P R O D U C T G U I D E

JET-LUBE®

Cleaning Wells & Pipelines

Eliminating Iron Bacteria

DESIGN WATER TECHNOLOGIES

BY JET-LUBE

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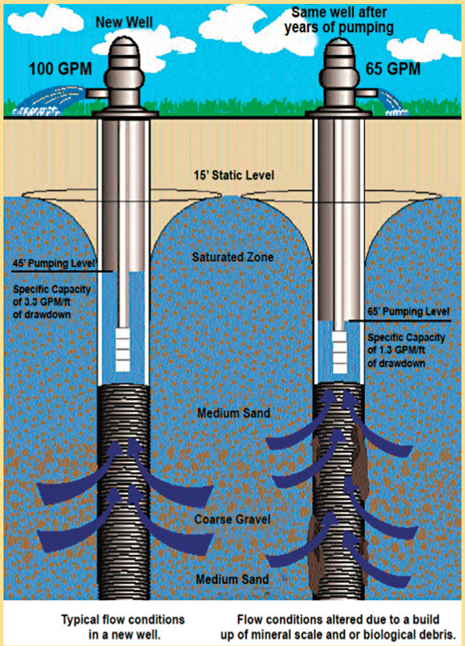
Eliminating Iron Bacteria



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Unfortunately, well maintenance is too often performed in an emergency basis without taking time to understand the true problem. Monitoring of well and pump performance as well as the scheduling of routine maintenance is not often done. During well rehabilitation, 50's vintage chemicals are often poured into a well, surged, and simply pumped to waste 12 hours later. There is little understanding of how well the chemicals did or did not work other than comparing the pumping rates before and after the project. Little attention is given to the dangers of chemicals to on-site personnel, the effects of corrosive liquids on well casings or screens, and the potential of contaminating aquifers with non-biodegradable, hazardous chemicals.

Jet-Lube® is changing the direction of well rehabilitation. We promote: 1) understanding a problem before solving it 2) manufacturing safe chemicals that provide consistent and long lasting results 3) monitoring these chemicals during the cleaning process 4) disposal of products properly once the project is complete.

Problem Evaluation and Keeping Accurate Records

It is critical to keep good records of well and pump performance. Yield alone is not a good indicator of well performance. Changes in yield could be due to pump problems or changes in the piping system. The only true method of monitoring well performance is to calculate Specific Capacity (SC) and compare to previous tests done at similar times of pumping.
Let a well set for several hours and record the Static Water Level (SWL). Then measure the Pumping Water Level (PWL) at a consistent pumping time, (example: say 30 minutes for domestic wells and at several hours for larger diameter wells) along with the Gallons Per Minute (GPM). Subtract SWL from PWL to obtain Draw Down (DD). Divide the GPM by DD to obtain Specific Capacity (SC) or GPM per foot of DD. This is the number to use for comparative purposes to determine declines in well yield, not the pumping rate only. For example: 32' PWL-15' SWL=17' of DD at 30 minutes pumping 20 GPM. 20 GPM ÷ 17' DD=1.17 GPM/ft of DD at 30 minutes. Always record the SC at approximately the same pumping rate and time for a more accurate comparison. If the pump yield and AMP readings are lower than previous data and the SC is higher, the pump needs repair. Conversely, if the pumping rate and the SC have declined, the well needs rehabilitation. Compare all information at least once a year on municipal or industrial wells. Record SC on all new wells and set a target at 60% of the original SC for planned rehabilitation. Check all domestic wells whenever any maintenance is performed. If the SC declines more than 30-40%, the problem should soon be addressed. It is more difficult to remedy a plugging problem caused by mineral scale if the SC has declined more than 40%. It is easier to successfully rehabilitate wells with plugging problems due to slime and iron bacteria, even if the SC is zero because the plugging is closer to the bore hole. A decline in the Specific Capacity can be blockage due to 1) mineral scale 2) slime bacteria 3) fine sand or silt infiltration into a screen area or bore hole 4) physical blockage in the bore hole or well screen 5) physical changes in the aquifer itself, i.e., reduction in static level and even seismic activity. Chemicals are not always the solution. Determine if any sand is being pumped which can often be found in pressure tanks, water lines, or holding tanks. Check the well depth, as there may be several feet of sand or debris in a screen or open borehole which can reduce yields. Determine if there is any build-up of hard scale or slime on pumps or on the ID of piping systems. Check available water quality information. You cannot make an accurate determination of the problem without good well records.

Mineral Scale Problems

Ground water often has high concentrations of dissolved minerals. Natural carbon dioxide (CO_2) in water produces carbonic acid, which keeps minerals in solution. During pumping, a portion of the CO_2 is lost through increased velocity and pressure losses causing a portion of the minerals in solution to precipitate as hardened, mineral scale. Temperature changes enhance mineral precipitation. Sulfate levels less than 70 ppm can precipitate when velocity is extremely low, which happens when the pump is turned off. A layering effect of the various types of minerals can occur with sulfates on the surface and carbonates beneath. Sulfate levels greater than 70 ppm can precipitate in the same manner as carbonates.

FIELD DIAGNOSIS FOR MINERAL SCALE

1. The specific capacity of a well declines slowly and somewhat consistently over several years, i.e., 5-15 years, depending upon water quality. A history of specific capacity should be reviewed in time.

2. A hard scale is noticed when pulling the pump or check the ID in a piping system. The color associated with each type of scale is as follows:

   red/brown = iron **black** = manganese

   green/blue = sulfates **white/light brown** = calcium

3. If you have information on water quality, look for any one or combination of the following:

   pH > (greater) 7 **iron** > 1.0 ppm **hardness** > 200ppm

   sulfates > 20 ppm **manganese** > .02 ppm

4. Nodules or bubbling that appear on pumps or pump column is a sign of corrosion due to electrochemical activity. Check total dissolved solids and if greater than 600 ppm, corrosion may be due to galvanic corrosion (electrolysis). When dissimilar metals are placed in water that is highly conductive to electricity, corrosion will occur on low carbon or galvanized steel and actually deposit on stainless steel.

5. In a video of a well, the buildup will be present in sections of screen where water velocity was at one time. Parts of the screen may be totally clean which indicates little or no velocity. (Figure 1, page 12) Also note that the debris will flake off and fall during camera movement. It generally will not show a cloud like discoloration.

Mineral deposits may occur in screened wells (slotted, bridge slot, louver, or continuous slot well screen) or open bore holes (fractured rock/shale, sandstone, or limestone). The type and amount of debris will depend upon water quality and usage of the well. Over pumping a well or cascading water will increase precipitation. Acids are commonly used to dissolve these deposits and return a well yield.

