GCSAA ReTool

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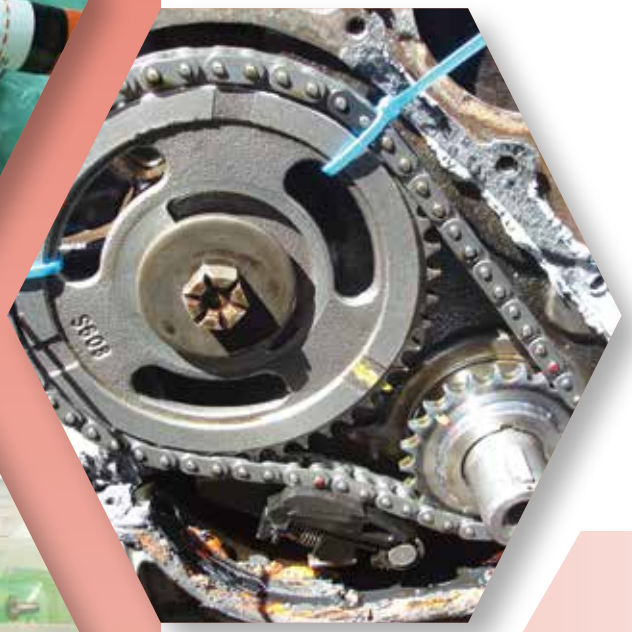

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CEO Message

Dear Equipment Manager,

In 2015, GCSAA members voted to create an Equipment Manager classification, welcoming this vital position at the golf facility into the membership fold. Since that time, equipment manager volunteers on the Equipment Manager Task Group have assisted GCSAA in developing programs and services to elevate and recognize the true professionalism of the golf course equipment manager.

To provide you with another tool in the toolbox, we introduce ReTool — a collection of equipment management tips and tricks, paired with the highlights of GCSAA's member benefits for equipment managers. These articles are taken from GCM's popular bi-monthly Shop column, authored by former GCSAA staff member Scott Nesbitt.

Your work as an equipment manager directly impacts the enjoyment, growth, and vitality of the game of golf. GCSAA's mission and yours are one in the same. If you're not a GCSAA member, let us welcome you into this dynamic association of golf industry professionals. If you're already a GCSAA member, we invite you to elevate your engagement. You can learn more about member benefits for GCSAA Equipment Managers at www.gcsaa.org.

If you have questions, contact us at 1-800-472-7878. We're here to serve you.

Sincerely,

J. Rhett Evans
GCSAA CEO

ReTool CONTENTS

Timing troubles

Engine control computer programs may reduce engine power and efficiency when a loose timing chain causes inaccurate data to come from input sensors. **Photos by Scott R. Nesbitt**

A chain-and-sprocket system coordinates crankshaft and camshaft positions to set the foundation for fuel, air and ignition control and adjustment.

Replacing the timing chain set requires disassembling the front of the engine, and that may involve removing lots of chassis components.

Easily overlooked, the timing chain system can be the most important factor in the poor performance of many four-cycle gasoline and diesel engines found in turf equipment and on-road vehicles.

Old-timey mechanics used the term "tuneup" to refer to the installation of new parts and adjustments to the fuel-delivery and ignition systems of engines. Like a guitar or violin, an engine sounds in good tune when all the operating pieces are synchronized and balanced.

Modern engines use a computer to achieve proper tuning (top photo). The computer program makes modifications in response to input data from sensors that report on the movement of the crankshaft and/or the camshaft, the density and temperature of incoming air, the position of the throttle plate, and the cooling system's temperature.

Output commands adjust the amount of fuel sent to the cylinders and the time at which spark plugs fire in a gasoline engine. "Knock" sensors and oxygen sensors report whether things are out of sync because the plugs are firing too soon, or because the air-fuel mixture is too lean or too rich. The computer is programmed to maximize power and efficiency.

All of this electronic wizardry assumes there is proper coordination among the mechanical parts — the crankshaft-piston system and the camshaft-intake-exhaust-valves system. The camshaft must rotate at half the crankshaft speed, and be synchronized so the valves open and close at exactly the right time as the pistons move up and down. If the cam and crank are close together, a set of gears keeps them connected and coordinated.

Most engines use a set of sprockets connected by a chain or belt. Chains are mounted inside the engine, sealed in with the lubricating oil. Belts are mounted outside, given that oil destroys them. Belts are made of materials that don't stretch, so timing remains accurate, but belts must be changed periodically or you risk engine destruction.

Engine-makers are increasingly going back to chains, which can last for many decades and thousands of hours.

Chains, however, can stretch, and sprockets can wear down, especially if the engine oil gets too thin or contains grit. Stretching increases if the chain's workload rises, because weak oil increases friction as the camshaft lobes slide against the valve train components to open the valves. You see this same effect when you have to frequently tighten a chain saw's chain that has to slide along the bar rails. An engine control computer that uses only one sensor to monitor either the crank or cam cannot know that things are not in sync. A computer that uses both crank and cam sensors will get conflicting input data. Some engines monitor the camshaft by putting the sensor in the ignition distributor, which is rotated by the camshaft. This adds more moving parts, increasing the chances of an out-of-sync situation. Depending on its program, the computer may refuse to let the engine start, or may switch into low-power "limp" mode while triggering a "check engine" warning light.

Replacing the timing chain and sprockets can be easy or painful, depending on the engine installation. At the worst, you'll have to pull the engine out to replace the timing chain set. Always follow the factory service manual to make sure everything is right and tight. Never pound on the sprockets or chain — you can soak the chain in hot oil to make it grow a bit, easing installation.

For more on engine management and the role of timing chains, search online for "loose timing chain." Good coverage of engine control can be found at www.enginetuner.com/learn-engine-management.

This article originally appeared in *GCM* Magazine, February 2017.

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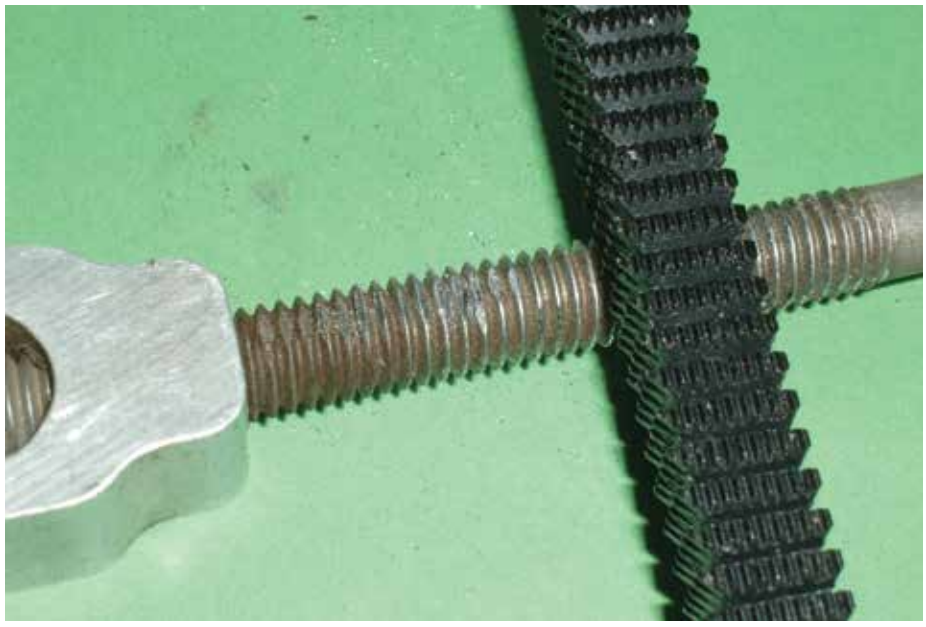
Restoring threads



These threads were returned to usable condition in just a few seconds via a thread restoring file.
Photos by Scott R. Nesbitt

Small enough to fit in any toolbox, an external-thread restoring file can save hours by quickly taking the nicks and dings out of threaded fasteners.

Dad's toolbox included a weird kind of file that had eight different file faces but was pretty useless for shaping wood or metal. A few weeks ago, browsing an industrial surplus liquidator, I saw the same type of file in a nice, new package and finally learned what it was: an external-thread restoring file. Sixty some years later, I now realize that I should have asked Dad what it was, and that every technician needs one — or maybe four of them — in every toolbox.

The top photo shows patches of damaged threads on each side of some good threads. The damaged threads were repaired in under 30 seconds using that surplus "thread chaser" file that brought back memories of boyhood tinkering and all the hassles I'd have avoided for several decades if only I'd asked Dad about that odd tool.

The thread repair is simple: Determine the file face that matches the threads, and pull back lightly to "feel" the proper angle across the threads. Apply modest pressure while pushing the file forward, and no pressure on the return stroke. Check your work every five or six strokes.

Before finding my file, I'd have spent maybe a half-hour cleaning the threads with a tiny jeweler's file, or wasted time, fuel and cash fetching a new turnbuckle from the hardware store. Using tools from the tap-and-die set wasn't an option, because those are left-hand 3/8-16 threads, and I don't have that die.

