DIY All-Thread Hydraulic Press with Power Pack

By Mike Garrett

Introduction

Originally published in 2013. Updated in 2026 (blue text).

This article is a summary of the design and building process for an all-thread hydraulic press with a power pack. It was built to press small to medium sized rocket motors, smaller (4" x 4") star plates and other pyro items. At the time I didn't have much practical experience with mechanical systems or hydraulics so building this press was a great learning experience. It gave me the opportunity to dive into the engineering problems of making a useful and reasonably safe powered hydraulic press. Of course, one can buy a press similar to this but what fun would that be? It is my hope this article will inspire others to take the plunge and build their own powered press. But don't be misled, it is very likely your DIY press will end up costing about the same or more than a commercially available model. Not only do you have to consider the materials costs but also all the time required. After you have done the engineering then you must source all the parts, get the frame fabricated (I don't have a mill big enough for this and had to use a fabricator) and then do the assembly. I did this project because at the time most commercial presses were not very portable (but that is different now, see Caleb's small press at Woodysrocks.com) and I wanted to learn about hydraulics. The extra cost was chalked up to education for me.

> ***Standard disclaimer*** – If you build a press similar to this one, you are solely responsible for any and all consequences caused by that action. I, Ned, and anyone else named in this article have no control over what you build, the materials you choose, the engineering performed, or the general quality of your construction. You do so at your own risk and we cannot and will not be held responsible for any damages caused by or consequences of your actions. Furthermore, you will likely use this device on energetic pyrotechnic compositions. Again, we have no control over your actions and therefore cannot be held responsible for the results. As they say, YMMV. Be careful, be safe, and have fun.

Off-the-Shelf or DIY?

My first hydraulic press for pyro use was a manual Harbor Freight 20-ton model like this one in *Figure 1*. It got me started pressing as a beginners' tool, but its many limitations quickly became irritating. Besides the rather poor quality of the press, it was very slow for pressing a large quantity of items. It required 45 minutes or more to press a single 1 lb. motor. I could pound a motor faster than I could press one. At our local club events I would like to build lots of rocket motors for girandolas so a greatly increased rate of production was desired. The rate needed to improve by a factor of two, three, or even more, if possible.

> **Notes from 2026** – There are a few things to consider carefully when deciding whether to build your own press. The first is "just exactly what am I going to use it for?" A general purpose press might be able to use tall skinny tooling like rockets

and short squat tooling like star plates. That means you will need some way to accommodate the large difference in tool height. Whatever method you choose for that must be stable and not prone to ejecting from the press at high speed.



Figure 1. Initial press solution had limitations.

The first powered presses that I saw in person were Kurt Medlin's and Ben Smith's. Kurt had a fairly typical all-thread type powered press. There was a lot to like about it – it was small, powerful enough, and reasonably portable. The only thing I didn't like was the all-steel construction. That's just too much spark potential for my taste. Ben's machine, on the other hand, is mostly built of aluminum and stainless steel which mitigates the spark issue. However, his press is very big, heavy and rather expensive because it was designed to easily press larger items. It can clearly run circles around my powered press for any use above 3 lb. tooling, but the premium in weight and $$ for that future potential was more than I wanted to pay. Some time ago I received a copy of an article written by Robert (Dan) McMurray titled "A 12VDC Hydraulic Press". In it he described a press very much like Kurt's. After reading the article and seeing Kurt's and Ben's presses it occurred to me that I could do that.

Initial Design Considerations

The basic design guidelines for this press were as follows –

- It should be capable of pressing a 3 lb. whistle rocket to 9K psi. At this time I mostly make 1 lb. black powder rockets so designing for a 3 lb. whistle rocket provides some margin and room for future growth.
- It should be light weight and portable enough that one person can lift and set it up at a remote location such as a weekend shoot.
- It needs to be reasonably safe for the operator and anyone close.
- It should use non-sparking materials wherever possible but the hydraulic cylinder, power pack, threaded rods, and hydraulic fittings cannot meet that requirement.
- The power source will be a deep cycle 12V battery such as those used on boats or RV's.

- The cylinders and power pack should be double acting so the press powers both up and down.
- The system should break into 3 pieces for easier transport and setup:
  1) The pressing frame with blast shield and cylinder attached.
  2) The power pack with hoses, and
  3) The battery.
- The polycarbonate blast shield must also provide easy access for loading and unloading tooling and composition increments.



Figure 2. The final press without the blast shield attached.

