

# CONVERTING DIVE TANKS FOR OXYGEN SERVICE WITH GMC OXY-SAFE PRODUCTS © 2002

By  
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*Second Edition / January, 2002*

## OVERVIEW

This manual describes procedures for converting common scuba air tanks for pure oxygen and / or specialty gas service using Global's Oxy-Safe Products. Presently within the TEK-diving community, many questionable, unresearched, and highly variable methods are being used for oxygen cleaning; some of these techniques are based largely on hearsay and are so poorly documented that they might not withstand legal scrutiny in the aftermath of an accident. Most of the chemicals being marketed for this purpose are sold entirely without specific instructions applicable to scuba cylinders. Thus, GMC has written this expanded manual to not only insure the safe and proper use of our oxy-cleaning products, but also to provide some general information on the overall subject of tank conversions.

**The following procedures should give consistently satisfactory results if carried out as explained. However, GMC cannot promise reliable results if users undertake significant variations in the described techniques and / or substitute other chemicals or alter the suggested concentrations.**

If you are a novice to tank cleaning in general, doing oxygen preparations is a bad place to start to or to experiment. GMC strongly recommends that in addition to following these procedures, you seek advice and training from an experienced scuba technician or technical diving training agency. We further suggest that you read the GMC Bulletin "Tank Tumbling Tips" (GMC #42130), hereafter referred to as "Tips", to acquaint yourself with general tumbling / cleaning materials and methods. Also, Luxfer's manual, "Guide to Scuba Cylinder Inspection", is a fine reference on aluminum tank maintenance.

As you will note, the methods described in this manual require a certain amount of basic equipment; without it, the procedures become very labor intensive and subject to considerable variation. For example, a tank containing a specific cleaning medium rotated on a tumbler at 25 rpm for 1 hour will give reasonably consistent results tank after tank. When done by hand-rolling and by different individuals, the procedure can give highly random results! Although these new cleaning techniques are simple and similar to those used in the dive industry for many years, certain protocols must still be followed if suitably clean cylinders are to be obtained on a routine basis.

You will be undertaking procedures that are relatively "Big League" when compared to those employed for normal breathing air. They require an elevated degree of cleanliness, operational care, and special equipment. To attempt to shortcut these requirements is flirting with disaster for you, your shop, and your customer. If you are unable or unwilling to invest in the time and equipment to carry out these procedures properly and safely, you have NO business in the mixed gas arena! Oxygen mishaps are deadly and can be sustained by even experienced experts...consider NASA's Apollo 13 or the Valujet crash in the Everglades.

**GETTING STARTED:** First, you must assume that the cylinder being cleaned may at some time contain 100% oxygen at high pressure. Once it has been cleaned, unless the cylinder belongs to your shop, you have no control over its future use. Applications could range from holding simple Nitrox I (32% oxygen) to being fully pressurized with pure O<sub>2</sub> for an in-water decom bottle! Therefore, any idea of a "fairly clean" cylinder should not be tolerated; immaculate cleanliness is required in all cases!

Next, you must determine the suitability of each cylinder for elevated oxygen service. Just as you have been required to make judgment calls on the serviceability of air tanks, you must now do the same for oxygen vessels. However, here the requirement for cleanliness is far more stringent and the tolerance for error is narrower. In our quick-to-sue society, customers will readily blame the scuba shop for any dive equipment mishaps that they perceive as hi-tech service mistakes! Being conservative with your judgments would seem to make good sense!

**TANK SELECTION:** Converting brand-new or sparsely used air tanks for O<sub>2</sub> service presents relatively few problems. However, divers often resist the idea of dedicating new tanks to singular gas use; thus dive shops will often be asked to resurrect older "salvaged" dive tanks for such purposes. Subsequently, scuba technicians must make judgment calls regarding the suitability of such cylinders for the intended use. Situations will occur where what the customer thinks or wants may be diametrically opposed to what is safe and prudent.

In that regard, one should reject older, STEEL cylinders that contain ANY internal lining. During the late 60's and 70's, various paints, epoxies, and plastics were used to coat the inside of tanks as anti-rust barriers. These internal linings often evolved cracks and pits in which contaminants could develop or collect. Impurities hidden beneath such linings resist removal, creating a potentially dangerous situation when pure O<sub>2</sub> is introduced! Remember that under certain conditions, pressurized pure oxygen can react violently and spontaneously with many substances, especially hydrocarbons. Materials of unknown nature trapped under tank linings offer a potentially dangerous situation that should NOT be tested. Moreover, the oxygen-compatibility of the linings themselves, or lack thereof, is completely unknown and unresearched. It is very probable that these materials would burn vigorously in an oxygen environment. Because of such intrinsic hazards, coupled with the fact that linings are nearly impossible to remove by normal, safe methods, lined steel tanks should be rejected for mixed gas service.

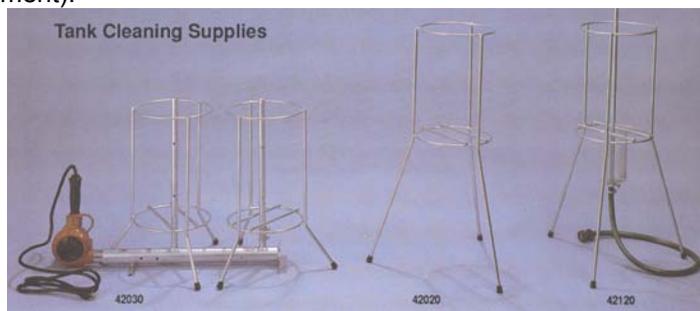
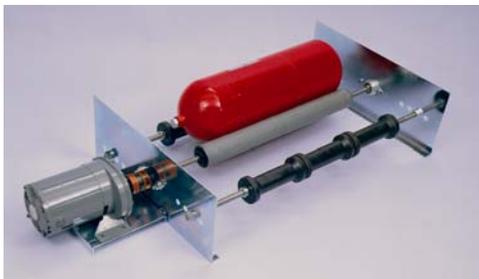
Also regarding steel cylinders, the Compressed Gas Association (CGA) recommends special handling and filling procedures for steel tanks containing pure oxygen that may be immersed in salt water. If even small amounts of salty water get into such vessels, corrosion is so rapidly accelerated by the O<sub>2</sub> that explosive failure may occur within 60 days! For details, see CGA Special Bulletin SB-7, "Rupture of Oxygen Cylinders in the Dive Industry."

