Steam Brake Cylinder

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There are two major components to the steam brake system, the cylinder/pistons and the valve. The cylinder/pistons are fairly straightforward and described here. The brake valve is a more than a simple on/off -- it's usually three position --- "brakes off", where the cylinder is vented to the outside, "brakes on" where steam is applied to the cylinder and "brakes hold", where both the steam supply and vent are closed. The plan is to postpone making the brake valve and instead initially implement the function with a couple globe valves.

Kenneth provides a drawing for the steam cylinder but it didn't seem to match my recollection of the steam brake cylinders I'd seen at Cass. As I recalled, the back portion was bigger diameter, since it applies the brakes to both the middle and rear trucks. Before making the trip to Cass in the spring of 2003 I checked some photos of Cass No 5 taken in the fall of 2002. The photo below shows that the cylinder is the same size front and rear (so much for my recollection of the two ends being different sizes), but the rear portion is set a couple of inches lower. Also, the total cylinder is about 1/3 longer than Kenneth specifies

In the spring of 2003 I looked at Cass 10 first, a yet to be restored Shay that is bare bones with the brake hardware exposed as

shown above. The brake cylinder is one piece uniform diameter rather than the two pieces as on Cass 5 shown earlier. It's also shorter than the cylinder on Cass 5 --- in fact, it's a pretty good match for Kenneth's specification. I was curious why the uniform diameter since the rear part should do double duty --- the middle and rear trucks. Upon closer inspection (crawling underneath) it was discovered the middle and rear trucks aren't linked. Further, there are air brake units connected to all three trucks. So, Cass 10 had steam brakes on the front and middle trucks and air brakes on all three trucks.

Then it was on to Cass 5 since I was pretty sure that the middle and rear trucks are linked. The trucks are indeed linked. Also, the cylinder was changed between the fall of 2002 and spring of 2003. And no, the pictures aren't of some other locomotive --- I have photos that include both the brake cylinder and the number on the side of the cab for both 2002 and 2003. They changed the cylinder over the winter. The rear part of the new cylinder is much bigger diameter as shown in the following two photos.

Isn't it neat to see the steam?

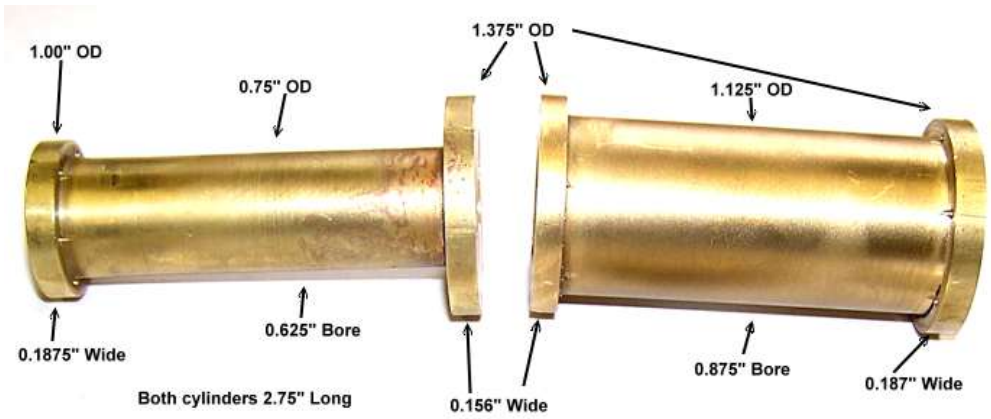
So, which should I model? The cylinder above with the two different outside diameters seems more interesting so I decided to go with it. Note that I don't link the middle and rear truck brakes; I use the rear truck for the park brake. That would suggest the pistons should be the same size. However, to get near scale dimensions I want to cut the forward piston from 3/4" diameter of Kenneth's specification to 5/8" diameter. This of course reduces the braking force. To compensate, I'll make the rear piston 7/8". One rationalization for this is that the rear truck will have greater weight since it carries part of the engineer's weight so it

can stand a bit more braking force. If the middle truck locks up too easily, I'll have to connect the rear truck --- maybe a project for the future.

