Rust Removal using Electrolysis

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Electrolysis, the science behind it

From http://antique-engines.com/electrol.asp

First we'll look at the word; The word "electrolysis" can be broken into two parts: electro and lysis. 'Lysis' means to break down, or break a bond, to "tear apart". 'Electro' roughly means electric or electric current, electricity. So the word electrolysis is a combination of two terms and means to break a bond or take apart using electricity. I believe they are Latin terms, lysis coming from a Greek word meaning to "release". So it is literally breaking a bond, or releasing by means of electricity - using an electric current to take something apart. In this case, we do want to take something apart - we want to break "rust" down and get good iron back.

Rust is a combination of iron and oxygen. In the process of electrolysis as I use it, we use electricity to break the bond between oxygen and iron atoms. This is a very simple explanation, if you wish, you can find more complex details in science books, or on the Internet, etc. There is a lot more that happens than can be explained here, but these are the basics. Atoms are partially made up of electrically charged particles - electrons with a negative charge and protons with a positive charge. It's these electric charges that cause certain atoms to want to "stick together" in certain combinations. Oxygen and the iron in the steel stick together to form rust. Electrolysis will help to take them apart again. Atoms can lose or gain electrons. This gives them a positive or negative charge because there is no longer a balance between the number of electrons and protons in an atom. Electrons can be "bumped" from one atom to another. The solution made with water and washing soda is simply to make a safe, simple solution that will allow the electricity to work through it and not interfere with the process or produce chemicals that would be unsafe. Oxidation is a chemical reaction where something gives up electrons. Reduction is when something accepts electrons. Oxygen likes to be "reduced". When oxygen is reduced, or accepts electrons, it makes oxide, O--. If we put oxygen together with iron metal, the iron is oxidized (gives electrons to the oxygen) and the oxygen is reduced (accepts the electrons lost from iron). The result is one form of rust, ferric oxide, Fe_2O_3. Whenever something is oxidized, something else must be reduced. Electrons must come from somewhere (oxidation), to go somewhere (reduction). With the process of electrolysis, we are going to reverse the process to "break the bond" between metal and oxygen using electricity.

We will use metal rods called "electrodes" to help in this process. The electrodes will be submerged in the water and washing soda solution. One electrode will be called the "anode" because it will be caused to have a positive electric charge. The anode is hooked to the positive wire of the battery charger. The positive wire accepts electrons. If the positive wire is accepting electrons something is losing electrons (oxidizing). When 12 volts is applied to the anode, water is oxidized at the anode surface and gives electrons up to the anode. The product is oxygen. The bubbles you see coming from the anode are oxygen that resulted from the oxidation of water. The other electrode is called the Cathode. In our case, the part we want to remove the rust from will be the cathode. Cathode is the word for an electrode with a negative charge. The cathode is connected to the negative wire of the battery charger. The negative wire supplies electrons. So something must gain electrons at the

cathode (reduction). Two things are reduced at the cathode, water and the rusty iron. The reduction of water produces hydrogen. The bubbles coming from the cathode are hydrogen gas. (The fuel for the space shuttle is hydrogen and oxygen. Rust electrolysis should be done in a well ventilated area so that explosive concentrations of hydrogen and oxygen are not reached.) The rusty metal takes on electrons and is no longer attracted to the oxygen atoms, and the bond is broken. The rust is "reduced". If this process is done on a large scale (for example, the trailer frame shown on my pages) a lot of water is lost to "reduction" in the process and needs to be replenished. A lot of oxygen and hydrogen are formed. This same process is used to keep a supply of oxygen in submarines. The hydrogen is disposed of for safety reasons.

During electrolysis the rust turns from orange to black. In most cases, the rust next to the iron is reduced to iron metal. This reduced iron will form a somewhat porous layer of new iron on the metal object being cleaned. After electrolysis the iron object will rust very quickly unless it is protected because this porous layer of new iron has a high surface area. The rest of the rust may reduce to a variety of compounds depending on the compounds in the original rust and the details of the electrolysis. Typically the black stuff that can be rubbed off after electrolysis is a mixture of iron metal and magnetite, Fe_3O_4 , an oxide of iron. Magnetite is an intermediate product in the reduction of rust to iron metal. It is the black stuff in magnetic recording tapes.

So once your parts are cleaned or removed from the solution, you'll want to rinse and brush them off to remove the loose iron, dry them quickly and completely, and protect them with primer or other rust preventative.

Several years ago, and I can't recall how it happened, I came into an inexpensive and easy way to clean rust and grease, and, in some cases, paint, from your rusty cast iron and sheet metal parts. Taking advantage of common household cleaning products, items many of us have laying around the garage, kitchen or laundry room, and some science, you can clean parts from a single bolt up to an entire trailer frame through a process known as "electrolysis".

What you need:

- A non-conducting container - a large plastic bucket works really well.
- Battery charger - big is better, however even one able to produce 6 to 10 amps should do. A student recently used my site as the basis for a school project and used a computer power supply in place of battery charger.
- Sacrificial electrodes. Concrete reinforcing rod works well (re-bar) cut into lengths about 4" taller than your bucket or container. Do not use stainless steel! The results are a health hazard and illegal (more on that later)
- Arm and Hammer LAUNDRY soda, also called washing soda.
- Wire and/or cables for connecting electrodes together.

- Water.
- Small lengths of small chain (used to suspend the rusty parts in solution) or some other means to suspend the part to clean into the solution.

The Setup:

Using a plastic, or non-conductive bucket (not metal), mix a solution of 5 gallons water to 1/3 to 1/2 cup laundry soda. Mix well so all soda is dissolved. Do not try to use other salts. You won't get better results and dangerous effects may occur. Caustic soda, for example, is far too corrosive. Solutions of ordinary table salt can generate chlorine gas (toxic) at the positive electrode (anode).

Clean the electrodes so they aren't too rusty - especially at the top ends - they need to make good electrical contact with your wire or cable AND with the water. I take mine to a wire wheel and give them just a real quick going over. Place electrodes in bucket around sides, so the clean, rust free ends stick up above the bucket. Use clamps or some means to hold them in place around the perimeter of the inside of the bucket or container so that they cannot move freely or fall into center of bucket. The electrodes must not touch the part(s) to be cleaned, which will be suspended in center of bucket. I use small C clamps. Whatever you use, it shouldn't be copper, and will get a bit messy if it gets into your cleaning solution.

Tie the electrodes together with wire or cables. I use copper wire twisted around the top ends, and have used old jumper cables. All electrodes need to be tied together "electrically". This will become the "anode" grid. Since the cleaning process is somewhat "line of sight" it's best to surround the part to be cleaned to some extent with the electrodes.

Suspend part to be cleaned into bucket so it hangs in the middle, not touching bottom, and not touching electrodes. I place a piece of re-bar across top of bucket (see photo below) and bolt a small piece of chain to my part to be cleaned, and clamp the chain on the rod so that the chain hangs from the rod, and suspends the part into solution below. The part to clean then becomes the "cathode".

Attach battery charger - place **NEGATIVE LEAD** (this is critical!!) on the piece that is to be cleaned. Attach **POSITIVE**, or **RED lead** of charger, to electrode "grid" formed when you placed electrodes, or rods, into bucket and tied them all together.

Make sure electrodes and part to be cleaned are not touching each other, then turn on charger. Within seconds, you should see a lot of tiny bubbles rising from the part suspended in the mixture. Do not do this inside, or in a closed area - those bubbles are the component parts of water - H2O - hydrogen and oxygen. Remember the Hindenburg?

See how the rust and bubbles are attracted to the electrodes in the photo below? You will need to clean them from time to time - they will get covered with gunk; in fact, after many uses, they will have eroded down and need to be replaced. That is why I use re-bar - it's easy to get, cheap, and most of all - SAFE FOR YOU and your environment! You can pour the waste solution on the lawn and it won't hurt it. Do watch out for ornamental shrubs, which may not like iron rich soil, however. No use making your spouse mad!

How large an item can you clean? Well, it's up to your imagination, your budget - because it takes water, your time and wife's patience. Terry Lingle demonstrated this process on a very large scale using a tank made of plywood and lined with plastic, a DC welder for power supply and hundreds of gallons of water. You will need to use more electrodes with larger parts and a larger "tank". The resulting photos can be seen here - along with an explanation of his setup.

How small? A student recently used the description on my web site as the basis for her science project in school. She used a computer power supply for the power source to clean a small part in a plastic bucket on a table. (photos coming soon)

Safety Precautions:

- Make sure no spills can get to the battery charger. (electrocution potential as with any electric appliance)
- The leads from the charger are relatively safe, but you may still get a bit of a shock if you put your hands in the solution or touch the electrodes while the charger is running.
- Turn off the current before making adjustments to the setup. Just as a "spark" can cause a charging battery to explode in your face, this process produces similar gases because this process splits water into hydrogen gas (at the negative electrode) and oxygen at the positive electrode).
- Hydrogen will burn explosively if ignited. All flames, cigarettes, torches, etc. must be removed from the area, and sparks caused by touching the leads together must be avoided. The work should be performed outside or in a well ventilated area to remove these gases safely.
- Washing soda solutions are alkaline and will irritate the skin and eyes. Use eye protection and gloves. Immediately wash off any solution spilled or splashed onto your body.