**SPECIAL NOTE:** GMC IS OF THE OPINION THAT ANY CYLINDER THAT REQUIRES EXTRAORDINARY CLEANING PROCEDURES SHOULD BE REJECTED FOR USE WITH OXYGEN OR HIGH O<sub>2</sub> MIXTURES. Whenever heroic measures must be used to restore a cylinder, the possibility of resistant or residual contaminants presents an unacceptable risk for O<sub>2</sub> usage.

Having ascertained that a given tank is suitable for elevated oxygen applications, you must next determine what degree of cleaning is required. Obviously, a new aluminum tank does not require the same amount of preparation, as does a 20-year old, rusty, steel vessel. In the case of new aluminum tanks, a TUMBLING WASH (degreasing) is generally all that's needed. On the other hand, the corroded old steel tank will certainly require a standard tumble (PRETREATMENT), followed by a degreasing wash, plus an anti-rust treatment to halt flash rusting during the drying operation.

**GMC OXY-SAFE CHEMICALS AND SPECIAL EQUIPMENT:** As already stated, the cleaning procedures to be described require certain special equipment and chemicals. These materials must be oxygen-compatible in nature, i.e. under a specified set of conditions; pure oxygen will not violently react with them. As you will note, these conversion procedures go to great lengths to remove all residues of the cleaning agents after their function has been completed. Nevertheless, should a trace remain and go undetected, one would want that substance to be oxygen-compatible rather than oxygen-reactive!

**SUGGESTED EQUIPMENT:** These oxy-cleaning procedures were designed for the dive shop that already has a modern tank-servicing department including a tank tumbler and related equipment. While the described methods can be used without ALL the suggested equipment, the task then becomes more labor-intensive, time-consuming, and possibly error-prone. The following items or their equivalent should be available: Tank Tumbler (GMC #42000); Tank Draining Stand (GMC #42020); Tank Washer (GMC #42120); dedicated tumbling media. (For a more complete selection, see the list of suggested materials at the end of this document).



GMC's chemicals and equipment have had a long precedent of use in the metal sheening industry where cleaning and preparing of oxygen vessels is commonplace. Adapting them for scuba tank conversions is a fairly straightforward task as long as the methods / equipment are employed as described.

**NEW SPECIAL CLEANER #42100:** This bluish fluid is a powerful alkaline degreaser that is non-toxic, biodegradable, and largely odor-free. It has excellent rinsibility and no flash point. Special Cleaner has several uses during tank cleaning operations: During tumbling of regular air tanks, it is often used as an adjunct to suspend the dirt and debris which are

removed from the cylinder's surface. As a powerful degreaser and hydrocarbon solvent, it's an excellent choice to prepare tanks for oxygen service. (This BLUE fluid replaces our former GREEN Special Cleaner which was discontinued by its manufacturer in 2001.)

**OXY-SAFE CITRATE TANK CLEANER (GMC #42075):** This new cleaner is a mild organic (citric) acid which, when used in diluted form, is suitable for preparing cylinders for oxygen service and is safe for all metals. It replaces the laborious and sometimes tricky trisodium phosphate (TSP) scrubs with a reasonably simple washing / tumbling procedure. Various older oxy-cleaning methods required the use of heated TSP solutions that tended to leave unwanted precipitates upon cooling. Other cleaning solvents such as the trichlor degreasers are too toxic to be used in dive tanks and also have a propensity for ionic bonding within the cylinder walls; in fact, the EPA has banned many of these chemicals for general use.

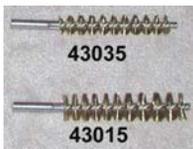
**SPECIAL NOTE:** Citrate cleaner is a thick, green, concentrated liquid that is diluted with water for use. However, liquid citrates are susceptible to mold growth; several species of Penicillium can grow in them, but only at the very surface. These are the same harmless green molds that grow on old oranges or grapefruits, and they form a thick, pasty surface film on the concentrated citrate. They do not harm the chemical nor will any mold particles in the cleaning solution pose any danger to the dive tank or its user. This mold pellicle can be poured off or prevented entirely by refrigerating the concentrate. Diluted solutions do not need refrigeration.

**OXY-SAFE RUST INHIBITOR (COMPOUND 0) #42220:** This liquid is a water-soluble, biodegradable, non-toxic, oil-free, non-hazardous, rust-inhibiting concentrate of diethanolamine used for the prevention of flash rust in STEEL dive tanks. It mixes readily with hot or cold water to produce a transparent yellow solution. Compound 0 replaces Compound B (sodium nitrate) which IS NOT OXYGEN-COMPATIBLE and should NOT be used for preparing tanks for elevated O<sub>2</sub> mixtures because it contains an oil-based dispersal agent. On the other hand, Compound 0 can be used on BOTH air and oxygen cylinders.

**SPECIAL NOTES:** Flash rust is a reddish, corrosive deposit that occurs in cleaned STEEL tanks due to improper drying techniques. If you are unfamiliar with the potential problems caused by flash rust, GMC suggests that you consult our bulletin "Tank Cleaning & Tumbling Tips" (GMC #42130). Without this information, you will surely encounter troubles that you might otherwise avoid when cleaning steel tanks for O<sub>2</sub> service. The topic is also covered in Section C of this bulletin.