My file has a square shaft, 7/16 inch on each side, and is 8⅜ inches long. There are eight file segments, each labeled for a specified threads-per-inch (TPI) count: 11, 12, 13, 14, 16, 18, 20 and 24. Those TPI counts are used on U.S. standard fasteners from 1/4- to 5/8-inch shaft diameter.

Restoring files are also made for metric threads, with spacings of 0.80, 1.0, 1.25, 1.5, 1.75, 2.0, 2.5 and 3 millimeters. Another is designed for U.S. pipe threads, and another handles extra-fine and extra-coarse U.S. threads. There are files for threads used on hydraulic hose fittings, and others for Whitworth thread system fasteners used on old British Empire machinery.

The biggest challenge in using one of these files is making absolutely sure you match the file to the threads you're restoring. Using the wrong file face will only cause more damage. Eyeball the thread/file matchup in strong light. If you can't see that damaged exhaust manifold stud, match the file to a companion stud, or use a light touch with the file.

If the flawed fastener is in a high-stress situation, such as a connecting rod bolt or something in the steering system, employ safety-first thinking and invest in a new bolt. For most fasteners in most settings, though, it's fine to clean up some damage or remove rust and crud from the threads and then get on with the job without hauling back to the shop for parts or something from the tap-and-die set.

Despite the obvious usefulness of these files, I couldn't find a single one on display at any big-box, hardware or auto/tractor/truck parts retailer I haunt, nor do I recall any tool truck salesman pushing me to buy a set. The best bet is to go online, where even office supply stores stock the files.

The Nicholson 33024 set of four files, priced at $51.52, seems to be the most common offering. Diligent searching turned up comparable files for $10 apiece. Some proud tool suppliers want a whole lot more for files with the same dimensions and thread faces. Shop wisely, and enjoy.

This article originally appeared in *GCM* Magazine, April 2017.

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From reel measurement to a one man brake bleed — check out this collection of **5-Minute Fix Videos** for quick and simple solutions to equipment-related issues.

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Torque tech

When bolts are properly tightened, they act like springs and provide the best possible clamping force to hold machine parts together and ensure against failure, and the only way to know whether tight is right is with an accurate torque wrench.

A digital torque adapter makes calibrating torque wrenches easy, and use of such a gauge increases the likelihood that equipment leaving the shop after service will keep performing out on the golf course. There are many brands of torque adapters available at prices that are a bargain if the device helps you avoid a serious mechanical problem or safety issue from a loose or broken fastener.

Engineers have spent the past century designing and testing bolts and other threaded fasteners. Factories draw upon this wisdom to guarantee the bolts in new machines stay tight. Assembly-line torque wrenches are frequently calibrated to provide accurate twisting force that is correct for the fastener. In other words, it's the bolt — not the parts it's fastening — that dictates torque. The length of the fastener doesn't matter — just its diameter, thread pattern and steel grade.

Lots of science goes into developing specific alloys of steel for fasteners. Industry organizations set standards to which reputable bolt makers conform. Bolt heads are marked to identify the grade. Published torque standards assume the bolt is lubricated (engine oil works fine) and that there's no damage to the threads. Bolts installed dry may require 25 to 30 percent more torque, and dry bolts pose a risk of damaging the mating internal threads, especially if those are aluminum or magnesium.

A 5/16-inch, 18-threads-per-inch (5/16-18) coarse-thread Grade 5 (SAE bolt with three lines on the head) needs 13 foot-pounds of torque. The same size bolt in Grade 8 (six head lines) needs 18.5 foot-pounds. A metric 8-millimeter, 1.25-threads-per-millimeter (8 mm-1.25) bolt looks like those SAE-grade bolts, but the metric with an 8.8 head marking needs 14 foot-pounds while the stronger 10.9 bolt needs 20 foot-pounds.

Clamping a digital torque adapter in a vise let us verify that the clicker-type torque wrench was clicking at 14.9 foot-pounds of torque when it was set for 15 foot-pounds. Such adapters can also be used directly to measure torque during machine assembly in the shop. **Photo by Scott R. Nesbitt**

Those torque figures are minimum values, and service manuals usually specify a range. We just worked on a water pump that called for 8 mm-1.25 bolts that required 14 to 18 foot-pounds. That 4-pound range is the "elastic deformation zone" in which the bolt is actually stretched as the threads pull the shaft deeper into the threaded hole. When removed, the bolt snaps back to its original state and can be reinstalled. An over-torqued common bolt will suffer permanent "plastic" deformation and will lose some of its spring-clamp properties. Modern "torque to yield" bolts for cylinder heads actually take advantage of this permanent deformation. Each head bolt is torqued and then over-torqued by rotating the bolt a specific number of degrees. This makes the bolt longer and somewhat weaker, but the specialized steel alloy takes on better "springiness" properties that let the bolt hold tight during combustion.

To use a digital torque adapter, mount the unit between the wrench and socket. All adapters will beep and/or flash a light when you hit the torque you've programmed in via buttons like those on the Pittsburgh digital adapter shown above (sold by Harbor Freight as item No. 68283). Most units beep/flash only when your desired torque is between 30 and 150 foot-pounds — way more torque than necessary for most of the bolts. So, for torque under 30 foot-pounds, you'll need to be able to see the display, and that's not always possible in tight spaces.

Most digital adapters are 2 inches long and designed for 1/2-inch drive tools. Most technicians I know use 3/8-inch or 1/4-inch tool sets. To use your usual wrenches and sockets, you'll have to add a reducer like the one on the wrench in the photo. Chances are you'll find yourself frequently using your calibrated clicker or beam torque wrench, reserving the adapter for easy-access jobs.

The lack of signal at lower torque values can be resolved with the ACDelco ARM602-3, which buzzes between 3 and 59 foot-pounds and is designed for 3/8-inch drive tools. The ACDelco ARM602-4 has a buzzer range of 4 to 147.6 foot-pounds and 1/2-inch fittings. Both cost about $60 — about twice the price of most competitors. There's also the Bike-Master RJ7541 adapter, which has a range of 2 to 22.1 foot-pounds, is designed for 1/4-inch tools and sells for about $40.

Manufacturers of digital torque adapters are likely to keep improving their products. Your research on adapter features and prices should include checking out online reviews as well as YouTube video reviews to determine whether such a device would be useful in your shop.

This article originally appeared in *GCM* Magazine, June 2017.

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Little helpers

Little things mean a lot, especially when they help smooth out the workday in the shop.

1. Paint pens. These are invaluable anytime you're disassembling complex machinery, particularly if you have to order parts and wait just enough days that you forget the details of what goes where. I use a yellow pen for marking dark-colored items, blue for lighter items such as aluminum parts, and red for an alternate color. Paint pens are practical for a variety of purposes — marking which rubber hose goes to which fitting, identifying which part came off in what order, labeling small units such as trimmers and chainsaws with ID numbers, writing on an engine when it will be due for an oil change, or marking which end goes up. The semipermanent waterproof paint dries quickly, resists being rubbed off, and can be removed with chemical solvents.

I found mine in Walmart's craft department for about $2 (they were twice that much at a local auto parts store). Online prices vary wildly. To see a huge selection of what's available, including pens that write under water, go to www.markingpendepot.com.

2. Screw grabbers. Nothing wastes time like having to find that tiny screw you dropped, and no sound is sadder than hearing it tinkle its way down into the depths, never to be seen again. My favorite preventive solution is a nonmagnetic screw grabber (or "starter"). Magnetized screwdrivers and the magnetized screws they hold tend to grab nearby steel and iron. Often, you lose the screw.

Grabbers use spring-loaded tips. The screw hangs on until you can get the threads started. Just pull the grabber away to release the screw. The tool's thin shaft (about 5/16-inch) gives you good visibility in tight spaces. The photo shows the grabbers for slotted and Phillips screws. There's a grabber for Torx screws, but mine rolled away into an engine compartment, never to be seen again. Grabbers cost under $10 apiece, and some feature nonconductive fiberglass shafts. Handy.

Photos by Scott R. Nesbitt

3. Wire tracers. Hours of frustration can be avoided with this two-piece tool. A transmitter sends a radio signal into a wire, and the receiver picks up the signal and then beeps or squeals as you move the transmitter along the wire — even a wire bundled in a loom. Shorts, breaks or high-resistance spots in the wire are indicated by changes in the signal tone. My Cen-Tech unit from Harbor Freight (about $25) uses 9-volt batteries and works OK, but the beeper's volume is a bit too low for my old ears. Spring for a pro-grade set with strong signals for about $75. And read and follow the directions! You'll destroy the unit if there's live electric current in the wire you're tracing.

4. Salt for the coffee. When my wife, Vicki, was a night-shift nurse, she learned to add some salt to the coffee filter to reduce the bitterness and smooth the taste of the essential brew. We use three shakes for a 12-cup pot. The salt seems to make drinking coffee that's been on the heat for several hours tolerable, as well as making decaf drinkable. Even my cardiologist endorses the technique despite the low-salt orders he's issued.

This article originally appeared in *GCM* Magazine, August 2017.

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Don't trust — verify

Technicians tend to assume that the people who make machines and repair parts know what they're doing. The following episode emphasized, for me, the need to verify rather than trusting, and to reason your way through unwanted surprises.