Why you should not use stainless steel electrodes for electrolysis

Many people using the electrolysis method for rust reduction swear by stainless steel, stating (incorrectly) that it's not consumed, stays clean and seems safe.

Stainless steel is indeed consumed when used in the electrolysis process, although slowly. The main problem with using it is the hazardous waste it produces. Stainless steel contains chromium. The electrodes, and thus the chromium is consumed, and you end up with poisonous chromates in your electrolyte. Dumping these on the ground or down the drain is illegal. The compounds can cause severe skin problems and ultimately, cancer. Hexavalent chromate is poisonous. These compounds are not excused from hazardous waste regulations where household wastes are.

These compounds are bad enough that government regulations mandate "elimination of hexavalent chromate by 2007 for corrosion protection."

Does your electrolyte turn yellow? That's a sign of chromates.

If you have been using stainless steel for the anodes (positive electrodes), wear rubber

gloves when working with or near the liquids. If you need to dispose of it, allow it to evaporate into powders and dispose of the powders in sealed containers during your local "hazardous waste clean-up days".

Best bet - don't use stainless steel no matter how tempting it is.

Rust Removal Using Carbonated Soft Drink

When I was about 12 years old and just getting interested in engines I heard my uncle swear that he got a stuck piston out of a motorcycle he had by using bottle of Coke. It had set out in the yard all winter and had rusted up inside. But we all know pop is sticky, water based and wouldn't it make a worse mess? After all, Mom always said "don't spill your pop, it will make everything sticky".

As I grew up and got interested in cars and motorcycles myself I started to hear of other such "urban legends" and decided, hey, maybe there is something to this. The people that said it worked were quite insistent, and there sure was no proof that it did NOT work. So I decided to investigate. (amazing what little it takes to entertain me)

So here is what I've found - many carbonated beverages will remove rust. This is because the gas used, carbon dioxide when mixed with water, makes carbonic acid. To make rust, the iron oxidizes - it combines with oxygen. This is why rust is also called iron oxide. The carbonic acid reverses this reaction - this reversal is called "reduction." Here's a better reason - take a look at your Coke can - it has phosphoric acid as an ingredient. Phosphoric acid is the basis of Naval Jelly, a commercial product used for rust removal. Phosphoric acid dissolves iron oxide very quickly while etching metallic iron very slowly so you can leave metal in phosphoric acid with little damage.

The downside is that all acids contribute some hydrogen to the metal structure, weakening the steel by hydrogen embrittlement - so always use only as much time as is absolutely necessary to remove the rust. An advantage of phosphoric acid is that it leaves a fine protective coating of iron phosphate. Because this coating is not thick or durable some protection is still required. Years ago supposedly Volkswagen use a process of phosphating metal prior to painting as it provided a chemical protection against rust under the paint layer.

So, spilling your Coke into your old engine wouldn't really be a bad thing if you were trying to remove some rust.

What is the method?

http://www.stovebolt.com/techtips/rust/electrolytic_derusting.htm

Electrolysis is a technique for returning surface rust to iron. It uses the effect of an

small low voltage electric current and a suitable electrolyte (solution). It has advantages over the old standbys, like vinegar, Coke, muriatic acid, Naval Jelly, wire brushing, sand blasting etc -- These methods all remove material to remove the rust, including un-rusted surfaces. With many, the metal is left with a "pickled" look or a characteristic color and texture. The electrolytic method removes nothing: by returning surface rust to metallic iron, rust scale is loosened and can be easily removed. Un-rusted metal is not affected in any way.

What about screws, pivots, etc that are "rusted tight"?

The method will frequently solve these problems, without the need for force, which can break things. Is it safe? The solutions used are not hazardous; the voltages and currents are low, so there is no electrical hazard. No noxious fumes are produced. The method is self limiting: it is impossible to over clean an object. Small amounts of hydrogen are emitted in the electrolysis process. Good ventilation or an outdoor work site is all that is needed.

Where did this method come from?

Electrolysis is a standard technique in the artifact restoration business. I wrote this up for the *Chronicle of the Early American Industries Association* a few years back. Most of the tool collectors around here use it.

What do I need?

A plastic tub; a stainless steel or iron electrode, water and washing soda (Arm & Hammer, for example) and a battery charger. About a tablespoon of soda to a gallon of water. If you have trouble locating the washing soda, others have reported success with baking soda. Also household lye will work just fine. It's a tad more nasty -- always wear eye protection and be sure to add the lye to the water (NOT water to lye!!!) The solution is weak, and is not harmful, though you might want to wear gloves. **NOTE:** *It is the current that cleans, not the solution; nothing is gained by making a more concentrated solution* -- **DON'T!**

How long does the solution last?

Forever, though the loosened rust will make it pretty disgusting after a while. Evaporation and electrolysis will deplete the water from the solution. Add water ONLY to bring the level back.

What about the stainless/iron electrode?

The electrode wants to be large (within reason); if possible, larger than the object being cleaned. The iron electrode works best if it "surrounds" the object to be cleaned, since the cleaning is "line of sight" to a certain extent. An iron electrode will be eaten away with time. Stainless steel has the advantage (some alloys, but not all) in that it is not eaten away. I have had good success with sheet stainless salvaged from a paper towel dispenser. It has a large surface area and is easily shaped to fit the container.

How do I connect the battery charger?

THE POLARITY IS CRUCIAL!! The iron or stainless electrode is connected to the positive (red) terminal. The object being cleaned, to the negative(black). Submerge the object, making sure you have good contact, which can be difficult with heavily rusted objects. Get it backwards and your object will be relentlessly eaten away! Make connections on a part of your electrode that protrudes out of the solution, or your clamps will erode rapidly.

How do I know if it is working?

Turn on the power. If your charger has a meter, be sure some current is flowing. Again, on heavily rusted objects, good electrical contact may be hard to make-it is essential. Multi-part objects may not have good electrical connections between them. Fine bubbles will rise from the object when cleaning is in progress.

How long do I leave it?

The time depends on the size of the object and of the iron electrode, and on the amount of rust. You will have to test the object by trying to wipe off the rust. If it is not completely clean, try again. Typical cleaning time for moderately rusted objects is a few hours. Heavily rusted objects can be left over night.

How do I get the rust off after I remove the object?

Rub the object under running water. A paper towel will help. For heavily rusted objects, a plastic pot scrubber can be used, carefully. Depending on the amount of original rust, you may have to re-treat. The amount of mechanical action will depend on the fragility of the object. Use your discretion.

My object is too big to fit. Can I clean part of it?

Yes. You can clean one end and then the other. Lap marks should be minimal if the

cleaning was thorough.

After I take it out, then what?

The clean object will acquire surface rust very quickly, so wipe it dry and dry further in a warm oven or with a hair dryer/heat gun. You may want to apply a light oil or a coat of wax to prevent further rusting.

Will the method remove pitting?

No. It only operates on the rust in immediate contact with un-rusted metal. What's gone is gone. What will it look like when I am done? The surface of rusted metal is left black. Rusted pits are still pits. Shiny un-rusted metal is untouched.

What about nickel plating, paint, japanning and the like?

Sound plating will not be affected. Plating under which rust has penetrated will usually be lifted. The solution is likely to soften most paints. Test with a drop of solution in an inconspicuous place. Remove wood handles if possible before treating.

How can I handle objects that are awkward to clean?

There are lots of variants: suspending an electrode inside to clean a cavity in an object; using a sponge soaked in the electrolyte with a backing electrode to clean spots on large objects or things that shouldn't be submerged (like with lots of wood)

How can I dispose of the solution?

The bath will last until it gets so disgusting that you decide it is time for a fresh one. There is nothing especially nasty about it-it's mildly basic-so disposal is not a concern, except you may not want all the crud in your drains.

Can I use metal containers?

This is highly risky. Galvanized metal can introduce zinc into the solution. If you have used lye, it will attack aluminum. You may have problems with electrical shorts, etc. Stick to plastic.

How can I clean odd shaped objects?

Be ingenious. Plastic PVC pipe and eave troughs, wooden boxes with poly vapor barrier, kids wading pools, etc.

Electrolytic Rust Removal

David L. Huffman, U.S.A.

http://enews.heywoodenamels.com/common/eNAMEL_rust_removal_electrolytic_method.html

The main thing you need is a battery charger (automotive type). Any source of DC current will do, the higher the amperage, the better. In theory, a 9-volt "Wal Mart special" will do, but it would take a long time for any larger article.

You also need a plastic container, a scrap sheet of metal, preferably stainless steel, and some baking soda.

Fill the bucket with water and add a handful of baking soda, about a tablespoon per gallon. Washing soda works well too, if you can find it.

Prepare your sheet metal anode. Stainless sheet works best (since it holds up longer), but a flattened tin can will do in a pinch.

Wire the POSITIVE to the scrap steel. This will be the anode. You'll want to keep the clamp out of the solution, or it will eventually dissolve too.

You need to connect the article to be cleaned to the NEGATIVE side of the charger, again, keeping the clamp out of the solution. You've got to make a connection on a clean bare metal spot on the article, so you may need to sand or grind through the rust at the point at which you connect your contact.