Design Process

I started by selecting the hydraulic cylinder, and then replaced the tie rods with longer all-thread rods that would be suitable for this purpose. The press frame was next, which involved specifying the top and bottom plate dimensions and tie rods. Following this, I selected the DC power pack and dealt with other miscellaneous stuff. The final step was assembling the hydraulic parts and that was the most challenging aspect for me.

Hydraulic Cylinder and Tie Rod Design

I had two commercial hydraulic cylinders available to choose from. The smallest was a 2-inch diameter by 10-inch stroke tie-rod cylinder with the following specs:

- Maximum hydraulic Pressure, P_{hmax} = 3,000 psi
- Piston diameter, D = 2 inches -> Piston area, A = $(Pi*D^2)/4$ = 3.142 in^2
- Maximum rated force, F = A * P_{hmax} = 9,425 lbs.

The larger cylinder was 3-inch diameter by 12-inch stroke tie rod cylinder with the following specs:

- Maximum hydraulic Pressure, P_{hmax} = 3,000 psi
- Piston diameter, D = 3 inches -> Piston area, A = $(Pi*D^2)/4$ = 7.069 in^2
- Maximum force, F = A * P_{hmax} = 21,206 lbs.

The smaller cylinder meets my requirements so that is the one that was used. I can use the 3" diameter cylinder to build a larger press in the future if the need arises. The four tie rods on the 2" diameter cylinder were replaced with longer pieces of all-thread rod for mounting onto the press frame. The original tie rods are 0.335" diameter with 3/8" x 16 rolled threads. Some quick math indicates that each tie rod must withstand a force of -

- F_{rod} = F/N = 9,425 lbs. / 4 = 2,356 lbs. per rod

Even though the rods are slightly smaller in diameter than the threaded area, it is the threads that are the weakest link. The threads have a tensile stress area of 0.0775 in^2 (tensile stress area charts are readily available online) while the rod has an area of 0.0881 in^2. So the maximum tensile stress on each rod is –

- T = F_{rod} / A = 2,356 lbs. / 0.0775 in^2 = 30,400 psi

If we assume a safety margin of 4x, the tensile strength required is about 122,000 psi. Grade B7 alloy steel comes in at 125,000 psi which is likely what the manufacturer used. The readily available all-thread rod found in the big box stores or the local Ace hardware is of questionable material but very likely has about 1/3 to 1/4 of that tensile strength. I'm not comfortable with the uncertainty of that stuff so I used Grade B7 all-thread rod from either Fastenal or McMaster-Carr, I don't recall which. *Figure 3* compares the Grade B7 tie rods and nuts with those that originally came with the hydraulic cylinder.



Figure 3. Tie rods and nuts (at top) used for press, compared to original tie rods provided with hydraulic cylinder (bottom two).

Press Frame Design

The press frame is fairly simple. It has top and bottom plates which are identical except the top plate has mounting holes and a ram pass-through hole for the cylinder. The two plates are connected with all-thread rods on the four corners. We determine how thick the plates need to be using beam bending calculations. First, we need to know the basic size and material properties. I chose to go with 6" x 16" aluminum 6061 material because that is readily available to me. The threaded rods will be inset from the corners by one inch so that gives an effective bending beam of 6" x 14". The standard rule of thumb for the maximum allowable deflection of a beam is 1/250 of its length. Using that number, we want a deflection that is 0.056 inches or less at the maximum applied force. This press will typically be used at 1/3 of the maximum force so that should be ample margin.

The formula for calculating the maximum deflection at the center of a uniform rectangular beam with support on both ends is:

$$\mathrm{dy} = \left(\frac{F \times l^3}{48 \times E \times I}\right)$$

Some additional information is needed to perform this calculation:

dy – Beam deflection

F – The maximum force applied by the press = 9425 lbs.