It started with a simple timing chain replacement on a 2.5-liter, four-cylinder gasoline engine that has been in production for 30 years. It's an ancient design — a cast-iron block and head with push rods and rocker arms. A timing chain sprocket on the crankshaft rotates the camshaft sprocket at half the speed of the crankshaft.

The teenaged pickup had only a quarter-million miles. The factory paint on the timing chain cover was intact, indicating this would be the first timing chain replacement. What could go wrong?

After removing pulleys and the timing chain cover, we *trusted* that we'd simply remove the sprockets and timing chain and install the new parts. The only trick was to make sure the alignment marks — a small dot on each sprocket — were lined up when installing the new sprockets and chain. All four-cycle engines use such marks, whether they're a simple two-sprocket system or an engine with several sprockets for multiple overhead camshafts, balance shafts, and water and oil pumps.

Surprise! The timing mark on our camshaft sprocket was 180 degrees off. Somehow, the factory had installed a camshaft with the positions of the small and large pin holes at the sprocket end of the camshaft reversed. The dowel pin in the larger hole mates with a hole in the sprocket, creating yet another alignment point. Camshafts are made on computer-controlled machines. Somehow, the computer had messed up. On the assembly line, someone had turned the sprocket 180 degrees, mounted it on the camshaft, and sent the engine on its way.

The factory installed this camshaft dowel pin in the wrong hole, putting the sprocket 180 degrees out of position. Pointing the distributor rotor to the No. 1 cylinder position (inset) verified the error, as did checking the positions of that cylinder's intake and exhaust valves. **Photos by Scott R. Nesbitt**

A new yellow camshaft sprocket timing mark, opposite the red-marked factory dot, provides proper sprocket alignment on the mismade camshaft. Zip ties temporarily held the chain to the sprocket to ease installation. This shot was taken during disassembly to install the new camshaft.

The engine was running before surgery. We had followed normal procedure and rotated the engine to align the distributor rotor with the No. 1 spark plug position (inset photo). The distributor is gear-driven off the camshaft, which provided yet another point to verify that the camshaft lobes were in the right orientation. We pulled the valve cover to double-verify that the No. 1 cylinder valves were in the all-up "firing" position. Pulling the valve cover to check valve position would be required on newer engines that use magnetic sensors to check camshaft and crankshaft positions and distribute computer-controlled spark.

We marked the factory timing dots in red, and painted on new white marks to show the actual sprocket alignment needed to let the engine run. Zip ties held the chain to the sprocket during installation. The new timing chain and sprockets improved the engine's performance, although a month later, we installed a new camshaft, hydraulic lifters and a reconditioned cylinder head in hopes of pushing the old truck to the half-million-mile mark.

The timing chain incident reinforced the importance of verifying. During the same week, two string trimmers and a power blower would start, but wouldn't throttle up. Pouring the fuel mix into a glass jar and letting it sit overnight resulted in a layer of water settling to the bottom — the problem was water in the non-ethanol gasoline we use for two-cycle engines. Who can you trust?

If there's a lesson here, it's that when things don't go as expected with a repair job, adopt paranoia instead of panic. Verify instead of assuming that suppliers and original-equipment sources always get things right.

This article originally appeared in *GCM* Magazine, October 2017.

Equipment Management Certificate Program (EMCP)

You're not sure. Do you have time to add the EMCP to your already packed to-do list? Is it really worth it? Equipment managers, like you, have asked similar questions — we've got answers and the details that can help set you apart as an expert turf equipment manager.

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Golf Course Superintendents Association of America I 800-472-7878

Cool yule tools

With the season of giving (and getting) coming up, odds are too many techs will get ties they'll never wear or gift certificates to stores they rarely visit.

Having just (again) reorganized my tool boxes, I came across a few cool tools that might make fine gifts. They reside in a drawer marked "special tools" — the kind of gadgets you grab when service situations get sticky.

I recently got out the Squeezewrench when I saw less than 1 inch clearance between the engine compartment wall and the 10-millimeter bolts holding a water pump pulley. The wrench is about a half-inch thick and rotates the fastener 45 degrees with each squeeze. Its hex-socket head fits 14 millimeters (9/16 inch) and comes with adapters down to 8 millimeters (5/16 inch). There's also a quarter-inch adapter to handle fasteners or quarter-inch hex drive bits.

In 30 years, the Squeezewrench has saved me countless hours and scraped knuckles. Websites offer competing versions from different makers. The best price I've found for mine is from the manufacturer (www.spec-tools.com). There is a newer "Pro" model with a longer reach, a 3/8-inch square drive adapter, and mating extra-short hex sockets in 16, 17 and 19 millimeters (5/8, 11/16 and 3/4 inch). The Pro reverses ratchet direction with the flip of a switch, whereas my older model makes you flip the wrench over.

A Gator Grip multi-pin socket fits fasteners from 7 millimeters (about 1/4 inch) to 19 millimeters (3/4 inch), including rounded-off hex nuts and bolts. It will also grip squares, flats, multi-point Torx fasteners and other odd shapes. Online prices are low enough to give a Gator Grip as a stocking stuffer.

Step drills stay in my portable tool box because I'm a little clumsy and ham-fisted. I drop and/or break regular drill bits. A lot. Most of the time, I'm drilling holes in plastic or sheet metal, the latter of which has tendency to snag or break a drill bit just when the hole starts to open. My five cone-shaped step bits handle pressure and wobble, and the quarter-inch hex shanks give a no-slip grip in keyless chucks. Mine range from 4.76 millimeters (3/16 inch) up to 35 millimeters (1 3/8 inch). My collection includes a tapered reamer that opens holes from 3 millimeters (1/8 inch) to 13 millimeters (1/2 inch). Online prices are also in the stocking stuffer range.

Lock ring pliers have jaws that open when you squeeze the handles. They open up the spring steel rings used in engines, transmissions and other high-load assemblies, and they also work to install springs, remove hydraulic lifters from an engine block, spread brake pads when working on disc brakes — you get the idea.

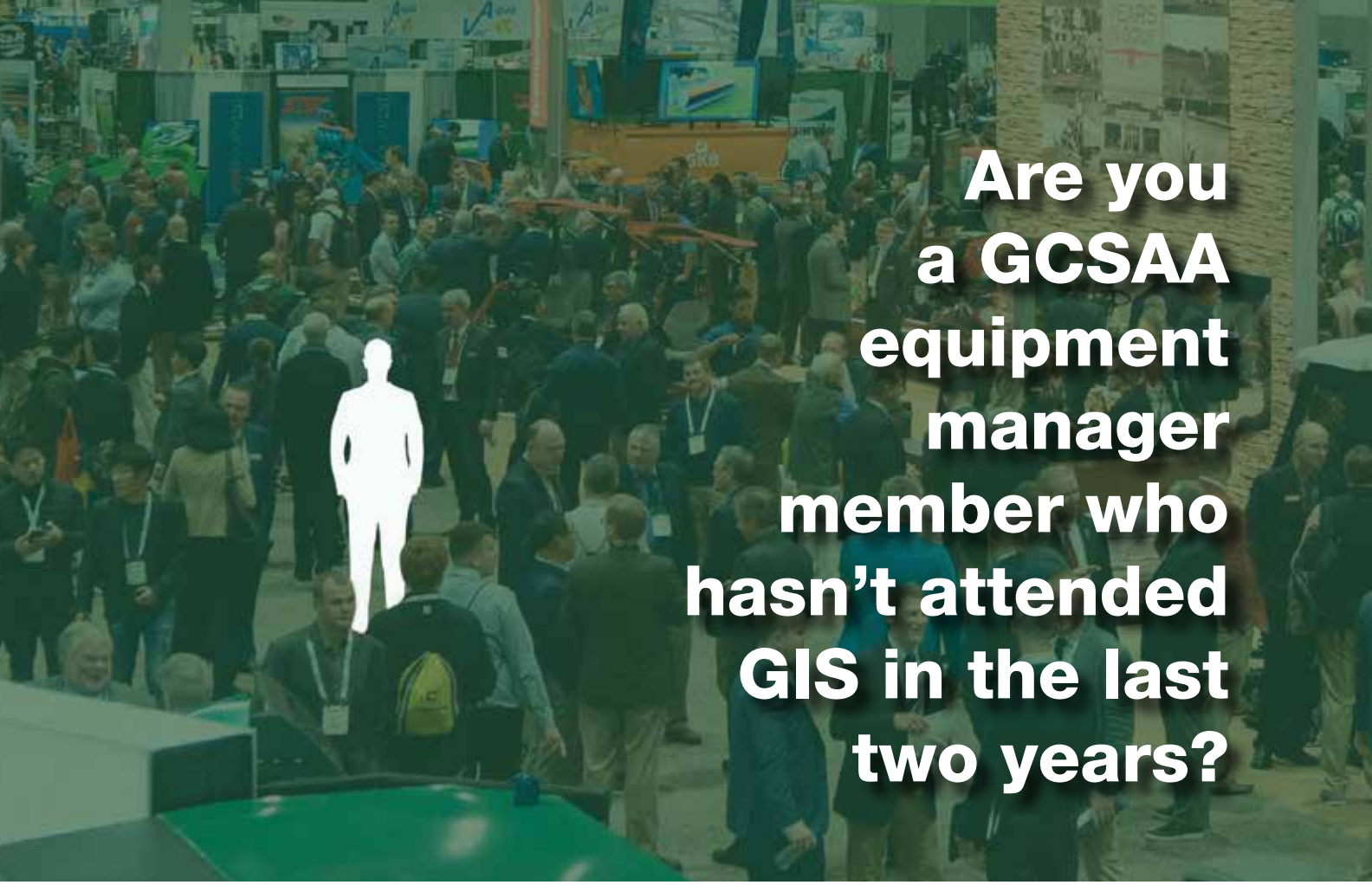
Enjoy your holidays.