Compound 0 should be used only to prevent flash rust in wet STEEL tanks prior to drying. Its rust-inhibiting effects are only transitory and dissipate within a few hours at best. These chemicals CANNOT be used as long-term rust preventives! Obviously, no reason exists to use rust inhibitors in aluminum tanks.

**THREAD CLEANING BRUSHES:** When converting tanks for O<sub>2</sub> service, the valve must also be cleaned and rendered oxy-compatible. The procedure is discussed later in Section E. In addition, the cylinder neck threads must be thoroughly scrubbed and freed of all dirt, oxidation residues, and former lubricants. GMC offers a number of special brass and stainless brushes to simplify the task of cleaning internal neck threads. Brass is the preferred metal for such tools because any brass particles, that might accidentally remain after scrubbing and rinsing are very difficult to ignite in high oxygen atmospheres, whereas plastic or steel fragments are not. Stainless bristles are also suitable, but are less ignition-resistant than brass.



GMC brushes offered for this purpose are: Brass brush #43015 is for common tanks with large apertures, whereas #43035 is for small-necked models (hi-pressure steel and old 1/2"-NGT thread types). These brushes can be operated by hand or with an electric drill. #43025 is another drill brush especially suited for cleaning the O-ring groove in large-necked cylinders.

### **CRITIQUE OF TANK OXY-CLEANING PROCEDURES**

The following is an expanded outline of the operations involved in cleaning and converting scuba tanks for oxygen and specialty gas service. The chemicals and equipment required are fully explained. Differences between the handling of steel and aluminum cylinders are also denoted. A simplified key to the techniques is also available for quick reference.

**The process begins by inspecting the cylinder for general cleanliness and absence of contaminants. Based on this inspection, rank the cylinder as CATEGORY I or CATAGORY II, and proceed accordingly as described.**

**CATEGORY I:** In ALL cases the tank appears visually clean and free of rust and other notable contaminants, AND (A) the tank is new and unused, but its state of O<sub>2</sub>-cleanliness is unknown, OR (B) the tank has had brief use with regular compressed air, OR (C) it has been in O<sub>2</sub> / Nitrox service for some time, but now needs re-cleaning.  
**ACTION NEEDED:** ONLY A TUMBLING WASH IS REQUIRED.

**OVERVIEW OF THE TUMBLING WASH:** This simple procedure consists of a short tumble with media (glass beads) augmented by an oxygen-compatible degreaser. Media is required because it is well established that certain contaminants can form ionic bonds to the tank's inner surface, i.e. they invade the metallic pore structure. Others can electrostatically cling to the vessel walls. Examples of this are the persistent odors that often develop in dive tanks during prolonged storage and are so difficult to remove. However, agitation of the tank wall by media during tumbling destroys this bonding so that the solvent can dislodge the contaminants. Some shops are presently preparing O<sub>2</sub> cylinders by simple washing only, i.e. without wall agitation; it is questionable whether this always yields a truly clean product.

The medium of choice for Tumbling Washes is 4-5 mm spherical glass beads (GMC #42045). Aluminum oxide or ceramic media ("chips") are less desirable for this purpose because they tend to deposit residual grit during tumbling. They also react with many cleaning agents to produce excessive gas and foam. Glass beads deposit little or no grit, and do not react with adjunct solvents. Beads are not very abrasive and will not harm the protective internal finish (Irridite/Alrock) of aluminum vessels. Because glass has minimal porosity, beads do not tend to pick up residual surface contaminants; nevertheless, they should be washed with detergent and hot water after use to insure their continued cleanliness.

**UNDER NO CIRCUMSTANCES SHOULD MEDIA BE INTERCHANGEABLY EMPLOYED FOR CLEANING AIR AND OXYGEN CYLINDERS.** Using the same media for BOTH air and O<sub>2</sub> tanks presents and unacceptable risk for cross-contamination derived from especially filthy air tanks. MEDIA USED FOR O<sub>2</sub> CLEANING MUST BE DEDICATED TO THAT PURPOSE ONLY!

Various solvents can be used for Tumbling Washes: Diluted GMC Special Cleaner (#42100), Crystal Simple Green, Blue/Gold, 409 Cleaner, Alconox, SD-13, just to list a few. These chemicals are all powerful degreasers with virtually no flash point, no toxicity, and high rinsibility. Their only disadvantage is the pungent odor exhibited by several of them.

A Tumbling Wash usually requires about 5-10 minutes on a tank tumbler at 25-50 rpm. The rotational speed of a tank depends on its diameter. Smaller cylinders like pony bottles will turn faster than will full-size models. As long as the number of rotations are reasonably within the suggested range, satisfactory cleaning will occur. (The process can also be accomplished by hand rolling, but this is very laborious and may NOT always yield reliable or consistent results). Lastly, the cylinder must be drained of media and solvent, rinsed until it's free of ALL residues, and then properly dried.

**ONCE A TUMBLING WASH IS BEGUN, THE PROCEDURE SHOULD BE CARRIED TO COMPLETION AS SOON AS POSSIBLE! DO NOT STALL THE TUMBLING PROCESS OR ALLOW THE VESSEL TO REMAIN WET OR UNRINSED FOR ANY EXTENDED TIME. IN SHORT, ONCE CLEANING OPERATIONS HAVE BEGUN, CARRY THEM PROMPTLY THROUGH TO CONCLUSION WITHOUT INTERRUPTION.**

### **SECTION A: PERFORMING A TUMBLING WASH**

**SPECIAL NOTE:** Many stages of the Tumbling Wash (and Pretreating Tumble) are a very messy business and are best carried out over a floor drain, in a large sink, or special "catch basin" designed for that purpose. Prior planning with the proper work area / equipment will greatly simplify these inherently dirty and laborious jobs.