Different deposits react differently to acids. Calcium is the easiest scale to dissolve. When using hydrochloric (Muriatic) acids (HCl) in high calcium deposits, a violent reaction can occur. This reaction causes overfoaming or an explosion of acid spewing 20-30' out of the well. It can create a hazardous cleanup condition since inherent ingredients consist of heavy metals, i.e., lead, arsenic, zinc, etc. benzenes and other toxic organic compounds (TOCs). Muriatic is also very dangerous to store, ship, and use in the field. It is a gas by-product of other manufacturing processes, mixed as a liquid. Extreme care must be taken when working with hydrochloric, as the fumes released are instantaneously lethal. It is very corrosive and is generally not Hrecommended to use in a well or pipeline for longer than 12-16 hours, even with inhibitors. Inhibitors only last approximately 6-8 hours. HCl will be slower reacting with high concentrations of iron, manganese, and extremely slow reacting with sulfate scale. Do not use HCl in a well more than 4 times as may cause excessive corrosion, even in stainless steel screens and the screen may collapse.

Sulfamic acid was developed in the 50's to more safely dissolve calcium carbonate scale. It is not effective with scales or decayed organic debris consisting of iron, manganese, or sulfate. It is generally considered much safer than hydrochloric but is classified as a corrosive product and has shipping limitations. UNICID™ GRANULAR was developed in 1990 to safely dissolve all scales with the consistency of hydrochloric, but more safely than sulfamic. It is not corrosive to metal parts or harmful to plastic, so the time working in a well or pipeline is only limited to dissolving scale and organic debris. This is effectively done by monitoring color and pH to determine when the job is complete.

Treatment in Wells for Mineral Scale

PHYSICAL CLEANING OF WELLS

A specific amount of chemistry is required to dissolve an equal amount of scale, therefore it is beneficial to physically remove as much scale as possible prior to chemical treatment. Less product would then be required and it allows chemicals to more easily penetrate into the formation. Sonic jetting, dry ice, and high energy air pressure are methods used to successfully fracture hardened scale. These procedures are often used only on large-diameter wells because of the costs involved. Refer to manufactures recommendations and use qualified personnel to handle explosives. Another method to remove debris from the inside of the screen is to use a wire brush. This can be made easily with 1/4 to 1/2" steel cable cut slightly longer than the inside diameter of the casing, and welded horizontally through a piece of pipe with drilled holes for stability. All debris should be bailed or airlifted out of the well prior to chemical treatment. Our steel WIRE-HOG™ Casing Brushes are available up to 8" diameter.

Chemical Treatment of Wells with UNICID™ GRANULAR Acid

TREMIE LINE METHOD

Mineral scale is generally a problem only in the screen area of unconsolidated formations or fracture zones and solution channels in rock wells. If severe scale is present in the casing, it is advisable to physically remove excess scale by a wire brush or casing scrapper. Then air lift or bail the debris out of the well prior to chemical treatment. We recommend that UNICID™ GRANULAR be mixed with water and delivered through a tremie pipe just above the screen or open borehole in a concentrated form. All types of pipe can be used (PVC, black, or galvanized) as a tremie. Any pump can be used for mixing and pumping because UNICID™ is not corrosive to metal parts and will not damage pump seals or bearings.

Refer to the dosage chart in Table 1 (page 6) for the recommended amount of UNICID™ GRANULAR product for screened wells. For example: 8" pipe size, 15' long screen would require 2.6 lbs/ft of screen x 15' = 39 lbs. Mix the recommended amount of UNICID™ GRANULAR acid into a tank using two pounds per gallon of water as a maximum mix ratio. The 39 lbs of UNICID™ GRANULAR should be mixed into 20 gallons of water (39 ÷2=19.5). If the screen is less than 20' long, set a tremie pipe just above the top of screen and pump the acid into it. Displace the acid out of the tremie with plain water. In screens longer than 20' or multiple screens, acid should be placed with a tremie throughout the screen area in 20' sections and in equal amounts or between a packer system to localize the acid placement. Development should be started immediately. (Development, page 10).
Refer to Table 2 for dosage in consolidated rock wells and multiply by the total footage of the formation. Use a tremie line to install liquid acid just above the formation. If the formation is thicker than 40', place the acid in equal increments. Development should be started immediately.

POUR FROM SURFACE METHOD:

UNICID™ GRANULAR can be poured from the surface, but if the static water level is shallow and the well deep, the amount of product can be costly when calculating pounds required per foot of water in the well. Since mineral scale is generally a problem in the screen area or formation only, it is better to place acid through a tremie line. If you must pour UNICID™ GRANULAR from the surface, use the dosage shown in Table 2. The recommendations are based on pounds per foot of water in the well. For example: An 8" well with 15' of screen, static water level of 10', and a total depth of 115' would require 111 lbs. (115'-10=105' of water in the well x 1.1 lbs/ft of water=111 lbs). Note the dramatic advantage in the amount of product by placing the acid in a concentrated amount in the screen area.

UNICID™
GRANULAR

SCREENED WELLS Multiply pounds per foot of screen times length of screen. Mix as liquid, tremie into screen.	
Screen Diameter	***Pounds acid per foot of screen***
2"	0.50 lbs
4"	0.70 lbs
5"	1.00 lbs
6"	1.50 lbs
8"	2.60 lbs
10"	4.00 lbs
12"	6.00 lbs
14"	7.00 lbs
16"	9.50 lbs
18"	12.00 lbs
20"	15.00 lbs
24"	23.50 lbs
For other diameters of screens: Calculate total gallons of water in well screen x 8.33 x 0.12 (12%)	

ROCKWELLS Multiply pounds per foot times aquifer thickness. Mix as liquid, tremie throughout the aquifer.	
Screen Diameter	***Pounds acid per foot of formation***
2"	0.25 lbs
4"	0.30 lbs
5"	0.50 lbs
6"	0.70 lbs
8"	1.10 lbs
10"	1.75 lbs
12"	2.50 lbs
14"	3.00 lbs
16"	4.00 lbs
18"	5.00 lbs
20"	6.25 lbs
24"	10.00 lbs
For other diameters of rock formations: Calculate gallons of water in open formation x 8.33 x 0.05 (5%)	

CHEMICAL TREATMENT OF WELLS WITH UNICID™ BULLETS (PELLETS)

UNICID™ BULLETS are pelletized (same formulation as UNICID™ GRANULAR) with no adhesives.
A pelleted product dropped from the surface falls to the bottom of the well. Use the UNICID™ BULLETS only in screens shorter than 5', because all the pellets end up at the bottom of the screen. The saturation point is approximately 22%, so the pellets may not dissolve without a great deal of development action. Liquid acid weighs 9.5 lbs. per gallon and can be difficult to move up toward the top of a screen longer than 5'. Scale is more likely to precipitate in the upper portion of the screen than a lower area Development is critical to push acid outside the screen to dissolve scale in the formation. ("Development," page 12.) Do not use in wells with over 250' of water as the pellets will dissolve before reaching the screen. Simply drop the pellets in the well, surge for 1-3 hours. Let set overnight. Monitor pH in the morning and adjust accordingly ("Field Monitoring," pages 14 and 15).

REMOVING STUCK SUBMERSIBLE PUMPS WITH THE UNICID™ BULLETS

UNICID™ BULLETS may also be used to loosen stuck pumps due to mineral scale buildup or a paste created by pellet chlorinators. Simply pour 4 to 5 pounds of UNICID™ BULLETS on top of the stuck pump. You may have to break up the UNICID™ BULLETS to get them through the pitless adapter. Let sit overnight, and work the pump up and down to loosen the pump. In severe cases, an overshot casing scraper may be required to scrape the scale to the pump. Use an airline to blow debris out of the well prior to installing the UNICID™ BULLETS.