Put both the pieces (the article and the scrap steel anode) in the solution, as close as possible but NOT TOUCHING.

The part being cleaned will begin to bubble. After about two hours at 12 volts, six amps, you can take it out and examine it.

The part being cleaned, if originally badly rusted, will now be covered with a black powder which you can wire brush off.

Then return the article to the solution for another 6 hours and you'll see all that is left of the rust is a little more fine black powder, and the high spots may be getting shiny. At this point, you can take the article out, rinse it off, wire brush it some more, and then lightly oil it with linseed oil. Linseed oil is great for tools, but be careful. . .rags soaked in it can spontaneously combust, and I've seen this happen, so better put them in the burn bin or bury them. If they're cotton, you can put them in the compost, everything in this case is organic, just don't store them in the house or garage.

You can, of course, substitute any kind of oil you'd like, but you'll need to get that raw metal covered with some sort of protection as soon as possible.

This demonstration was employed on a large steel punch, about 1/2 inch in diameter and 5 inches long. It was badly rusted, but not pitted. Even pitted steel will clean. The pits will still be there, but they'll be clean of rust. Times for smaller articles could be significantly shorter. Obviously, the less rusted a piece is, the shorter the cleaning time.

I don't think that higher concentrations of baking or washing soda will shorten the time, as it's not the same as using an acid or alkali to clean, the soda is used only to make the water more conductive.

Electrolytic Removal of Rust

by Kevin Chamberlain, Member HTPAA (published in Tool Chest #63, February 2002)
http://www.htpaa.org.au/article-electro.php

Introduction

At our last Tool Conference, there was a Panel Discussion dealing with the cleaning and restoration of old hand tools. This is a key concern for anyone interested in collecting old tools, since one rarely finds tools in mint condition in an original box. It is much more common to find tools showing the combined effects of correct usage, abuse, neglect and simple aging. The primary question is: should cleaning and/or restoration be attempted at all?

The answers are conflicting; some aim to restore the tool to a brand-new appearance, eliminating all evidence of its life history. Others think any attempt at restoration will destroy the character and value of an antique tool.

Most think some intervention is desirable to remedy the effects of abuse and neglect, while still retraining as much patina and character as possible. There is an important caveat - "when in doubt, do nothing". Cleaning and restoration of antique tools should be done in a careful and meditative mood - otherwise rash actions may cause loss of valuable information and/or further damage.

Removal of rust from old tools or other artifacts may or may not be a desirable goal. In some cases (museum specimens) stabilization to prevent further deterioration may be all that is necessary. Rust may be regarded as undesirable by tool users or collectors because it obscures identifying marks, causes seizure of moving parts, creates an unpleasant rough texture to the touch, stains the hands and/or the workpiece, or is simply unsightly. I believe rust removal is often justified, but the method chosen should not alter the surface in other ways and should result in a reasonably attractive surface appearance.

The electrolytic method of rust removal meets these aims very well and is also a gentle, cheap and adaptable method. Electrolysis is now being used by a wide range of artifact restorers, from tool collectors to marine archaeologists.

In this article, I mainly aim to outline the practical aspects of the electrolytic method so that members can try it for themselves. Several HTPAA members have been using the method

for some years and find it very useful

What is Rust?

Rust arises from the surface oxidation of iron or steel in the presence of atmospheric oxygen and moisture. As the rust forms, the surface of the iron is eaten away, sometimes evenly, but often deep local pitting occurs beneath wart-like protuberances. Rust occupies more volume than the iron it replaces, and so moving parts will tend to seize as they rust. Chemically, most red rust is hydrous ferric oxide FeO(OH). If water enters this chemical structure, yellow-brown limonite may form $FeO(OH).nH_2O$. Quite often, black iron oxides are also present usually magnetite (Fe_3O_4), an iron oxide which both conducts electricity and can be magnetized. The rusting process, and the conditions which promote, inhibit or stabilize it, are all important topics which are beyond the limits of the present article.

Methods of Rust Removal

Rust usually binds strongly to the underlying iron or steel. Various methods have been used to remove rust. Mechanical methods include the use of emery paper, sandpaper or wire brushes (either manual or powered). More aggressive methods include sand blasting or shot blasting. Plastic bead blasting is a more recent and gentler variant. Clearly these methods will scratch the metal surface if the abrasives are harder than the metal. Wire brushes, for example, do not appear to scratch hard steel surfaces but they can be quite damaging to soft iron surfaces.

Gas flames are sometimes used to dislodge rust, relying on the different expansion rates of the oxides and the metal in response to heat. Simple boiling in water is also used to loosen rust. Here the thousands of tiny bubbles which form and grow at the metal surface may act to mechanically dislodge the rust layer.

In industry, chemical methods of de-rusting include the use of strong acids under carefully controlled conditions. These acids are too dangerous for home use. Vinegar or dilute phosphoric can be used successfully at home, although the latter leaves a uniform gray appearance which some find undesirable. Acids attack the iron oxides directly, but also etch the mental surface to some extent, generating hydrogen gas in the process.
Other chemical agents include the commercial product "Corro Dip" (from Liquid Engineering International Pty Ltd) and the traditional molasses solution. The molasses method usually takes weeks and may work because of acids formed in the molasses solution by fermentation. I have been told that iron or steel objects left too long in molasses solution will eventually be eaten away, supporting the idea of an acid etching progress. However other chemical reactions may also be involved in this old method.

The Electrolytic Method

The electrolytic method is a cheap, gentle and effective method which causes minimal alteration to the metal surface. It may seem complex, but is actually easy to set up and use.

It is quite safe, provided certain sensible precautions are taken (see below). The electrolytic method involves immersing the rusty object in an electrically-conducting solution of washing soda (sodium carbonate). The negative lead (black) from a battery charger is attached to the object, and the positive (red)lead is attached to a stee1 electrode dipping into the solution. When the current is turned on, electrochemical reduction reactions occur at the metal/oxide interface on the object's surface. These reductions loosen the rust layer, allowing it to be easily brushed off. These reactions may involve the direct reduction of iron oxides to finely divided iron. However, it is clear from observation that a major reaction at the negative electrode involves the production of thousands of tiny bubbles of hydrogen from the electrochemical reduction of water. The hydrogen may in turn react chemically with the iron oxides, or it may simply act to physically dislodge the rust layer. Whatever the mechanism, the process does not appear to cause etching or deposition on the metal surface. Of course, removal of rust will reveal any damage to the surface (such as pitting) which has already occurred.

Important Safety Precautions

1. Since pure water is a poor conductor of electricity, a soluble salt, (called an electrolyte) has to be added to make an electrically conducting solution. The best salt to use is sodium carbonate (washing soda). A packet can be bought in supermarkets for a few dollars. Washing soda solutions are alkaline and will irritate the skin and (especially) the eyes. *Always use eye protection and gloves and wash off any spills immediately.* Do not try to use other salts - no better results will be obtained and dangerous effects may occur. Caustic soda, for example, is far too corrosive, and even strong solutions of ordinary table salt will generate toxic chlorine gas at the positive electrode.

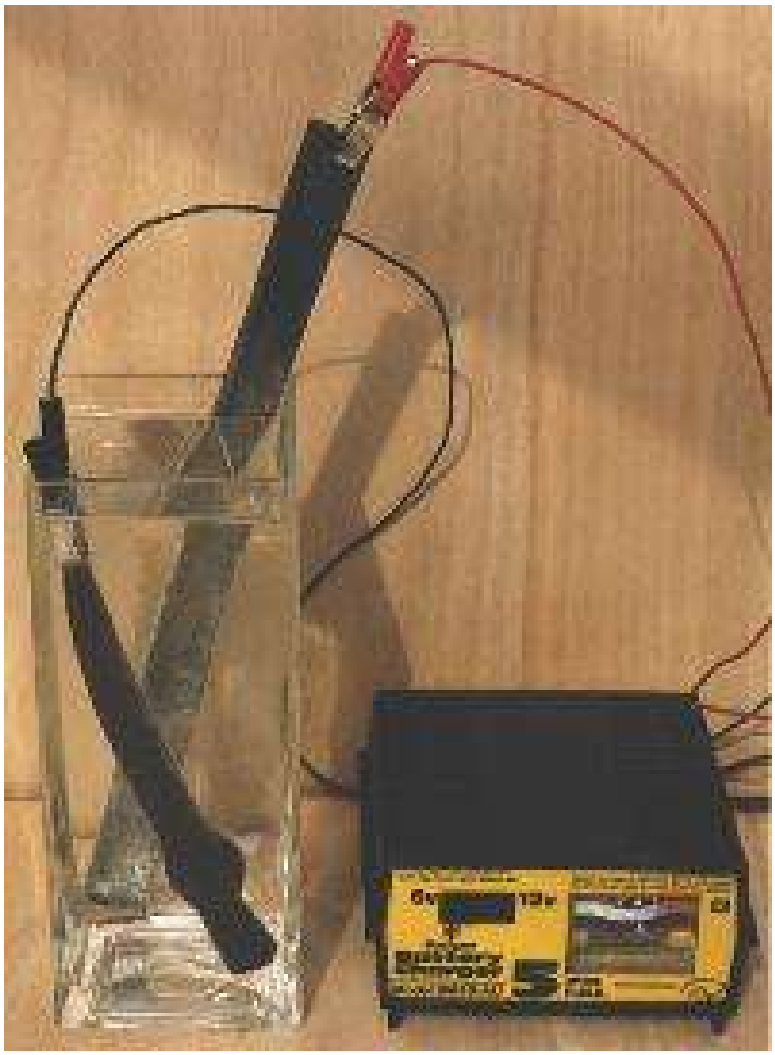
2. The battery charger is attached to the mains and must be completely shielded from the solutions which conduct electricity. *Make sure no spills can touch the battery charger - especially when it is unattended.* The 6/12 volt leads from the charger are relatively safe, but you may still get an unpleasant shock if you put your hands in the solution or touch the electrodes while the current is running. *Turn off the current before making adjustments to the electrolysis bath.*

