# Home made Magnalium

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## Safety basics for working with molten metals, and magnesium alloys in particular.

- Never attempt to melt wet or damp metals, water can get trapped inside and cause an explosion of molten metal
- Always wear heavy leather gloves when working with metal casting
- Magnesium fires are extremely difficult to put out, and will melt right through your crucible if not extinguished
- Always use a crucible that is up to the task – If you're very careful, you may be able to get a soup can to work, but if the melt spills out and ruins your grill, don't blame us!
- There is some information floating around the net that you can extinguish small Mg fires and prevent the melt from burning by sprinkling some sulfur on – it has been our experience that this causes the Mg to spark and throw burning globs around, but I have spoken to many folks who share our experience, and only one or two who successfully used sulfur. Also it will contaminate your Mg/Al with sulfur/sulfide/sulfate.


### The tough part - Where and how to find magnesium!

Possibly the easiest place to find magnesium is a scrap yard – the only problem is getting permission to go rooting around in the cast aluminum pile. What you'll need is a dropper and a small container of vinegar to test the metal you suspect is magnesium. Put a drop of vinegar on the metal, and if it fizzes, what you hold is primarily magnesium. Magnesium, when aged, attains a distinctly darker gray oxide layer than aluminum – we'll have some samples to see. Good things to look for include old "mag" car wheels, older green mower decks – lawn boy still makes a magnesium deck mower!

Another good place to look is a transmission shop. These places keep the empty housings and sell them to a scrap yard, some transfer cases on newer vehicles are made from magnesium. Sometimes the shop employees will know which ones are Mg and which aren't, but vinegar is cheap and beer can liberate what you find.

If you know someone that works in a foundry, Mg is used to remove sulfur from steel/iron melts, and Si is also used in foundries.

Common Mg alloys are typically 3-6% aluminum, but Mg is rarely alloyed with more than 10% of other elements. Since we won't know the alloy of what we find, we typically add in an extra 5-10% of the magnesium component to our mix, to compensate for this alloy difference and for the oxidation that will happen when you introduce Mg to the melt.

## The "Furnace"

You are welcome to use any sort of furnace or fire/flame you wish to achieve the melt – a friend uses his neighbor's propane forge furnace with great success. We use a charcoal starter chimney. It contains the fire, allows a good updraft around the crucible, has no moving parts and the reduced atmosphere at the top helps to keep the melt from catching fire. Also, they are quite cheap and charcoal is fairly inexpensive. You can even use your own lump charcoal!

## Crucibles

You're going to need a crucible of some sort. It IS possible to use a soup can, we have managed it, but 3 out of 4 times the steel can burns through – literally. The steel is so thin that any excess oxygen in contact with it (say, at the bottom of the can) oxidizes the steel into rust, and typically by the time you've added all your aluminum, you have a nice big hole for it to drain out of.

What we use is a stainless steel drink shaker. The stainless resists the heat very well, does not oxidize appreciably, and they are tapered, so you can cool an entire ingot and it will simply fall out. I picked up ours for $5 each at a surplus place. Also, they come with LIDS – a very handy feature. I welded some up with handles for convenience sake, but pliers or even fireplace tongs, or a loop of coat hanger wrapped around would serve to pick it up and move it.

## Aluminum

Not nearly so difficult to find as Mg, aluminum is easy to procure. There are many alloys we can safely use – all of them. Like Mg, aluminum is typically alloyed with less than 8% of other elements. Here's a short list of the common alloys of aluminum extrusions. Extrusions will be the most convenient source, as they are shapes (like rod or channel) that have been squeezed out of an extruder, like pasta. For what it's worth, cast alloys are very similar in composition to extruded, although more complex shapes like transmissions are typically alloyed primarily with silicon, at 6-8%.

| Alloy | Si | Fe | Cu | Mn | Mg | Cr | Zn | Ti | Zr | Limits†† | | Al |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Each | Total | |
| 2024 | 0.50 | 0.50 | 3.8-4.9 | 0.30-0.9 | 1.2-1.8 | 0.10 | 0.25 | 0.15 | | 0.05 | 0.15 | remainder |
| 3004 | 0.30 | 0.7 | 0.25 | 1.0-1.5 | 0.8-1.3 | | 0.25 | | | 0.05 | 0.15 | remainder |
| 5052 | 0.25 | 0.40 | 0.10 | 0.10 | 2.2-2.8 | 0.15-0.35 | 0.10 | | | 0.05 | 0.15 | remainder |
| 5356 | 0.25 | 0.40 | 0.10 | 0.10 | 4.50-5.50 | 0.05-0.20 | 0.10 | 0.06-0.20 | | 0.05 | 0.15 | remainder |
| 6005 | 0.6-0.9 | 0.35 | 0.10 | 0.10 | 0.40-0.6 | 0.10 | 0.10 | 0.10 | | 0.05 | 0.15 | remainder |
| 6061 | 0.40-0.8 | 0.7 | 0.15-0.40 | 0.15 | 0.8-1.2 | 0.04-0.35 | 0.25 | 0.15 | | 0.05 | 0.15 | remainder |
| 6063 | 0.20-0.6 | 0.35 | 0.10 | 0.10 | 0.45-0.9 | 0.10 | 0.10 | 0.10 | | 0.05 | 0.15 | remainder |
| 7005 | 0.35 | 0.40 | 0.10 | 0.20-0.7 | 1.0-1.8 | 0.06-0.20 | 4.0-5.0 | 0.01-0.06 | 0.08-0.20 | 0.05 | 0.15 | remainder |
| 7075 | 0.40 | 0.50 | 1.2-2.0 | 0.30 | 2.1-2.9 | 0.18-0.28 | 5.1-6.1 | 0.20 | | 0.05 | 0.15 | remainder |

Please note that 6061 is by far the most common extruded alloy – almost anything that has been welded will be 6061, although a number of other alloys can be, 6061 is the easiest to weld by a large degree. Soda cans are 3xxx series, 3004 or similar, with about 1% each manganese and magnesium. If you want to use cans for your aluminum, it is do-able, but use a chunk of aluminum to start the melt, then add cans to the pool of molten metal. If you don't, it's hard to get the cans to make a pool as they tend to oxidize quickly due to the large surface area.