l – The effective length of the beam (distance between rods) = 14 inches

E – Young's modulus of elasticity for Aluminum = 10,000,000 psi

I – Bending moment of inertia = B X $H^3/12$

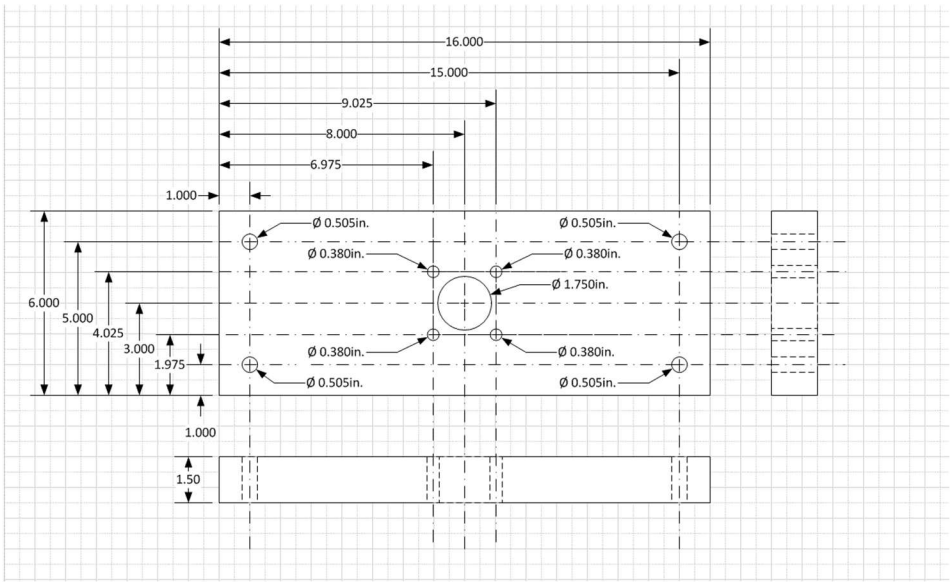
B – Width of plate = 6 in.

H – Thickness of the plate, the number we want to calculate

Substituting, rearranging, and solving for H gives a plate thickness of 1.244 inches. Move up to 1.5-inch thickness for added margin and because that is a more standard thickness for the width.

Therefore, the top and bottom plates are 1.5” x 6” x 16” aluminum. Calculating the expected deflection of each of these plates under maximum force gives 0.032” which is good. Note the deflection is a very strong function of the beam length and beam thickness. Intuitively we know this, but to see the equation and realize both quantities are raised to the 3rd power is an eye opener. Small changes in either length or thickness make big differences in stiffness. See *Figure 4* for the CAD drawing for the plates.

Notes from 2026 - If I were to start over on this press, I would reduce the width between the support rods from 14” to about 10”. That dramatically increases stiffness and reduces the deflection under pressure. The largest star plate that can practically be used with a 2” cylinder at 3,000 psi is only 4” x 4” so there is still plenty of room to work. The extra width has never been required with any tooling that I put into the press. Redo the calculations with a beam length of 10” to see what I mean about the significant change in stiffness – it’s a good exercise and ensures that you know what you are doing when using these equations. Don’t forget to change your maximum deflection (dy) based on your new width like I did the first time ;). Furthermore, you can also reduce the plate thickness (H). The math says it can go down to 0.98” but I think I wouldn’t go thinner than 1.250” just for the extra margin. Regardless, that is significantly less material and therefore reduced weight and cost.



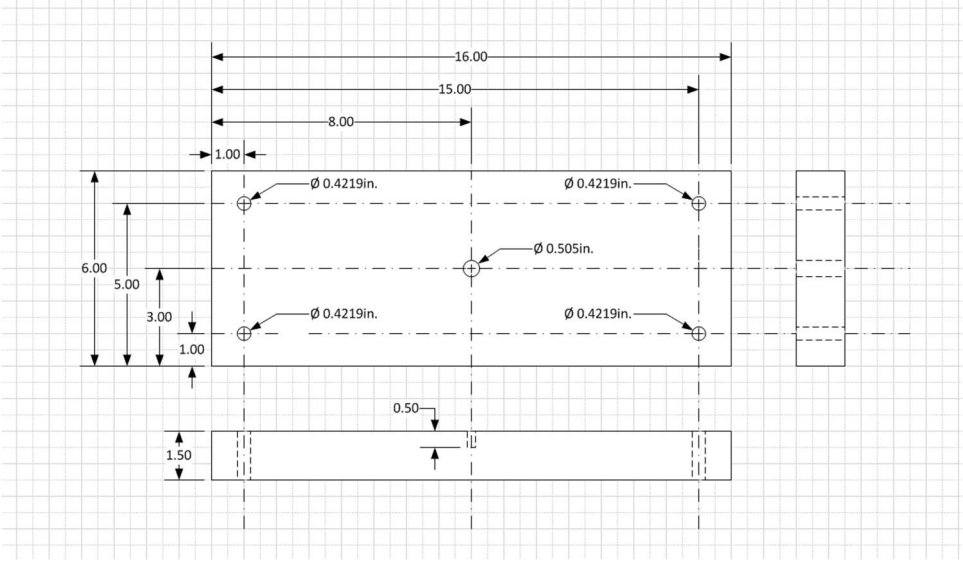


Figure 4. Here is the CAD drawing for the top and bottom plates. Note there is a registration hole in the exact center of the lower plate. Tooling can be made with a pin to fit into this hole to keep everything co-axial for uniform pressing forces.