3. A major reaction occurring in the bath is the splitting of water into hydrogen gas (at the negative electrode) and oxygen at the positive electrode). *Hydrogen will combine explosively with oxygen or air if ignited.* (Remember the Hindenburg!) All flames (including cigarettes) must be removed from the area, and sparks caused by touching the leads together must be avoided. The work should be well ventilated to dilute and remove these gases safely. *Do not use this method in a confined, poorly ventilated area.*

Preparation of the Electrolyte Solution

A sufficient concentration of washing soda is about 10 gram/liter (about 1 teaspoon per pint). The concentration may be increased somewhat but the results will not change greatly. Make sure all the crystals have dissolved before using the solution.

The Electrolytic Bath



The simplest variant of this method requires a non conducting inert plastic container (plastic dish, box, bath, bin etc.). Some ingenuity is needed to find containers deep or long enough for items such as long saw blades or leg vices. After removing any wooden handles, brass fittings, etc. from the object, sufficient washing soda solution is added to completely submerge it.
A stainless steel strip is recommended for the positive electrode or anode (e.g. a piece about 2-3" wide and long enough to emerge from the solution). Ordinary scrap iron or steel can be used, but the surface will quickly clog up with corrosion. Do not use copper or other metals, as these will be rapidly eaten away. The reactions at the anode involve the production of bubbles of oxygen gas from oxidation of water, plus the direct oxidation of the metal electrode. Stainless steel is most resistant to the latter process, but even it may show some minor pitting after a while. The anode should be brushed clean at intervals. The red lead from the battery charger should be clipped to the anode where it emerges from the solution. If this

attachment clip dips under the surface, it will be eaten away. The negative lead (black) is attached to the rusty object. In this case, the attachment clip may be submerged under the solution - corrosion does not occur at the negative electrode (cathode). It is very important to have good contact at the attachment point, so these should be cleaned by wire brush or emery paper. The object and the positive electrode should be separated by at least a few inches. If they are allowed to touch, a short circuit will occur and the battery charger may be damaged.

The Battery Charger

Any 6 or 12-volt battery charger will work, provided it can produce a few amps of direct (DC) current. A current of about two amps at 12 volts is typical (a charger with a current meter is useful as it shows you what is happening). If several objects are attached in parallel, or a very large object is attached, the current may rise. Be careful not to exceed the capacity of your charger. The current may be reduced by increasing the separation between the object and the anode or by diluting the solution with water. A car battery would also work as a DC power source.

The Process

Once the circuit is completed, tiny bubbles will stream from both electrodes. The time required for effective de-rusting will vary from 30 minutes for small objects (such as auger bits) to many hours for large objects such as a leg vice. Overnight operation is common. No harm is done by leaving the circuit on for long periods, as long as the charger does not overheat or gases do not build up in an unventilated area. After a time the object should be

rotated to avoid "shadow" effects (uneven de-rusting). If part of the object has been left projecting above the solution, the object should also be inverted to de-rust the exposed part. As time passes, some of the rust will fall off and sink to the bottom of the container. When enough time has elapsed (learned mainly by experience), turn off the charger, remove the object from the bath and rinse off the electrolyte with water.

The residual rust will now appear as a dark surface sludge which can be easily removed with a hand wire brush or plastic scourer. This is less messy when done under water (e.g. in a water-filled bucket). After rinsing and thorough drying, the object will now appear free of red rust, but there may still be a thin layer of closely-adherent black oxide.

For certain antique artifacts, this gray-black appearance may be quite attractive. However, brief power brushing will quickly remove this thin layer and give a progressively shiny and burnished appearance (appropriate for items such as plane blades).

Illustration 1Rust sludge remains on object surface after electrolysis

Illustration 2Clean steel surface after sludge has been brushed off

Baking in an oven for an hour or two at about 150°C (300°F) is an option which will give the objects an attractive bronze-yellow patina, deter further rusting and protect against hydrogen embrittlement (see below). Alternatively a rust inhibitor such as RP-7 may be applied, or the object simply oiled or waxed to deter future rusting. If only part of the object was submerged there will usually be a faint "tidal mark" where the object emerged from the solution. This is one reason to seek containers large enough to submerge the whole object at once. I find that intact japanning is not usually damaged by electrolysis, but loose paint of any type will be stripped off and this is often a useful feature of the method.

The method works best on objects that are electrically well-connected. Ideal objects for de-rusting by this method include augurs, ax heads, saws, single bow hand shears, plane bodies, cast iron pots etc. Whenever the object has multiple parts, the electrical contact between the parts will affect the results obtained. If the contact points are coated with rust, dirt or grease, little current will flow from one part to the next and de-rusting may be slow. If only a few parts are involved, it is easy to connect each part separately by providing

several branches from the negative lead or use short leads to connect each part to the next using clean contact points.

Other Variants of the Electrolytic Method

1. The bath itself may be made of stainless steel and used as the anode (positive electrode while the rusty object is suspended in the middle of the solution without touching the container. This method maximizes the size of the anode and allows current to flow to the object from all directions - thus minimizing shadowing effects.
2. The opposite of the above. Hollow vessels such as iron pots are filled with the electrolyte solution and attached to the negative lead, while the anode is suspended in the middle of the solution. This allows excellent de-rusting of the inside of such pots. A similar method has been used to remove rusty encrustations from the inside of cannons found in sunken ships.

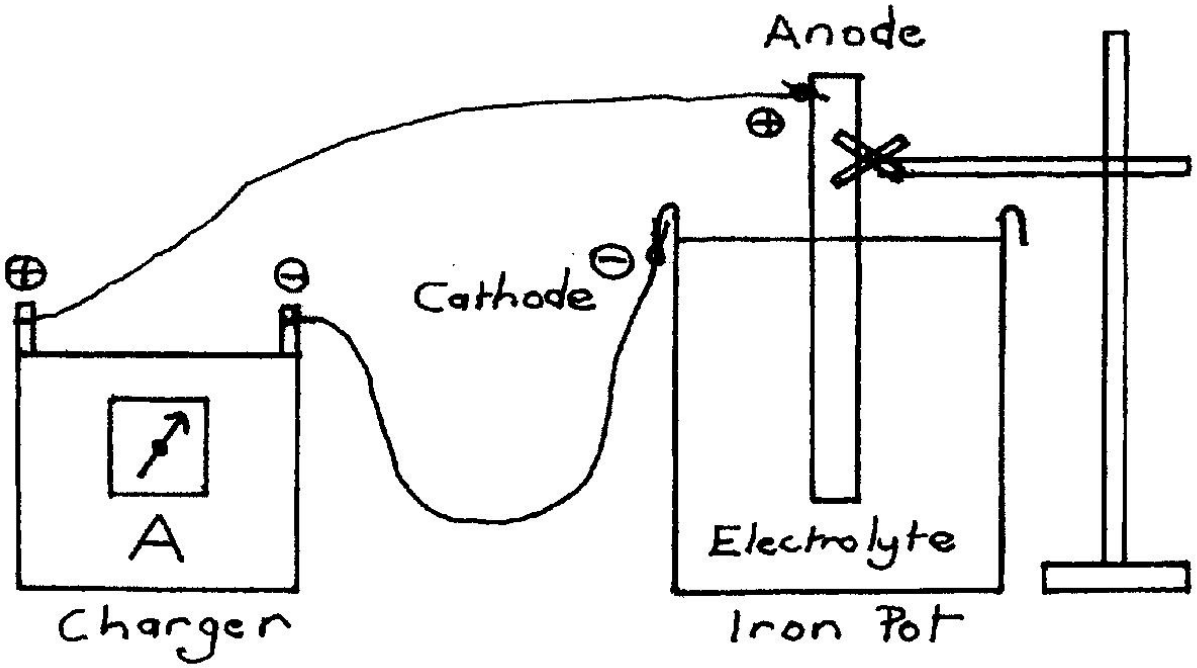


Illustration 3De-rusting the inside of an iron pot using a suspended anode

3. Small items may be placed on a stainless steel grid suspended in the solution and electrically connected to the negative (black) lead. The rusty items make electrical contact with the grid and do not need to be individually connected to the lead. However the de -rusting will proceed rather slowly unless the items have been cleaned where they touch the grid. Small chains and other intricate objects with connected parts may be de-rusted using this technique.

