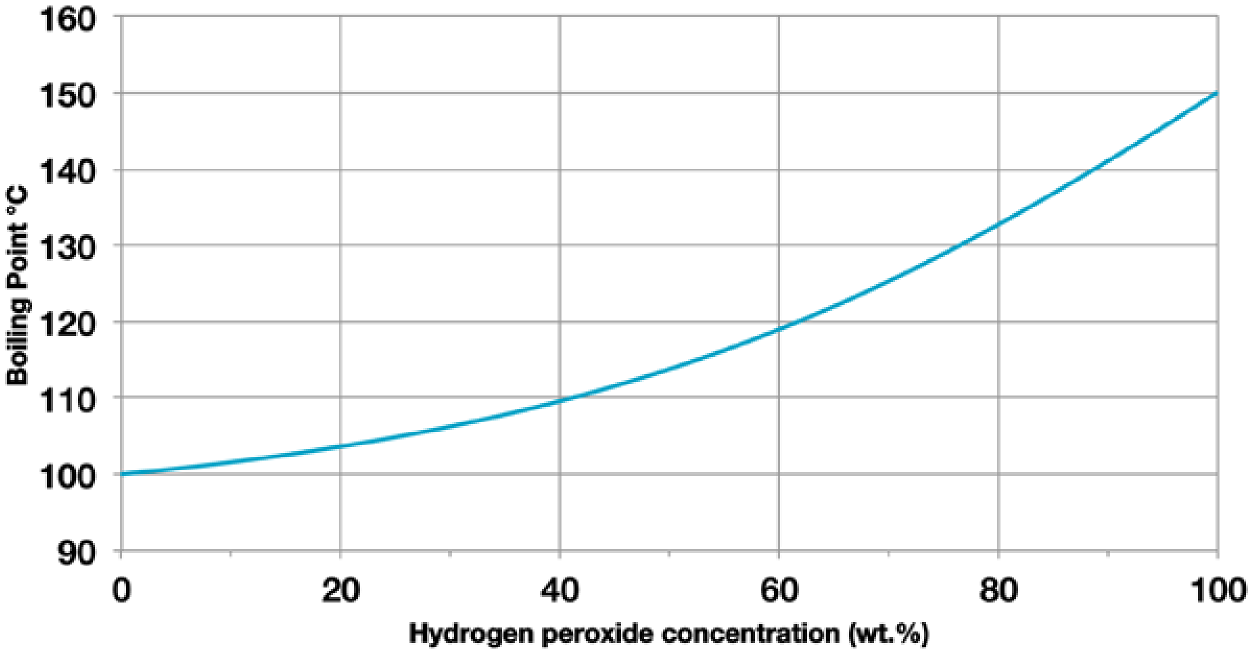
Physical data for AkzoNobel hydrogen peroxide solutions

Concentration Weight (%)	Density @ 20°C/ 68°F (kg/m³)	Boiling Point (°C)	Freezing Point (°C)	Boiling Point (°F)	Freezing Point (°F)	Viscosity @ 20°C/68°F (cP)
0 (water)	998	100	0	212	32	1.002
35	1131	108	-33	226	-27	1.110
50	1195	114	-52	237	-62	1.170
70	1289	125	-40	257	-40	1.240

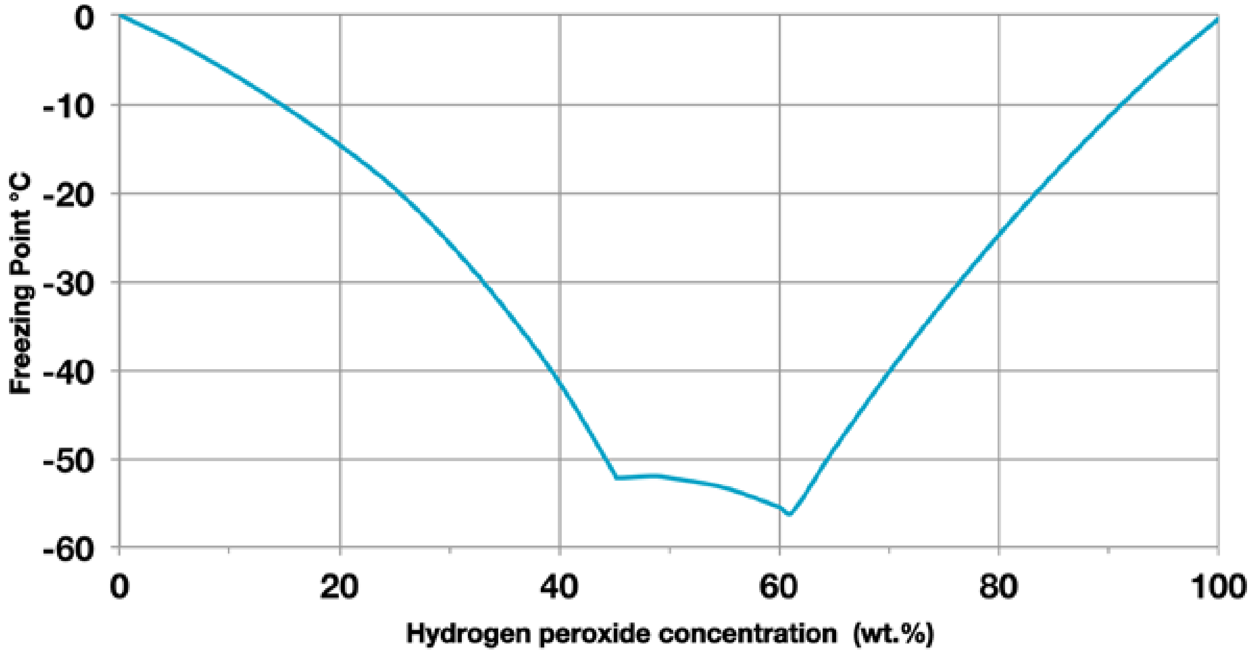
Density. This chart illustrates the density of aqueous hydrogen peroxide solutions at different temperatures.



Boiling Point. The boiling point of aqueous hydrogen peroxide solutions at atmospheric pressure are:



Freezing Point. Hydrogen peroxide solutions of different concentrations freeze at different temperatures, as this chart shows.