The final calculation to be performed is for the threaded rods used at the corners. That turns out to be the same as the calculation for the cylinder tie rods. I increased the diameter up to ½" to make the entire press a bit more rigid and less prone to twisting or wracking from unbalanced forces. In addition, the exposed all-thread rods were covered with close fitting aluminum tubes. The tubes perform several beneficial functions for this press:

1. The tubes cover the sharp edges the all-thread by itself presents thereby reducing bloody knuckles when working around the press.
2. The aluminum is non-sparking and that was one of the original design guides.
3. By carefully trimming the tube lengths in a lathe to get four equal lengths we have an automatic alignment feature when assembling the plates to the rods.
4. The increased diameter and smooth surface of the tubing is much easier on the hands when moving the press during setup and tear down.
5. It looks good to my eye. The all-thread rod on the hydraulic cylinder was covered in a similar manner.

We know the top and bottom plates deflect during pressing. Because the bottom bows outward from the ram force the press becomes unstable and can rock during pressing which is not safe. Therefore it is important to have feet extending from the bottom corners of the press. As the bottom plate deflects the feet remain in constant contact with the work bench surface providing stability. Leg extensions were added to further stabilize the press by enlarging its footprint. Small adjustable leveling pad-type feet were installed at the ends of the extensions.

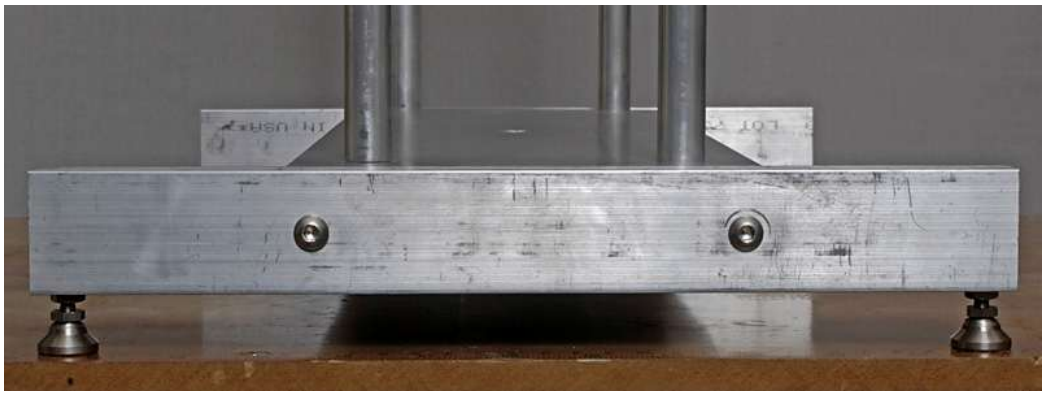


Figure 5. Bottom plate with leveling feet attached.

Blast Shield Design

The leg extension will also be used to secure the blast shield. The blast shield is made from ½" thick polycarbonate sheet. Recall one of the basic design goals stated above was to have a blast shield that did not significantly interfere with the use of the press. A blast shield that moves is inherently more difficult to make and might have strength compromised. A fixed blast shield is simple to make and can be quite robust. The problem is to make a fixed blast shield that is not a pain in the rear to use. Lloyd S. gave me a very good suggestion to solve that problem. The blast shield can attach to the end of the press 90 degrees from the 'normal' position. The operator only needs to move from the front of the press when loading/unloading to the end of the press when pressing. To make that procedure efficient requires setting the press up on the corner of a sturdy work surface. The operator then only needs to move about 2 feet left and right during operation. Slick!