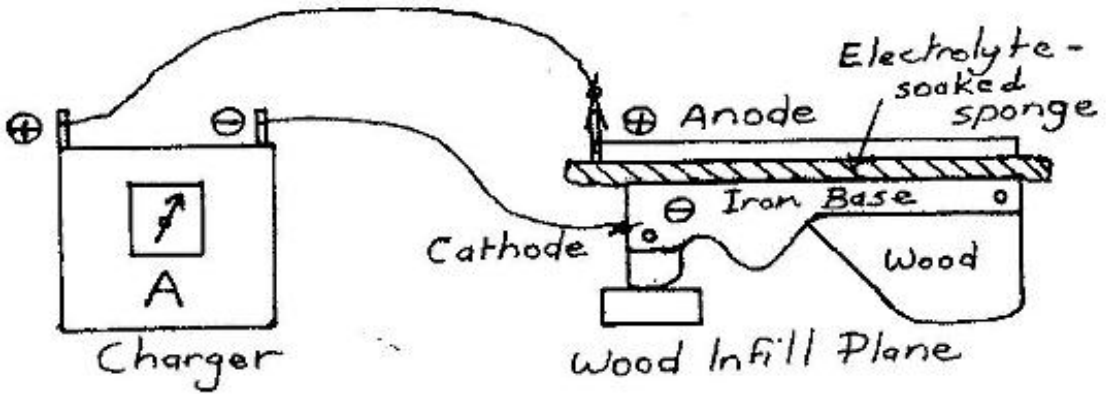


Illustration 4Localised de-rusting of the sole of an infill plane using an electrolyte-soaked sponge

4. To avoid immersion of objects such as wood-infill planes the bath may be replaced by a solution-soaked sponge or cloth which lies between the object and a stainless steel plate which acts as the positive electrode. The negative lead is attached to the object and current flows only through the soaked sponge. Be careful to avoid any short circuits. More solution should he added to the sponge periodically as it heats up and tends to dry out. This method can be used to de-rust small parts of artifact quite precisely without wetting the whole object.

Hydrogen Embrittlement of Steel - A Cautionary Note

Atoms of hydrogen absorbed by steel are known to enter the lattice of iron atoms and prevent the layers from sliding past each other easily. This causes the steel to become more brittle and liable to crack. The absorption of hydrogen by steel is a familiar problem in industry which arises during steel refining, heat treatment, acid pickling or electro-plating. It can also happen as a result of simple corrosion. The standard remedy is to bake the objects in ovens to drive out the absorbed hydrogen (200°C for four hours would be a typical regime in industry). The simple passage of time is also known to cause loss of hydrogen from steel. Hydrogen embrittlement may occur to some extent during electrolytic de-rusting. This may be a cause for concern with saws or other edge tools. It might be wise to wait a while before setting saw teeth after prolonged, electrolytic de-rusting. Alternatively, baking the tool in the oven for hour or so at about 150°C (300° F) should remove absorbed hydrogen. Note that this baking temperatures is low enough to leave the temper of most steels unaffected. Since hydrogen embrittlement is reversible, it should not cause too much anxiety. I believe that the advantages offered by electrolytic de-rusting justify wider experimentation by tool collectors. As more experience is gained clearer knowledge of its advantages and disadvantages will emerge.

Problems with Stainless Steel Anodes

Some thoughtful correspondents have pointed out that the use of stainless steel for the positive electrode (anode) may have some undesirable consequences. Most stainless steels contain high percentages of chromium and nickel which may be released into the bath as the anode is slowly eaten away. These are likely to be released initially as soluble cations just as the iron is released initially as ferrous ions. However, since all three cations are being released into an alkaline solution, they are likely to be immediately converted to insoluble hydroxides or oxides and form encrustations on the electrode or fall to the bottom as sediments. In this bound form the nickel and chromium are likely to be less hazardous but nevertheless waterproof gloves should always be worn when working with the bath and the bath sludge should be disposed of appropriately. It may be better to avoid the problem entirely by using simple iron electrodes and brushing the sludge off regularly.

References:

Jane and Mark Rees. Tools. A Guide for Collectors. Published by Roy Arnold, Suffolk. 1996. p22. Nathan Lindsay. Cleaning Rusty Tools. Electrolysis Made Easy. http://rusty21.com
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FAQ Derusting with Molasis, www.steamengine.com.au/ic/faq/mollasis.html
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Electrolytic Rust Removal

From http://www3.telus.net/public/aschoepp/electrolyticrust.html

If you're looking for a effective, relatively safe, and (best of all) cheap method for removing rust give electrolytic rust removal a try. I know that it sounds intimidating but it is actually very simple and won't damage the underlying material. This method basically consists of submerging the rusty metal in an electrically conducting solution of washing soda (also known as sodium carbonate). I've been told that baking soda (sodium bicarbonate) also works but I have no personal knowledge of this. The positive lead from a automotive battery charger is connected to a steel electrode and the negative lead is connected to the piece to be cleaned. When the charger is turned on a reaction occurs at the metal/rust interface on the object. this loosens the rust so it may be easily brushed off. This method does not appear to damage the underlying metal in any way, it seems to only remove the rust. Of course it will not improve the finish of the metal under the rust so any pitting on the metal will remain, just the rust will be removed from it. The cleaning solution should last almost indefinitely, only add water to replace that lost by electrolysis and evaporation.

Important Safety Precautions

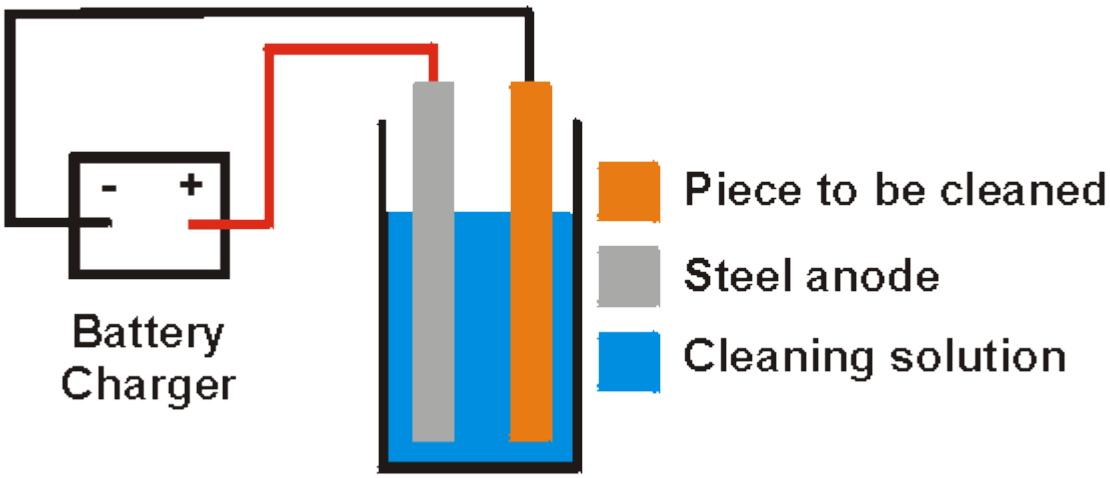
- The cleaning solution is alkaline and will irritate the skin and your eyes. Always use eye protection and rubber gloves when working with the solution and rinse off any spills.

- The battery charger must be completely shielded from the cleaning solution. Make sure the battery charger is in a location where you won't accidentally spill any water or cleaning solution on it. The 6/12 volt leads from the charger are relatively safe but it is still possible to get a shock if you put your hands in the cleaning solution or touch the electrodes while the power is on. Turning off the power to the charger will eliminate that risk.

- One of the side effects of the electrolysis is that the water will break down into its components, hydrogen and oxygen. For this reason you should work in a well ventilated area and avoid any sources of ignition, ie. cigarettes, or sparks from shorting out the battery leads.

What do you need to start?

- water
- washing soda (sodium carbonate)
- a battery charger (with a current meter if possible) or a car battery
- steel or iron electrode (I use re-bar as it's cheap and the anode will eventually be eaten away)
- a plastic tub (slightly larger than the part to be cleaned, although it is possible to clean a part with some of it sticking above the solution and then rotating it to clean the rest it may leave a small mark or discoloration which is undesirable)



The Procedure

The first step in the process is to prepare the cleaning solution. dissolve roughly 1 tablespoon/gallon of washing soda in water. Ensure that all the crystals are dissolved.

Roughly clean the steel anode. It doesn't have to be perfect just good enough that you can get good electrical contact. Attach the positive lead (red) from the battery charger to the steel anode. Submerge the anode in the cleaning solution, ensure that the clamp from the battery lead isn't submerged. If it is it will be eaten away with this process. The steel electrode will also be eaten away but very slowly. If you are trying to clean a large piece you will likely need more than one anode as this process almost works "line of sight". In other words the anode and part to be cleaned shouldn't be hidden from each other, for example if you are cleaning a large piece and only have one anode the side facing the anode will clean better than the side facing away from the anode. You can use multiple anodes so that the piece to be cleaned is surrounded, just connect them together with wire.

Attach the negative lead from the battery charger to the piece to be cleaned. Submerge this piece, it doesn't matter if this clamp is submerged as it won't be eaten away. Ensure that this piece and the anode don't contact each other as this will cause a short circuit. They should be separated by several inches.