The chemical reactions that form the basis of hydrogen peroxide's technical usage are principally of three types:
– decomposition
– redox-reactions
– transfer of the O-O group

pH
Stabilized aqueous hydrogen peroxide solutions have a pH < 4.0. Solutions are most stable within this range.

Decomposition
In its pure form and at low pH, hydrogen peroxide is a relatively stable compound. However, decomposition can be initiated and accelerated by light, heat, high pH or the presence of various impurities, such as metals or by mixing with other oxidizers or reducing agents.

Decomposition is an exothermic reaction, which means it liberates heat and oxygen, often in considerable quantities. This liberation of heat can in turn accelerate the decomposition process.

$H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2 + \text{Heat}$	Hydrogen peroxide decomposes into oxygen and water.

Homogeneous decomposition
When hydrogen peroxide is contaminated by certain soluble metal salts, a very rapid decomposition can take place even at very low levels of contamination (a few ppm). This is called homogeneous decomposition and occurs in the presence of salts of, for example, iron, copper, chromium, vanadium, tungsten, molybdenum and platinum.

Heterogeneous decomposition
Heterogeneous decomposition is the name given to the sometimes very rapid decomposition that occurs when hydrogen peroxide comes into contact with insoluble materials (e.g. unpassivated metals objects) It occurs on contact with virtually all materials, but the rate of decomposition varies widely.

Redox reactions
Hydrogen peroxide has a high oxidation potential and acts as a powerful oxidant. An example of such a reaction is:

$H_2S + H_2O_2 \rightarrow 2H_2O + S$	Hydrogen sulfide dissolved in water is oxidized.

This reaction makes it possible to eliminate strong smelling sulfide odors in sewage treatment or chemical operations.

Bleaching of pulp
The bleaching of pulp is performed at an alkaline pH and the active bleaching species is the hydrogen peroxide anion (perhydroxyl anion), HOO^-:

$$H_2O_2 + OH^- \leftrightarrows HOO^- + H_2O \quad (pKa\ 11.75\ at\ 20°C)$$

Transfer of 0-0 group
Here the ability of hydrogen peroxide to form other per-compounds, both organic and inorganic, is utilized according to the following stoichiometry:

$$H_2O_2 + 2RX \rightarrow ROOR + 2HX$$

Reactions with alkaline substances
If the pH of the hydrogen peroxide is raised substantially above pH 4, its decomposition rate increases sharply. This can occur if alkaline substances (e.g. caustic soda, water glass, limestone, hypochlorite or ammonia) are mixed with hydrogen peroxide.

Reactions with organic substances
Hydrogen peroxide can cause ignition of wood, grass, sawdust, paper pulp and similar organic materials; combustion is not always spontaneous and could be delayed by hours or days as the hydrogen peroxide solution dries.

When in doubt about mixtures with hydrogen peroxide, please contact your AkzoNobel Representative.

Reactions with metals
Many metals (such as Fe, Cu, etc.) and their compounds cause catalytic decomposition of hydrogen peroxide. But very pure, passivated stainless steel and pure aluminum do not have this effect. They can therefore be used as construction materials for tanks and piping etc. (Read about passivation in the equipment section)

Reactions at high concentrations
AkzoNobel manufactures hydrogen peroxide solutions in concentrations up to 70% and such solutions cannot give cause for explosive hydrogen peroxide gas. **Hydrogen peroxide in the gas phase can become explosive if the concentration in the gas phase exceeds 26 mol%**. At atmospheric pressure, a 74% or greater concentrated hydrogen peroxide solution gives such a gas mixture. The concentration limit drops as pressure increases!

Safety and handling

All handling of hydrogen peroxide should be done in conformance with applicable regulations. Please refer to the CURRENT hydrogen peroxide SDS for the CURRENT regulatory information about its safety and handling. Your AkzoNobel representative will be able to provide you with this document.

Hydrogen peroxide is a relatively "user friendly" chemical, especially in low concentrations; nevertheless certain safety precautions must be observed to prevent accidents and possible injuries. While hydrogen peroxide is non-combustible, decomposition can occur when it comes in contact with anything organic, often producing enough heat and oxygen to start a fire.

Mandatory safety attire

Because hydrogen peroxide should never come in contact with combustible materials like cloth and leather, it's imperative that workers handling the chemical always wear the appropriate protective clothing. A proper safety ensemble includes all of the following:

1. A protective suit of vinyl, neoprene, PVC or polyethylene.
2. A pair of vinyl or neoprene boots.
3. Protective goggles that fit snugly over the eyes.
4. Rubber gloves of vinyl or neoprene.
5. A hard-hat with a full face shield.

A number of other safety regulations and procedures should be observed:

1. Safety showers, eye wash stations and jump tanks should be located close to where hydrogen peroxide is unloaded and stored.
2. Follow local regulations when taking care of any spill. Always use large amounts of water to dilute and wash away any spills of the chemical. Never use mops, rags, or other combustible materials. A water hose should be provided within easy reach for dilution and flushing of any spilled hydrogen peroxide.
3. Make sure workers don't wear leather shoes around hydrogen peroxide storage areas. Stepping in even a small puddle of concentrated hydrogen peroxide can initiate combustion of leather footwear. Combustion is not always immediate and could be delayed by hours or days as the hydrogen peroxide solution dries.
4. Because hydrogen peroxide has a strong reaction to most metals, workers should keep all keys, tools and other metal objects away from unloading and storage areas.
5. In laboratory work with hydrogen peroxide, mechanical pipetting equipment must be used.
6. Tanks and containers should be marked with the appropriate hydrogen peroxide concentration as well as an oxidizer and corrosive chemical warning. The tank should also be labeled with the appropriate local/regional hazard ratings placard to assist emergency personnel in the event of a fire or other situations.

All personnel who work with hydrogen peroxide should be well versed on these basic safety regulations.