This article originally appeared in *GCM* Magazine, December 2017.

1 Step drill bits tolerate pressure and wobbling, and they can cut several sizes of holes in plastic and sheet metal. The shanks are quarter-inch hex-shaped, so they eliminate slippage in drill chucks.
Photos by Scott R. Nesbitt

2 Lock ring pliers have jaws that open when the handles are squeezed.

3 The Squeezewrench and similar tools rotate a nut or bolt by squeezing the handles. Only a half-inch thick, it fits many common metric and SAE sizes in tight spaces. The multi-pin Gator Grip socket (bottom) can handle damaged fasteners.



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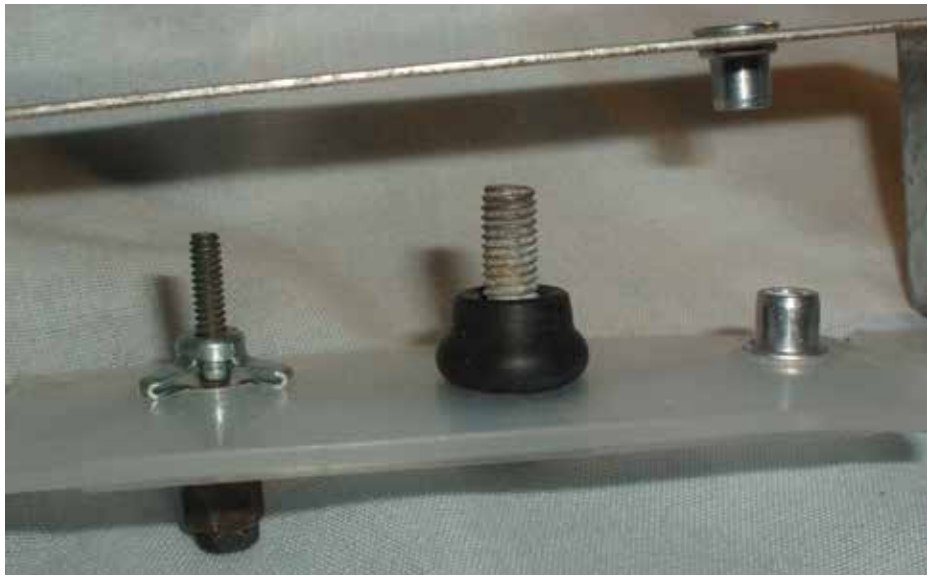
GCSAA and the EIFG gratefully acknowledge funding provided by the Kendrick B. Melrose Family Foundation.

Blind anchor solutions



Above: A rivet nut mounted in steel (top right), with a jack nut (lower left) and a rubber nut (center) both mounted in soft plastic. At lower right is a rivet nut that squeezed the plastic too tight, distorting the panel and easily pulling out when put under a light load. **Photos by Scott R. Nesbitt**

Right: A blind fastener kit stocked (at top) with a drill size gauge and two "rigs" for installing steel rivet nuts, with parts for other rigs in the far right of the center bin. Silver-colored aluminum rivet nuts in the top bins are installed with the hand tool at bottom. Jack nuts are in the left of the center bin, next to black rubber well nuts. The brass-colored rivet nuts are steel and are installed using the rigs assembled from bits and pieces of the shop's fastener supplies.

Get a grip with "blind" fasteners, which resist the vibrations inherent in turf care equipment. These fasteners give you a solid anchor on panels and plates, whether metal, plastic or fiberglass. They require more time and tools than sheet metal screws, but the benefits are worth it. They're called "blind" because you need not see or touch the back side of the panel to put a nut on a bolt. Even if you can reach the back side, installing a blind fastener will give you a solid mounting point, likely saving you time and trouble.

When I used sheet metal screws to fasten the "D" ring cargo anchors in my pickup truck's bed, the screws kept loosening. Installing ¼-20 rivet nuts (also called "rivnuts") solved the problem. Installing some expanding rubber nuts (also called "well nuts") and jack nuts gave me anchors in the cab for a cell phone holder and a trash bag mounted on the cab's plastic dashboard and door panels. These accessories are attached with threaded fasteners that can be removed, unlike "pop" rivet blind fasteners that require drilling to remove.

Although blind fasteners are common in all manner of vehicles and home appliances, your local hardware store probably won't have them. Go online and search the terms above, and you'll find them.

Glance at the photo of the four anchors, and the concept is intuitive. For proper mounting, though, you absolutely must start by drilling a hole of the proper size. My blind anchor kit includes a drill bit gauge to find the hole size that best matches the anchor's outside diameter. Too large a hole, and the anchor won't grip enough of the panel to resist twisting.

No special tools are needed for the rubber well nuts, or for the jack nuts that have wings that easily open when a bolt is screwed in. These anchors work nicely in plastics and fiberglass, because they spread the load over a wider area.

Straight-sided rivet nuts take more force and some practice to develop a feel for. For aluminum rivet nuts up to ¼ inch in diameter, the hand-squeeze installation tool works well. For plain and stainless steel rivet nuts, you'll need to assemble a simple installation rig. Take a steel bolt, slide a lubricated plain washer on, and then slide on a next-size-larger hex nut. Then slide on a lock washer, put a dab of oil or grease on the bolt threads, and screw on the rivet nut.

Put the rivet nut in the hole, grip the hex nut with an open-end wrench, and use a box-end or short ratchet wrench on the bolt head and start tightening. You'll feel resistance at first. Resistance will decrease when the sides of the rivet nut start expanding. When the rivet nut's threaded end touches the panel, you'll feel the resistance increase. Wiggle the wrench holding the rig's hex nut and tighten the installation bolt a bit, if needed, to make sure the rivet nut is gripping the panel firmly, then remove the rig.

Because the rivet nut, rubber nut and jack nut have less "meat" than a standard nut, be careful when doing your final assembly. Don't go crazy with tightening. Adding a lock washer or a bit of thread-lock liquid to the final assembly should help hold things in place. Excess torque can damage the internal threads, or can weaken or crack the panel material.

The kit I've assembled (for under $45) includes 6-32 jack nuts and aluminum rivet nuts in that size and 8-32, plus 10-24 and ¼-20 aluminum nuts, and steel rivet nuts in 8-millimeter and ⅜-16 sizes. The rubber nuts take a 6mm-1.0 bolt, the commonly found metric fastener that usually has a 10-millimeter hex head. That seems to cover every need so far, from mounting items on engine shrouding to customizing my truck.

This article originally appeared in *GCM* Magazine, February 2018.

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Lubricating O-rings

When searching for a "will fit" O-ring for a non-pressured, noncritical assembly like a hand-pump sprayer, the best choice is to look through the green and purple parts that are made of HNBR synthetic rubber and lubricated with pure silicone oil. There's no way to know what materials were used for the collection of O-rings that are left over from previous jobs. **Photo by Scott R. Nesbitt**

Having wrongly thought that O-rings were simple things, I've added a small container of 100% pure silicone oil to the toolbox. That liquid lubricant is making life in the shop easier and increasing confidence in the longevity of many repairs.

No longer will I squirt just any old spray oil onto any rubber-like gaskets, seals, O-rings, or the adjoining metal or plastic parts. Here are some basic terms and concepts worthy of inclusion in the technician's knowledge base.

The term "rubber" was first used in the mid-1700s, when Europeans saw that dried sap from a South American tree could be rubbed across pencil marks to erase them. Working with petroleum, chemists developed synthetic versions of the sap. Today, "natural rubber" comes from trees or oil wells and is called latex or isoprene. It is used for pencil erasers, car tires and many other things. More oil-based synthetic rubbers were developed, and others were created from rock-like minerals. These are called fluorocarbons (Teflon) and silicone.

From string trimmers to tractors, a few dozen synthetics are currently used, but there's no color code or other system to tell them apart. You're gambling when replacing an old black O-ring with a new black one. When working with a critical pressurized system, such as hydraulics and fuel and coolant systems, it's safest to use parts from the OEM (original equipment manufacturer) or a name-brand gasket kit. When I need a "will fit" part, I check my supply of HNBR (hydrogenated nitrile butadiene rubber) O-rings designed for auto air conditioning systems. These resist most automotive fluids over a wide temperature range. They work, for example, to seal fuel injectors mounted in intake manifolds.

Pure silicone oil helps resolve many of the unknowns in the rubbery domains. It helps prevent mishandling O-rings or other gaskets and to avoid their failure. Rolling an O-ring down a shaft or across screw threads can cause damage or distortion. Ditto for putting a dry O-ring into the groove cut in a machine part. (That groove is called a "gland" in many service manuals.) The lube lets rings slide into place. Because it doesn't dry over the long haul, it helps gaskets flex when heat changes and when vibration causes movement in places where a rubber gasket acts as a seal between metal or plastic parts. The pure silicone oil reduces galling and improves accuracy when fasteners are tightened to a specific torque into plastic or metal components.