UNICID™
BULLETS

POUR BULLETS FROM SURFACE		
Screen Diameter	***Number of total pounds for screen***	***Pounds per foot of screen***
2" x 5'	2.50 lbs	0.50 lbs
4" x 5'	5.00 lbs	1.00 lbs
5" x 5'	7.50 lbs	1.30 lbs
6" x 5'	10.00 lbs	2.00 lbs

Slime or Iron Bacteria Problems

COMMON SOIL ORGANISMS

Most slime problems are caused by naturally occurring, common soil bacteria found in every aquifer. These are often referred to as heterotrophic bacteria. The most common of these are identified within the families of Pseudomonas, Aerobacter, Acinetobacter, and Flavobacter. Most are not a health issue. These bacteria process soluble nutrients (iron, manganese, etc.) and exist normally in numbers in single digit to tens of colonies per milliliter (< 50 colonies/ml). Many of these families are aerobic and may be highly mobile. Aerobic bacteria like areas of high oxygen in a well, ie., high velocity areas of a screen during pumping or at the static water level, cascading water, etc. Anaerobic bacteria like areas of low oxygen, ie., nonpumping wells, low permeable area of aquifers, sumps beneath screens in wells, or beneath large amounts of scale/slime debris, etc. Anaerobic bacteria often produce odors and can cause corrosion of well casings, screens, or pumps.

SLIME PRODUCTION

Aquifers have a natural direction of flow called a gradient. When a well is installed and pumped, the direction of flow and velocity change drastically toward the bore hole. This flow has a tendency to continuously bring more of these naturally occurring bacteria to the well. The natural flow velocity within an aquifer is measured in feet per year or even inches per year, whereas the flow around a well during pumping is measured in feet per second. Since slime formers are aerobic in nature, they like areas of high water movement. The numbers will increase dramatically at the bore hole over time. In lab studies, the number of bacteria will often be in the high hundreds of colonies/ml when slime problems exist. This can be compared to numbers in the tens of colonies when slime problems do not exist.

Tremendous changes in velocity and pressures also occur in the pump, pump drop pipe, and in the piping system. Massive amounts of slime may be found in these areas with little slime production in the well. Poor development techniques in new wells, which results in low well efficiency, increases the tendency for both precipitation of minerals and the production of slime. Poor well efficiency increases the velocity of water moving toward the bore hole and therefore increase the tendency for slime production. Actual plugging in wells and piping really only appear in approximately 3-4% of all well and most often occur in the first 4 years of operation.

Bacteria have a 22 minute life expectancy at 70°F and slightly longer in lower ground water temperatures. Once bacteria die, any slime produced will slowly decay over a long period of time. This becomes a ferric oxide and plugs wells just as mineral scale would. As water flows over this ferric oxide, CO_2 converts ferric to ferrous and concentrations of iron in water may fluctuate or elevate substantially. Levels of manganese and sulfates may also fluctuate.

The slime produced is a natural protection against harmful chemicals. Studies show shock chlorination kills only some of the bacteria and will oxidize or harden the surface of the slime mass. Bacteria may be damaged and will not repopulate as quickly for a period of time. At normal ground water temperatures, the time required to repopulate is generally weeks to several months. Bacteria can survive acid solutions with a pH of 2 for long periods which is impossible to maintain in the entire thickness of the bore hole and aquifer. Any attempt to kill bacteria with standard chemistry like chlorine, hydrochloric and hydroxyacetic acids is, at best temporary. UNICID™ will provide long term results.

IRON BACTERIA

It was thought that iron bacteria was the main culprit of slime problems in wells, but they have only been identified in less than 10% of our water studies in the past 10 years. It was also thought that iron bacteria was introduced into wells through dirty tools of well drillers and pump installers and is a possibility. Both site cleanliness and disinfection are important, but iron bacteria can also occur naturally in aquifers, in small numbers. These can only be identified under a microscope or in enzyme test kits. Iron bacteria produces a stalk or tube like, sheath. This becomes a framework that slime bacteria attach to or fill in, which increases the severity of plugging. Iron bacteria like areas of high nutrients, i.e., steel casing, pumps, and decayed debris from other bacteria. They secrete a very corrosive enzyme to process nutrients and corrosion is often found on metal surfaces. Physical indications may include musty, oily, or fishy odors and even an oily film on water. The most common families of iron bacteria are Galleonella, Crenothrix, and Leptothrix.

SULFATE REDUCING BACTERIA (SRBs) (ROTTEN EGG ODOR)

SRBs are anaerobic in nature, which means they survive in an environment where oxygen is not present. These areas include sumps below the screen or non-producing areas of a screen or aquifer. They are often found in wells that are not pumped frequently causing oxygen to be depleted.

New wells: SRBs reduce sulfates in water and require fairly substantial levels of sulfate or gypsum to survive. They process sulfate by releasing an organic acid that is very corrosive, creating a ferrous sulfate or ferrous oxide. These can be naturally occurring bacteria present in new wells within areas of clay or shale lenses. Completion of wells in clean sand with short sections of screen or casing driven to clean sandstone can minimize or eliminate these odors. Hydrogen Sulfide (H_2S) is a gas therefore the odor will be present in water when first poured into a glass but will dissipate in seconds. If the problem exists in a new well, the odor can be eliminated by aeration. DO NOT CHLORINATE AS IS A SHORT TERM FIX. Use either a bladder pressure tank with an air injection, a pressure tank without a bladder, or an open water storage tank to allow the gas to escape. A bladder pressure tank does not allow the gas to escape and the odor appears at the point of use.

Older wells: The sudden presence of a rotten egg odor in an older well where the problem did not exist may indicate a change in well environment as slime growth and/or mineral scale deposits. These bacteria may be found under growth and scale because it provides a low-oxygen environment. The total biological mass may include layers of aerobic slime formers on the surface and anaerobic bacteria at the base. All could be intermixed with precipitates of minerals and dead and decayed bacterial debris. A massive odor of H_2S can be present during the wire brushing of a well before a chemical treatment for slime bacteria. (Page 9) This odor may not be present until a well or system is treated with chlorine or acids. Once the outside protective shell of the scale or slime is removed, the odor appears as the bacteria are exposed to the environment.

FIELD DIAGNOSIS FOR SLIME OR IRON BACTERIA

1. Well yields (Specific Capacity) may decline suddenly and drastically within months or a couple of years. A history of Specific Capacity should be reviewed in time.

2. Slimy debris may be present on pump column or in the piping system. Slime may be any color, even clear. When dry, this slime may turn into a very fine, fluffy powder, or hardened scale.

3. Musty, oily, fishy odors or an oily film on water may indicate bacterial activity.

4. Hydrogen sulfide odor (rotten egg) that suddenly appears in a well that was not originally present, may indicate in increase of slime forming debris in a well.