Personal injuries and first aid

Hydrogen peroxide presents a significant physical hazard at high concentration. It can cause injuries, mainly through its ability to form free, active oxygen. Below are examples of different types of exposures, their effects and the first-aid steps to take. **Always refer to the current SDS for the most current information.**

1. **Skin and mucous membranes:** At concentrations of about 10 percent (5 percent on mucous membranes) hydrogen peroxide acts as an irritant. At higher concentrations it is corrosive. Contact causes whitening of the skin with subsequent itching, due to the formation of small oxygen blisters inside the skin which give rise to subcutaneous emphysema. Remission occurs within an hour, normally without any permanent injuries.

   First aid: In case of contact, flush with plenty of water. Remove contaminated clothing and wash as soon as possible. If redness occurs on prolonged contact with concentrated hydrogen peroxide, seek immediate medical attention

2. **Eyes:** Hydrogen peroxide can be dangerous to the eyes even in concentrations as low as 5 percent. Concentrated hydrogen peroxide can cause permanent corneal injury and possibly blindness. The injuries may not become noticeable for a week, so if there is any suspicion that the chemical has splashed into the eyes, first aid steps should be taken immediately.

   First aid: If hydrogen peroxide splatters in the eyes, flush with plenty of water for at least 15 minutes. Remove contact lenses. Seek immediate medical attention, preferably an eye specialist.

3. **Inhalation:** Inhalation of concentrated hydrogen peroxide vapor or mist mainly affects the upper respiratory passages, which can cause irritation. Inhalation over a prolonged period of time can result in injuries to other parts of the respiratory system. In high concentrations there is a risk for bronchitis and fluid effusion in the lungs (pulmonary edema).

   First aid: In case of inhalation, get fresh air, flush nose, mouth and throat with water. Rest. If the irritation does not stop or if the exposure has been severe, seek immediate medical attention.

4. **Ingestion:** Ingestion of hydrogen peroxide can cause bleeding of mucous membranes in the mouth, esophagus and stomach. Oxygen gas in the esophagus and stomach cause dilation, leading to severe injuries.

   First aid: In case of ingestion, drink large quantities of water. Try to burp up gas from the stomach, but don't induce vomiting. Never give anything orally to an unconscious victim. Seek immediate medical attention.

Spills

It is essential that all personnel handling hydrogen peroxide have sufficient training and knowledge in safe handling, first aid and emergency response. It is the responsibility of each customer to set up operational procedures, an emergency plan and organize regular training. **Please contact your AkzoNobel Representative if you need assistance to meet above obligations.**

Hydrogen peroxide in concentrations below 10 percent is relatively non-hazardous as far as material damages are concerned. However, handling of the chemical in higher concentrations entails greater risks. The hazard of gas liberation must always be taken into consideration. If hydrogen peroxide should spill on the ground or any equipment, take immediate action.

> **Safety action:** Flush with plenty of water. When sufficiently diluted (1 percent or lower), hydrogen peroxide is non-hazardous.
>
> In the event of discharges to watercourses or sewage installations, customers should ensure that appropriate safety and notification requirements are followed.

Swelling plastic packaging

If a plastic container holding hydrogen peroxide begins to swell, this is the sign of elevated internal pressure. Swelling can also be caused by a defective venting valve, or by ongoing and possibly accelerating decomposition in the container.

> **Safety action:** Personnel wearing full safety equipment should immediately wash down the container from a remote location with cold water. If the container should burst, quickly dilute the contents with large quantities of water. Also, be sure to dilute with water any organic material that may have come into contact with the spilled hydrogen peroxide. Contact AkzoNobel Pulp and Performance Chemicals to report the occurrence as further investigation of the cause will be necessary.

Decomposition in storage tanks

Rapid decomposition of hydrogen peroxide is rare but can occur as a result of contamination. The rate of decomposition is dependent on the solution temperature. As this reaction is exothermic, preventive measures include monitoring the temperature of the tanks.

Construction of storage tank and temperature monitor

The tank should be equipped with:
- Local temperature reading
- Remote reading of the temperature
- Alarm indication with a high temperature

The temperature alarm point should be set just over the normal liquid temperature and adjusted according to the season and climate. **Please contact your AkzoNobel Representative for more detailed advice regarding your particular circumstances.**

Temperature alarm alert

Actions with a high temperature alarm or decomposition of hydrogen peroxide

Safety action:
- Check that it is not a false alarm.
- Check whether the tank has a higher temperature than the surroundings.
- Monitor the temperature trend continuously.

Constant or falling temperature - there is no immediate danger.

Rising temperature - further actions must be taken. Follow your pre-established emergency plan that can include the following actions:
- Water is poured on the outside of the tank.
- The content of the storage tank is diluted with water via the fire water coupling.
- The tank is drained via the bottom drain. The drained hydrogen peroxide is diluted with large amounts of water.
- IMPORTANT! Contact the Emergency Services and other relevant authorities.

In the event of a temperature increase above 50°C or 122°F, personnel should be evacuated from the vicinity of the tank. Safety is important. Decomposition can cause the vessel to burst and/or overheat.

Fire

While neither flammable nor combustible, hydrogen peroxide can sustain combustion. Hydrogen peroxide can cause ignition (spontaneous combustion) of wood, sawdust, paper pulp, fabric and other organic materials; combustion is not always spontaneous and could be delayed by hours or days as the hydrogen peroxide solution dries. Heating of closed containers can result in the vessel exploding.

Safety action: Extinguish only with large quantities of water. Do not use foam or powder. Keep exposed containers well cooled with water. Keep hydrogen peroxide, in even the smallest concentrations, clear of combustible substances.

Procedures for safe handling.

Even though hydrogen peroxide presents risks, personnel who handle the chemical should know those risks and how to handle them with care. Those procedures include the following:

1. Keep hydrogen peroxide in its original container for as long as possible. Containers must be stored in an upright position to prevent liquid from blocking the venting device installed atop the container.
2. Hydrogen peroxide should never be returned to its original container or tank once it has been removed. Dispose of any unused quantities according to local regulations.
3. Extreme cleanliness must be exercised in the handling of equipment and apparatus for hydrogen peroxide.