Chemically, pure silicone oil is almost completely inert and neutral — it won't cause deterioration, swelling or shrinkage of virtually any synthetic or natural materials. It retains lubricity over a wide range of temperatures and stays put under pressure. There is a small chance silicone oil might partially dissolve a gasket made of pure silicone, but such gaskets are used mostly in food processing equipment, rarely in systems found on engine-powered machines.

It's the chemical issue that should limit use of spray or liquid lubricants on anything other than purely metallic components, such as chains. Petroleum-based chemicals pose a challenge because they can deteriorate oil-based synthetics. Many lubricants labeled as silicone contain 5% or less of the polydimethylsiloxane or polymerized siloxane chemical. The rest of the product is a liquid carrier. If the package says the stuff leaves a dry lubricant film, it's not the pure oil.

You probably have some nearly pure silicone oil on hand, as a component of the dielectric tuneup grease used on spark plug boots. However, the heavy body of the grease could interfere with some assemblies, and it should be a second choice. Be guided by experience and common sense.

You probably won't find pure silicone oil in a hardware store. Look for it online. It may be carried by gun shops, as it's the required lubricant in certain firearms and air-powered pistols.

My half-ounce bottle cost $8, including shipping. It takes just a tiny bit and is worth the investment.

This article originally appeared in *GCM* Magazine, April 2018.

Soil moisture seeped into this aluminum power cable. Metallic elements in the soil reacted with the aluminum and eventually cut through the cable, shutting down power to a garage. **Photos courtesy of Scott R. Nesbitt**

Antioxidant gel that electricians use to prevent corrosion of aluminum wires and components works as a reasonable general-purpose protective coating for battery terminals and as an all-purpose anti-seize and anti-corrosive when working away from the shop.

Corrosion control

Corrosion never quits, but damage can be controlled with easy additional maintenance during routine servicing and by using the right stuff when replacing parts.

Dramatic damaging corrosion was the culprit when electric power to our shop failed. The incoming power cable was accidentally covered by some dirt. Soil moisture containing who-knows-what minerals apparently penetrated the outside insulating jacket. The photo shows how the aluminum cable corroded and broke apart. A new cable with underground insulation restored power and illustrated how corrosion keeps working until something breaks.

Almost any metal will very slowly exchange electrons and ions when in contact with a different metal. Add an electrolyte — liquid acid, alkali or salt — and the process moves rapidly. Corrosion of metals generates electricity. Alkaline batteries work by mutual destructive corrosion of zinc and manganese bathed in potassium hydroxide. The corrosion is partially reversed in rechargeable batteries, such as Ni-Cd (nickel-cadmium) used for cordless tools.

On turf equipment, destructive corrosion is most obvious near the lead-acid battery used to start and run the machine, since the battery gives off a fine mist of acid fumes. Replace an aluminum water pump mounted with steel bolts, and odds are at least one bolt will show corrosion from coolant liquid seeping into the steel-aluminum joint. Copper wire grounding terminals connected to a steel chassis will often develop corrosion, shutting down the electrical system. A layer of moist gunk on equipment can provide the electrolyte needed to spawn mutual corrosion between dissimilar metal components that are some distance apart.

Washing off dirt and chemical residues after the workday can ward off corrosion. Use compressed air and/or sunshine to dry off the equipment. Spraying clean, dry equipment with silicon adds a water-resistant layer. But consider that sunshine can corrode nonmetallic parts made of rubber, plastic and fiberglass. Ultraviolet (UV) energy in sunlight encourages "dry rot" in rubber tires by helping atmospheric oxygen combine with petrochemicals in the rubber. Plastics become brittle when UV light breaks apart their molecules. UV blocker sprays are easily found at auto parts stores and are worth applying, especially in high-sunshine, hot-weather areas. Petroleum-based sprays are not recommended because they can degrade rubber and plastic.

Specialized anti-corrosives should be used when possible. Antifreeze, for example, contains anti-corrosives that prevent cooling system damage fostered by plain water. Anti-seize coatings help keep nuts and bolts from being damaged by corrosion.

My traveling toolbox includes a tube of electrician's antioxidant. It's a zinc-containing conductive gel that's required to resist corrosion of aluminum wires. I find it works pretty well on battery terminals and as a general-purpose thread lubricant for nuts and bolts. The tube doesn't spill, it fits in with the tools, and while it may not perfectly stop all metallic corrosion, it certainly can't hurt.

This article originally appeared in *GCM* Magazine, June 2018.

Gauging your measurements

Good technicians rely on accurate measurement, but accuracy is tough to achieve when dealing with "gauge" dimensions for wire, sheet metal and drill bits.

In the United States, copper 20-gauge electrical wire is thinner, but not half as thin, as 10-gauge. In steel plates, a 3 gauge is one-fourth-inch thick, but 11 gauge is one-eighth-inch thick.

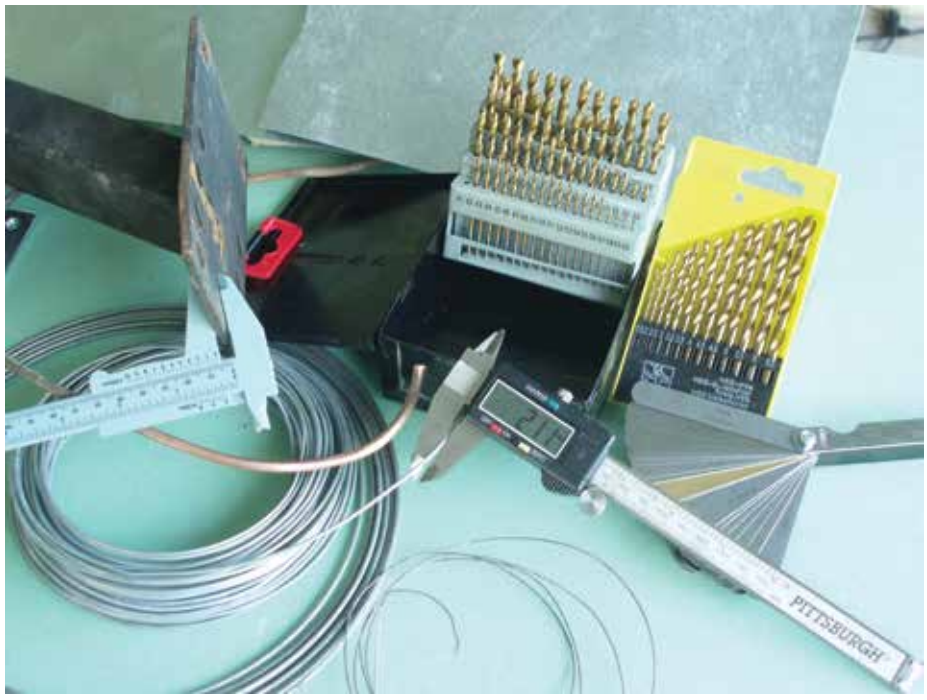
Gauge systems assign higher numbers to thinner materials. They don't add or subtract like the numbers you learned in school.

A technician's best bet is an accurate micrometer or caliper and actual measurement — in metric units — to understand materials and get in sync with the rest of the world. Without your own measurements, can you really understand the merits of one company's 10-gauge mower deck compared to a competing 12-gauge?

Service-manual specifications can be misleading because there are multiple gauge/dimension systems. Which did the manufacturer use? It can vary widely, depending on where the machine's components and assemblers are located and when the specs were published.

"Gauge" originally described the size of hole (or gauge) that softened hot metal was pushed through to form a round wire. Pushing softened metal through smaller and smaller gauges produced thinner wire: more gauges, thinner product. Different producers used different-sized holes and created their own gauge-to-dimension systems. This chaos started in the 1300s.

When mass production of steel became practical in the 1850s, wire-gauge dimensions were often applied to the finished sheet metal, and again proprietary gauge/dimension systems were used. It took two world wars to foster international standards, which are almost all based on reporting the metric dimension of the product. But traditions and oddness persist.



Calipers give accurate dimensions of different gauges of steel and copper wire. Wire gauge numbers were applied to sheet steel (top right) and plate steel (middle left), while the aluminum sheet (top left) uses a different system. Increased sizes of numbered drill bits don't always follow arithmetic progress, while what you see is what you get with metric drill bits (in yellow holder). The feeler gauges, fanned out at right, offer a quick conversion from U.S. to metric dimensions. **Photos by Scott R. Nesbitt**

Metric-labeled drill bits, at left, are becoming the world standard, displacing the Anglo-American numbered drill bits often referenced in technical manuals.

For example, the law named 15 U.S. Code § 206 defines the gauge numbers used for actual dimensions of steel and iron sheets. But that system isn't carried over to sheets of aluminum, copper, brass and other metals. Even stainless steel uses a different gauge/dimension system.