5. Fluctuating or increasing iron or manganese concentrations in water. This may indicate an increase in oxides created by decaying bacteria. Compare past water chemistry to present information. Consider doing a "timed" test for iron or manganese.

6. In a video of a well, note any stringy, long chains of debris that may be tied to iron bacteria. You may note ribbons of large amounts of floaty-like debris that could be slime formers. When the camera scrapes the side wall, you may see a puffiness or cloudiness in the area. Debris will often float and not settle easily. The buildup will be present in sections of screen where water velocity was at one time. Parts of the screen may be totally clean which indicates little or no velocity.

Treatment of Slime or Iron Bacteria in Wells

PHYSICAL CLEANING

We highly recommend to physically clean the well casing, screen, or open borehole below the static level prior to chemical treatment. Removal of debris potentially, 1. reduces the time required for treatment, 2. reduces the amount of chemistry required, 3. allows faster penetration of chemistry into the formation. This physical process can be done by wire brushes, sonic jetting, CO_2, or air blast systems. Airlift or bail all debris from the bottom of the well. The WIRE-HOG™ Casing Brushes allow the physical cleaning and simultaneous, airlift removal of debris from the well.

CHEMICAL TREATMENT OF WELLS FOR SLIME AND IRON BACTERIA

Three separate plugging problems may exist-slime, normal mineral scale and oxides created by dead and decaying bacteria. Decayed organic debris is a nutrient for future bacterial growth. Products or treatment methods touted for killing slime bacteria do not deal with the oxides and mineral scale effectively and consistently. Acids alone may dissolve mineral scale and oxides but do not kill bacteria. Sulfamic is not effective at dissolving iron oxides so nutrient remains for future growth. Hydroxyaecitic is somewhat effective but pH rises so quickly, is ineffective against organic debris. Chlorine kills some bacteria but only damages the upper layer of the bio mass and has little effect on mineral scale and oxides. Bacteria will repopulate and the problems will return within months. Any products that attempt to kill bacteria produce only short-term results.

The combination of UNICID™ GRANULAR and UNICID™ CATALYST deals with all problems consistently and for longer periods of time with a single application. The dispersion chemistry of the UNICID™ GRANULAR dissolves oxides created by decaying bacteria and any mineral scale. The UNICID™ CATALYST penetrates the bio mass, detaches live bacteria, suspends them in solution through a series of polymers (independent of pH). This allows all debris to be pumped from the well.
All physical plugging is now removed, allowing the flow characteristics of a well to return with normal bacterial counts.
Once treatment is complete, airlift all debris from the bottom of the well, contain all chemicals in a surface tank, and neutralize prior to disposal. Our chemistry can simply be disposed to any ground surface but low pH (below 5), chemistry may kill grass and plants.

PRODUCT PLACEMENT IF THE SWL IS LESS THAN 100' OR THE COLUMN OF WATER IS LESS THAN 200'

Use a pour from surface method in applying the UNICID™ GRANULAR and UNICID™ CATALYST.Refer to the dosage charts on product labels or Tables 2.1 and 4. The amount of UNICID™ GRANULAR is calculated in pounds per foot of water in the well. Multiply the total feet of water in the well (total depth minus the static water level) times the pounds per foot recommended for the UNICID™ to get the number of pounds recommended for the initial treatment. The amount of UNICID™ CATALYST is calculated based on gallons per foot of water in the well. Multiply the total feet of water times the gallons per foot recommended for the UNICID™ CATALYST to determine the total gallons of UNICID™ CATALYST required. For example: a well has 4" casing, 20' static level, and a 65' total depth. 65-20 = 45' of water in a well. UNICID™ GRANULAR: 0.3 lb/ft of water x 45'=13 pounds. UNICID™ CATALYST: 0.04 gal/ft of water x 45'=1.8 gallons. Pour all the UNICID™ GRANULAR into the well from the surface first, followed by the UNICID™ CATALYST. Wash down the inside of the casing with plain water to remove the chemicals above the static water level. Start the development process immediately (Development, page 12), monitor pH, and adjust accordingly. ("Field Monitoring," page 14.)

PRODUCT PLACEMENT IF THE SWL IS DEEPER THAN 100' OR COLUMN OF WATER IS GREATER THAN 200'

Calculate the amount of chemistry as above. Mix the UNICID™ GRANULAR first at a maximum dosage of 1.5 lbs per gallon of water in the tank. Use any standard pump as chemistry is not corrosive to any man made material. Mix the required UNICID™ CATALYST into the acidic chemistry. Set a tremie line and place the liquid in equal amounts throughout the column of water. This can be done in equal sections through a tremie line or between packers into specific areas of the casing and screen. Use dosage recommendations to determine the correct amount of UNICID™ GRANULAR and UNICID™ CATALYST. See Tables 2.1 and 4. Create a liquid by mixing the required amount of UNICID™ GRANULAR at a maximum mix ratio of 2 lbs per gallon of water. For example, 200 lbs. ÷ 2 equal a minimum 100 gallons of water. Circulate with any pump to mix. Pour the UNICID™ CATALYST into this acidic blend, mix, and pump into the well in equal increments. Start development immediately, monitor pH, and adjust accordingly. ("Field Monitoring," page 14).

CLEANING A PUMP FOR SLIME, IRON BACTERIA OR MINERAL DEPOSITS

When treating a well infested with slime/iron bacteria, it is important to chemically clean the pump and any submersible cable before reinstallation. It does not help to clean the well and reinstall a pump that is contaminated. Disassemble a vertical turbine pump and put it in a 4% solution of the UNICID™ GRANULAR (.3 lbs per gallon) and UNICID™ CATALYST (.04 gallons per gallon). The chemicals will not damage pump parts. For small submersible pumps, the entire pump and submersible cable can be soaked in a surface tank. Use a 30 gal clean garbage can or drum. Mix 6 lbs (20 gal x 0.3 lbs/gal) of UNICID™ GRANULAR into approximately 20 gal of water. Mix 0.8 gal UNICID™ CATALYST (20 gal x 0.04 gal/gal) into that acidic blend. Set the domestic submersible pump and cable into the solution. It does not matter if it is set vertically or horizontally. Install a short nipple to the discharge and an elbow setup to blow chemistry back into the tank. Connect the electrical wire to a starter box. After 2 hours of soaking in the chemistry, energize the pump and blow debris out of the pump. It will take approximately 15-20 seconds for the discharge to somewhat clear. Allow the pump to soak for another 2-3 hours. Repeat until discharge is clean. We recommend new drop pipe be installed on domestic wells, as it is difficult to clean and cheap to replace.

CHEMISTRY TO REMOVE SLIME AND IRON BACTERIA

UNICID™ GRANULAR

USE WITH THE UNICID™ CATALYST. CALCULATE THE FOOTAGE OF WATER IN WELL

Well Diameter	Pounds per foot of water in well
2"	0.25 lbs
4"	0.30 lbs
5"	0.50 lbs
6"	0.70 lbs
8"	1.10 lbs
10"	1.75 lbs
12"	2.50 lbs
14"	3.00 lbs
16"	4.00 lbs
18"	5.00 lbs
20"	6.25 lbs
24"	10.00 lbs

For other diameters of wells:
Calculate total gallons of water in the well x 8.33 lbs/gal x 0.05 (5%) for total pounds of UNICID™ GRANULAR.