Turn on the battery charger. If the current is too high on the battery chargers current meter there are a number of things you can do to reduce it;

- increase the distance between the part and the anode
- dilute the solution by adding more water
- if you have a 6/12 volt charger set it to the 6 volt setting

In the picture below you can see the plastic drum I use for cleaning large parts. The electrodes around the side are pieces of re-bar connected with the black wire on the outside of the drum. If necessary I can have all the electrodes connected or only some of them. The piece that is in there has been connected for a few hours and you can see the rust colored scum now floating on the top of the solution. It's not visible in this picture but the negative (black) lead from the battery charge is connected to the bar from which the part is hung.

Once it is set up and working you should see small bubbles of hydrogen and oxygen coming of the electrodes. Now you just have to wait. the time required to clean a part will depend on many variables:

- size of the part
- current used
- how badly rusted the part is

If necessary it is acceptable to leave the operation on overnight so long as it is not in an enclosed space (see the safety precautions above). You may have to move the piece occasionally for better cleaning as the best cleaning is done on the part that is in direct view of the anode (line of sight). If a piece is too large to fit in the bath you will obviously have to rotate it at some point. It may also be necessary to take the part out of the bath and clean it with a wire brush to remove some of the now loose scale which will look like a dark sludge.

You can use a plastic scrub brush an water to remove the sludge, if it looks like you took the

piece out too soon simply put it back in the cleaning solution. Once the piece is finished it will be a gray color. If it is an antique this may be an acceptable finish, otherwise use a wire brush to remove the gray oxide coating. Now you have to make sure the piece is dry so that it won't start rusting again and put some sort of rust inhibitor, wax, or oil coating.

Below are some photos of a test I did. The first shows a badly rusted disc blade. The second picture is after being removed from the cleaning solution. The black stuff on it is quite loose and came off easily with a wire brush. The final picture is of the completed disc blade after wire brushing.

NOTES

- Sound plating should not be affected by this process but if it is loose for any reason it will likely flake off.
- The cleaning solution may soften some paints.
- Remove wooden parts/handles before cleaning if you plan to submerge the whole part.
- The cleaning process relies on electrical contact for the cleaning. If you are cleaning a piece with more than one part (such as a pair of scissors) you must make sure that both parts have good electrical contact with the negative lead from the charger.
- If you want to clean a piece that can't be submerged you can use a sponge soaked in the cleaning solution. Place it on the piece then an anode on top of it and make the electrical connections as before. You will have to re-wet the sponge to ensure it doesn't dry out.
- Use your imagination for the containers. You can use whatever will safely hold your parts, such as Tupperware containers, plastic drums, vinyl eaves trough, wooden container lined with plastic, or whatever works for your piece.
- This method may also help remove rusted screws or other fasteners.
- While I have not concerned myself with it yet there is a chance that metal cleaned this way may be subject to hydrogen embrittlement. This can happen in many processes such as electroplating or welding. It should not be a problem unless you are cleaning hardened steel such as saw blades, knives, or chisels. If you are and you intend to use the item (rather than simply displaying it) you may want to try baking the part in an oven, I've

heard of using temperatures from 300°F to 440°F (150°C to 225°C) for several hours. ASTM-B633 is a standard relating to zinc plating of parts and it specifies baking at 375°F (190°C) for 3 hours within 4 hours of plating. As I haven't done this myself I can't provide any more information on the process other than to say that you will have to watch the temperature to ensure that you don't affect the temper of the piece.

Electrolysis - A Superior Cleaning Process

From http://users.eastlink.ca/~pspencer/nsaeta/electrolysis.html

NEWS – Warning

I have been made aware of the potential health problems with the use of stainless steel for the positive electrode. The stainless breaks down and releases chromium into the liquid electrolyte and a gas can be released (in the form of the compound hexavalent chromium) in the mist directly above the bath. Studies have shown that repeated and long term exposure to the liquid increase the risk of skin problems and repeated, long term inhalation of fumes increase the risk of lung cancer. For the most part, the users of this process are not exposed to levels that should cause immediate concern. The studies have been performed on those who do this as a daily job over a long period. It is probably best not to use stainless material but if it is, wear protective gloves when working in the liquid and adequate ventilation and/or breathing protection should be used.

An electrolysis primer – Introduction

One of the most tedious jobs we encounter while restoring old iron is the process of removing many layers of paint and rust as well as freeing up seized bolts and pistons. The following introduces you to a method of parts cleaning that has proved to be the most effective means of de-rusting and paint removal I have ever used.

Background

The electrolysis process has been used by archivists for years to clean metal objects. I saw a show where a 1700's vintage French brass cannon was cleaned to reveal the complete Royal Insignia, and this was after 250 years in the sea. I had always expected it was too expensive and complex but it is not.

I can personally vouch for this process since it was used exclusively for the cleaning and un-seizing of my own engines and machinery. Anyone who has ever tried to clean up rusty iron (or any metal) will embrace this method with a passion equal to their love for the object itself.

A specific experience with this process has been recently tested when I overhauled a Type J, twin cylinder Atlantic Marine Engine. This engine was no exception to the state in which we often find our engines. The parts that were not covered in 10 layers of paint, were heavily encrusted with rust and many parts (including both pistons) were seized solid. The engine is

now completely apart and clean using electrolysis exclusively and without the use of rotary wire brushes, chisels, flame heat or excessive force. And it is cheap and easy to implement and is even more environmentally friendly than the use of caustic and petroleum-based cleaners. There are no foul odors and the solution (if you use washing soda) is not irritating to the skin.

What is Electrolysis?

For the purposes of the information contained herein, electrolysis is a process that passes an electric current through an **Electrolyte**, causing the migration of the positively charged **ions** to the negative electrode (cathode) and the negatively charged ions to the positive electrode (anode).

Simply put, if you connect a power supply to a container of liquid with 2 rods immersed in the liquid, chemical changes occur to both the rods, which must be a metal, and the liquid, (electrolyte).

The process of electrolysis is not new, in fact it is as old as electricity itself. The same process occurs naturally when a metal in the environment is exposed to a reactive liquid such as salt. A small battery is created. Lead-acid battery of today produce power by the process and electroplating is performed by using electrolysis. For our purposes, we are trying to remove paint, grease and rust from metal. Rust and corrosion is formed by electrolysis. We will use the same method to remove it, and more.

Electrolyte

A substance, in solution with water or another liquid, which is chemically changed by passage of electric current thought it.

The electrolyte we use and refer to is the substance you mix with water in a bucket into which you place an electrode and the part you wish to clean.

Ion

An atom or group of atoms that carries a positive or negative electric charge as a result of having lost or gained one or more electrons.

The particles of metal which travel from the part being cleaned to the electrode are in the form of ions. An atom of iron (for example), once acted upon electrically through an electrolyte, is broken away from the base metal and becomes an ion with a negative charge. It travels through the electrically conductive electrolyte and goes to the electrode since it has an affinity (attraction) for the positive electrode. At that point the ion will lose its negative charge and either stick to the electrode or drop to the bottom of the bucket. If the particle is small and light enough, it may become part of the electrolyte solution.

What can be cleaned?

The greatest success has been with steel and cast iron but essentially any metal can be cleaned or for that matter any electrically conductive material. But special caution is needed with aluminum or plated items. The process removes layers of metal at a molecular level and very slowly (if washing soda is used).

Some warnings which may not apply at this time but in the future.

"Light" metals such as aluminum, white metal or other alloys break down much quicker than steel, cast iron or brass. I think it's because at the molecular level, there is a weaker bond, but I am not a chemist. A smooth aluminum surface that has light surface corrosion can still be cleaned with electrolysis, but only immerse the material for short periods (15 minutes) and clean with a soft brush. Longer periods will discolor, badly pit or even completely dissolve aluminum etc.

Also, materials with a thin or not well bonded electroplated surface may be adversely affected by long periods. The plated surface may actually peel away. Experimentation is required no matter what you are working with. Try short immersions first and gradually lengthen the periods. My main tests on heavy, thick cast iron and brass parts show that they can be left "cooking" in the electrolysis bath for hours, days even weeks with no noticeable loss of metal and the brass may have some tarnish or discoloration. This is cleanable with conventional metal polish and/or a buffing wheel.

Precious metals,(gold or silver) can be cleaned but;

a) Some amount of precious metal is removed and this may be highly undesirable.(I did try a dirty gold neck chain. It worked but likely devalued it).

b) If the item is plated (brass, gold, sliver), it may peel off the plated layer and effectively ruin it.

c) Coins and other items with fine detail can be cleaned but the delicate lines and raised words may be lost on badly corroded coins. If a truly vintage coin, other methods should be tried first.

So in general, experimentation is required while taking notice of the cautions outlined above. So don't blame me if your aluminum carburetor/engine block dissolves overnight. Or if your silver-plated water jug is reduced to the original tin shell.

I can't emphasize enough that aluminum

...requires special care. The polished housing on a motorcycle engine can be pitted and etched leaving a very poor mottled surface.

Other information on what you can clean is in Questions and Answers.