Even the metric-based international systems are a bit wacky: Standards for electrical wires specify not the diameter, but the cross-sectional area of the wire. To learn the outside diameter, you work through the equation for the area of a circle:

$$\text{Area} = \pi \times r^2 ,$$

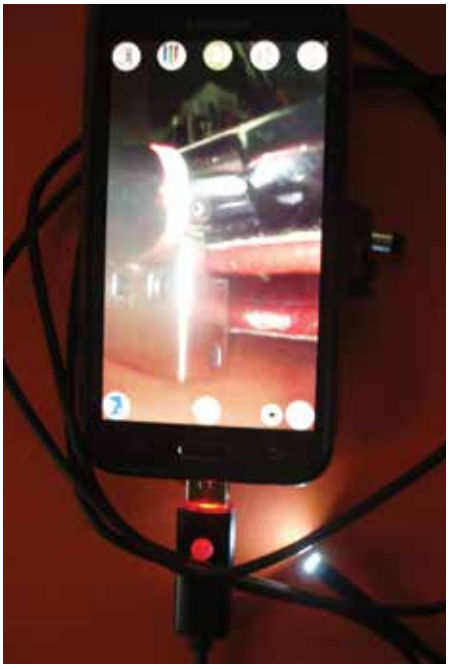
where the area equals π (which is 3.1416) times r^2, which is the radius of the circle squared.

Gauge numbers for drill bits are even more complex and include lettered gauges. Holes drilled in wood, metal and plastic serve different purposes, including allowing passage of liquids in spray equipment and providing a baseline hole for inserting a tap to create screw threads. Something like the modern twist drill or auger has been around for about 5,000 years — plenty of time to develop a bewildering array of gauges/dimension systems in different industries and countries.

The history is murky, but it's likely that early in the Industrial Age, it was best to instruct a factory worker to use a No. 19 drill bit instead of specifying 4.22 millimeters or 0.1660 inch or 83/500 inch.

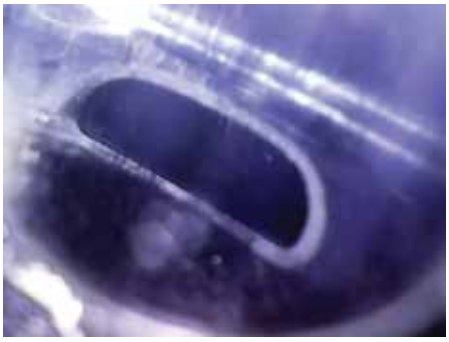
Visit gcmonline.com for two helpful tables clarifying many common wire and sheet gauge systems. One shows official U.S. dimensions for iron and steel sheet gauges; the second gives the millimeter equivalents of American and British gauges that are often referenced in English-language publications. There you'll also find two tables for drill bits.

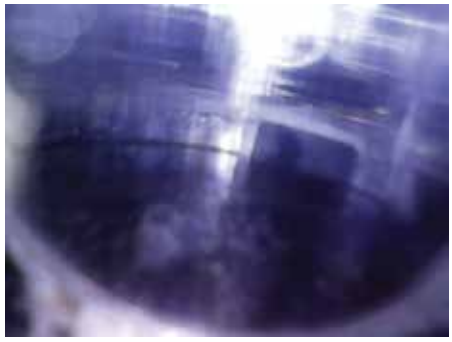
This article originally appeared in *GCM* Magazine, August 2018.



Left: An inexpensive borescope camera with light (lower right) takes an image of the dual-USB plug that connects it to a Samsung Android phone running the MScopesPro application. That app has simple icon buttons to record images at different resolutions. **Photos by Scott Nesbitt**

Above: This borescope fitted with periscope mirror connects to a wireless transmitter that shows up as the ZCF signal when mating with an Apple, Windows or Android phone, computer or other device.





Images from an inexpensive borescope of damaged walls inside a leaf blower's tiny cylinder weren't in sharp focus. However, they still proved useful in diagnosing the blower's issues without the need for a costly teardown or diagnostics.

Vision in hidden places

A borescope lets you see in tight, tiny places. For less than $25, it can save oodles of labor time. The tiny camera, with lights, is on the end of a cable and sends full-color still or video images to computers, smartphone or tablets.

While not perfect, the two inexpensive borescopes we tried were worth the modest cost and make it worth considering a more sophisticated (and costlier) unit. If searching Amazon, eBay or other websites (or stores), you may also find the device called endoscope, borecam or snake camera. Look for a borescope rated at 1080p resolution for more clarity than our older 720p units.

Our first borescope was a $10 unit with a 5 mm (about 0.2-inch) lens mounted on a 2-meter (78-inch) flexible cable with a clever dual USB plug that fits the port on a computer or smartphone. The second, a $20 unit, has an 8 mm (5/16-inch) lens on a 1-meter (39-inch) semirigid cable with a mini-USB plug that fits into a small Wi-Fi transmitter. Either one plugs directly into our Samsung J320 phone. The phone's battery powers the borescope. The Wi-Fi borescope's wireless images can be seen and recorded with the proper software on Windows, Android or Apple devices.

Both borescopes work well to find dropped items and components, like sensors or electronic controls that are often hidden in engine compartments or behind dashboards. Each came with a somewhat useful small hook and a small magnet that mount on the borescope's 1.5-inch solid camera/light end.

Each also came with a "periscope" mirror that aims at 90 degrees to the lens. Inserted with the mirror into the sparkplug hole of a hard-starting leaf blower, each borescope provided a fuzzy-but-discernible view of scuffed and scratched cylinder walls that led to scrapping the machine. That's a big saving over doing diagnostics or a teardown.

But the mirrors were low-quality and gave distorted images, and the borescope cameras' fixed lenses only have decent "focal length" between about 3 to 20 inches. To see inside a blower or chainsaw cylinder that's under 2 inches across, you need something like the Teslong Short Focus Endoscope ($220-plus).

To view and record the images, we tried several "apps" (software) for the Samsung phone. Our favorite was MScopesPro by Zyepro (under $5 for the no-ad version). This worked well when the borescopes were plugged directly into the phone. For the wireless system, WIFI VIEW 2.0.4 by Shenzhen wxl Technology (free, with no ads) did the trick.

Images stored on an Android phone can be transferred to a PC/Windows computer for viewing on a larger screen. First, click on the My Computer desktop icon to show the computer's drives. Using the charging cable, connect the phone to the computer's USB port. Hit F5 on the keyboard, and your phone should appear among the computer's drives. If not, you need a USB cable that carries data as well as charging current.

The images will be in the Movies or Pictures folder on the phone. Use the Search functions, or "drill down" to find the folders. On my system, the path is House PC\Scottcel\Phone\Pictures\MScopesPro. Copy (or drag) the images to a folder on your desktop, and you're all set.

You can also plug a borescope directly into a PC (with Windows 7, 8.1 or 10). Bring up Device Manager (in Control Panel or Settings). Plug in the USB Borescope, and it should be listed under Camera or Imaging Device. Click on that and install drivers. Then go to the programs and open the Camera program. The images have rather small file sizes that pixilate when enlarged but are good enough to see what's otherwise hidden.

This article originally appeared in *GCM* Magazine, October 2018..

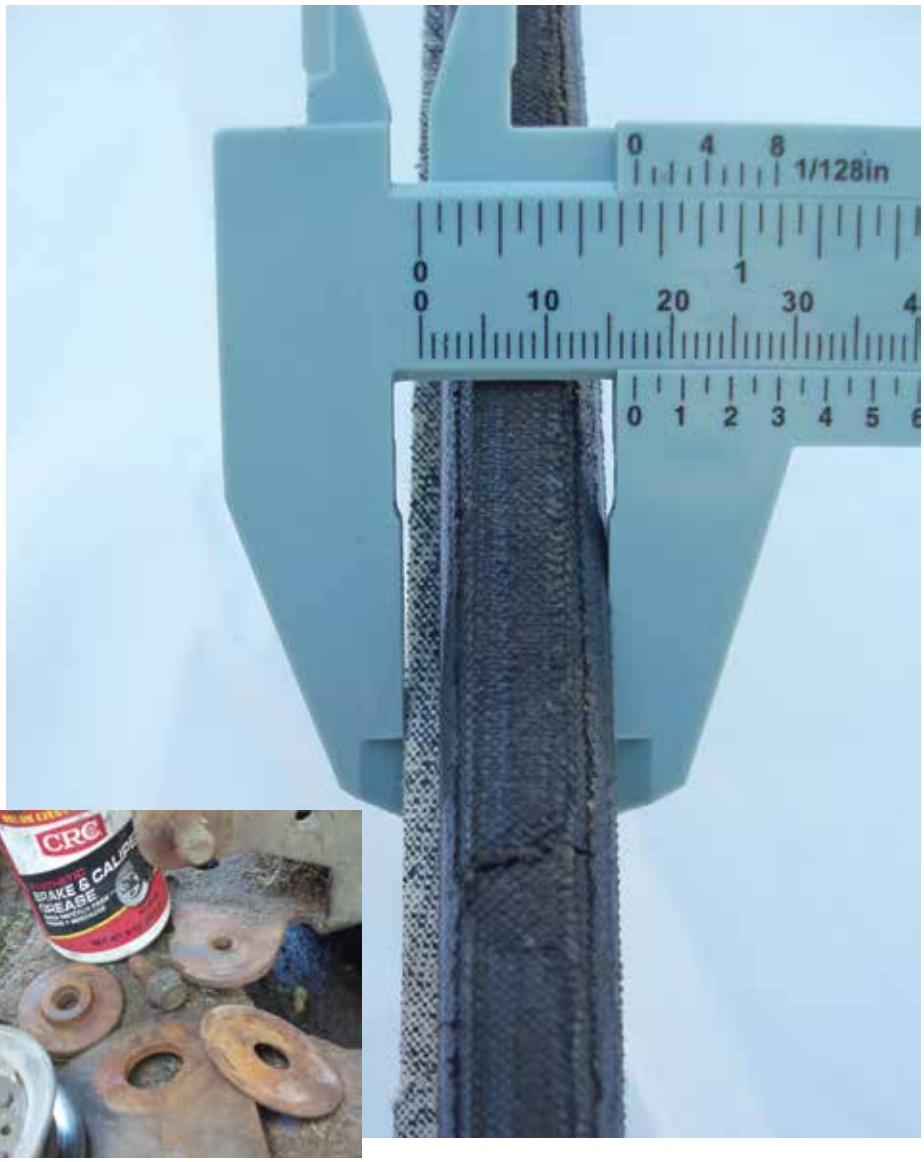
Frayed belt solution

The fabric covers on a new V-belt were being ripped off an hour after installation on a belly-mount rotary mower deck. The grass being mowed was extra tall because of abnormally heavy rains that delayed mowing … but this was ridiculous.