Table 2.1

UNICID™ CATALYST

USE WITH THE UNICID™ GRANULAR. CALCULATE THE FOOTAGE OF WATER IN WELL

Well Diameter	Gallons per foot of water in well
2"	0.02 gal
4"	0.04 gal
5"	0.05 gal
6"	0.08 gal
8"	0.13 gal
10"	0.20 gal
12"	0.30 gal
14"	0.36 gal
16"	0.48 gal
18"	0.60 gal
20"	0.80 gal
24"	1.18 gal

For other diameters of wells:
Calculate gallons of water in well and multiply by 0.05 (5%) for total gallons of UNICID™ CATALYST

Table 4

Disposal of Chemicals

Disposal issues should include chemicals that are non-hazardous; biodegradable; and upon disposal, adjustment of pH. Check MSDS sheets and ask for ID of any "Inert" ingredients. A pH of 6 to 9 is considered safe for disposal by environmentalists. Lime/soda ash are often used to neutralize acids but require huge amounts of product, are difficult to determine dosages, do not mix well with acids, and are dangerous to work with in windy conditions. These products offer no control of pH with an immediate rise of pH above 10. There will also be 20-30% of the powder in the bottom of mix container as a sludge. These are alkaline, classified as hazardous, and requires proper disposal.

pH NEUTRALIZE has several advantages:

1. Dosages are consistent so estimated amounts can be calculated
2. It is a liquid for easy and safe mixing
3. It requires only a few containers on site, rather than many bags of powder that can break or get wet
4. pH is controlled as it rises and will not rise above 9
5. A chart provides specific dosages dependent upon the pH of acid being neutralized (Figure 4)
6. Can neutralize any type of acid.

Do not pour pH NEUTRALIZE into a well to neutralize acids. This liquid weighs 12.4 lbs per gallon and may force debris out the screen or bore hole and cause additional plugging. When treatment is complete, airlift (or pump) all chemistry from the bottom of a well or system into a tank. Measure the average pH of acid, and pour the required pH NEUTRALIZE (Figure 4) into the acid, and mix slightly. pH will rise quickly. Once a pH of 6 is obtained, dispose of chemicals, according to federal, state and local regulations. Pump a second batch of acid from the well and repeat the process. The pH may vary substantially throughout the pumping process until natural pH returns to normal. These estimates would be the minimum amount of product to have on site for neutralization of acids after treatment. The calculation in Figure 4 assumes an average pH of 4 and approximately 3 times the volume of the bore hole that would require adjustment. This number may vary depending on the calcareous content (calcium) of the formation, the amount of acid used, and the time the acid is in the well. 6 to 12 volumes of the bore hole may be required.

ESTIMATES FOR TOTAL pH NEUTRALIZE TO HAVE ON SITE

Bore Hole Diameter	Gallons per foot of water in well
2"	0.01 gal
4"	0.04 gal
5"	0.06 gal
6"	0.10 gal
8"	0.15 gal
10"	0.29 gal
12"	0.31 gal
14"	0.38 gal
16"	0.50 gal
18"	0.65 gal
20"	0.80 gal
24"	1.20 gal

Table 4

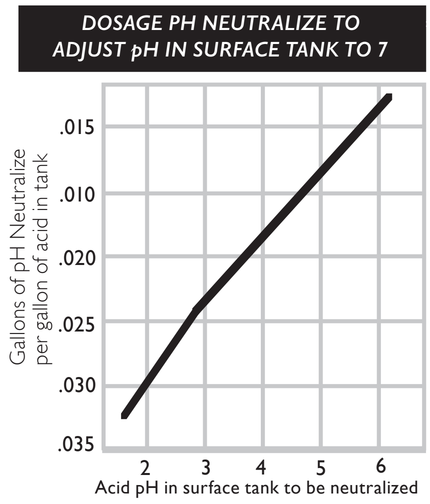


Figure 4

Disposal issues for chemistry used in well. All Jet-Lube® UNICID™ products are biodegradable and safe for disposal once neutralized. UNICID™ can be land disposed without being neutralized, but any low pH product may kill plants. Hydrochloric (Muriatic) liquid acids may have inherent (Inert) ingredients that are not biodegradable and are classified as hazardous such as lead, arsenic, zinc, and unmeasurable TOCs. Hydrochloric and sulfamic acids may vary greatly in actual percentages of acid. The amount ofE pH NEUTRALIZE required to adjust pH may vary slightly (less) from the above dosages.

Development in Wells

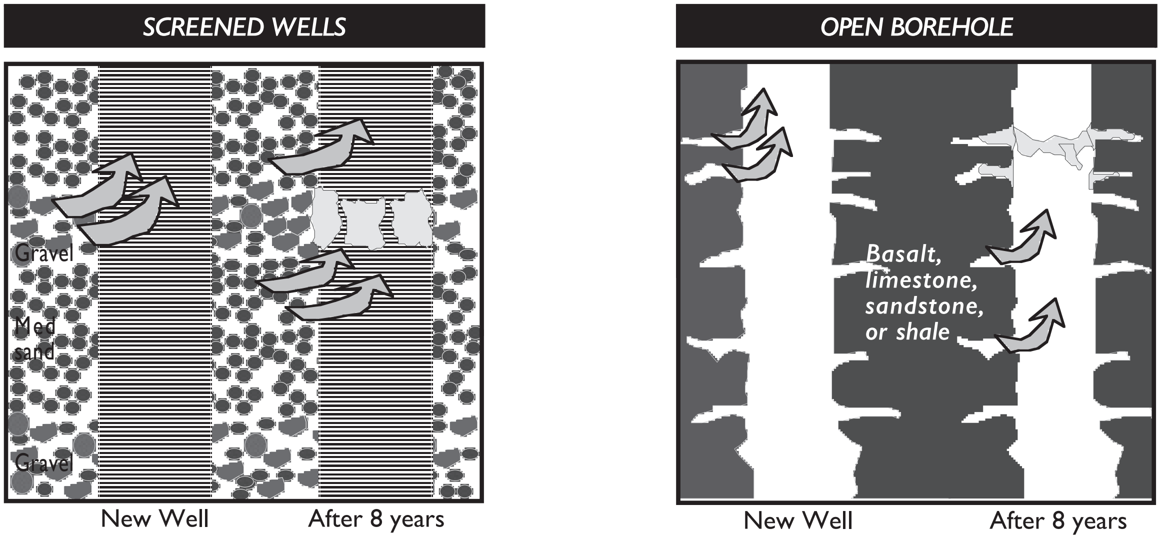


Figure 1

Figure 1 indicates how flow velocities in wells may change over time due to plugging caused by mineral scale or biological buildup. Incrustation (mineral scale) and slime produced by bacteria often occur first in areas of the screen or bore hole where the water velocity is the highest. Once that area is plugged, the water is forced to flow from other areas. This creates greater head loss, increased drawdown, and potentially sand pumping. If new wells are not developed properly, plugging due to drilling muds and drill cuttings can force higher velocity to the bore hole and enhances plugging due to mineral scale and/or slime bacteria. Development is especially critical in well rehabilitation. It is the agitation that allows the detergent to work successfully. Chemicals are too often dumped into wells, surged slightly or not at all, and pumped out in 12 to 24 hours with no understanding of why a process did or did not work. Chemicals need to be pushed back and forth through openings in the screen (unconsolidated) or into fracture zones (consolidated formations) during the development process. During well rehabilitation with UNICID™ and proper development, the specific capacity is often increased over the original specific capacity. If the development action consists only of airlifting water and allowing it to fall back into the well or surging the well with a vertical turbine pump, acid may follow the path of least resistance through areas of the screen that are already open. In longer screens (> 20'), localized development becomes more important.