1. **Place Media in the Tank:** Add 8-10 pounds (3.5 kg - 4.5 kg) of glass beads (GMC #42045) to the tank using a large funnel to prevent spillage. (This quantity of beads is based on a 72-80 cu. ft. tank and can be adjusted for larger / smaller volume cylinders.)
2. **Prepare & Add Washing Solution:** Prepare a washing solution by diluting GMC Special Cleaner (#42100): 1 oz. solvent per gal. of water (10 ml per liter). If other degreasers are used, follow the dilution recommendations of the manufacturer. Pour about 2 quarts (2 liters) of the washing solution into the tank and plug the neck to prevent loss of liquid during the tumble. (See "Tips" / GMC #42130 for information on commercially available tank plugs.)
3. **Tumble the Cylinder:** Place the cylinder on a tumbler for about 10 minutes at 25-50 rpm.

4. **Remove the Tumbling Media:** Remove the tank from the tumbler and drain the beads and liquid into a catch pan. This operation can be problematic because the media often jams in the neck aperture and obstructs drainage. Tanks with small necks can be especially troublesome in this regard. A handy trick to overcome such situations involves the injection of low-pressure compressed air into the tank. The gas slightly pressurizes the area behind the beads, causing them and the liquid to be rapidly expelled from the cylinder. GMC's Tank Purge Air Gun (GMC #42225) is just the tool to perform this task. Snap this air gun onto any pressurized BC hose, place the curved tube nozzle into the neck of the tank that is inverted in a GMC Tank Draining Stand (GMC #42020) and inject a steady burst of air to expel the media. The pressure created will quickly jet the liquid and media into a catch basin placed under the stand.
5. **Inspect the Cleaning Solution:** Examine the cleaning solution removed from the tank; if it's notably dirty or discolored, hidden contaminants may be present in the cylinder. In such instances, a PRETREATING TUMBLE should be performed (See CATEGORY II). If the liquid appears reasonably clean, proceed to Step 5.
6. **Clean the Cylinder Neck Threads:** At this stage in the cleaning procedure, it is often convenient to thoroughly scrub the tank neck threads to rid them of ALL CONTAMINANTS. As the vessel is now upside down in the Tank Draining Stand (GMC #42020), vigorous scrubbing of the neck threads is convenient and easy to do. Using the previously described brushes, thoroughly clean the threads to remove all debris, oxidation products, and grease. Some fresh tumbling solution (at greater strength if desired) can be used as a detergent. As scrubbing continues, the progress can be evaluated by rinsing the threads with clean water from a "squirt bottle". Any remaining residue / detergent will be purged in the rinsing step that immediately follows.
7. **Rinse the Cylinder:** Rinse the cylinder thoroughly: This is best done by inverting it in a Tank Draining Stand (GMC #42020) and flushing the interior with a small hose. A GMC Tank Washer (#42120) also makes short work of this messy task. Flush the tank for 2 cycles of 2 minutes each...stop between cycles long enough for all water to drain out of the tank; then resume washing for another 2 minutes. This pause will allow any residual degreaser foam that is "floating" on the surface of the rinse water to settle into the neck area and thus be flushed by the final wash cycle. Cold or tepid water is preferred for rinsing STEEL tanks because hot liquid may induce flashing of the polished metallic interior.
8. **Perform a WASH (SHAKE) Test:** After this last rinse, perform a WASH (SHAKE) Test as described in SECTION B. Additional tests can be applied as desired.
9. **Perform a Rust Inhibitor Treatment on STEEL Tanks:** Once washed, STEEL cylinders will require a treatment with Oxy-Safe Rust Inhibitor / Compound 0 (GMC #42220) prior to drying; without it, flash rust will frequently form during drying (See SECTION C: PREVENTING FLASH RUST.)
10. **Dry the cylinder:** PROMPTLY dry the cylinder with a compressed air jet or using GMC's Tank Dryer System (GMC #42030). (See SECTION D: DRYING TANKS.)

## **SECTION B: POST- CLEANING TESTS**

**TESTING THE FINAL PRODUCT:** After cleaning regular scuba AIR cylinders, a VIP is usually considered to be a sufficient final test. Not so for oxygen cleaning. In addition to a VIP, some proof of the oxy-clean status of the completed tank should be obtained and recorded. There are a number of recognized simple tests available for this purpose, and the prudent dive shop will employ one or more of them and record the tank serial numbers to which they were applied. Some of these procedures are indirect in nature because direct tests for hydrocarbons are limited in scope or are too lengthy, complex, and expensive for routine dive shop use. Various procedures are described below.

### **WASH (SHAKE) TEST**

**OVERVIEW:** Years ago, conventional wisdom said that tanks intended for O<sub>2</sub> service should be inspected for hydrocarbon contamination with ultraviolet (UV) light. So-called Blacklight, the longest wavelengths of the UV spectrum, cause many hydrocarbon residues to glow. Unfortunately, two of the most likely dive tank contaminants, silicone grease and synthetic compressor oil residues DO NOT GLOW under Blacklight. Thus most agencies have abandoned UV inspection of dive tanks as an ineffective exercise that does not justify the high cost of VIP Blacklights. However, small blacklights suspended over your work area can be useful for determining the cleanliness of valve and regulator parts that are not "closed containers" like scuba tanks.

In lieu of blacklight testing, certain indirect qualitative analyses such as SHAKE Tests are often employed. The theory of a SHAKE Test is simple: If the cleaning procedures have been carried out correctly, all hydrocarbon contaminants are now dissolved in the degreaser solvent. Thus if any of the degreaser was to remain within the tank, the dissolved hydrocarbon material would also remain. Conversely, if the solvent is totally purged from the tank, the hydrocarbons are likewise removed. Therefore, once thorough rinsing has been completed, if we can test for any remaining degreaser, we would also be indirectly testing for the presence of residual hydrocarbons. Fortunately, most alkaline degreasers produce copious bubbles or foam when agitated; this is true even when only micro-amounts are present. It is this foaming property that allows us to easily test for minute amounts of degreaser solvent.