The new belt was from the original equipment maker, so we assumed it was good quality and properly built.

The operator had kept the ground speed low while mowing the tall, juicy grass. He didn't remember hitting anything solid that might have jammed the blades — just a lot of slow going through tall, damp grass.

The technician who installed the belt said he had left the mower deck mounted on the tractor to save time. The old belt had thinned and developed cracks and looked ready to break. He reported that he needed a lot of force to get the new belt installed around the blade pulleys, but more rain was threatening, and the mowing really needed to get done.



Matched with a new belt, the original belt (left) was developing cracks and had lost about 20 percent of its width. The fabric cover of a new mower deck drive belt (top right) started coming off after one hour of service.Synthetic grease was used to lubricate this idler arm pivot (bottom right) after cleaning off rust that had blocked the idler system's instant shock-protecting action. **Photos by Scott Nesbitt**

Rushing and shortcutting ended up costing more time and money. A second new belt was needed, along with a new idler pulley, since the bearings in the deck's idler pulley were growling. Chances are, the pulley would have locked or come apart in the near future, destroying yet another new belt.

As the rain came down, the mower deck was dismounted and analyzed.

The underside of the deck had accumulated considerable cut-grass clumping, but the blades could rotate freely. The quill assembly bearings didn't rumble when the blades were spun. When a shot of grease was injected, some excess immediately came out from the bearing chamber under the top drive pulleys, as is normal. This showed there was adequate grease in the bearings. The blades were not excessively dull and didn't show any nicks or bare-metal scrapes to indicate contact with rocks that might have jammed the blades.

The deck returned to normal function after we found corrosion had jammed the ability of the spring-loaded belt idler system to respond quickly to changes in load. The deck had been cleaned routinely with high-pressure water after mowing, which led to rust jamming the pivot of the idler pulley arm and contributed to an early death for the idler pulley's bearings and the purchase of a new idler.

We're not familiar with any turf equipment that provides for that pivot and idler pulley to be greased, yet the movement of that arm and smooth rotation of the pulley are critical to maintaining the ability of the spring-loaded idler system to respond instantly, protecting the belt from shock load damage.

After cleaning the rust off the idler arm pivot, we added shim washers to limit the up-down motion of the arm (to keep gunk out of the pivot) and lubricated with synthetic brake and caliper grease. While expensive, that grease seems to resist wash-off and to work well in dusty conditions.

Now we clean the deck, along with our other equipment, with high-pressure air instead of water. And after 140 hours of service, the idler system is still flexing and protecting the belt.

This article originally appeared in *GCM* Magazine, December 2018.

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– Ben Ellis, *Inside the Shop Episode 1: Diesel and Gas Mishaps*

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GCSAATV

Diesel smoke

Two large-bore radiator hoses, with a steel pipe inside to reinforce the joint, formed a new intake air hose and put this 1978 Satoh tractor back in full operation.

The inner liner of the air intake hose broke loose, partially blocking air to the engine and causing nasty clouds of black smoke and an inability to get above 1200 rpm. **Photos by Scott R. Nesbitt**

Two old diesel tractors recently lost a lot of power, and both sent smoke signals to let technicians know there were problems. Each problem was simply fixed, but each illustrated the need to remember the basic air-and-fuel simplicity of diesel engines and avoid over-complicated troubleshooting.

A 1978 Satoh Stallion S750 started blowing nasty black exhaust smoke and would not get above 1200 rpm. The tractor is an "orphan." Satoh of Japan started in 1914, was absorbed into Mitsubishi in 1980, and in October 2015 the company became Mitsubishi Mahindra Agricultural Machinery Co. Ltd. There's one U.S. Satoh parts distributor and no dealer network. But the 1.8-liter, 38-hp, three-cylinder Isuzu diesel engine had only 242 hours and ran great a month earlier pulling a 6-foot brush hog in foot-high damp grass.

Then a 1993 Kubota L2650 lost power, stumbled and stalled while brush-hogging. This tractor had under 700 hours and had always been reliable. The three-cylinder engine displaces 1.4 liters and puts out 29 horsepower.

The owners called tractor dealerships and repair shops, asking for suggestions. Both were told they might need new injection pumps or injectors, or cylinder head rebuilds. To be fair, the phone technicians couldn't see or hear either machine. It's often best to prepare a potential customer for the worst. But none of the phone contacts suggested what turned out to be simple solutions.

The Satoh's problem was lack of intake air. After 40 years, the cloth inner liner of a flex tube collapsed, partially blocking the path from the air cleaner to the intake manifold. A new intake tube was cobbled together.

The Kubota's problem was that the fuel filter had not been replaced for 25 years. A new filter cured the problem.

Diesel engines need only a lot of air and little fuel to produce power. The Satoh's 1.8-liter engine draws in 0.9 liter of air for every full revolution (one intake stroke, one exhaust stroke). At 1000 rpm, it needs 900 liters of air every minute. That's about 240 gallons every minute, or 4 gallons every second. The partial blockage limited the air supply. The black smoke was unburned fuel.

A diesel's fuel supply is regulated by a governor in the injection pump. Push the throttle to accelerate, and you stretch a spring connected to a valve called the fuel rail. The cylinders get an excess dose of fuel, which increases power and engine speed. Higher speed increases the force produced by a set of spinning weights in the fuel pump. This force pushes against the spring and moves the fuel rail to cut back fuel flow. Until the spring and weights strike a balance, excess unburned fuel shows up as black particles in the exhaust.

The Kubota's owner had noticed the tractor's exhaust was cleaner than normal. The fuel filter was replaced, the engine again puffed a little black smoke when accelerating, and power was back to normal. Both old tractors finished early-winter weed cleaning and seemed ready for spring.

Visit gcmonline.com for two handy trouble-shooting guides for old diesels and newer emission-controlled engines to help sort out the possible causes of black smoke and other challenges signaled by the engine exhaust and other operating problems.

This article originally appeared in *GCM* Magazine, February 2019.

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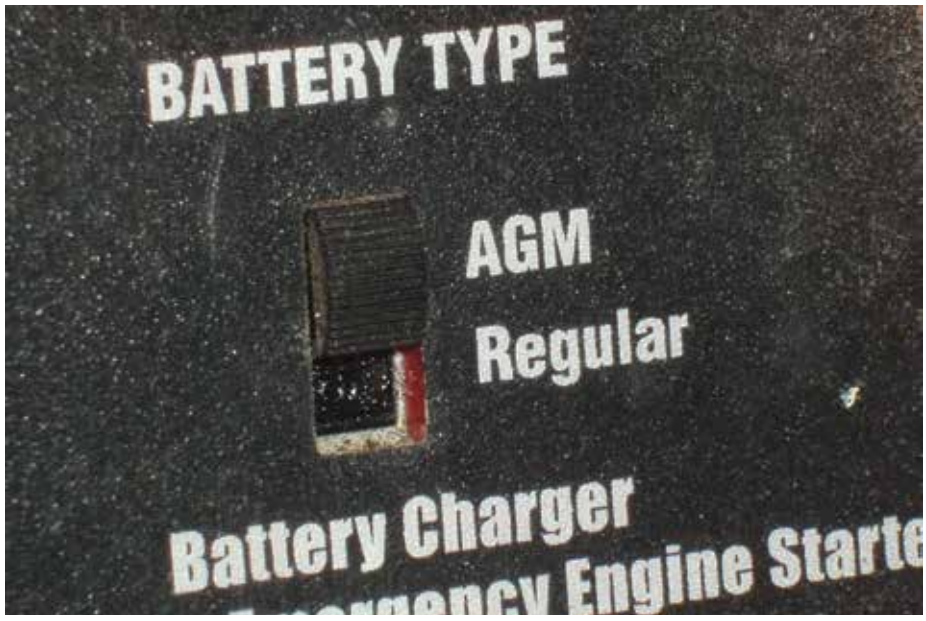
AGM: Better batteries



Flipping the switch to the AGM position is one of the few extra duties imposed by adopting absorbent glass mat batteries for the course maintenance fleet. **Photos by Scott Nesbitt**

It's worth considering installing absorbent glass mat batteries in the equipment fleet. The switch will add cost but could save money by reducing downtime for equipment and staff.