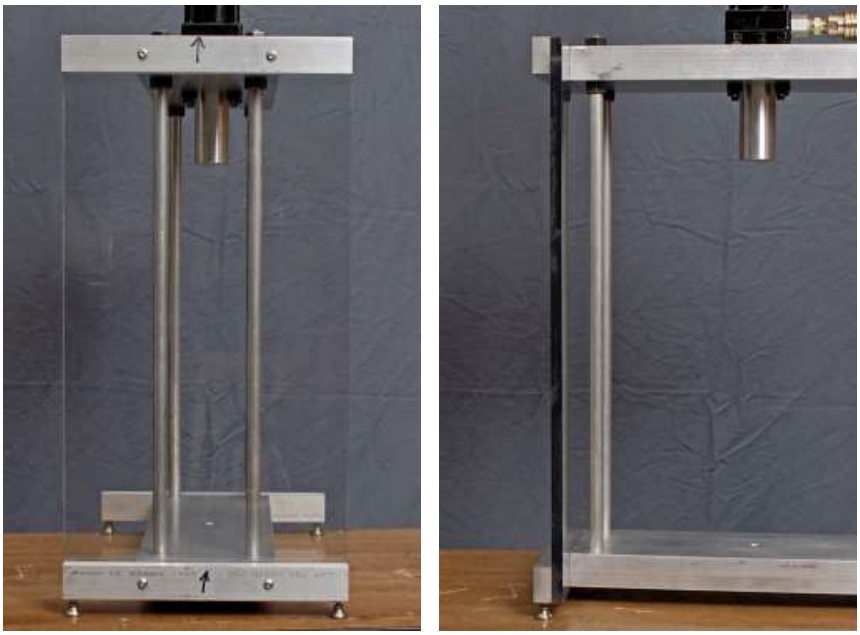


Figure 6. Blast Shield is attached to one side of the press, giving easy access to the front of the press for loading and unloading.

DC Power Pack Selection

The double acting DC power pack I chose for this press is an SPX model sold by Surplus Center. There are other power packs that will work as well. This power pack was originally intended for snow plows, lift gates, car lifts and similar applications where holding position without applying power is important.



Figure 7. DC power pack has a "center hold" feature.

Hydraulic hoses and other miscellaneous bits

The hydraulic hoses chosen are 12 feet long so the electric motor on the pump is some distance away from the press frame. This is a safety concern when working around energetic pyrotechnic compounds. You may want to increase their length to suit your personal comfort rating.

The ram on the hydraulic cylinder is threaded to accept a screw on clevis connector. The clevis connector is removed for our purposes. That leaves a not-so-perfectly-flat steel ram exposed for pressing. The clevis connector on the 'head' end can either be left as is or removed. I chose to cut it off in a band saw leaving a shorter and smother assembly. This photo is representative of the type hydraulic cylinder I used but is not the exact one.



Figure 8. Hydraulic cylinder has clevis connectors on both ends that I removed for my press.

Recalling the initial design guideline of minimum spark producing materials I have made aluminum 'shoes' for the ram end. They are simple in concept but rather difficult to make without CNC milling capability for the internal threads. A drawing of the shoes is below. I made several different lengths to accommodate different tooling sizes. They simply screw on to the ram and so far have not been prone to loosening during use.

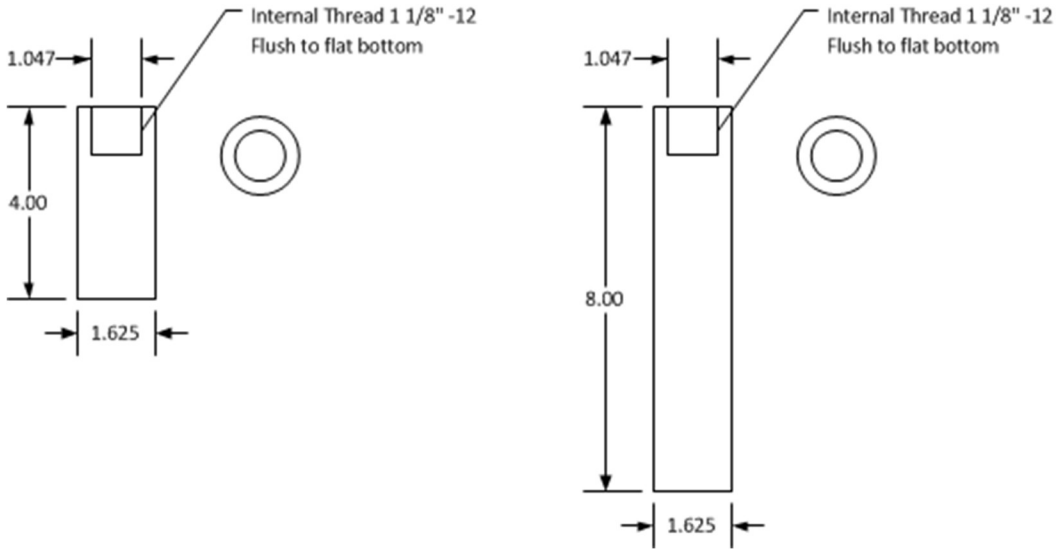


Figure 9. CAD drawing for ram end "shoes" with internal thread to connect to the ram.