Conduct the test as follows:

1. When the final rinse water flowing from the cylinder appears to be clean, clear, and free of foam, collect a small sample in a clear test tube or similar glass container. Plug the tube and shake it vigorously; let it stand a few seconds. If detergent is no longer present, any bubbles which form will "pop" or quickly dissipate. Rinse water containing even tiny traces of degreaser will readily produce foam or a bubble ring that will last for several minutes and usually much longer. For a reference control, the test sample can be compared to a second shake tube containing only pure rinse water.
2. If the test is negative (no persistent bubbles), proceed to dry the tank. If the test is positive (persistent bubbles or a foam ring), continue rinsing the cylinder until a satisfactory test is obtained.

## pH TEST

**OVERVIEW:** Another effective indirect test involves the pH of the rinse water, that is, it's relative acidity or alkalinity. As previously explained, our objective is to confirm that all the degreaser solvent has been removed from the tank. Another chemical property of many degreasers is their strong alkaline nature. At full strength, some of these cleaners possess a pH of 13.0 in a system where 14 is full scale! Therefore, even a tiny amount of degreaser left in the rinse water will significantly shift the pH of water upward in the alkaline range. If we first establish a control by determining the normal pH of our water, any upward shift from that point means degreaser must be present in our rinse water. When the pH of our rinse water returns to its normal (control) level, all the degreaser should be gone.



It's easy to do with so-called "pH Paper" (GMC #42235). These inexpensive papers can be purchased at swimming pool, school, or medical supply stores. They are strips of parchment treated with pH-sensitive dyes that turn specific colors at specific pH values and can detect shifts of as little as 0.1 unit. With them, one merely tests by color the pH of the rinse water from the tank until it exactly matches the color produced by pure, control water.

A warning about "control" water: Depending on its source and your geographic location, your local water is likely to have a pH other than neutral (pH 7.0). In fact, tap water can easily vary from pH 6.7 to 7.4 or more. This is not crucial other than to know what is NORMAL for your local water because this is your REFERENCE or CONTROL STANDARD. Therefore, you should test your pure rinse water EVERY TIME you do this test.

The test is conducted as follows:

1. Test the pure rinse (control) water and determine its pH by color comparison to the chart provided with the test paper.
2. If you wish, test a sample of the rinse water taken from the tank just as rinsing commences. You'll find it to be highly alkaline (pH 9-10 or more). This step is optional, but can be quite informative.
3. When washing is complete, test a sample of the rinse water from the tank. If all the degreaser has been purged, the pH of the sample should match that of the pure "control" water as determined by matching colors. If the pH is still elevated, continue rinsing until it returns to normal.

## WATER BREAK TEST

**OVERVIEW:** A Water Break Test is occasionally useful for inspecting cleaned regulator or valve parts, although its application is limited to horizontal surfaces. It has little or no application for dive tanks. The theory again is quite simple: If an object harbors an invisible layer of oily material, water sprayed upon its surface will usually quickly bead up.

Conduct the test as follows:

1. The cleaned parts to be examined must be resting horizontally or gravity will interfere with the test. (This mandatory requirement obviously restricts the usefulness of this procedure.)
2. Spray DISTILLED WATER on the "test surface". Use of DISTILLED WATER guarantees the elimination of any interference reactions from materials in the water itself.
3. The thin water coating should remain unbroken for at least 5 seconds. If the liquid quickly "beads up", the surface is not oil-free. Re-clean / re-rinse as necessary and repeat test.

#### **WHITE LIGHT VISUAL INSPECTION TEST**

**OVERVIEW:** This is an extremely common test useful for inspecting cleaned parts from valves or regulators, but it has only minor application for tanks. It's based on the fact that the human eye can discern particulate matter bigger than 50 microns (.002 inches) and can therefore detect relatively large deposits of lint, oil, fibers, grease, filings, chips, etc. In other words, some contaminants can be seen if you look closely under bright light!

Conduct the test as follows:

1. Under bright white light and without magnification, carefully scrutinize the finished part on a clean surface. Rotate the object to inspect all areas from different angles.
2. If any of the aforementioned contaminants are detected, the part must be re-cleaned. Any suspicious-looking deposit that cannot be identified or explained should be treated as a possible pollutant.

#### **SECTION C: PREVENTING FLASH RUST IN STEEL TANKS**

**OVERVIEW:** If the cylinder being cleaned is STEEL alloy, a pre-drying treatment with Oxy-Safe Rust Inhibitor / Compound 0 (GMC #42220) should be given; without it, flash rust may form during drying operations (See "Tips" for details). DO NOT USE THE NOW RETIRED GMC PRODUCT, COMPOUND B (GMC #42060) FOR THIS PURPOSE; IT IS NOT AN OXY-COMPATIBLE CHEMICAL.

GMC recommends that Compound 0 NOT BE REUSED. Reusing the same rinsing solution in many of tanks would create the risk of carrying trace contaminants from one vessel into another. It is true that Compounds O and B can be recycled and reused until their yellow color dissipates; however, one gallon of Compound O can treat about 1000 scuba tanks, so attempting to reuse it is simply false economy. The risk of carryover contamination is not worth taking for the minor savings achieved!

