Tonnage Dunnage

The Many Meanings and Uses of the Familiar Ton

By Dave Gerr, © 2008 Dave Gerr

> "She was the ***Visigoth***—five hundred tons, or it may have been six—in the costing trade; one of the best steamers and best found on the Kutch-Kasauli line. . . ."
>
> *The Wreck of the* **Visgoth**
> Rudyard Kipling

Tons and tonnage—you can scarcely read or talk about boats and ships without reference to them. Gross tons and net; deadweight and displacement; volume and cargo—the ton has taken on so many meanings, indeed, that it's often hard to figure out what's being referred to. Yet, tons and tonnage are so inescapable and so useful that everyone involved in the boating business ought to understand their uses—at least in general.

Almost certainly, this ton stuff all started with spirits—you know: beer, wine, ales. Though nearly every sort of cargo has been transported by sea, the oldest and most frequent seems to have been—you guessed it—alcoholic beverages. All those ancient Greek, Phoenician, and Roman wrecks that have been excavated in the Mediterranean are most commonly stuffed with amphorae—graceful pottery containers. Though these had often contained olive oil, grain, or spices, even more commonly they'd held wine.

A Barrel of Tons

Our taste for wine hasn't abated one whit over time, and it was thus the "standard" shipping wine barrel that gave us the word ton. Indeed, "tun," or "tonne" was the Old English and Old French word for barrel. Naturally, with merchantmen carrying cargos of wine in barrels, the government—back then The Crown—wanted a piece of the action. (Ah, this sound all too familiar.) In 1302, for instance, King Edward I charged a duty of 2 shillings per tun (per barrel) for every single tun shipped, plus he gave himself the right—convenient to be a king—to take 1 tun (1 barrel) from every boat carrying between 10 and 20 tuns, and 2 tuns from every ship carrying over 20 tuns. I suppose—what with a large court and several castles—he had to give his people something to drink. Anyway, from Edward's time on, tons have been inextricably intertwined with boats and shipping.

Interestingly, the original "tun" (wine barrel) was described as "containing not less that 252 gallons or 954 liters." (I wonder how big they could get?) The most common size enclosed about 40.3 cubic feet or 1.14 m^3 (42 cubic feet or 1.19 m^3 including the barrel itself). It's no coincidence that the filled barrel weighed about 2,400 pounds (1088 kg)—very close to the modern long ton. The "ton," though, has many meanings or applications—a unit of weight; a unit of volume; and an arbitrary measurement unit for registration, licensing, and taxes.

Weighty Tons

Weight is fairly straightforward. A long ton is 2,240 pounds (1016 kg), and a short ton is 2,000 pounds even. (That's 907 kg, not even). Long tons are used almost exclusively with reference to boats unless, of course, you're in Europe, in which case it'll be metric tons—the *tonne*. A metric ton or tonne is exactly 1,000 kilograms. Not surprisingly, since a kilogram's 2.204 pounds, a metric ton equals 2,204 pounds. This is close enough to a standard U.S. long ton for the difference to be ignored for anything but exacting engineering work.

Odd Measures

Now, if you're old enough to remember the old British money system, you won't be surprised to learn that some rather peculiar British measures added up to exactly one long ton. Brits consider a long ton to be equal to 20 hundred weight, but a hundredweight equals 112 pounds (NOT 100 pounds). There's actually a logical reason for this (if anything about old British measure can be said to be logical); it's that one hundredweight exactly equals 8 "stone," since a "stone" is 14 pounds. (Why a "stone" is 14 pounds and not, say, 10, 12, or 15 I'll probably never know; maybe it's best not to).

The Brits had another peculiar measure, the "chaldron." This was applied to bulk cargos like coal. The old sailing flat-bottomed barges called "keels" used to carry cargos of coal that were taxed by the chaldron. A chaldron about equaled 36 bushels, and this much coal weighs about 2,200 pounds (998 kg)—a ton again.