Storage

Through stabilization hydrogen peroxide attains good storage characteristics. The addition of stablizers will give a level of tolerance against unintentional contamination. A low pH value (< 4.0) in the product contributes towards good stability. Hydrogen peroxide is sensitive to heat and contamination. As heat develops during the decomposition of hydrogen peroxide an accelerated rise in the temperature can take place. Under specific conditions hydrogen peroxide also has the capability to ignite combustible materials. Hydrogen peroxide should preferably be stored in a dark and cool location (refridgeration is not necessary). It should also be protected from the risk of being contaminated and kept away from combustible substances. Heating hydrogen peroxide increases decomposition. As a guideline value, the rate of heterogeneous decomposition doubles with a temperature increase of 10°C. At room temperature you can expect a decomposition of approximately 1- 2% per year. The concentration has some bearing on the stability, which in general increases with increased concentration. Diluting with water always impairs stability. Some organisms have the ability to break down hydrogen peroxide with the help of enzymes. The risk of contaminating the hydrogen peroxide is avoided by selecting the right materials to construct the storage system.

AkzoNobel will willingly offer advice about the design and fabrication of storage systems for hydrogen peroxide. The information presented in this manual will serve as a guide and illustrate best practices.

Please be aware in most countries there are strict regulations regarding storage of hydrogen peroxide. It can involve tank design, safety distances and spill/tank collapse collection bund.

To comply with U.S. law, any facility that plans to store hydrogen peroxide in concentrations greater than 52%. and in quantities greater than 7,500 pounds must conform with OSHA's Process Safety Management (U.S. customers only).

Under EU directive 2004/73/EC all hydrogen peroxide volume (≥ 50%.) should be considered in determining if the Seveso directive is applicable or not.

Dilution

Virtually all dilution, even with very pure water, impairs stability. This is because minor amounts of contamination can never be avoided, partly because the concentration and effect of the stabilizers decreases with the increase in volume and partly due to the pH value rising with dilution. Therefore avoid diluting large quantities at the same time. Instead dilute small quantities, which can be used on the same day. Use distilled or ion exchanged water. It is very important that the water is free from metal ions. **Please contact your AkzoNobel Representative for advice about water quality.**

After dilution it may be suitable to adjust the pH value to between 2 and 4. This can be done using phosphoric acid. Dilution with alkaline solutions results in increased degradation; thus the shelf-life of such diluted materials is short and limited to hours or days. Consequently, hydrogen peroxide cannot be mixed with alkaline solutions other than in consumable processes. It is very important that the dosage pipes from the hydrogen peroxide system do not feed other systems so that back flow can never occur. Dosage pipes should open up above the possible liquid level in an open container. The hydrogen peroxide system must never be connected to other systems thus creating interconnected vessels. Prepared mixtures must never be enclosed in vessels or in pipe systems without adequate venting and/or pressure relief system.

Transportation

Please refer to the CURRENT hydrogen peroxide SDS for the CURRENT regulatory information about its transporation. Your AkzoNobel Representative will be able to provide you with this document.

The volume of hydrogen peroxide used by a particular application is relevant when selecting the mode of delivery transport and type of container. It is recommended that consultation with an AkzoNobel expert is made in the planning stage, before FINAL decisions are made. Hydrogen peroxide is classified as a dangerous good. Transportation modes as well as container design are subject to transportation regulations.

AkzoNobel's hydrogen peroxide is supplied as an aqueous solution with a maximum concentration of 70% and is available for delivery in bulk tank trucks, bulk rail cars and ISO containers. Concentrations below 52% are also available in drums and tote tanks. Concentrations above 52% are governed by PSM regulations (US Government - OSHA) and are subject to more stringent regulations. Alternative packaging may be desirable for some applications and will be considered on an individual basis. Transport can take place by road, rail and to sea.

Containers and tanks with hydrogen peroxide should always be equipped with warning signs and information about the contents and concentration. There should always be a route card in the vehicle when transporting by road. The driver should be fully informed of the risks and necessary actions in the event of an accident. See the safety data sheet for more information.

Examples of containers/packaging

Drums

Isotainers (tank containers)

Totes

Road tankers

Railway tank wagons

Unloading

Emptying of tank truck or railcar
Combustible material must never be present in the vicinity of the railcar or tank truck. Use brakes and wheel chocks to make sure the vehicle or car cannot move. We recommend that the unloading area be cordoned off to prevent collision. A warning sign or light should be installed to indicate that unloading of the chemical is in progress.

Please plan ahead to prevent overflows; ensure that the storage tank has more than adequate capacity to hold the quantity of the container being unloaded. In order to prevent contamination (unloading of another product), a physical barrier must be established (minimum requirement), for instance by a cap or a valve closed with a key, under the responsibility of a responsible member of the personal of the plant. Coupling: a dedicated coupling is recommended. Pipes must be dedicated to HP: no cross connection, no common header. Label clearly the unloading zone and pipes (particularly the connection point for unloading).

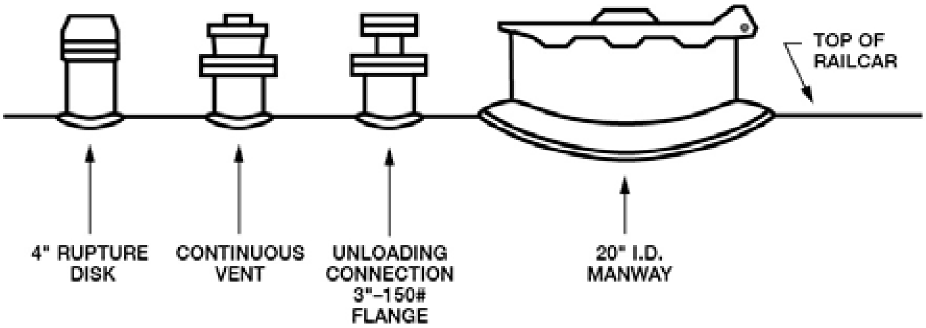
Check the venting, overflow piping and overfilling warning indicators of the container. (Note: Only suitable, thoroughly cleaned materials should be used in the construction of all tanks and containers. For recommended materials and design guidelines see the section on equipment section of this manual.)