Always check the well for any fill when pulling the pump and prior to installation of chemicals. If you find sand or silts that have filled into the well, the restriction of flow may be caused by these physical issues. Bail or airlift all debris and retest for yield. If the yield remains low, chemically treat the well.

In the early stages of rehab, you may not find any physical debris (sand/silts) coming into the well. As the development process continues, sand may be pulled into the screen as the debris is dissolved and there is greater access to the formation. Do not be alarmed. Now finer sands can been pulled into the screen, and further development of the formation may be required. Monitor the amount of sand over time to make sure it is declining in volume. This will increase the yield of the well. Development does not have to be constant over 24 to 36 hours. Do as much as physically possible and economically feasible. Large diameter wells generally warrant more effort, but the development of domestic wells should not be forgotten. Surge a domestic well for 3 to 4 hours the first day, check pH and adjust as necessary. Let the chemicals sit over night. Surge for 30 minutes. The next morning, check and adjust pH as necessary. This is much better than no development at all. Sell the development process. Monitoring and adjusting pH is just as important in domestic wells as in municipal wells, because you want a successful and complete rehabilitation.

Types of Development: There are four very basic types of development: 1) Surging with the pump or "rawhiding," 2) Airlifting or air development, 3) Surge Block, and 4) Jetting. Each has advantages and disadvantages but the choice should be based upon effectiveness, not cost. Development plays a more critical role in well rehab than it does in a new well. You can pump water from a new well even if it is only 30% efficient (lack of good development). Efficiency may be virtually zero in a well plugged with scale or biological debris. The energy required to move chemistry against this blockage will be much greater. The longer the screen or open bore hole, plus the greater the decline of Specific Capacity, the greater the requirement for more effective, localized development.

Surging with the pump or Rawhiding: This is done with a vertical turbine pump by removing the nonreverse ratchet. The purpose is to pump chemistry to the surface, shut off the pump and allow the chemistry to fall back into the well, using the pump column as a conduit. Submersible pumps cannot be used because of a check valve. The greatest advantage to this method is low cost, because the pump is not removed. The disadvantage is that it becomes impossible to obtain specific or localized velocity against plugged areas (Figure 1, page 12). Chemistry will take a path of least resistance and flow in and out (already) open areas of the screen or bore hole. A high Static Water Level does not allow much head pressure for back flow velocities. We only recommend this method of development as a last resort, especially in long screens (> 20') or boreholes.

Airlifting or air development: This is done by installing a rigid airline into the casing and forcing air into the well to lift chemistry upward without overflowing at the surface. A quick cutoff of air allows chemistry to fall in the well for the two way development action. This method does provide a two directional flow. This process is somewhat limited in longer lengths of screen (> 20') or open bore hole (> 50') as specific, localized velocity against plugged areas may not be obtained. Chemistry will follow a path of least resistance and have a tendency to flow outward, into areas of a formation that are already open. This method can be done between two packers to force localized development in specific areas and is much more effective. In larger diameter wells, use an eductor pipe. This is a second, larger pipe placed fi rst into the well with the airline inside. Keep the airline within the eductor pipe to achieve a pumping and surging effect. The smaller annulus between the airline and educator pipe minimizes the air requirement. It is a great way to "vacuum" debris from the bottom of a well after wire brushing or upon completion of well rehabilitation to completely remove debris and chemistry.

Surging/surge block: This can be done with a tight-fitting, flexible surge block and a rig with a sand reel or free-fall line to create a block velocity (up and down) of approximately 3-5' per second. The downward motion of this block acts like a plunger, forcing chemistry outward into the formation. The upward motion pulls debris into the screen or bore hole. A cable tool rig works best for this as it allows a 3' stroke and an automatic action with a walking beam. This is highly effective in low open area screens (slotted, bridge slot, or louvered) and high open area screens or open bore holes. Some pump truck manufacturers make a walking beam insert that can be installed and removed from the bed of a pump truck. It is very versatile, mobile, and easy to set up and tear down. Most hydraulic rigs do not provide the vertical speed required for good development action and the operator is required to constantly operate controls.

Jetting: This method is not effective in low open area (3-5%) slotted pipe because 95-97% of the energy is directed against blank pipe. In bridge slot screens, the slot design diverts the flow sideways. Jetting is effective in louver screens if the flow is directed at an angle, directly toward the bore hole. It is also very effective in continuous slot screens. It provides a very specific, high energy, development action directed throughout the entire length of screen. It is absolutely necessary to keep chemistry in the well concentrated during well rehabilitation. Jetting with plain water while chemistry is active in a well will dilute and reduce chemical effectiveness. One of the other development methods should be used first. Jetting with water is highly recommended, once pH is stabilized in a well and the chemical treatment is complete. ("Monitoring of pH," page 15) We highly recommend to simultaneously pump (airlift or a submersible pump) the well 2-3 times the amount of water injected through the jetting tool. This pumping action adjacent to the jetting tool provides a gradient toward the well to remove debris. Monitor this debris at the surface and spend more development time in areas of the screen that appear more dirty. Jetting can be used during chemical rehabilitation but you must maintain a concentration of chemistry under high pressure and return the chemistry to the surface for: 1) monitoring of pH and color, 2) adjustment of pH, 3) settling of debris before re-injection. This is a complex process requiring highly technical equipment and a very competent contractor.

Field Monitoring of UNICID™ During Treatments

For the first time in well rehabilitation, there is a method of monitoring chemistry during treatment. This helps determine: 1. the type of debris encountered as it may vary drastically during treatment, 2. when or if to add acid. 3. when the bore hole is clean as pH will not rise if no debris is present.

COLOR GUIDE USING UNICID™

Debris in suspension (not dissolved)	Debris in solution (dissolved)
Iron = cloudy and dark brown	Iron = clear and yellow
Manganese = cloudy and black	Manganese = clear and red or red/yellow
Calcium = tan/brown	Calcium = white/tan
Sulfate = cloudy and brown/green	Sulfate = clear and gree

COLORATION OF ACID

Monitor pH and color of the UNICID™ chemistry during any project. The color of the chemistry is unique and is an indicator of the type of debris encountered and if that changes. For example, if the aquifer has a high hardness level (calcium) but the debris is iron related (mineral or biological), the initial color of the chemistry will be yellow but after several hours may change to tan. There is no need to continue to adjust pH by adding more of the UNICID™ GRANULAR because the plugging debris is already dissolved.