Conduct the anti-rust treatment as follows:

1. Dilute Compound 0 by putting 1 oz. of the concentrate into one gallon of oil-free water (10 ml per liter). The use of distilled water for this purpose will insure the elimination of any unwanted contaminants in the water, and the diluted solution will remain active for approximately 30 days. (The undiluted concentrate has an indeterminate shelf life). This preparation will inhibit rust formation on the wet, inner surface of the steel scuba tank during the drying process. This rust-inhibiting effect is merely transitory during the drying process ... it has no long-term action within the tank.
2. Pour about 1 pint of the diluted Compound O into the damp tank immediately after the rinsing process. Return the tank to the tumbler for 3-5 minutes to allow the rust-inhibitor to evenly and completely cover the interior.
3. Pour out the liquid, RETURN THE TANK TO THE WASHER APPARATUS, AND FLUSH FOR ANOTHER 5 SECONDS ONLY. CAREFUL TIMING OF THIS FINAL RINSE IS VERY IMPORTANT to remove most, but not all, of the Compound 0. The trace remaining will halt flash rust and be dissipated during drying. However, excessive rinsing will negate the anti-rust activity. Remove the tank and IMMEDIATELY dry it using one of the recommended methods.

## **SECTION D: DRYING TANKS**

Dry the cylinder using a compressed air jet or GMC's Tank Dryer System (GMC #42030). These drying operations are essentially the same as those employed when cleaning regular compressed air tanks. If you are unfamiliar with such procedures, see our "Tips" bulletin before going further. Drying should be carried out PROMPTLY after the final rinse. If drying is accomplished with compressed air, it must be oil-free (Grade E is satisfactory for this brief, low-pressure purging procedure). If heat gun dryers are used on ALUMINUM TANKS, beware of overheating (325° F), which can seriously weaken the alloy. Also, avoid placing the dryer system in an area where contaminated air, dust, debris or other contaminants might be forced into the now clean tank.

Consistent elimination of flash rust often takes a little practice. Intrinsic interacting variables such as water quality, hardness, strength of the Compound O solution, or mistakes in the rinsing or drying techniques can occasionally lead to a process failure ... i.e. flash rust still occurs! Some experimentation to counteract such problems is sometimes required until one gets the procedure "down cold". You are always welcome to consult with the GMC Techsupport Dept. @ (P) 414-774-1616, (F) 414-774-9568 or (E) techsupport@gmcscluba.com.

## **SECTION E: VALVE SERVICE & CONVERSION**

When converting air tanks for oxygen / Nitrox use, cleaning the cylinder's interior is only part of the job ... the valve must also be cleaned and converted. This involves complete dismantling, thorough cleaning and decontamination, plus the replacement of any parts that are marginally oxy-compatible, and the application of oxy-compatible lubricants as needed. Be aware that not all scuba valves can be rendered totally oxy-compatible because some manufacturers do not yet provide parts such as valve seats for oxygen service. For information on such matters, consult the manufacturer or recognized experts on this subject. The general steps for valve conversion are given below.

1. **Valve Disassembly:** The valve should be COMPLETELY disassembled prior to cleaning. Any "suspect" parts should be replaced with new ones to be included in the cleaning process. Although it is most important to oxy-clean those parts that are directly within the gas flow pathway, it is probably prudent to include all other parts as well. Ancillary parts could serve as sources or reservoirs for contaminants that might eventually migrate into critical areas by various mechanisms.
2. **Pretreatment / Gross Cleaning:** As a pretreatment, all encrusting salt or other pollutants must be removed by a suitable acidic bath. Diluted GMC Regulator Cleaner (GMC #43190) or Hydrosonic Cleaner (GMC #43101) both work well for this purpose. This process, whether performed by hand or with an ultrasonic cleaner, is essentially the same technique that would be employed in cleaning parts for normal air applications.
3. **Rinsing and Inspection:** Rinse the parts thoroughly and perform a visual bright light inspection. Should any contaminants remain, repeat the pretreatment cleaning, rinse and inspection.
4. **Final Treatment / Degreasing:** The precleaned parts should now receive a final treatment with a suitable alkaline degreaser. GMC Special Cleaner (GMC #42100), diluted 1 oz. to 1 quart of water, (or one of the other solvents previously listed diluted as per that manufacturer's recommendations) can be used. Soaking and hand scrubbing will yield adequate cleanliness, but ultrasonic cleaning produces immaculate materials and is highly recommended for these operations.
5. **Final Rinsing, Testing, and Inspection:** Following the final treatment / degreasing process, all parts should be thoroughly rinsed with warm, running water. After rinsing, a sample of the rinse water should be tested to determine if all the solvent has been purged (see instructions for the Shake and pH Tests in Section B of this bulletin.) As already described, other simple tests can also be used to examine valve and regulator parts, including UV-light. Small overhead UV-lamps, such as GMC #43305, are inexpensive and can be easily employed to inspect parts that are frequently exposed to different types and sources of contamination than are scuba tanks, which are in essence, sealed containers. While UV-light is one of the few DIRECT inspection methods available, remember that many potential contaminants DO NOT FLUORESCENCE.
6. **Compatibility and Replacement of Components:** Certain internal parts should be replaced if actual oxygen-compatible components are available. Most scuba valves contain seats made of Nylon 6/6 which is not considered to be very oxygen-compatible. While Nylon 6/6 does have marginal oxygen-compatibility, field use has shown that pure oxygen and oxy-rich Nitrox slowly vaporizes that material, often resulting in a complete seat failure. Some manufacturers provide alternate seats containing recognized oxygen-compatible materials such as

KEL-F. For example, Sherwood valve seats (Sherwood #3506-9K) contain Kel-F polymer, which will fit many valves that Sherwood-Selpac produced for other distributors over the years.

All nitrile O-rings, such as valve stem and bonnet seals, must be replaced by Viton or EPDM (Ethylene-propylene) material. The white backing rings used in most valves are Teflon and therefore are oxy-compatible. But these, and any other part that will come in contact with pure oxygen, must be cleaned prior to installation. Unless oxy-compatible parts are received from the manufacturer in a sealed package marked "oxygen-clean", do NOT assume them to be oxy-clean. Clean them as you would other materials to be used in oxygen service.