Displacement, Volume, and the Ton

As a measure of boat weight or size, a craft's displacement's is given in pounds or long tons. (Long tons is the marine standard.) When you survey *Tons Of Fun*, and learn that it weighs 10,300 pounds, its displace-

Modern Shipping Tonnage

Until fairly recently, there were numerous international measurement systems for the tonnage of ships: U.S., British, Panama, Suez, and more. In 1969 the Inter-Governmental Maritime Consultative Organization met to agree on a universal measurement system. (The Inter-Governmental Maritime Consultative Organization is now the International Maritime Organization or IMO.) Known as the "International Convention on Tonnage Measurement of 1969," not only did this simplify and unify many of the tonnage systems (no more complex loopholes), but it officially changed the basic unit of tonnage measurement from cubic feet to cubic meters. Accordingly, the official unit of tonnage volume is now 2.83 m^3 not 100 cubic feet, and the word "ton" isn't employed in official Convention tonnage documents for ships. Instead, a ship is referred to as having "Gross Tonnage 1234" or GT ITC or GT, or "Net Tonnage 1234" or NT ITC, and so on. Even though the word "ton" is no longer officially used in shipping admeasurement, this is still based on Moorsom's tons of 100 cubic feet (2.83 m^3). Requirements for the Conventions Measurement System can be found under 46 CFR, Subpart B.

U.S. ships and boats under 79 feet (24 m) must use the older and more "entertaining" Standard system of tonnage measurement (still officially based on 100 cubic feet). This older system remains the one that determines the applicability of U.S. shipping regulations. Though complex, it is this system in particular which allows extreme reduction in admeasured tonnage for regulatory advantage—if, that is, the rules are followed correctly.

The new international system is often referred to as the "Convention Measurement System" and the old system used for U.S. regulations is often called the "Standard" system, but is most accurately termed the "Regulatory Measurement System." Tonnage in this system is "Gross Registered Tonnage" or GRT. U.S. flag commercial vessels over 79 feet (24 m) must be measured under both systems. Keep in mind that a craft that's been finagled to get a low, say, 99 gross registered tonnage measurement under the old Standard or Regulatory Measurement System by playing all the allowable tricks, may well end up as a 600 gross tonnage vessel, or more, under the Convention System, without the "tricks."

ment is 4.6 tons—or if it weighs 4672 kg its displacement is 4.76 tonnes (metric tons). Displacement is a powerful concept however. Because a boat displaces the same amount of water it weighs, the volume of the hull—below the waterline—is equal to its weight in water. Since seawater weighs 64 pounds per cubic foot, our 4.6-ton *Tons Of Fun* displaces 161 cubic feet. Or—another way to look at it—is that the volume of the hull below the waterline is 161 cubic feet. In metric, since seawater weights 1030 kg per m^3, our 4.76 tonne *Tons Of Fun* displaces 4.62 m^3. See sidebar for useful relationships.

Now, as we've discussed, displacement is the true weight of a boat at a given loading. It's sometimes called "displacement tonnage." This, though, is landlubber talk. It's redundant like saying, "12:00 o'clock noon P.M."

Legal Tons

Tons of weight or volume apply simply and directly to every boat. They just describe how big or heavy a vessel is. For registration, licensing, and tax purposes, however, there are several other "tonnage measurements"—gross tonnage, net tonnage, registered tonnage, and deadweight tonnage.

These—in their current form—are largely result of a commission set up by the British Admiralty back in 1849 to try and straighten out the considerable confusion resulting from many different tons, tonnages, and tonnage measurements. A fellow named George Moorsom was made honorary chairman, but he ended up so disagreeing with the commission's findings that he wrote his own, which has become known as Moorsom's Rule. The basic problem had been that different cargos had different densities—35 cubic feet equal 1 ton for seawater; 44 cubic feet for coal; and so on—how to standardize the taxable cargo volume of differing craft? Moorsom's suggestion was to arbitrarily call 100 cubic feet (2.83 m^3) equal to 1 ton (2,240 pounds or 1016 kg) of general cargo capacity. A brilliant simplifying stroke, Moorsom's basic approach is used to this day.

Commercial Tonnage

From here, it's an easy jump to all those commercial-ship measurements. "Registered tonnage" is the interior volume of the hull, inside the entire usable structure (measured inside plating, inside frames, above floors, under deck beams, and so on). It's calculated in cubic feet divided by 100 . . . Moorsom's tons. Registered tonnage has no real direct relationship to displacement; however, it is further divided into three principle subcategories—"gross," "net," and "underdeck" tonnage.

For Seawater

English		Metric	
1 cu.ft.	64 lb.	1 m^3	1030 kg
1 cu.ft.	7.48 gal. U.S.	1 m^3	1000 liters
1 gal. U.S.	8.56 lb.	1 liter	1.03 kg
1 long ton	262 gal. U.S.	1 tonne	1000 kg
1 long ton	2,240 lb.	1 tonne	970 liters
1 long ton	35 cu.ft	1 tonne	0.97 m^3

The "underdeck tonnage" is the volume in cubic feet (divided by 100) of all the hull capacity under the tonnage deck—the upper deck in a one- or two-deck ship, and the second full or continuous deck, up from below, on all other vessels. "Gross tonnage" is all the volume below the upper deck, minus legally and arbitrarily defined areas supposedly not suited for cargo—for instance minus water-ballast tank volume. "Net tonnage" is gross tonnage minus major deductions (again, arbitrarily defined by law) for areas not deemed usable for cargo.