Preferably, hydrogen peroxide should be unloaded using a self-priming centrifugal pump; this pump must be dedicated to the use of hydrogen peroxide. The unloading by clean dry air (oil free) or nitrogen is nevertheless acceptable ONLY if suitable equipment is present and this practice is permitted by local regulations. If this method is to be employed, the gas system should be equipped with a proper filter, pressure reducing valve (secured at 2.5 bars), safety valve and pressure gauge (do not use engine discharge). The compressed air lines must be manufactured of materials approved for hydrogen peroxide. **In North America unloading of railcars and tanker cars with COMPRESSED AIR is NOT PERMITTED as they are not equiped for this method. Attempts to unload the railcar with compressed gas may result in damage to the continuous vent. Before attempting to unload the product using compressed gas, please contact your AkzoNobel Representative. Typically unloading is performed by AkzoNobel trained/certified drivers.**

It is important that all equipment used for unloading hydrogen peroxide be dedicated solely to that purpose.

Note: Any unloading facility must be approved by AkzoNobel personnel prior to being used for unloading hydrogen peroxide. For more information on Process Safety Management, contact your AkzoNobel Representative.

Figure 1
Illustration of features required on a hydrogen peroxide dedicated railcar.



Labeling and placarding
Hydrogen peroxide in concentrations from 20 to 60 percent (UN 2014) and hydrogen peroxide in concentrations greater than 60 percent (UN 2015) are classified as a "class 5.1 oxidizer" and must be marked, labeled and placarded accordingly. All hydrogen peroxide solutions of ≥20% are also required to have a “class 8 corrosive” label.

All packaging and tanks used for sea transport should have the proper shipping name
- On packaging on one side
- On IBC’s on two opposite sides
- On tanks on all four sides of the containers

Marking and labels should be grouped closely together on the container face(s).

Please contact your AkzoNobel Representative for advice on the correct labeling and placarding. Customer are responsible for ensuring that all placarding and labeling is done in conformance with applicable regulations.

Transportation emergencies
In case of an emergency please report details to appropriate authorities immediately.
When reporting an emergency be prepared to give the following information:
1. The caller's name and organization.
2. The caller's phone number and location of the emergency.
3. Details of the incident.

For all emergencies, call:

US	+1-800-424-9300 (Chemtrec)
Canada	+1-613-996-6666 (Canutec)
International	+1-703-741-5500 (Chemtrec)

Please refer to SDS for additional contact information.

Equipment

All equipment designed to contain hydrogen peroxide should be engineered first and foremost to address the tendency of this chemical to decompose and form oxygen gas in the event of contamination. For that reason, tanks and other containers should be designed to prevent contamination. Moreover, design should be of a quality that minimizes the possibility of explosion or catastrophic release, even if extensive decomposition should occur.

Always contact AkzoNobel prior to initiation of projects involving new construction or revisions to hydrogen peroxide related processing facilities.

Materials

Materials used in the construction of containers or other equipment should be chosen with great care. The suitability of some common engineering materials is discussed here. Instructions for welding and passivation are provided for aluminum and stainless steel. Aluminum is considered an inferior fabrication material, and therefore we recommend austenitic stainless steel when manufacturing tanks.

Aluminum

The aluminum must be highly pure (at least 99.5% to 99.7% Al, Aluminum Association Designations 1060, 1080A, 1260, 5254, 5652. Aluminum can be used for manufacture of both tanks and pipes. However, for fabrication related reasons, aluminum is usually used only for tanks, while stainless steel is used for piping. TIG (tungsten metal-arc) or MIG (gas metal-arc) welding with shielding gas (e.g. Argon) must always be used for aluminum welding. Tungsten electrodes should be used for TIG welding. It is important that the filler metal has the same composition as the base metal and be free from moisture and other impurities. A high degree of cleanliness must be observed during fabrication to make sure no dirt or other organic matter becomes absorbed into the aluminum. Tools and cleaning equipment should be plastic or stainless steel. Aluminum equipment must always be pickled and passivated before being filled with hydrogen peroxide. This process should be repeated every 3 to 5 years due to the corrosive action of hydrogen peroxide on aluminum.

Stainless steel

This is the most suitable material for hydrogen peroxide equipment. It is recommended that instruments, piping and the like should be made of stainless steel equivalent to grade AISI 316L (EN 1.4404). Pumps should be AISI 316. This material can also be used for tanks and mixing vessels. When possible, TIG welding with shielding gas should be used. The piping must be well-filled with shielding gas to ensure a good weld on the inside. A properly executed TIG-welded pipe joint does not need to be pickled on the inside. Cleaning with water and passivation with hydrogen peroxide is sufficient. If it's determined that the piping does need to be pickled, it must be done with nitric acid. Make sure steel plates are protected during the fabrication. Tanks, which cannot be filled with shielding gas, are usually welded using the metal arc welding method. It is important that the filler rod is of the same composition as the parent material. When the slag has been removed the weld should be cleaned with a rotating wire brush (of austenitic stainless steel) and treated with pickle paste. The pickle paste is removed with a hard plastic brush and water. The supplied metal sheets must be protected during manufacture. Damage when rolling and grinding must be treated again with pickle paste.

Stainless steel tanks must be cleaned and pickled before final passivation with hydrogen peroxide and/or nitric acid. **Contact your AkzoNobel Representative for additional information about passivation of new equipment.**

Plastics

Certain plastics like HDPE can be used for equipment. However, with plastic there is a greater risk of damage in the case of a collision and because of aging of the material. Care should be taken to position or install a plastic tank to protect it from collision and possible rupture. Fluoropolymers, such as Teflon® (PTFE), are other appropriate materials to use with hydrogen peroxide. Gaskets and seals should preferably be made of these materials or of polyethylene, uncompounded PVC or silicone rubber.

Glass and porcelain

These materials are reserved for use in the laboratory.

Hoses

It is strongly recommended that hoses be 316L SS metal braided. A suitable alternative material is reinforced flexible PVC or cross-link polyethylene lined.