- Lubricants:** All existing INTERNAL lubricants, thread-locking agents, and dielectric pastes must be completely removed during the cleaning process and replaced with oxy-compatible types such as Christolube 111 (GMC #42165), Krytox, Tribolube, Halocarbon, Fluorolube, Braycote, or other approved synthetic lube. Before installation, valve threads must be relubricated with an oxy-compatible dielectric (insulating) grease / paste. SILICONE GREASE (DOW 111) AND MOLYKOTE 557, COMMONLY USED ON AIR VALVES, CANNOT BE USED FOR OXYGEN SERVICE AND MUST BE REPLACED. GMC now recommends an aerospace polymer called CHRISTOLUBE MCG 125 (GMC #42135) that contains molybdenum disulfide. This grease can be recognized by its BLACK COLOR and should not be confused with Christolube MCG 111, which is WHITE. Formula 8, Christolube 111, and Lox-8 Grease can also be used for this purpose. However, MCG 125 is thought to be superior because molybdenum disulfide is a highly effective barrier against thread corrosion, seizing, and galling. Apply only a very light coat of this lube on the valve threads.
- Cylinder Labeling:** The converted tank should now be clearly marked with respect to the type of gas that it will contain. Stickers (available from GMC), decals, tags, or special paint codes are available for this purpose. Several diving accidents have occurred due to mix-ups among scuba tanks that contained gases other than air.

**Category II: The tank has had extensive use with air or other gases and now contains visible contaminants such as filtrant dust, rust, concretions, oil residues, Bayerite or aluminum oxide powder. Presence of any "tank lining" calls for rejection for oxygen service.**

**ACTION: TANK MUST UNDERGO A PRETREATING TUMBLE FOLLOWED BY A DEGREASING WASH.**

## **SECTION F: PRETREATING TUMBLE AND WHIP CLEANING**

**PRETREATING TUMBLE OVERVIEW:** This procedure consists of a standard tumble using dedicated abrasive media and diluted Oxy-Safe Citrate Tank Cleaner. This procedure should remove all unwanted hydrocarbon contaminants and will often produce a burnishing of the interior in steel tanks. There is no "magic" time period required; steel cylinders usually come clean within 2-4 hours and aluminum types in 30 minutes or less. Any cylinder that cannot be cleaned within these time parameters is probably unfit for specialty gas service, although some steel tanks may take longer times (4-8 hours), and still come satisfactorily clean.

Glass beads should NOT be used for this operation because abrasive action is needed to achieve proper cleaning. Ceramic pellets (GMC #42050) are more desirable than aluminum oxide chips because they generate relatively little gas production with citric cleaners. In addition, the uniform size and shape of ceramic pellets produces a very consistent, predictable cleaning action. Aluminum oxide nuggets vary greatly in size and coarseness and therefore have a somewhat more erratic activity, especially as the media becomes polished with use. Nonetheless, with a little experience, one can achieve satisfactory cleaning with either media. To produce uniform and complete cleaning of the entire interior, the cylinder must be at least HALF FULL of media as it lies HORIZONTALLY on the tumbler.

Once the Pretreating Tumbling has begun, continue through each step as described and then proceed immediately into the Degreasing Wash phase. These processes must be carried out as a nearly continuous operation without allowing the cylinders to stand wet or idle for extended periods of time.

### **THE TUMBLING PROCESS:**

- Add the Media to the Tank:** Place the required amount of media into the tank using a large funnel to speed the process. The pellets should be sprinkled or swirled slowly into the funnel to avoid clogging within the neck. The

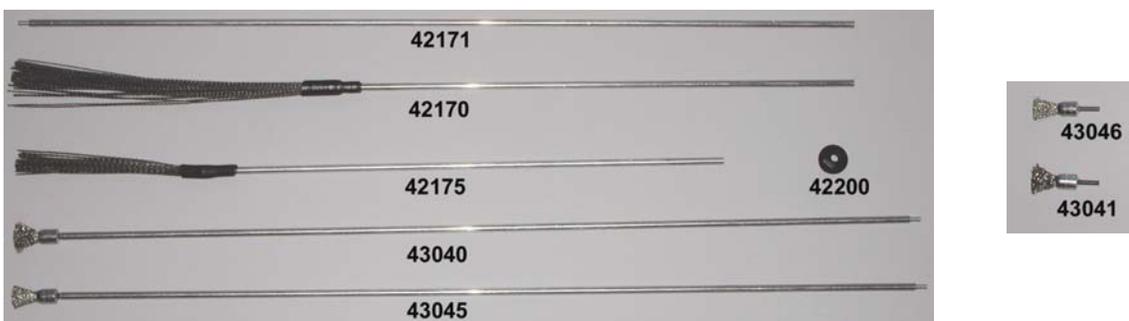
following is a guide to the APPROXIMATE amount of media needed for various size tanks: (50 cu.ft. / 20 pounds) (72-80 cu.ft. / 25 pounds) (104 cu. ft. / 30 pounds). If incomplete cleaning of the neck or bottom regions occurs, increase the amount of media used.

2. **Dilute and Add the Citrate Cleaner to the Tank:** Dilute the Citrate Cleaner by putting about 1 oz. of concentrate into a gallon of water (10 ml per liter). Pour about 1-2 quarts (2L) of the diluted cleaner into the tank and plug the neck. For effective cleaning, do not use more than 2 quarts (2L).
3. **Tumble the Tank:** Tumble the cylinder as follows: (Steel tanks ... 2-4 hours). (Aluminum tanks ... 15 minutes). With a little practice, an experienced technician can usually judge the required tumbling time based on the amount and type of pollutants / corrosion observed within the tank during the VIP.
4. **Remove the Media and Rinse the Tank:** Remove media from the cylinder as already described in the TUMBLING WASH section. Thoroughly rinse the tank to remove all residual scum and cleaner. Quickly inspect the wet cylinder for any residual contamination in case further tumbling might be required.
5. **Perform a TUMBLING WASH without Glass Beads:** Proceed directly to the TUMBLING WASH as previously described in SECTION A. Glass beads can be omitted from this TUMBLING WASH because the PRETREATING TUMBLE has already sufficiently agitated the cylinder walls. This final degreasing wash should guarantee the removal of any residual hydrocarbons left within the vessel.
6. **Rinse, Test and Dry the Cylinder:** Complete the TUMBLING WASH procedure by rinsing, performing a SHAKE Test, an anti-rust treatment (steel only) and drying operations as explained in SECTION A.