For more information on tonnage go to:

http://homeport.uscg.mil

and in the search box type in "Tonnage Measurement." You will get a screen with several useful PDF documents to select from.

Tonnage Loopholes

Because Coast Guard and shipping regulations as well as duties and fees are based on tonnage measurements, designers are endlessly playing games with the legal deduction rules to keep registered (legally-defined) tonnage low. For instance, a charter boat that

Tonnage Reduction Tricks under "Standard" or "Regulatory" Tonnage Measurement

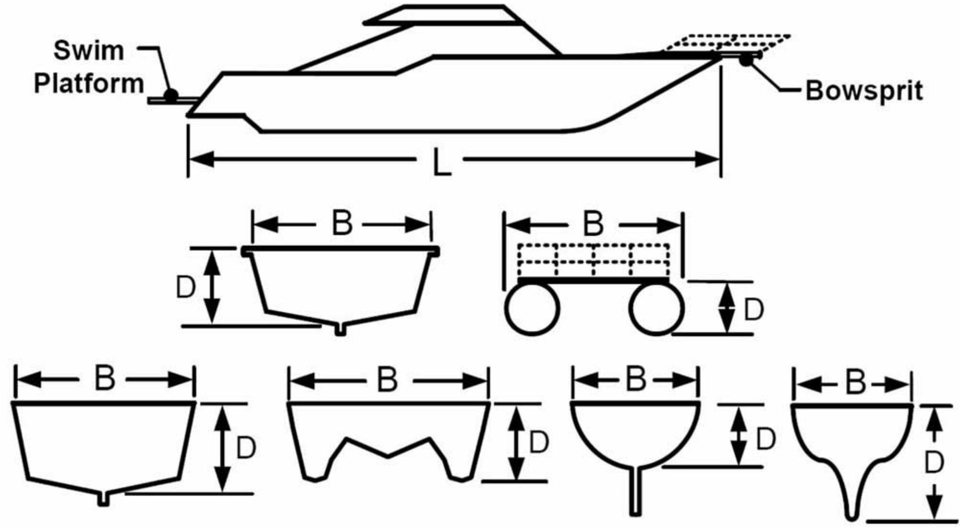
The old "Standard" or "Regulatory" tonnage measurement system used in the U.S. is based on rules which date back to wooden ships. These rules measured usable interior cargo volume to the inside of the framing as the closely spaced wooden frames wouldn't allow storage between them. In addition, various accepted spaces can be exempted from tonnage volume to reduce gross tonnage. These include, for example, all spaces used for water ballast. So one way to reduce tonnage is to include large water ballast tanks. (They must be fully and properly plumbed, equipped with pumps, and operational.) As long as the volume of water ballast is 30% or less of gross tonnage volume, it will generally be accepted as fair deducted volume. Over 30% will require proof that so much water ballast is really required. Offshore supply boats for the oil industry are often allowed even more water ballast volume. All this is only for water ballast an not for fuel or other tanks, so a tank that does double duty (fuel and water ballast) won't count for any deduction.

Because it's originally based on the concepts from old wooden vessels, the tonnage volume is measured inside the framing even on a metal boat, not to the inside of the planking or plating. (IMPORTANT NOTE: This applies only to all transversely framed boats without longitudinals, not to longitudinally framed metal hulls. If you intend to use deep framing to reduce gross tonnage, you generally have to use an all transverse framed structure.) The height for volume is measured down to the top of the floors. If at least every other floor/frame (or floors/frames spaced no more than 96 inches) comes up quite high, then you can take the depth of hull as the height to the top of these high floors. This can result in a dramatic reduction in volume and so gross tonnage. In fact, if you don't need the under-deck space, you could run every other floor as a non watertight bulkhead right up to the underside of the deck and have no measured volume in the hull at all, except in the machinery space, where such high floor/bulkheads couldn't be employed. Similarly very deep frames athwartships would reduce the measured width. There are further restrictions on the size of lightening holes and similar openings in any deep frame intended to reduce tonnage volume.

You can also run high floors up into tanks to reduce measured volume (any kind of tank, including fuel and fresh water). This works well as the high "floors" serve well as tank baffles.