Hydraulic Design

The hydraulic part of this press gave me the most anxiety before starting the project. I simply had no experience in the area of hydraulics and it seemed like black magic or some other related dark art. It turns out that was far from the truth. Hydraulics is well understood and when you get a few concepts in your head it all just falls into place.

The power pack has several subsystems already put together which greatly simplifies this process. It has a reservoir for hydraulic fluid, a pump to move the fluid and create pressure, valves and ports to direct the flow in the correct direction, solenoids to control the valves and ports, an electric motor to drive the pump, and a solenoid to connect the motor to electric power. Hoses, fittings, gauges, flow control valves, and quick disconnect couplers allow the hydraulic fluid to be pumped from the reservoir on the power pack into the cylinder to do the work at hand. The power pack can

be operated by either an electric switch control or a mechanical valve. I choose the pendant control due to the remote location of the power pack. The pendant has a 10 foot long cable. I did have to rewire the internal switch connections so the pictures on the buttons would correspond with my press. The pendant apparently is intended for lift gates or car lifts where the UP arrow corresponds to extending the ram. I this case, pressing, the DOWN arrow needs to correspond to extending the ram.



Figure 10. UP-DOWN pendant-style controller for hydraulic ram – check the direction the ram moves when pressing each button. For my application, the direction was reverse of the arrows!

A laundry list of all the fittings that I used for my particular press could be given but it really won't be correct for your application. If you choose to build a press like this you will have to go over the entire hydraulic schematic and make sure that you have all the correct fittings to make the connections. For reasons beyond me, hydraulic systems seems to use a mixed bag of various standards for fittings. You might see National Pipe Tapers (NPTF), National Pipe Straight Mechanical (NPSM), SAE 37° Flare also known as JIC, SAE Straight Thread O-Ring Boss (ORB), SAE O-Ring Face Seal (OFS), and possibly others. The good news is that each component specifies the type of connection it uses. The bad news is there are a large number of possible combinations. My press system has SAE-06 and SAE-08 O-Ring Face Seals as well as NPTF connections. The Power Pack and cylinder use the SAE connections while all the stuff in between them is NPTF. Just be methodical as you consider each elbow, coupler, and connection. Use a hydraulic rated pipe thread compound on each connection to ensure a good leak proof seal.

Be sure to include a pressure gauge on the pressing side (ram extension) of your system so you can monitor the hydraulic pressure. The measured pressure and the area of the cylinder piston give the applied force. I included a flow rate control valve on the ram extension side as well. Without it the ram this small diameter cylinder moves downward very fast and is difficult to control in some

circumstances. A flow rate control valve is not needed for larger cylinders. If your power pack can produce 2.4 gallons per minute (gpm) or more and you build a press with a small cylinder then consider a flow rate control valve. The flow control valve is adjustable from about 8 gallons per minute to zero. It has a check valve so the ram retract speed is at the full fluid flow rate. My flow control valve is usually set between 1.5 and 2 gpm to get a nice smooth controllable speed.



Figure 11. Pressure gauge and flow rate control valve enhance safety and control.

One of the initial design guidelines was to have the system break down into manageable subsystems for ease of transportation and setup in remote locations. Disconnecting the power pack from the press frame is required to achieve that. Quick disconnect couplers such as these were used.



Figure 12. Quick-disconnect couplers make it easy to break down the system.

The Press as Built

Weeks of planning, thinking, calculating, and asking questions finally had to come to an end. The hydraulic press with power pack needed to become reality soon because DO-IT 2013 was only a few weeks away. There was no way that I would be denied my full dose of rocket motor and

girandola construction for another year. Addiction is a strong force. So I sequestered myself in the shop and this is the final product.



Figure 13. The finished press (without blast shield) from several angles.