**PRETREATMENT BY WHIPPING:** Sometimes cylinders contain only light visual contaminants that do not warrant a Pretreating Tumble, but nonetheless must be removed. A common case in point would be the presence of a few Bayerite pustules within aluminum tanks. In such instances, use of a Tank Whip may be the answer. Tank Whips are essentially brooms possessing bristles made of an abrasive plastic crimped onto an aluminum rod. The whip is inserted into a tank and the rod is then rapidly rotated by an electric drill that causes the bristles to flare outward and flail the tank's interior walls.

This device is quite effective for removing common minor deposits, but should not be employed in cases of heavy contamination like thick steel rust. GMC makes a standard Tank Cleaning Whip (GMC #42170) for common size tanks and another for "pony" cylinders (GMC #42175). A plastic Whip Guide (GMC #42200) is a helpful tool for guiding and controlling the whip in tanks with the common large aperture (3/4-14 NPS neck thread). It centers the whip and aligns its angle of travel to prevent damage to the bristles while still allowing a good thrashing action.

Whips do an excellent job of burnishing cylinder walls, but bottom deposits are often difficult to remove without exerting excessive pressure on the whip. In such cases, a Bottom Brush often does the job. Global now offers two Tank Bottom Brushes to scour tank bottoms: a light-duty model with shaft (GMC #43040) for light rust in steel tanks or oxidation in aluminum models, and a heavy-duty model with shaft (GMC #43045) for heavier corrosion in STEEL cylinders. Replacement brushes only are also available in light or heavy-duty (GMC #43041 or #43046). If whipping / brushing does not give acceptable results within 4-5 minutes, tumbling must subsequently be employed. WHIPS AND BOTTOM BRUSHES USED FOR OXYGEN APPLICATIONS SHOULD BE DEDICATED TO THAT USE AND NOT USED INTERCHANGEABLY FOR AIR TANKS.



The whipping procedure is as follows:

1. Whip the tank interior for up to 4-5 minutes MAXIMUM. (See "Tips" for a more complete description of whipping). When the internal dust settles, inspect the tank for any residual pollutants; if unwanted contaminants persist, proceed to tumble the vessel.
2. After whipping, if the tank appears clean, conduct a TUMBLING WASH using glass beads. Beads should be used because whipping usually creates dust that clings electrostatically to the walls and resists removal by simple rinsing. Also, whipping can imbed tiny fragments of abrasive onto the walls that require agitation to remove.
3. Complete the TUMBLING WASH, RINSE, SHAKE TEST, AND DRYING as previously described.

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**Global Mfg. Corp.**  
**Converting Dive Tanks for Oxygen Service**

**Product Reference**

A suggested guide follows for the dive shop wishing to purchase the equipment and materials required to professionally convert dive tanks for oxygen service. The equipment and supplies needed to perform VIP's and standard tank tumbling procedures are not listed.

**\* Indicates those items that should be considered mandatory for tank cleaning and tumbling service center.**

**Tank Tumbling / Cleaning Hardware:**

- #42000 Tank Tumbler Machine
- #42030 Tank Draining Stand\*
- #42120 Tank Washer\*
- #42030 Tank Dryer\*

**Tank Tumbling Media & Chemicals:**

- #42045 Glass Beads\*
- #42050 Ceramic Media, 30 lbs. per single tank (re-useable)
- #42100 Special Cleaner, gal. (Oxy-compatible alkaline degreaser)\*
- #42220 Compound O, gal.\*

**Tank Whips / Bottom Brushes & Accessories:**

- #42170 Tank Cleaning Whip
- #42175 Pony Tank Cleaning Whip
- #42200 Whip Guide
- # 43030 Light-Duty Bottom Brush w/ Rod
- # 43041 Light-Duty Bottom Brush Only
- # 43045 Heavy-Duty Bottom Brush w/ Rod
- #43046 Heavy-Duty Bottom Brush Only

**Miscellaneous Supplies:**

- #42210 Standard Tank Plug\*
- #42205 Genesis Tank Plug\*
- #42225 Tank Purge Air Gun
- #42230 Tank Vacuum Attachment
- #43005 Brass Valve Thread Cleaning Brush\*
- #43015 Brass Tank Neck Thread Cleaning Brush, 3/4"
- #43035 Brass Tank Neck Thread Cleaning Brush, 1/2"
- #42165 Oxy-Safe Lube (Christolube)\*
- #42135 Oxy-Safe Christolube 125 Valve Lubricant\*
- #49000 Viton O-ring Kit (6 ea. of 10 common O-rings)
- #49214 O-ring – Viton - 3/4" valve to tank interface\*
- #49116 O-ring – Viton - HP "Genesis" valve to tank interface\*
- #49014 O-ring – Viton - standard valve to regulator interface\*
- #49112 O-ring – Viton - steel tank valve to regulator interface\*
- #61120 Oxygen Tank Sticker
- #61125 Trimix Tank Sticker
- #61130 Nitrox Tank Sticker
- #61135 Argon Tank Sticker
- #42080 Tank Vise
- #42085 Tank Vise Optional Base Plate
- #42130 Bulletin: Tank Tumbling Tips ( This publication)\*
- #42125 Bulletin: Converting Dive Tanks For Oxygen Service With GMC Oxy-Safe Products\*

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