Recommendations on construction materials for hydrogen peroxide systems

	Best	Good	Satisfactory
Tanks	316L Stainless Steel Alloy	Aluminum 99.5-99.7% Al (1060, 1080A)	HDPE (only up to 50% solution concentration)
Small Vessels	316L Stainless Steel Alloy	Aluminum 99.5-99.7% Al (1060, 1080A)	HDPE (only up to 50% solution concentration)
Pipes and Fittings	316L Stainless Steel Alloy	Aluminum 99.5-99.7% Al (1060, 1080A)	Rigid PVC
Pumps, Valves	316L Stainless Steel Alloy		
Gaskets, Seals	Teflon (PTFE), Polyethylene		Silicone Rubber Uncompounded PVC
Hoses	316L Stainless Steel Alloy BRAIDED	Reinforced Flexible PVC	Flexible PVC

Cleaning and passivation

All materials that come into contact with hydrogen peroxide must be thoroughly cleaned and passivated. No materials other than those mentioned in the equipment section of this manual should be usedwithout first consulting AkzoNobel. It is recommended that an AkzoNobel representative is present at the first use of the tanks with hydrogen peroxide.

Cleaning

Hydrogen peroxide is very sensitive to contamination. It is absolutely essential to thoroughly clean storage tanks, pipes, pumps and fittings in order to keep decomposition to a minimum. All accessible welds and ground surfaces on austenitic stainless steel must be pickled using pickle paste after fabrication or repair work. The pickle paste, which must not contain hydrochloric acid, is carefully removed using a hard plastic brush or a stainless steel wire brush and water. After pickling and cleaning, surfaces should be rinsed with water.

Do not use lake water or river water and never salt water. In the latter case, hydrogen peroxide and chlorides can give rise to available chlorine resulting in severe corrosion. It is possible to use drinking water, but cleaning should always be ended by rinsing with distilled or ion exchanged water.

Cleanliness demands on the tank or pipe system should be placed on a par with the cleanliness demands made on food storage.

Passivation

All equipment made of aluminum or austenitic stainless steel should be passivated. Passivation involves the surface being coated with an extremely thin protective oxide film. In oxidizing environments (e.g. contact with hydrogen peroxide) this gives very good protection to the underlying metal. This thin protective oxide film is fragile and can easily be compromised by exsposure to reducing solutions or mechanical damage.

Passivation is usually carried out using various concentrations of nitric acid depending on the material in question.

Always contact AkzoNobel for more detailed advice and assistance when cleaning and passivation are to be carried out.

Tanks

Always contact your AkzoNobel Representative for recommendations on your specific installation.

The following points are recommended for the design of hydrogen peroxide storage tanks. There are guidelines to help with a safer, more dependable operation. It is your responsibility to review and comply with all applicable legal requirements.

1. **Tank** - should be constructed of one of the materials listed in the beginning of this section. The material should meet carefully defined specifications for purity. The tank should be cleaned, pickled and passivated according to AkzoNobel recommendations (a good benchmark for cleanliness would be material sanitary enough to be used in food applications).

   U.S. and Canadian Fabrication Codes, API and ASME, contain general directions regarding the design of storage tanks. As a rule, insulating the tank is not recommended (see freezing point graph on page 7).

   The tank should be freestanding outdoors and be located within a dike. It should be marked HYDROGEN PEROXIDE and carry an NFPA warning label for a corrosive and oxidizer.

2. **Filler pipe** - Nominal size 3 inches (80mm) with a 2 inch (50.8mm) camlock fitting near the ground. The pipe should be fitted with a valve and coupling that conforms to AkzoNobel's recommendations. Make sure the pipe enters the tank from above and fits into the tank by 1 inch (20-30mm). It should be securely fastened to prevent severe vibration during filling. As with the tank, the pipe should also be labeled HYDROGEN PEROXIDE. There should be a tank level gauge with local display. (High and low alarms in the control room).

   To prevent mistakes during unloading of hydrogen peroxide, install a lock on the filling valve. The key for the lock should be entrusted exclusively to the person in charge of chemical receiving.

3. **Manhole** - Should seal tightly under its own weight and be mounted solely on a hinge, not fastened with bolts. This allows pressure release in the event of decomposition. The recommended minimum size is 24 inches (600mm), but the size should be increased to accommodate larger volumes and higher hydrogen peroxide concentrations.

4. **Local temperature measurement and alarm** - This equipment is connected to the control room or similar monitoring area. The high temperature alarm function should be set based on local conditions, normally15° to 20°F (8° to 11°C) above ambient temperature. If a 4°F rise per hour is experienced, this could be a sign of hydrogen peroxide decomposition and AkzoNobel should be contacted.

5. **Fire water connection** - Nominal size 3 inches (80mm), intended for instant dilution in the event of decomposition.

6. **Vent pipe** - Nominal size 6 inches (150mm) in North America and 8 inches (200mm DN 200) in Europe with a nominal cross-sectional area four times as big as the filler pipe. It should be short, weather-protected and discharge visibly from the unloading station. Connect the vent pipe to the tank via a flanged connection.

7. **Overflow pipe** - Nominal size 3 inches (80mm).

8. **Bottom nozzle** - This apparatus for draining the tank should be a nominal size of 4 inches (100mm). Note that the ball valve should be drilled for pressure release. See Figure 3. No drainage via siphon action.

9. **Tank placement** - Should be on a firm base or surface. If the base is concrete and the tank is aluminum, the tank bottom should be protected. A flexible PVC sheet 1/8 to 1/4 inch or 3 - 5mm thick is recommended.

10. **Floor drain** - If existing, this should be near the filler pipe and overflow pipe. Spills should be disposed of according to local environmental regulations.

11. **Water** - Outlets should be nearby and plentiful in case of a spill. Also, well-marked safety showers, jump tanks and eye wash stations should be located throughout the area.

Location

It's wise to locate hydrogen peroxide tanks so that large quantities of dust and other impurities cannot enter with atmospheric air. A filter on the vent pipe may sometimes be necessary. If so, the risk of moisture formation and freezing must be prevented.

There should be no flammable or combustible materials in the vicinity of storage tanks. Piping for other chemicals, such as caustic soda (sodium hydroxide) or water glass (sodium silicate), should be located away from hydrogen peroxide storage facilities to ensure that leakage will not damage tanks or come into contact with hydrogen peroxide.

The tank must not be located in a place where there is a risk of exposure to excessive heat or an open flame. If a tank should be placed outside an industrial area, the tank should be fenced in for security purposes.