Areas above the tonnage deck can be excluded by using "tonnage openings." A compartment is deemed "open to the weather" if it has an unobstructed opening at lest 48 inches by 60 inches or two such openings 36 inches by 48 inches, with unobstructed access 30 inches either side of the opening. Yet, this tonnage opening can be closed under the rules. You can't use a hinged door, you can't weld it closed, and it can't be gasketed or otherwise made watertight, but it can be closed with a removable cover (a strong welded one) that is held in place with J-bolts, no more than 12 inches on center, with the J hooking around an inside coaming. Such tonnage openings are usually built into the aft wall or bulkhead of the superstructure. You can continue to add similar "openings" inside the cabin structure on bulkheads that open to compartments leading to the previous tonnage openings. Using this trick, you can often exempt a large portion of the superstructure from being included in the tonnage volume. Note that there are additional restrictions on inside passages and bulkheads in spaces to be exempted by using tonnage openings.

U.S. tonnage rules (the Standard or Regulatory system) are covered in 46 CFR 69 Subpart C. There is also the Dual Measurement System (46 CFR, Subpart D). This is similar to the Regulatory system. It doesn't allow tonnage openings, but does permit deduction of areas for the stores and cargo above the tonnage deck. You can use the notes above and this rule for some guidance on designing or building to substantially reduce gross tonnage, under the Regulatory system, but be warned; these are the broad principles only. You really need to work with a tonnage specialist to ensure you achieve a low gross tonnage measurement if that's required. A good three quarters of the rules involve fine interpretations of picky and finicky details. It's not something for the uninitiated to attempt on their own.



measures under 100 gross tons (as admeasured under the law) will be required to meet less onerous regulations than the same craft registered at 101 gross tons or more. ("Admeasurement" is the oh so catchy legalese term for measuring a boat to obtain tonnage according to regulations.) For some craft, like offshore oil supply boats, the volume that can be deducted for water ballast tanks can make what should really be a 700 gross ton craft admeasure to a mere 199 gross tons! All vessels that measure over 200 gross tons must have a licensed captain even if only a yacht. Obviously, playing the tonnage-reduction game to keep a large boat under 200 gross tons is often desirable. Many types of vessels are automatically required to be U.S. Coast Guard inspected when they reach 300 gross tons or more.

Finally, deadweight tonnage (often abbreviated D.W.T. or DWT) is the real cargo capacity of a vessel—not some form of legalese. It's the difference between the weight or displacement of a vessel empty, but with full crew, complete supplies, and full fuel, water, and lube-oil tanks, and that same vessel with all this plus all the cargo it can carry.

Rule-of-Thumb Commercial Tonnage

If and only if the tonnage legal-loophole game hasn't been played to the hilt, a general rule of thumb is that—for a standard freighter—gross tonnage is 1.5 times net tonnage (or net tonnage is 67% of gross tonnage). Deadweight tonnage—true cargo capacity—is about 2.5 times net tonnage; and roughly 2.25 times gross registered tonnage will approximate true loaded displacement (real boat weight and volume). Accordingly, next time you read about some exciting mishap on 1,200-gross-ton ship, you'll know that it displaced roughly 2,700 tons, and had a net tonnage of 800, or thereabouts. This, by the way, is a pretty small ship.

Gross and Net Tonnage Applied to Boats

Does all this admeasured tonnage business apply to boats? You bet it does. If the owner wants to get *Tons Of Fun* documented in the U.S.—and there are often legal and financial benefits to documentation—*Tons Of Fun* must be admeasured for gross and net tonnage. Indeed, a boat must measure over 5 net tons in order to qualify for documentation at all. What's more, if the boat is intended for charter, you need to know its gross and net tonnage. It's also sometimes required on insurance forms.

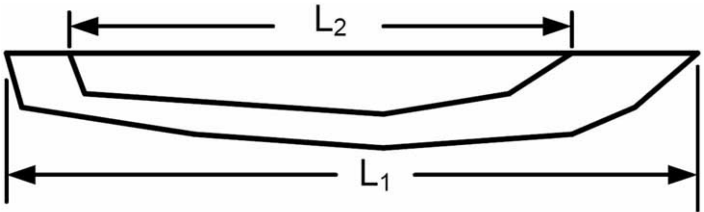
As we've seen, for large commercial vessels the complicated formulas and loopholes necessary to keep admeasured tonnage low—to reduce duties and fees—is a bureaucratic maze of the best (or should that be worst) kind. This, as we've discussed, is termed "formal," "standard," or "regulatory" tonnage measurement. It's advisable to consult a tonnage specialist early in the design process. The classification societies are the best source for this assistance—ABS, Lloyds, etc. In fact, they conduct the actual measurement process to obtain legal admeasured tonnage. Happily, for yachts, small charter vessels, and other boats under 79 feet (24 m), there's a simplified measurement system. Using it you can see how our example *Tons Of Fun* admeasures in a few minutes with calculator, pad, and pencil.