Materials Required

In addition to the part you are trying to clean, you need:

» **A non-electrically conductive container** large enough to hold the parts you want to clean, (i.e. a plastic bucket ? or for large engine parts perhaps an old (fiberglass) bathtub ???). There are other containers like a 45 gallon (about 200 liter) plastic drum that are used for soap and other materials sold in bulk. They are sometimes available cheap or free at recycling centers. An entire single cylinder engine could be put in one of these.

You could use a steel bucket, sink, pot etc. connected to the POSTIVE post as long as you are careful not to let the part being cleaned touch the side of the bucket (short circuit will occur).

» **A 12 volt battery or other DC power source** with high current capability. **A battery (in conjunction with a charger)will always give superior results**. A trickle (4 to 12 amps) battery charger can be used for small parts. A shop grade "booster" battery charger is quite effective for even large parts. 6 volt DC works as long as the current ability is high. Higher voltage DC sources will work of course BUT then it becomes a shock hazard. (see safety rules below).

» **Electrodes to connect to the positive battery terminal. Iron, steel, or any metal can be used.** Aluminum used as the positive electrode deteriorates quickly. Iron (and maybe brass) would last longer but requires regular cleaning. The electrode can be wire, bolts, fasteners, screening, sheet metal or thick plate.

** NEW INFO ** **Stainless steel WAS previously recommended** because the material I was using seemed to last longer and cleaned easier. BUT, as the electrode breaks down,the chromium in stainless steel becomes a compound (hexavalent chromium) which ends up in the liquid and there is the potential for the mist from the bath to become airborne and inhaled. LONG TERM exposure to the skin has been related to skin disorders and LONG TERM inhalation of fumes has been linked to lung cancer. In addition, the chromium in the electrolyte could be considered environmentally harmful so dumping in the ground would not be a responsible thing to do. Instead, allow the liquid to evaporate and dispose of the remaining debris as you would a hazardous waste.
Due to these problems, I can no longer recommend stainless steel to be used at all, especially in this very public forum.

» **Water** to mix with the electrolyte. Distilled water is not necessary but wouldn't hurt.

» **The electrolyte** (see above for more information). I used Arm and Hammer WASHING SODA -a common laundry detergent. I have also recently had success with Arm and Hammer Ultra Laundry Detergent. Main advantages here are; easy on your skin, NOT corrosive to the part being cleaned if you happen to leave the part in the solution, no worse than typical soap if it gets in your eyes, AND it leaves a nice soapy smell in the room. Also, the soap effectively gets rid of the putrid smell of old gasoline and oil. (great for cleaning out old gas tanks). Other soaps and detergents work fairly well and I'll leave that for you to experiment with.

Other electrolytes I have tried . Take note of the cautions mentioned

Baking Soda - Sodium Bicarbonate. It works but has much the same properties as salt in that it is mildly corrosive once electricity is applied. I have used it only only for brief tests. It is probably better to use it in place of washing soda than the others which follow.

Table salt- it is corrosive to metal in it own right. It also leaves a pungent chlorine smell behind. (It is sodium chloride). Very bad for aluminum.

Sea salt- it is corrosive to metal in it own right. But it is not the same as table salt. It actually contains many different types of dissolved minerals and salts. Some users have reported success with this. Very bad for aluminum.

Vinegar & acetic acid- Is a mild acid and has been reported to work but the smell it makes is undesirable.

Trisodium Phosphate (TSD) - Found in cleaners for heavy-duty use such as household wall and exterior cleaners, driveway cleaner etc. It is more caustic than soap (harmful to the skin and eyes) so extra caution should be used. The warning on the container says"*CAUTION: Contains Trisodium Phosphate. Wear rubber gloves and eye protection. Avoid eye contact or prolonged contact with skin. Wash thoroughly after handling. If eye contact occurs, flush with water for 15 minutes. Consult physician immediately*."

These work but are NOT RECOMENDED:

LYE - Sodium Hydroxide - Corrosive to metal in it's own right. Causes much more gasification of the water (LOTS of hydrogen and oxygen gas). Very hard on your skin and even worse **CAN CAUSE BLINDNESS** if splashed in your eyes. Very bad for aluminum , white metals (zinc alloys) or thinly electroplated materials.

Battery acid (sulphuric, hydrochloric, nitric) - I don't need to spell out that one for you do I? Way too hazardous.

Safety

(PLEASE read it all, especially the cautions regarding safety. Review the previous information on the type of metals you can work with and the suggestions on the "electrolyte" to use.

THINK SAFETY!!! - There are numerous common sense safety rules.

Power and voltage - Although you are working with a low voltage 12 volt system, some people may be more sensitive to that voltage. An unpleasant tingle will be felt if you touch both connectors from the battery or charger with your bare hands. More important is the high current capability. If you were to short circuit, the leads from the battery or charger, sparks will be created that could be a fire hazard. If you were to short circuit the leads with a coat hanger wire, a ring or necklace, it will glow bright red and cause burns and/or fire. To reduce the chance of personal injury, make all connections to the electrolysis bath before turning on the power. A shock hazard is more likely if you were to use a power supply greater than 12 volts.

Electrolyte - You may be using washing soda or other soap. They will not likely hurt your skin but splashing the soapy solution (which contains metal bits, grease and rust) in your eyes can't be good. If you use other electrolytes mentioned, they may be harmful to the skin and damaging to the eyes. Exercise caution

Gases produced - The electrolysis process splits water into it's elements, namely hydrogen and oxygen. Sparks (from the battery and connections) can ignite the hydrogen/oxygen mix. It is not enough to produce a Hindenburg-like explosion in your workshop, but it is flammable all the same so this should be done in a reasonably ventilated area and caution is advised.

Heat produced - Once the item to be cleaned has been in the bath for awhile, the water will get quite warm from the current transfer and may even be too hot to touch. This is a good way to help take apart seized parts without the use of torches.

Setup & Procedure

The example here uses a 5 gallon (20 liter) bucket. Use about 1/3 cup of washing soda in a 5 gallon bucket of water and mix thoroughly. If you are using larger containers, you will only need to add enough washing soda (or alternative electrolyte) to allow current to flow through the water. If you use other electrolytes, continue to add the substance until current flows (bubbling occurs). Excessive electrolyte simply uses more current without substantially improving the speed of the de-corroding process. Slower is better. After all, your old "whatzit" has been in the woods or under the ocean for decades or centuries,... what's a few more days?

Place the iron (stainless steel no longer recommended) or other electrode (rods, plates,wire etc) in the bucket and connect the **POSITIVE** battery cable. There must be a good electrical connection. Clean off any rust or dirt that may impede current flow. It might be best to clamp the electrode to the side of the bucket to keep it in place.

Connect the **NEGATIVE** battery cable to **the part to be cleaned** and place in the bucket. . There must be a good electrical connection. Clean off any rust or dirt that may impede current flow. The part could be clamped to the side of the bucket or alternatively suspended from the ceiling or from a piece of wood across the bucket. Turn on the power. You will immediately see bubbles and froth coming from the electrode and the part.

You may have to leave the part in for anywhere from several hours to several days or longer depending on the extent of the rust and paint **BUT USE GREAT CARE** with aluminum or other light alloys . In any case, it is useful to occasionally check on the part and partially clean it as the rust and paint soften. This can be effectively done with a small hand-held wire brush or stiff bristle brush and steel wool.

Large flakes of rust can be easily scraped off, smaller pieces will brush off in time and molecular-sized fragments float off into the water and become part of the froth on top. Paint may actually soften and can be peeled off in sheets, several layers at a time. This process is also good at softening rust inside water jackets and other tight places that are often difficult to get to. In addition, electrolysis will, in time, soften the rust layer between the piston and cylinder wall making it easier to remove. The same process softens the rust between a

seized bolt and its threaded hole or nut making it easier to remove without heat.

You can place several items in the bath at the same time but the more items (thus greater electrical surface area) there are, the more current flow is required. This also means that the stainless plate (if quite large) also increases the current flow. In addition, the proximity of the stainless plate (positive post) and item to be cleaned (negative post) changes the current required. The closer they are, the more current required. (just make sure they are a little distance apart-otherwise a short circuit) When cleaning large parts, a fully charged, heavy-duty 12 volt battery will be dead in several hours . So either use a smaller electrode, increase the distance between the electrode and part or use a BIG battery and /or heavy-duty battery charger.

As mentioned above, the rate of electrolysis can be affected in numerous ways. To reduce the process, increase the distance between the electrode and the part being cleaned, reduce the concentration of the electrolyte or reduce the size of the electrode. In all case, this increases the resistance which decreases current flow and slows the electrolysis process.

You can use any DC power supply of any voltage. Avoid high voltage just because of the shock hazard. A battery charger will work, especially if used in conjunction with a battery. (The charger will help keep the battery "up" or if you use a shop type "booster" charger, it can be used by itself. A 4 amp trickle charger won't do much except for small parts). A problem I have found with some battery chargers (if you do not have a battery included in the circuit), is that the rectifiers that filter the AC to DC are poor. This means that some of the material that has been pulled off the item you are cleaning, gets reattached to the part because a small fraction of the current flow is reversed. While not a huge problem, the part will not be as clean as it could be.