## Getting Started

Now that you have the needed supplies ready, you will need to weigh roughly equal parts Mg and Al, and ensure the pieces are small enough to fit in the crucible. I use my bandsaw at home to cut up mower deck pieces, F1 wheels and aluminum scrap. The batch I made for these pictures was 16oz of aluminum and 17oz of magnesium.

In the picture here I've laid out my crucible, the pile of Mg (left) and the aluminum, which is extruded pipe of unknown alloy, the flat looking piece is cut from a big piece of 6" pipe.


Next I setup the grill – I picked up this little thing in G-let for a whopping $8 at walmart. The charcoal chimney cost more than that, at $10, although I HIGHLY suggest buying the Kingsford brand starter as it's made of better, thicker steel. I pile in about 4" of charcoal, in this case I used the still-burning leftovers from grilling steaks, added a few pieces, set the crucible inside and filled around with more briquettes. I've already set a piece of the pipe inside to heat while the coals get going.

I like to set the next couple of pieces on top of the fire to preheat, it really cuts down on the time needed to complete a melt. Keeping the lid on the crucible helps keep the heat in as well, if you're doing other things around the yard while you melt your Mg/Al, I recommend keeping a lid on it, it will save the melt from oxidizing much before you remember to get back to it.


Here you can see the melt's going strong and the second piece of pipe is nearly melted. There is a method to the madness – the piece of 6" pipe sitting there won't fit very far into the crucible, so it's important to have the melt pool high enough for your next piece! I like to stir the melt with a SS rod, it's not really necessary but it does ensure good mixing and will give you an idea when everything is fully melted and liquid. The molten metal will go through a slushy phase when you add pieces, especially when the fire is young and the melt isn't very hot.

I am not sure if the red color will come out well in the printout, but here you can see I've gotten the melt quite a lot hotter than needed – it's glowing red. Not to worry, just dunk in the next piece. Overheating the melt is not a problem unless you are at the stage of melting Mg. NEVER overheat the melt once you start adding Mg – if the whole crucible of Mg/Al starts burning (more than a pinhead spot here or there) you will lose your crucible, furnace and probably whatever's under it.


Next up is pretty far along into adding the Mg, I did not see much point in showing a picture of every single piece added. As you can see, the paint on the Mg burns quite vigorously when you dunk it in molten metal. If you shove it under the surface too quickly, you can get some bubbling and foaming of the contents. I suggest stirring if this happens, it will help the bubbles move to the surface.



Just like Grandma used to make! Creamy rich Mg/Al goodness. This melt is done – after a couple you will get a feel for when the metal is fully melted. If you let it get too hot, it WILL start burning. Next step is to cover completely with airfloat charcoal – we usually use kingsford but anything will work.

Now that we've alloyed Mg/Al, we need to cool it – I like to quench the crucible in water. Put the lid on the crucible, put a brick or rock in the bottom of a bucket, fill enough so the level of water will be even or just slightly above the level of Mg/Al in the crucible, and immerse! The boiling will be intense, expect a 2lb melt to heat up 3 gallons of water to scalding heat.

Left: After dumping the airfloat off.

Upend the crucible and give it a tap or two on a board to drop the ingot out. Care should be given, as they will sometimes crumble into bits at this point, although it's not too common. We wire brush the tops to get rid of the excess AF and some of the magnesium carbide which forms from the Mg reacting with the charcoal. What you brush off here is incredibly flammable, if you sprinkle it over a fire, it will burn and make little fireballs.

## Processing your new ingot

I don't have any pictures of these stages – sorry – but I will describe them to the best of my ability. We will bring some of our tools to show. First step will be to break the ingot into smaller chunks, just bashing it with a hammer will work brilliantly. If you have made a passfire hammer mill, it would work fantastically. I suggest buying a cheap pot from a thrift store to do your breakup operation in, it will help contain the metal you've worked so hard to make. Once I've got thumb sized pieces, I have a meat grinder I run these through to produce –8 mesh. You will get a huge variety of sizes from meat grinding this stuff, everything from too-big chunks to airfloat.

After grinding, I sieve everything, keep the fractions I like, and the too-big stuff gets coffee ground or ball milled to a usable size.

Now, ball milling Mg/Al can be dangerous. Let me just put that out there to start with. The trick is, determining how long you can mill it before it becomes dangerously fine. I would suggest milling in stages, for an hour or two at a time, until it is as fine as you want it. STOP when the powder goes from looking silver to more of a dull grey color. There is simply no need for it to be finer than this – this size range will make lightning fast $MnO_2$ rockets and flash quite comparable to dark pyro aluminum. It is certainly possible to mill it finer, if you've got the stones for it.

One of the biggest dangers when milling your Mg/Al will be when you empty the jar. Of the several incidents I have read reports of, at least one was caused when pouring the jar out, and it WAS NOT cause by the material becoming pyrophoric – it was caused by the media sparking on something. I believe the media in question was iron or steel, likely ball bearings. So pour that jar out gently, let the media and material slide out in more of a lump than a stream. If the material is going to become pyrophoric, the danger will be far greater if you fluff everything up with a bunch of oxygen!