The unloading station should be situated where it can be easily reached by tank trucks. There should be sufficient room to allow for a wide turning radius by tank trucks.

Decomposition

Rapid decomposition of hydrogen peroxide is very rare, but can occur through external contamination or through an object, e.g. a tool, falling into the tank. Increased decomposition is first noticed through increased temperature. AkzoNobel will help to draw up safety procedures governing actions in the event of decomposition in the storage tank. The main elements are temperature monitoring, cooling, pressure measurement, water dilution and tank emptying. These safety procedures should be kept in the control room or the like. The instruction must be framed with focus on the installation and the tank equipment. See the safety and handling section for a general instruction about actions with decomposition.

Pipes and valves
Always contact your AkzoNobel Representative for recommendations on your specific installation.

Piping systems with pumps, heat exchangers, instruments, etc., must be designed with great care to eliminate the risk of hydrogen peroxide being confined between two closed valves or in other enclosed spaces. Such confinement, combined with decomposition, could result in pressure elevation until the weakest part of the system bursts.

This problem can be avoided by engineering the systems to always include a release or escape route for the pressurized gas to take. The following design recommendations are offered:

1. Use a minimum number of valves.
2. Where several valves in series cannot be avoided, a small safety valve for liquid or a small rupture disc can be used to provide pressure relief in the system. Blind flanges installed on the discharge side of a properly drilled ball valve can still result in over-pressure conditions. **Avoid this combination.**
3. Run a small recirculation line with restriction orifice from the discharge side of the pump back to the tank.
4. Avoid locating shutoff valves and bypass valves next to control valves.
5. Ball valves should be specially cleaned and drilled to prevent overpressure conditions. **Note the installation direction in Figure 2.**
6. Make sure the design keeps hydrogen peroxide from coming into contact, directly or indirectly (via return lines or the like), with unsuitable materials of construction or process liquids.
7. Valves and pumps requiring lubricants should be avoided. Lubricated power ends on pumps are acceptable when maintained properly.
8. Pipes should be plainly marked to identify their contents.
9. Follow the directions for welding on page 21.

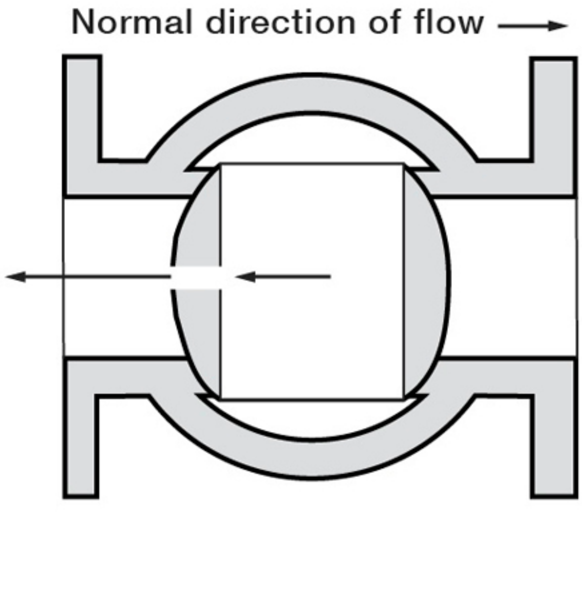


Figure 2
Drilled ball valve. Hole diameter of 1/8 inch (3mm) installed so that the hole faces upstream when the valve is closed.

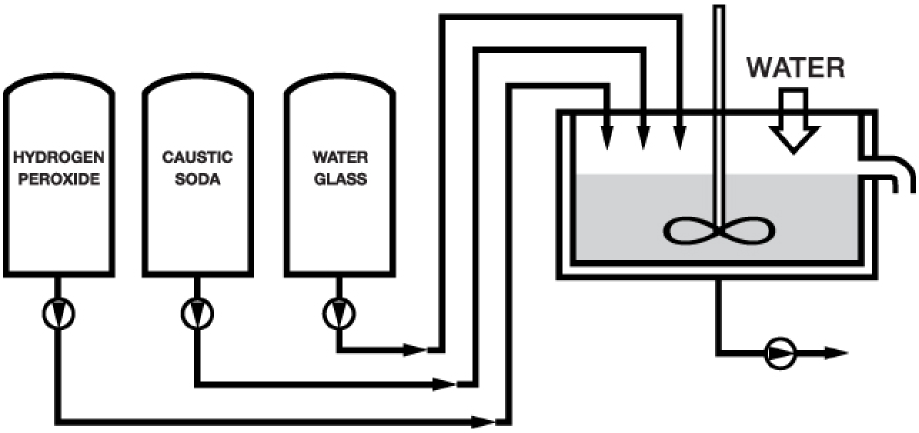


Figure 3
When hydrogen peroxide is pumped to a mixing vessel, the pipe should discharge above the highest level in the vessel.

Mixing and dilution

When hydrogen peroxide is mixed with other chemicals that hasten its decomposition, any risk that the mixture will be confined or siphoned back into the hydrogen peroxide storage tank should be eliminated. This can be done by allowing the liquids to run freely into a smaller mixing vessel, from which the solution is dosed into the system where it is to be used.

Any dilution water should be tested by AkzoNobel prior to use.

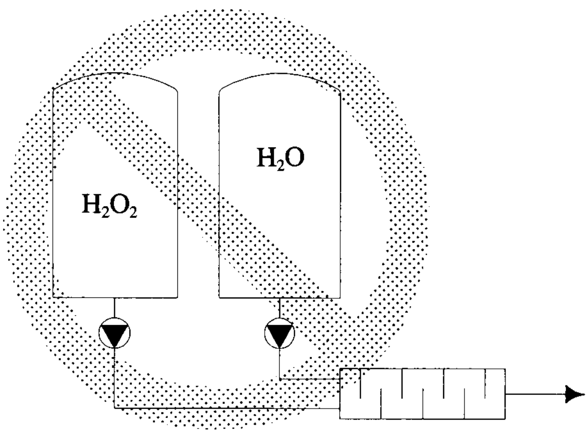


Figure 4
In-line mixing of hydrogen peroxide should never be done. Clogging in the mixer can lead to pumping chemicals into the hydrogen peroxide tank. Use the method illustrated in Figure 3.