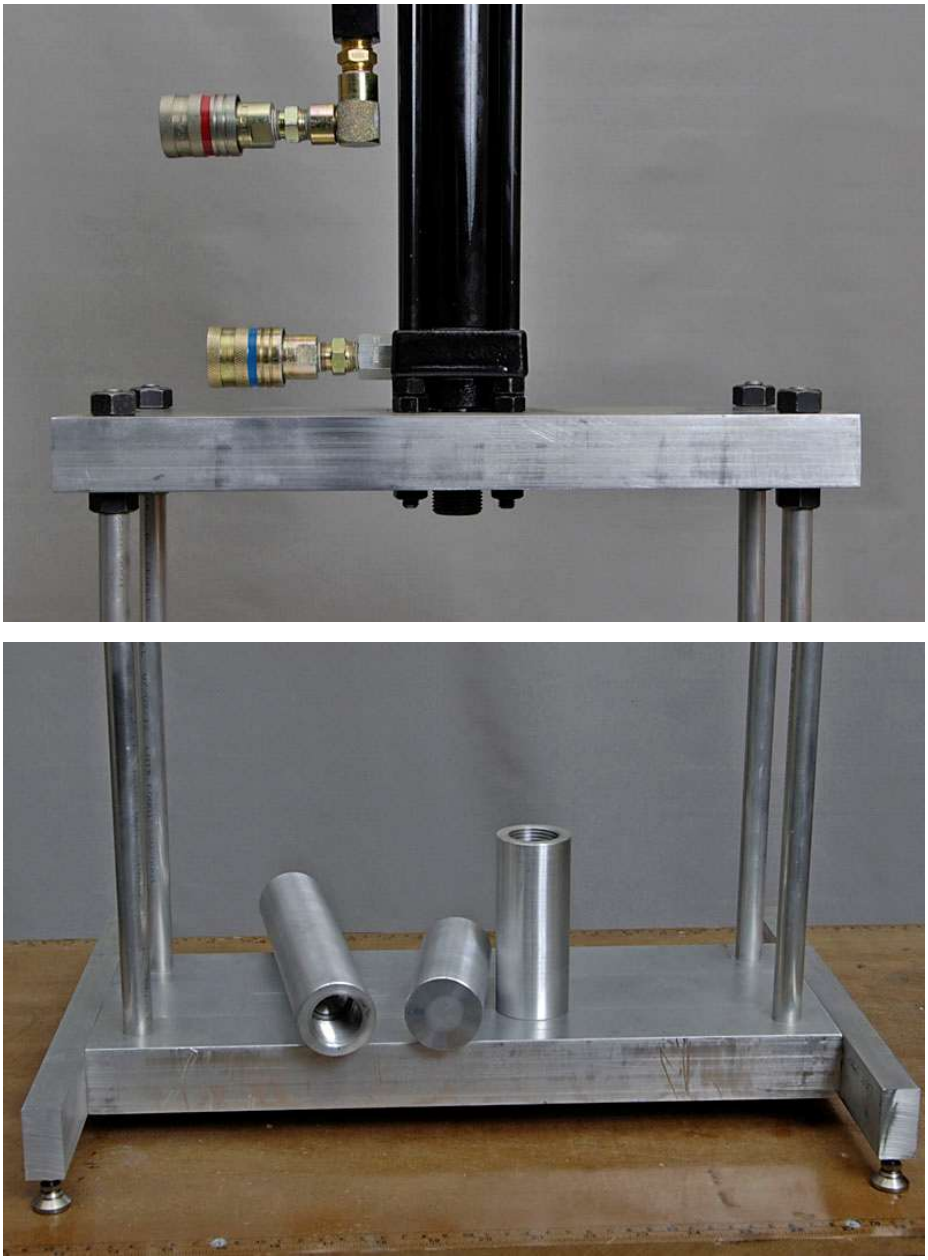


Figure 14. Close-up views of the upper plate and hydraulic ram couplings (top) and bottom plate with several ram-end "shoes".

Notes from 2026 – The "shoes" shown above did three things for me. First they fixed the issue where the threaded ram wasn't flat and smooth. I didn't have a lathe large enough to fix the ram problem. Second, with a few different lengths they eliminate any riser blocks needed with short tooling like star plates. Third, they covered the steel ram with aluminum which I preferred. Clearly, a nicely machined ram end and a set of riser blocks solves all those problems except the last one. I'm less worried about that exposed steel ram now knowing that everything else around it is aluminum or stainless steel.