Yellow color = iron. Iron levels in water might be greater than 1.0 ppm. Iron scale can be caused by normal mineral precipitation or iron oxides created by decaying bacteria. UNICID™ initially will be brown which indicates iron in suspension. As iron goes into solution, the chemistry will clear and turn yellow. You may notice some bubbling with 2 to 4 feet of foam building on the static water level while the acid is working, along with a moderate rise in pH. The amount of bubbling depends upon the amount of calcium carbonate in the scale along with the iron. Adjust pH accordingly. When pH has not risen for several hours, the bore hole is clean.

Reddish or reddish yellow = manganese or manganese and iron. Manganese levels in water would generally be > 0.02 ppm in a water analysis. The initial coloration will be black as manganese is in suspension. Chemistry will start to clear and turn reddish (oil like) or reddish yellow as the debris (mineral or biological) goes into solution. Manganese will have a tendency to dissolve more slowly than iron or calcium related debris. Monitor pH and adjust pH accordingly. When the pH has not risen for several hours, the bore hole is clean. Figure 3.

Tan or white color = calcium. Calcium or hardness levels in water would generally be higher than 150 ppm. This is the easiest and fastest scale to dissolve. You may see 4 to 6' of foam and heavy bubbling on the static water level, but it will not explode and spew out of the well, as may happen with hydrochloric acid. The bubbling is a release of carbon dioxide only and is not dangerous, but it is a good idea to work in a well ventilated area. Since this debris will dissolve more quickly, monitor pH every 1 to 3 hours. Adjust pH accordingly. When pH has not risen for several hours, the bore hole is clean. Figure 3.

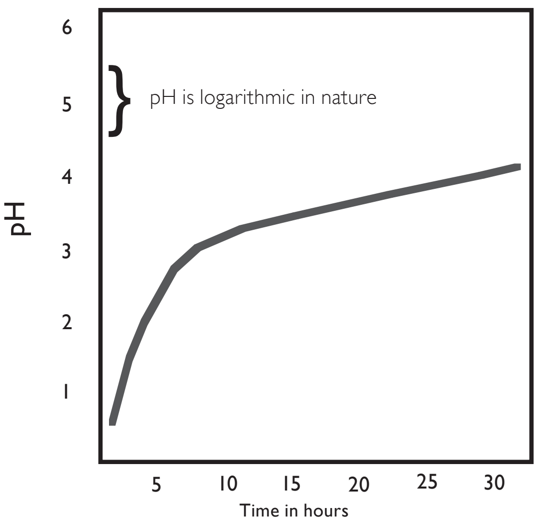
Green color = sulfate. Sulfate levels in water generally would be greater than 40 ppm. Sulfate scale is often found on the outside of several layers of other scale because it precipitate in slow moving or static water. When dissolving sulfate, UNICID™ turns green. pH is not affected when acid dissolves sulfate so pH will remain low. When encountering sulfate, the amount of bubbling on the static level will be minimal and foam nonexistent. Once the UNICID™ dissolves a sulfate layer, the acid may change color based on the scale encountered. A greater degree of bubbling may occur as dependent upon, the level of calcium carbonate, and pH will rise. Adjust pH accordingly and maintain the development effort.

A second layer of sulfate may exist and the color may change back to green and pH will remain low. Maintain the development effort and monitor color and pH. Adjust accordingly. Figure 3 for typical pH adjustments. You may find some wells with a constant green color from the start of the treatment. Measure total dissolved solids in the acid and when stable (does not rise) the project is complete. When a green color remains for more than one day, contractors have found great success by leaving chemistry in the well for 4 to 5 days and agitating periodically.

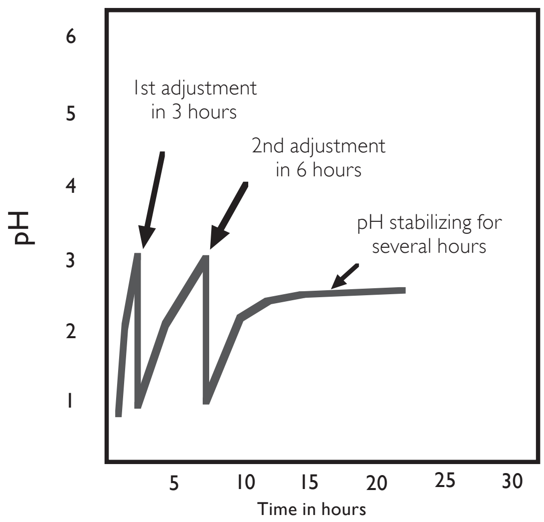
MONITORING PH

As acid dissolves debris, pH rises and the acid becomes weaker. pH is logarithmic, meaning, a pH of 1 has ten times the acid dissolving power of a pH of 2. A pH of 2 has ten times the power of 3, etc. In the field, if you had a particle of debris about the size of a US dime and it dissolved in 10 minutes in a pH of 1 acid, it would take 100 minutes to dissolve that same particle at a pH of 2, and 1000 minutes at a pH of 3 acid.

RELATIONSHIP OF pH TO TIME



TYPICAL ON SITE MONITORING ON pH



Recommendations for UNICID™ represent averages based on history. It is impossible to know exactly how much debris (mineral or biological) is present in a well or system, so it is impossible to know how much acid will be required to complete the job successfully. It is also impossible to predetermine where the debris is located, on the inside of casing and screen or outside the screen. If the former is true, wire brushing will remove most of the debris and may not require any pH adjustment. If the latter is true, wire brushing may not remove a large amount of debris and the chemistry will be require to move all that is outside the screen or into the bore hole.

A pound of UNICID™ GRANULAR and a pound of hydrochloric (Muriatic) acid both dissolve an equal pound of debris. The coloration of UNICID™ is unique to any acid and along with the monitoring of pH helps determine 1) if and when to add more acid, and 2) when the job is complete, and all the debris is dissolved. As long as debris is present, pH will continue to rise. When pH rises above 3, add 30% of the initial dosage of just the UNICID™ GRANULAR acid to adjust pH below 1.5. For example, if the initial dosage required 40 lbs of UNICID™ GRANULAR, 12 lbs would be required to adjust pH (40 lbs x 0.3). Add the dosage using the same method as the initial dose, ie.,"Pour from surface" method or "Tremie line" method. If more debris is still in the bore hole area, the acid has something to dissolve, and pH will rise. Adjust pH by adding a second dosage of 30%. Continue to monitor and adjust pH accordingly. Once all debris is removed, pH will rise not rise or will much more slowly, as the acid has nothing to dissolve. We recommend you have enough UNICID™ GRANULAR on site to do 2 pH adjustments.

The project is complete when: 1) the pH has not risen for 6-8 hours or has risen much more slowly, 2) the color of the acid remains yellow, reddish, or tan. Each well will be different.