When a dilution vessel for water is used, follow these procedures:

1. When starting, initiate the water flow first.
2. To stop, cut off the flow of hydrogen peroxide first.

Couplings

For hydrogen peroxide, AkzoNobel recommends uses a camlock fitting of stainless steel in a size of 2 inches (50.8mm)

Analytical procedures

Analytical determination of the hydrogen peroxide concentration
We recommend one of the following methods to determine the concentration of the hydrogen peroxide. In many cases when the residual concentration after a reaction is to be determined only the iodometric method can be used. The permanganate method is preferably used for the analysis of pure hydrogen peroxide. To confirm the concentration result two or several analysis sets should be carried out.

Permanganate method (pure hydrogen peroxide)
Solutions and chemicals
- Potassium permanganate, $KMnO_4$, 0.05 M For accurate analysis the solution needs to be filtered and the concentration determined.
- Sulphuric acid, H_2SO_4, 2.5 M.
- Saturated manganese sulfate solution, $MnSO_4$.

Performing the analysis
- Weigh accurately 0.2-0.6 g (see table to the right) of hydrogen peroxide solution in a 250 ml beaker on an analytical balance. -
- Add 150 ml distilled water and 10 ml 2.5 m H_2SO_4.
- Add a few drops of $MnSO_4$.
- Titrate with 0.05 M $KMnO_4$ until the color changes to pale pink.

H_2O_2%	Volume(ml)	Weight(g)
30	0.50	0.56
35	0.50	0.57
50	0.30	0.36
60	0.20	0.25
70	0.20	0.26

Calculation:

$$\text{Weight } \%\ H_2O_2 = \frac{V*C*8.502}{w}$$

V = consumption of potassium permanganate solution in ml
C = potassium permanganate solution's molarity
w = weighed in quantity sample in g

Iodometric method (residual concentration)
Solutions and chemicals
- Sulfuric acid H_2SO_4, 2.5 M
- Potassium iodide, KI, in solid form or solution (166 g/l)
- Ammonium molybdate, $(NH_4)_6Mo_7O_{24}{\cdot}4H_2O$
- Sodium thiosulfate solution, $Na_2S_2O_3$, 0.1M
- Iodine indicator, Thyodene or starch solution To make a 15% starch solution, heat to 70°C while stirring until the solution becomes clear.

Performing the analysis
Determining the concentration in g/l
- Measure up the exact sample quantity with a pipette. Adjust the sample quantity to the expected concentration of hydrogen peroxide (see chart on the following page)

- If the sample quantity is small, add distilled water to approximately 100 ml
- Add 10 ml 2.5M H_2SO_4 and 10 ml KI solution or 3g solid KI
- Add a spatula prong of $(NH_4)_6Mo_7O_{24}\cdot4H_2O$
- Titrate with 0.1M $Na_2S_2O_3$ to a yellow color
- Add iodine indicator, half a spoon or a few drops if a solution is used
- Continue to titrate until the solution is colorless

Expected Concentration (g/l)	Sample Quantity (ml)
0.01 – 0.1	100
0.2	50
1	10
2	5
10	1

Calculation:

$$g/l\ H_2O_2 = \frac{V * C * 17}{Vsample}$$

V = consumption of sodium thiosulfate solution in ml.
C = sodium thiosulfate solution's molarity
Vsample = sample quantity in ml

Iodometric method (second alternative for pure hydrogen peroxide)
Determining the concentration in weight
Weigh accurately 0.1-0.3g (see table below) of hydrogen peroxide solution in a 250 ml beaker on an analytical balance.

H_2O_2%	Weight (g)
30	0.26
35	0.26
50	0.14
60	0.10
70	0.10

- If the sample quantity is small, add approximately 100 ml with distilled water.
- Add 10 ml 2.5M H_2SO_4 and 10 ml KI solution.
- Add 1 drop $(NH_4)_6Mo_7O_{24}\cdot 4H_2O$
- Titrate with 0.1M $Na_2S_2O_3$ to a yellow color.

Add iodine indicator, half a spoon or a few drops if a solution is used.

- Continue to titrate until the solution is colorless.

Calculation:

Weight% H_2O_2 = $\frac{V * C * 1.70}{w}$

V = consumption of sodium thiosulphate solution in ml.
C = sodium thiosulphate solution's molarity.
w = weight of sample in grams.

This page is left intentionally blank

AkzoNobel Representatives will be pleased to discuss in detail the safe handling, application and benefits of Eka HP.

To arrange your personal interview, please contact your AkzoNobel Representative, email **bleaching_experts@akzonobel.com** or **ppcinfo@akzonobel.com** or call one of the phone numbers listed below:

Bohus
Akzo Nobel Pulp and Performance Chemicals AB
SE-445 80 Bohus, Sweden
T +46 31 58 70 00

Marietta
Akzo Nobel Pulp and Performance Chemicals Inc.
1850 Parkway Place, Suite 1200
Marietta, GA, 30067, USA
T +1 770 578 0858

Jundiaí
Akzo Nobel Pulp and Performance Química Ltda.
Rod. D. Gabriel P.B. Couto, km 65,2,
Jardim Ermida - Jundiaí – SP,
CEP 13212-240, Brazil
T +55 11 4589 4800

Tokyo
Akzo Nobel KK
KSK Build. 2F,
1-2-34, IchigayaSadohara-cho,
Shinjuku-ku,
Tokyo 162-0842, Japan
T +81 3 3235 9121

AkzoNobel

www.akzonobel.com

AkzoNobel is a leading global paints and coatings company and a major producer of specialty chemicals. Calling on centuries of expertise, we supply industries and consumers worldwide with innovative products and sustainable technologies designed to meet the growing demands of our fast-changing planet.Headquartered in Amsterdam, the Netherlands, we have approximately 47,000 people in around 80 countries, while our portfolio includes well-known brands such as Dulux, Sikkens, International, Interpon and Eka. Consistently ranked as one of the leaders in the area of sustainability, we are committed to making life more liveable and our cities more human.

AN_201595_270415