Machining Cylinders: Machining the cylinders was straightforward. The tricky part is to shape the heads and glands and to layout the head bolt patterns. Years ago I made a fixture to mount the lathe chucks to the rotary table. I used that fixture as shown on the right to shape the glands and mating surface of the heads. After shaping the glands I replaced the end mill with a center drill, got everything aligned properly and marked the first bolt hole with the center drill. I then rotated the table 60 degrees to each new bolt location. This was repeated for the other head. I also made a drilling fixture similar to a head for the bolt pattern between the two cylinders and marked the pattern on the fixture using this same setup.

This is a close -up shot of machining the sides of the gland and the mating section of the head. After the milling cuts, the sharp corners were rounded with a file.

Theses are the finished cylinder parts



The photo above shows the major dimensions of the cylinder. The smaller cylinder was made from 1" bar stock with a 1.375" OD ring soldered on the one end to make the larger OD flange. The head and gland flanges are 0.125" wide. The bottom of the cylinder flanges at the outer ends of the cylinders are tapped MTP 1/8" for the steam input. The part of the heads that slides into the cylinders are grooved on the bottom to provide a passage for the steam from the 1/8" hole into the cylinder. All holes are for 2-56 screws.

The inner end of the smaller half of the cylinder was left partially closed as shown on the right. This is to keep the small piston from entering the larger bore side. The slot on the end is part of the vent hole at the center of the cylinder. The hole at the end of the slot is into the bottom of the smaller cylinder to allow any water to escape. The threaded steam input hole is visible at the far end of the cylinder.

This is the assembled cylinder with a 1/8" nipple in one of the steam input holes. The screws are temporary. I need to order a box of stainless 1/2" long 2-56 screws. Will screw them in with Loctite and then cut off the heads to make studs. Then will use small pattern stainless nuts on the studs. (McMaster Carr has a good price on small stainless screws.)

Brackets: A bracket of sorts in needed to attach the cylinder to the locomotive frame. The photo at right show the top of the bracket for the smaller part of the cylinder on Cass No 5. A similar bracket is welded to the larger part of the cylinder. The earlier photos shows that the brake piston rods for Cass No 5 are several rod diameters below the bottom of the frame. The piston rods for Cass No. 10 are up just below the bottom of the frame. I prefer to keep the cylinders and rods as high as possible and the brake levers against the bottom of the frame.

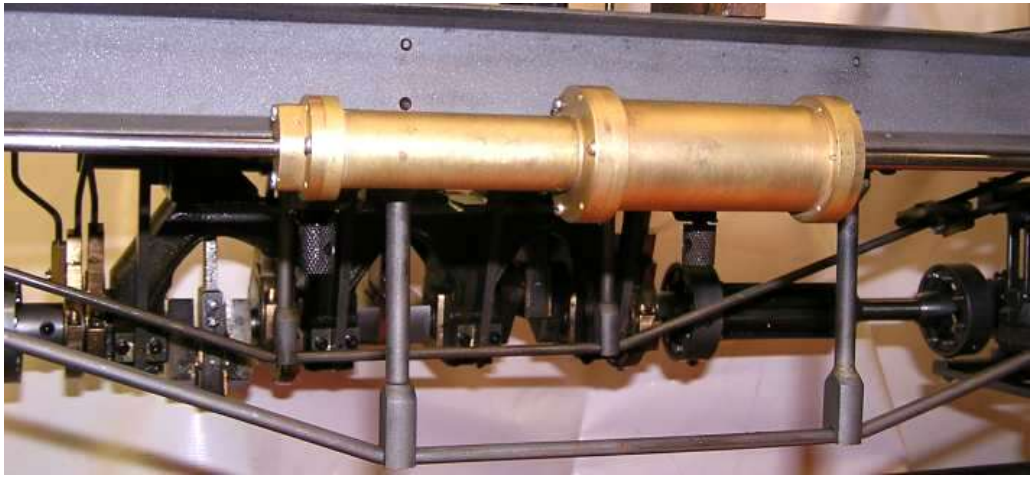
This shows the under side of one of the brackets beside one of the queen posts.

The simplest solution seemed to be to mill 3/16" wide slots in the end flanges and silver solder 3/16"X 1/2" brass bars in the slots. The slots give the joints extra strength and helps keep the bars positioned when soldering. After the soldering, the ends of the flanges were filed smooth and the head bolt holes in the bars drilled and tapped using the heads as templates for the holes.