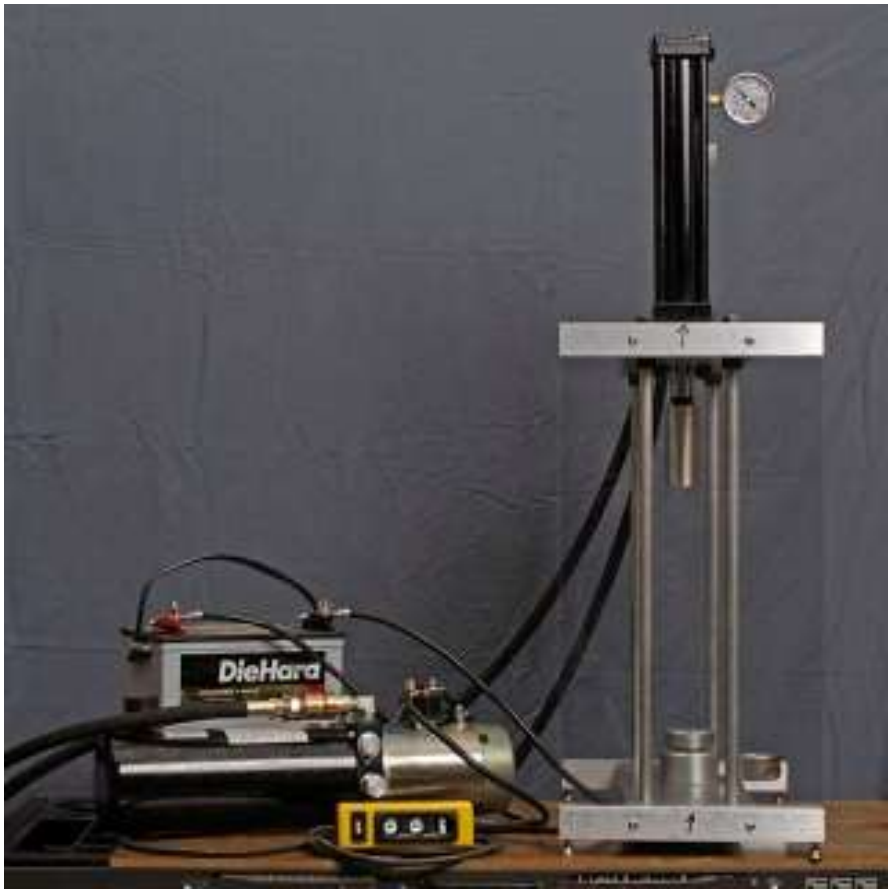


Figure 15. Final assembled press with blast shield.

Review and Conclusions

The final press was checked to be sure it met the design requirements, and it can indeed generate a maximum force of slightly more than 9K pounds. The typical force that will typically be used is closer to 3K pounds so there is plenty of margin in the design.

Deflection of the top and bottom plates under full rated load was measured to be approximately 0.038" and 0.036". That is a bit more than expected but still acceptable.

The final weight of the press frame with blast shield attached is about 60 lbs. That is a manageable weight for one person to move and set up at a remote location. The power pack and battery each weigh less than the frame so the portability requirement has been met. Aluminum was used as a construction material where ever possible to reduce weight and spark potential.

The original battery chosen had AGM technology which inherently has good deep cycle capability and is physically robust. That battery served for over ten years with a trickle charger on it. I have since upgraded to a $LiFePO_4$ type battery. If you go with that solution, be sure to verify that the Battery Management System (BMS) circuit built into the battery allows for a maximum output current of at least 300 amps. These hydraulic power packs draw tremendous currents under load.

Finally, the blast shield has a novel attachment location which greatly simplifies its construction and still provides the necessary safety and desired ease of use.

Notes from 2026 – If you build a shorter press which will mainly press stars and inserts in plates then you almost certainly want to go with a 3" (or larger) cylinder. The larger your star plate, the faster you can make large quantities of stars. Since the time I built this small press, I have acquired a larger 3" cylinder model. Six-inch plates work very well in that press which doubles my production rate for stars compared to the 4" plates but still is a lot of pressing for say a 6" 3-break Italian shell. Size does matter but 6" star plates are the largest commercially available currently. If you can make your own plates or can get custom plates fabricated, then your budget is the limit. Realize that the minimum practical hydraulic pressure is probably somewhere around 200 to 300 psi. When using a 3" cylinder that is still a lot of force if you attempt to press with small tooling like an 8oz. rocket or small comet pump. What that means is you may find there are two presses in your life – a small one and a larger one.

I would strongly suggest putting a pressure control valve within easy reach mounted to the press frame. Making pressure adjustments on the power pack quickly becomes tedious. Set the power pack adjustment to maximum pressure and do the fine control with a convenient knob mounted on your press frame.

I have had trouble with hydraulic lock where there is pressure in the lines that cannot be released. That makes it nearly impossible to reconnect a pressurized hose into a quick disconnect fitting. There are at least two solutions. First is to relieve that pressure with some sort of valve or simply loosen the threaded coupler until a few drops of fluid come out. Simple but messy. Do be careful not to get a squirt of hydraulic fluid into your face or eyes. The second option is a hydraulic quick disconnect tool that I have not actually used but have been told works well. It's a modified wood clamp with fittings which grab and compress the quick disconnects into place.