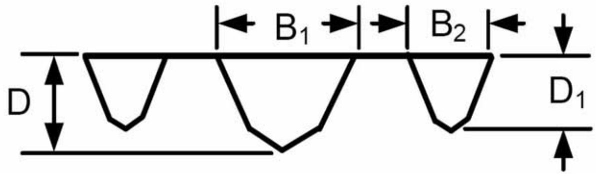
Simplified Tonnage Formulas

The Simplified Measurement formula for boats under 79 feet (24 m) is under CFR 46, Subpart E. Basically it is:

Gross Tonnage = 0.84 x (LOA x Beam x Depth of Hull)/100 (for barge like hulls)
Gross Tonnage = 0.66 x (LOA x Beam x Depth of Hull)/100 (for motorboats)
Gross Tonnage = 0.50 x (LOA x Beam x Depth of Hull)/100 (for sailboats)
Net Tonnage = 0.80 x Gross Tonnage (for motorboats)
Net Tonnage = 0.90 x of Gross Tonnage (for sailboats)

For multihulls, figure the tonnage of each hull and add the deck structure to that, if it has more volume than the hulls.





Note that the LOA (length overall) is measured from the face of the bow or stem aft to the top of the transom at the deck—don't include bowsprits, boarding steps, motor brackets, pulpits, etc. Depth of hull is the vertical height from the deck at side down to the top of the keel taken at midships—it is ***NOT*** draft. (See illustration above.)

If our *Tons Of Fun* has a quite large houseboat-type deck structure, that has to be calculated and added in separately. Just take the deckhouse length, breadth, and height (side of roof to top of main deck) and run it through the above formulas. Add the result to the hull tonnage. NOTE: Adding the superstructure volume to tonnage applies only if the volume of the superstructure is greater than the volume of the hull (or hulls combined on a multihull).

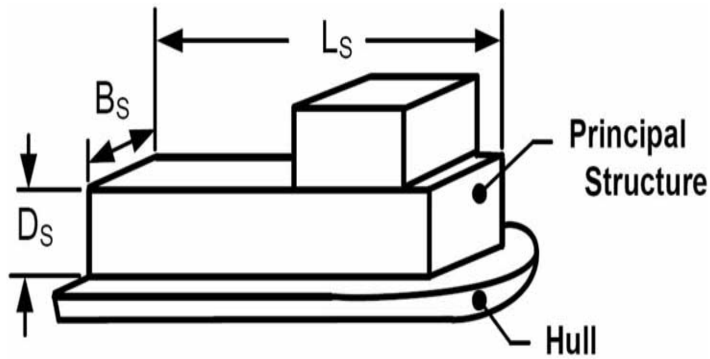
Say our *Tons Of Fun* was a typical sportfisherman. It's 34 feet overall including a 2-foot anchor pulpit and 12-foot 6-inch beam. You take a tape measure and find the height from the deck at side (at midships) to the top of the keel is 7 feet 3 inches (7.25 feet). Tonnage would be:

Gross Tonnage (for motorboats) = 0.66 x (32 ft. LOA x 12.5 ft. Beam x 7.25 ft. Depth of Hull)/100 = 19.1 tons

Net Tonnage (for motorboats) = 0.80 x 19.3 = 15.3 tons

Other Tons Aplenty

The ton has been with us so long and has been used for so many things that we've only scratched the surface. In refrigeration, for example, a ton is the amount of energy required to melt a 1-ton block of ice in 24 hours, or 12,000 BTU. Back on the water, sailing race rules have used tons for years. There was the old British B.O.M. (Builder's Old Measurement Tonnage), which evolved into Thames Measurement Tonnage for



assessing boat size. This rule encouraged extremely deep-bodied, narrow, heavy craft and was a source of considerable debate at the turn of the last century—the great “sloop-cutter controversy.” More recently, IOR racers of specified rated length in feet were classified as “ton boats.” There were quarter-toners, one-toners, etc. Naturally, none of this race-rule stuff is of much practical use and has no real relation to weight or carrying capacity at all.

Magic Moment, 52-foot aluminum ketch, by Dave Gerr