Compared to conventional "flooded cell" batteries, AGM batteries are much less likely to break down from vibration. They were first developed in the 1980s for airplanes and have become the first choice for watercraft and motorcycles.

AGMs use the same lead-acid chemistry that has been around for 150 years. The big difference is that the acid is held in a mat made of ultra-fine glass fibers positioned around and between the opposing (positive and negative) lead plates. This reinforces the lead plates and eliminates the need for liquid acid in the battery case.

This structural change boosts electrochemical efficiency. An AGM can be a little smaller and lighter than an equal-power conventional flooded-cell battery. No acid leaks if the AGM case is broken, and the sealed battery can be installed in any position, even upside down. You can't check the liquid level in the battery and don't need to because virtually no fumes leave the battery. Corrosion at the battery terminals is rare, reducing that common battery problem.

Experience confirms that AGMs hold a charge longer in cold weather and produce more starting power when cold. They are no worse in tolerating hot weather, and some newer AGMs are specifically designed to survive extreme heat from weather and machinery.

You will pay about 10 percent more for an AGM battery that's in the size range used in cars and light trucks. Bigger batteries for large tractors carry a premium up to 50 percent or more, as do AGM batteries in the U1 size used on riding mowers. Prices should come down as the AGM design becomes more necessary in highly electronified cars and trucks and the flooded cell becomes obsolete.

The gray and brown lead plates are separated and supported by the yellow and white glass fiber mats that are saturated with sulfuric acid in the two separate cells of this 4-volt AGM battery. **Source: https://commons.wikimedia.org/wiki/File:Opened_AGM_battery.jpg**

Of two batteries with equal power ratings, the AGM battery on the left is slightly smaller and lighter than the flooded-cell unit on the right.

AGM batteries are a "drop in" replacement, compatible with virtually all alternators that recharge batteries in vehicles and equipment, since alternator regulators send a relatively low-amperage charge to refill a battery after the vehicle starts. During the charging process, lead-acid batteries produce small gas bubbles that simply rise up in a liquid cell but travel more slowly through the glass fiber mat.

As a result, AGM batteries can be ruined if connected to a high-amperage booster with enough power to crank a large engine. It is OK to briefly jump-start an AGM off another battery, but in most cases recharging should be done with a battery charger that has an AGM setting that provides low-and-slow current controlled by a regulating circuit.

If you are considering switching to AGM as batteries need replacing, check the vast pool of info at https://batteryuniversity.com. It's a remarkable site full of noncommercial knowledge about all types of batteries, from the old lead-acid to the batteries in cell phone, cordless tools and electric vehicles — and even answers to, "Why does Pokémon Go rob so much battery power?"

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Service shop spray lubricants made from vegetable oils work as well as those based on petroleum in many applications, but the plant-based products are often hard to find or are no longer being made because of low demand and higher prices. **Photo by Scott Nesbitt**

Orphan oils

As environmental stewards, golf course personnel should favor use of vegetable-based oil, grease and other lubricants for the machinery that keeps the courses green.

Bio-lubes (for want of a better name) have been around for millennia, having served to keep machine parts sliding and spinning long before the world's first modern oil well was drilled in Russia in 1846. Within a few decades, petroleum from beneath the ground became the primary source of lubrication and energy on the planet, producing the industrialized world we now inhabit.

But petroleum has many negative and persistent chemical components that do harm to green growing things like bentgrass, fescue, bermudagrass and all the rest of the playing surfaces and living decorations treasured by golfers.

Vegetable-based oil is good for cooking and eating, and it works nicely to lubricate many elements of machinery. It easily biodegrades when released into the environment, causing little if any harm to plants and animals.

Inedible vegetable oils (IVOs) provide the base for hydraulic fluids and chainsaw bar oils that are widely available and widely used. Whale oil, until it was banned by the 1973 Endangered Species Act, was a key ingredient in transmission gear lubricants and was even used to make margarine.

Unwittingly, I've used IVO lubricants for many years, in the form of UltraLube general-purpose chassis grease and that brand of spray penetrating oil and chain lubricant. Recently, my favorite surplus store had $1.99 price tags on Simply Soy spray lube and Bolt Off penetrating oil. All those products work well, and spray oils are particularly good at leaving a rust-resisting oxidized coating that's often desirable. But it's a 60-mile round trip to the nearest store that regularly carries UltraLube. The website listed on Simply Soy products is now up for sale, and the parent company has apparently dissolved, leaving the products mostly in liquidation and surplus sources.

Current ample supplies of petroleum and natural gas limit IVO to less than 10% of the world's current industrial lubricant market, because it takes a bit of processing to turn soybeans into products for the service shop, driving up prices and reducing demand. Yet two world wars were fought with a lot of vegetable-based lubricants as nations fought over petroleum sources, among other things.

For the golf course service shop manager who cares to avoid damage to nature where possible, there are IVO-based products available online, particularly from Europe, where governmental pressure encourages reduction of petroleum in favor of renewable resources. Costs may be double or triple, but there are benefits. Trimming trees with IVO bar oil reduces chances of leaving harmful residue on the living tree or introducing traces of petroleum fumes to fires using the harvested wood. Turf is less likely to suffer and die from lubricants that drip when a machine is serviced in the field.

Employees and players on the course might also appreciate the extra effort to preserve petroleum supplies and reduce human exposure to various chemicals known to the state of California to cause cancer, as many shop lubricant labels proclaim.

As with many elements in life, "You pay your money and take your choice."

A more in-depth look at vegetable lubricants can be found at: www.machinerylubrication.com/Read/240/biodegradable-biobased-lubricants.

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I hereby submit my application for membership in the Golf Course Superintendents Association of America and payment of my dues for one year in advance. It is estimated that 6% of my membership dues will be used for advocating positions on government issues, as well as for payment of term life insurance dues for all members, excluding student, affiliate company, facility, friend and any non-U.S. citizens. This estimated portion of the membership dues payment is therefore not tax deductible as a business expense. I have read and agree to abide by the GCSAA Code of Ethics (visit www.gcsaa.org/about-gcsaa/governance/member-code-of-ethics).

Signature: _____ Date: _____

Top: Hardware to make a vacuum tank includes a metal tire valve stem, a ball valve, a lock-on air chuck and a cut-down sprayer tank pump assembly filled with silicone caulk. Use various tubes and fittings to tie it all together. Tools used include a "pine tree" drill bit with the ⅝-inch size marked and the wire puller to feed the valve stem into position **Photos by Scott Nesbitt**

Bottom: The last dregs of water-logged transmission oil were pulled out of a tractor using a vacuum pump, an old one-gallon hand-sprayer tank and some simple hardware.

Handy fluid vacuum

An old hand sprayer was converted into an effective vacuum tank that simplifies and speeds up all manner of fluid-handling jobs in the service shop.

The largest cost was about $100 for a vacuum pump as used for auto air conditioning work. You may spend a bit more if you buy a new garden sprayer and don't have a supply of various valves and tubes.

We vacuumed the 90W oil from the front and rear differentials of a four-wheel-drive pickup truck that had its axles under water during flood recovery work. That took about 60 minutes using the tank. The alternative was spending two-plus hours removing the differential cover plates, catching the nasty oil, sopping up the remnants with rags and bolting the covers back on. We didn't have to spend $40 for new gaskets.

Water-logged transmission oil was drained from a tractor, then the last dregs were pulled out using the vacuum pump, tank and tubing that included a ⅛-inch-inside-diameter tube that fit down the dipstick hole.

The red hose (¼-inch air line) is 12 feet long, so the pump and possible electrical sparks stay far away when vacuuming gasoline and other flammables.

To make a tank, cut everything except the cap and threads off a garden sprayer's pump assembly. Fill the bottom and/or top cavities with silicone caulk. Let it cure for a few days. Make sure the rubber seal gasket is in good shape. Get a metal tire valve stem and drill a hole (usually ⅝ inch, or 16 mm) near the top of the tank. Use a soft wire or valve stem chaser to pull the tire valve into position and tighten securely.

Keep the original tube that runs inside the tank from the spray wand outlet. The farther that tube's outlet from the tire valve, the less likely you'll draw waste liquid into the pump.

You may want to keep the spray wand's on/off control. Or spend some tinker time fitting vinyl tubing, shutoff valves or whatever to suit your preferences and resources.

We used ¼-inch air hose from the pump to an air chuck that locks onto the tank's tire valve.

Drain and replace the pump's oil frequently to avoid damage from contaminants. The vacuum pump can be disconnected after about five minutes, and the tank will hold enough vacuum to draw out a few quarts of fluids.

We first made a one-gallon tank used for clean work, like reverse-bleeding hydraulic brake systems by pressurizing the tank. The photo shows the parts used to make a two-gallon vacuum tank to be used for dirty fluids that will be discarded, like old engine oil.

The tanks can be emptied by unscrewing the tank top, or fluid can be discharged by pressurizing the tank through the valve stem, like inflating a tire.

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