The exception to this rule is when the acid becomes diluted from water entering into the screen from the formation. In this case, pH will rise very quickly (greater than 4.5) or may be difficult to maintain low after adjustment. This is an indication the treatment is also complete. The dilution rate may depend upon the permeability of the formation.

Cleaning Pipelines

DIMENSIONS AND CAPACITY OF PIPES			
Nominal Size Pipe	***Gallons/Lineal Foot of Pipe***	***Nominal Size Pipe***	***Gallons/Lineal Foot of Pipe***
3/4" diameter	0.035 gal/ft	4" diameter	0.64 gal/ft
1"	0.041	5"	1.04
1 1/4"	0.08	6"	1.5
1 1/2"	0.11	8"	2.6
2"	0.17	10"	4.2
2 1/2"	0.25	12"	5.9
3"	0.37	14"	7.17h

If you see plugging in the pump or well, it is likely to be in piping system as well. Symptoms may include: 1. reduced flow, 2. reduced pressure, 3. discoloration upon startup of pump, 4. In municipal systems, an increase in chemical injection (phosphate or chlorine) requirements may indicate a demand due to biological growths. Since the UNICID™ chemistry is noncorrosive to man made materials, the chemistry is safe for any piping, fittings, or any pump for recirculation.

FOR SINGLE LINE PIPELINES < 1000' OR WHERE A SURFACE LINE CAN BE USED FOR RECIRCULATION.
The idea is to constantly recirculate chemistry from a surface mix tank through a surface line into the buried piping back to the well, and back to the mix tank. Use the tank for mixing chemistry and during recirculation will act as a settling pit for debris. Use the UNICID™ GRANULAR (acidic, dissolving power) and the UNICID™ CATALYST (polymer for assist in carrying debris).

Surface line: Use any available piping such as a garden hose, coiled piping, fire hose, etc. If using garden hose, tape the threaded fi ttings with electrical tape to prevent leaking that could ruin grass because of low pH. Run the surface line to the back of the piping system to be cleaned. In a domestic system that can be the "Union Joint" by the pressure tank. In large diameter systems, that can be in a treatment building, etc. Mix tank: Volume: Add the total volumes of water in the buried piping and the surface pipe. Add an additional 20% to that volume (for settling during recirculation) for the total volume in the tank. Type: Use any standard tank made of metal, plastic, etc. Pump: Use any standard contractor pump for mixing and recirculation. It is not critical to have a large volume of movement but keep the chemistry in flow so debris does not accumulate in piping elbows, etc.

Dosage of chemistry and mixing: UNICID™ GRANULAR, use 0.3 lbs per gallon in tank. UNICID™ CATALYST, use 0.04 gal per gallon of water. Start the pump and recirculate water in the tank. Slowly pour the UNICID™ GRANULAR into the intake of the pump to mix. When mixed, slowly pour the UNICID™ CATALYST into the intake to mix. System setup: When the chemistry is mixed, connect the pump discharge to the surface piping. Connect the other end of the surface piping to the end of the buried piping going back to the well. For submersible pumps, there is often a pitless adapter with a discharge 5-7' below surface. The pump has to be pulled and the spool adapted to allow a stand pipe to the surface. Connect a flexible hose back to the mix tank. For large diameter pumps, simply connect into the piping at the well head back to the mix tank. Recirculation: Start the pump to recirculate chemistry (backwards of normal flow if possible) into the surface line which will discharge at the well back into the surface tank. Monitor the flow rate upon startup. Monitor flow rate in 4-6 hours and should increase. Physically inspect the piping at the "Union Joint" or connection piping.

Cleaning Water Storage Tanks

There may be applications to clean slime forming bacteria from water storage tanks. This can be done easily and safely with a combination of the UNICID™ GRANULAR and UNICID™ CATALYST products. The application is dependent upon the tank size and accessibility to the interior of the tank.

Most storage tanks are too large to fill with chemistry because the cost would be prohibitive, plus most are accessible through a manhole. We recommend to drain the tank and check the natural pH of water for a reference point, after the cleaning process. Once inside the tank, physically brush the interior walls and floor below the high water level. Simultaneously, high pressure spray the walls and floor to further remove debris. Set up a pump at the bottom of the tank and remove all debris or vacate from the tower base. Do not allow sludge to flow into the permanent pipeline. Once most of the debris is physically removed, chemistry can be used to microscopically clean bacterial attachment from the tank interior. Any type of high pressure sprayer can be used.

Calculate the amount of water in the sprayer tank and use a 3% solution of chemistry. The dosage for the UNICID™ GRANULAR is .25 lbs./gallon of water in the sprayer tank. Physically mix the granular into water and circulate with any standard contractors pump to mix more thoroughly. The dosage of the UNICID™ CATALYST is .03 gallons per gallon in the sprayer tank. Pour the UNICID™ CATALYST into this acidic blend. Physically mix or continue circulation to mix more thoroughly. Pour the chemistry into the tank and pressurize the unit. Spray the chemistry on to the side walls and the base of the tower while physically brushing the chemistry. Repeat the treatment in specific areas of large amounts of debris if not fully clean. Flush the interior with plain water under high pressure, until the discharge wate returns to a normal pH. This will require some time, but it is mandatory to follow this procedure before reconnecting water lines.

SAFETY ISSUES

Even though there are no dangerous gasses released by the chemistry, there may be a release of carbon dioxide from dissolving scale or decaying debris from bacteria. It is absolutely necessary to use a self-contained breathing apparatus while working in this enclosed environment. Use rubber boots, rubber gloves, and protective clothing along with full eyewear protection and/or goggles.

DISPOSAL

Chemical debris being flushed from the tower should be contained to prevent inadvertent runoff and maintain control for disposal of chemistry. Check local regulations for proper disposal. UNICID™ chemistry can be land disposed with a low pH, but any acidic chemistry with a pH below 5 may kill plant life. Calcium in the soil will neutralize acids and complete degradation is 27 days. Chemistry can now be disposed to sanitary sewers or land disposal without any environmental concerns. See MSDS sheets for further safety information.

Sludge/Debris Analysis

In large diameter wells, debris can be found inside piping at the well head inside gasketed check valves or water meters. In small diameter wells, look inside piping at the "Union Joint" by the pressure tank. This debris will give you an idea of what may be plugging the well. Instructions on taking and sending samples are available by calling 713-670-5700.

We do analysis of this debris to determine:

- The origin of debris (mineral or organic) which provides treatment direction
- If that debris is normal or something unusual that may require different chemistry
- Percentage of dissolvable debris vs non-dissolvable debris, i.e., sand, silts, corrosion by-product, fungus, non-dissolvable contaminants from environmental sites, etc.

Lab Services

Lab services are available to help determine problems in wells and systems and are often done on a "timed" basis to determine if the problem is contained in the well and treatable.

Tests can include:

1. Water chemistry to determine the tendencies for mineral scale and corrosion
2. Identification and quantification of slime-forming bacteria and iron bacteria
3. Severity analysis of anaerobic bacteria (odor and corrosion problems)
4. Total bacterial counts via ATP analysis
5. Includes a report explaining the problem fully

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