When you are finished cleaning the part, wash it with fresh water and dry it thoroughly over a heater or in the sun. The freshly cleaned metal will rust very quickly. It might be best to either prime the metal or spray with a light oil or penetrating oil (like WD40) to stop flash rust from occurring. Another trick is rinse the item with COLD water and dry it as quickly as possible. Since the item is cold, the water does not evaporate so fast. If rinsed in hot water, the water film disappears before you can dry it with a cloth or compressed air and flash rust is almost certain to occur.

Also remember that (with iron at least) if the part you have cleaned comes out looking badly pitted and rounded off, electrolysis did not do it. This is what the item looked like after natural corrosion ate into it.

Special Cleaning Methods

How to clean a bunch of small parts

If you have a lot of small parts (like a bucket of bolts), you can use a stainless steel screen (a common kitchen strainer works) shaped into a pouch or mini-bucket. Place some of the parts in the screen and immerse in the electrolyte as if it were a single part. Connect the battery NEGATIVE to the screen. All the metal parts which touch the screen (and in turn, each other as the corrosion dissolves and the parts can electrically touch each other) are cleaned together. Use a brush to stir the parts around occasionally. This helps to remove

loosened corrosion and improves the electrical contact between pieces. In time, all parts will be mostly de-corroded. Compare this to wire brushing 100 bolts individually.

Cleaning inside a tight area like a engine water jacket

Take a small diameter plastic or rubber hose, cut numerous small holes in it and slip a length of stainless steel wire through the length of the tube. Feed this assembly into the water jacket (or whatever you're working with) and connect the POSITIVE battery wire. The electrode is now inside a tight area and in close proximity to the part/area you want to clean without touching it. Getting all the loosened crud out can be a challenge but vacuuming, compressed air or turning the unit upside down to dump it out works. One problem is that the process causes large chunks of rust to drop off inside the unit. You may need to reach inside with a screwdriver or rod to break up the rust to get it out.

For cleaning inside of cylinders or other parts, use a stainless bolt or wire supported and hanging freely within the part. This will clean inside areas that can't be normally reached such as a gas tank .

Cleaning large items

The use of a drum (45 gallon) was mentioned above. These are usually big enough to place an entire small engine in (or lathe bed or wood stove etc). Surround the inside of the drum with screen or sheet steel (stainless is better) and connect to the **POSITIVE** battery lead. Lower the entire engine or part into the center of the drum using an engine hoist, chain block or suspended from the ceiling. Connect the **NEGATIVE** lead. Over time and with some brushing, the whole unit will be free of rust, grease and paint before you even take it apart. This will require considerable current so a large battery charger capable of maintaining 30 amps or more will be needed.

REUSE the electrolyte

After a while, the electrolyte gets quite dirty with suspended metal and dirt or grease. I have found (at least while using washing soda) that if you remove the electrodes, wires and parts from the electrolysis bath and leave the liquid to sit a few days, most material drops to the bottom. Siphon off the clear liquid at the top and re-use it, perhaps add a bit more electrolyte and water before starting the process again. HOWEVER, some material will remain in suspension and may affect (discolor) the part you are cleaning.

Example: If you have just cleaned a lot of brass, the electrolyte gets a green hue. Cleaning steel in this liquid may leave it with a slight brown discoloration. If this is undesirable, you will need a fresh batch of electrolyte.

If you don't intend to reuse the electrolyte and it was not used for extensive de-greasing, it can still be used as a soap to remove dirt and debris from metal. It is probably best not to simply dump the liquid outside in the ground as it may contain lots of metal and grease. BUT more importantly **if stainless steel was used** as the positive electrode, the breakdown of the material will leave chromium suspended in the liquid and it would be considered an environmental hazard. It is best to allow the electrolyte to evaporate in any case and dispose of the debris left behind in an environmentally responsible manner. If stainless steel was used, it should be considered a hazardous waste.

THIS IS NOT A MIRACLE WORKER. Some good old-fashioned elbow grease will still be needed but the effort is much-reduced.

Questions and Answers

The instructions (USED TO) mention a preference for stainless steel electrodes. Why? (NOTE WELL!!! - Stainless is no longer recommended due to the potential health hazards after regular/repeated exposure)

The electrode connected to the positive battery contact gains material during the process of removing it from the part you are cleaning. Aluminum and steel hold on to a lot of this material, (rust, corrosion, iron or copper bits) and eventually create an electrical barrier which nearly stops the current flow through the electrolyte. Regular cleaning of this material is needed by scraper or wire brush. Stainless steel does not allow as much material to stick, so it requires less cleaning and attention. In addition, stainless material does not break down fast so will outlast steel many times over. (In spite of the concerns with the use of stainless material, I stand by the comments of the last 2 sentences if a GOOD QUALITY stainless is used). Admittedly, it is hard to know the quality of the stainless material you obtain.

Where to I get stainless steel? (NOTE!!- Stainless is not recommended any longer)

Stainless steel is available in many forms. Wire, screen, bolts and thin or thick plating. These are mostly available at hardware stores or a bolt and fastener specialty shop. Stainless screen or plate may be available through a metal working shop that builds ducting or sheet metal products. New stainless is expensive but will last years. Try a scrap metal

yard for pieces of stainless. You may even find pieces of automotive trim in an auto junk yard made of stainless. It was used as door moldings and window trim.

Can I remove the chrome plating from an antique weapon (a pistol)?

Probably not. The electroplating process, if done properly, will include an acid dip to remove all dirt, rust and oxidation. The item is then plated many times over. If the chrome (or brass or silver plating) is well-adhered to the base metal, electrolysis will not have any effect on it.

Can this be used to clean an all-aluminum motorcycle or other small engine?

If caution is used, it will help to remove layers of corrosion from aluminum. But if you are trying to free up a steel part within an aluminum casting, **be warned,** the aluminum will be eaten away much faster than steel. This could effectively ruin the machine. If you have no other choice, it may be worth a try.

Will brass and/or babbitt be eroded using this process?

Any solid brass or copper will not be adversely affected outside of some discoloration. The babbitt (lead alloy) bearings found in many old machines will deteriorate somewhat faster than steel but the surface will not be quickly etched. The biggest issue is how well the babbitt was adhered to the base metal (iron or brass). If the bond is poor, the babbitt shell will be undermined and eventually come loose. If that is the case, you should be thinking of re-pouring the babbitt anyway.

Does the part need to be degreased before the electrolysis process? Will electrolysis remove good paint on clean, non-rusted metal?

The part you are cleaning needs no special preparation outside of insuring a good electrical connection. Grease falls off the part and dissolves in the soapy solution in conjunction with the heat produced by electrolysis. Paint, even baked enamel, will eventually peel off the base metal in single sheets.

How can I adjust the rate of the cleaning process?

Opposed to buying a very expensive scientific grade power supply to adjust the current flow, it is simpler to either a) use less washing soda to make a weaker electrolyte, b) move the part being cleaned away from the electrode or c) add a load in series with the circuit such as a 12 volt light bulb or electric motor. In all cases, the resistance increases, the current flow drops and the process is reduced in effectiveness.

Can a small battery trickle charger be used?

Small battery chargers in the range of 4 to 10 amps may not be suitable. This is not because the current is insufficient but the quality of the direct current (D.C) is not good. Ideally, you want a pure DC source as that from a battery. Battery and trickle chargers must convert the 120/220 volt 50/60 Hz alternating current (A.C.) from your wall socket to 12 volts D.C.. The diodes (or rectifiers) which filter A.C. to D.C. are not very good in small and cheap chargers. The end result is the A.C. which gets through can cause as much material from the electrode to stick to the part being cleaned as what has been removed from it. Experimentation is essential in any case.

Have you cleaned springs using this method? I am wondering if there would be any

loss of tension by running the current thorough it.

Yes I have cleaned springs and they should not be affected by electrolysis. A spring would normally only lose its tension through excessive heat or stress and electrolysis does not get that hot. I expect that if the spring is quite rusty, it will already be weakened in the pitted areas where corrosion is present .

User Feedback

The uses for this is quite broad with reports of successful use on stoves, lathes, engines and other car parts, tractors, WWI ordinance found on the sea floor and even Napoleonic -era artifacts. Here a couple of emails

.....I am using the electrolysis cleaning method outlined on your website to clean a 13" South Bend lathe. I am completely impressed by the results I am getting. I typically leave the parts in the tank for 24 hours. The grease disappears, the paint comes off in sheets, and the rust is completely gone. Nothing left but bare metal! Thanks so much for creating the website you did. I have found the instructions very clear. Just didn't expect the method to work so well! Thanks again for your work! Ron C. USA ...

.....I collect old cast iron frying pans and electrolysis gets them clean easily and leaves a nice finish. Beats the heck out of my old method of scraping, and the lye treatment that was suggested by someone. Bob S, USA ....

.....I tried it last night using a trickle charger (8amps I think), seawater, steel bolt as anode (+) and connecting the negative terminal to the aluminum part. It is scary how well that works. I just did some less critical parts like handles and levers. About 15 min. loosened all the paint enough to make it a 30 sec. wire brush job. A careful inspection with the magnifying glass did show some slight pitting. I would hesitate to do this with aluminum parts that have precise tolerance surfaces like blocks or cylinder heads. Still I am extremely impressed. Even if I can't use this one on every part it will still save me tons of time... Henry, USA