This is the top view of the assembled cylinder. The brackets will attach to the bottom of the frame I beam with a couple screws.

Pistons: The pistons were turned from scraps of bronze left over from making the bearings. The rods are 3/16" stainless steel about 10" long. They'll be cut down to the correct length after the brake levers have been installed.

O-rings are required: 5/8" OD -7/16" ID for the little piston and 7/8" OD - 11/16" ID for the big piston. If you do the arithmetic, the O-rings are 3/32" cross-section. I'll use the EPDM type from McMaster Carr.



This shows the brake cylinder clamped in position; a close match to the cylinder on Cass No. 5.

Have to put the up the Shay project for a while as I do something else. Hopefully the boiler will arrive and be ready when I get back to the project in a month or so.

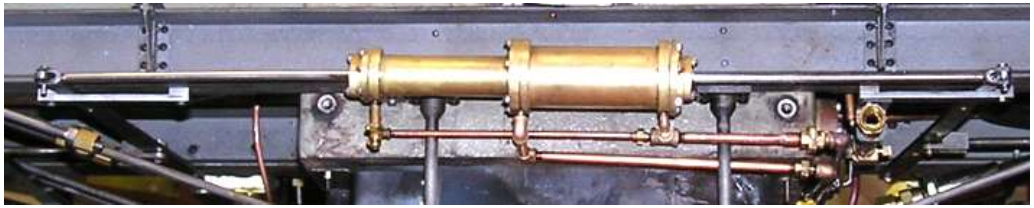
Update 12/14/03: Since this page was first done several brake valves have been made and the brake system tested on both compressed air and steam. The following changes were made after these tests:

- The tender brakes were linked to the middle truck brakes so that all three trucks have steam brakes like Cass No 5. This linkage is show on Brake Links page.
- The vent hole in the center was threaded 3/16" MTP to implement the brake backoff function (see brake valve page for description of backoff). The photos of the Cass 5 cylinder show the pipe connection to this hole.
- The #2 screws were replaced with #2 studs (screws with heads cut off).
- The clearances between the piston and cylinder and the stem and the packing gland were increased to make sure there is no binding. The stem is very long and it is difficult to align the brake levers perfectly. The final cylinder and stem clearances are ~0.015. The fit is sloppy but the O-Rings easily take up any slack.
- While the boiler pressure maxes out at 100 psi, the pressure is not always at max and we want the cylinder friction forces to be small compared to the operation forces. To this end, the unloaded piston was tested on about 20 psi air and adjusted so that it moved easily. The O-Ring gland depth is normally made so that there is 0.010" to 0.018" squeeze of the O-Ring (see Macro Rubber Website http://www.marcorubber.com/glands_dynamic_reciprocating.htm). This amount of squeeze resulted in too much friction so the gland depth was increased to make the squeeze about 0.005". The piston moved much smoother and there didn't seem to be any leaks.

The Macro Rubber website (http://www.marcorubber.com/index.htm) has a nice compatibility chart for O-Rings. They list EPDM as **"recommended"** for steam at 300 degrees or less but **"not recommended"** for steam over 300 degrees. The temperature of the 100 psi steam in the boiler is 337 degrees. This will be cooled somewhat when it gets to the cylinder, assuming it's actually 100 psi in the boiler. Also, there's probably a little margin in the upper limit, so we should be safe.

McMaster-Carr carries two different types of EPDM O-Rings. The following is the McMaster description of the one I choose: *NSF-Approved Ethylene Propylene (EPDM): Perfect for water transmission systems, this ethylene propylene (EPDM) meets ANSI/NSF Standard 61, which limits the amounts of chemicals permitted to leach into drinking water. It has excellent chloramines and compression-set resistance. Also meets FDA requirements for repeated use in food handling. Durometer is Shore A: 70; temperature range is -40° to +300°F.* The EPDM is not compatible with petroleum products so don't use any grease to lubricate the cylinder ---- the O-Ring will swell and get sticky (experience speaking). The condensate water is a satisfactory lubricant. If a lubricant is needed to get the piston in the cylinder, one could use soap or animal fat (butter) or vegetable oil (olive oil, corn oil, etc). McMaster-Carr sells the sizes used for the cylinder for in packages of 25 for about $5.

The following photo shows the cylinder in place and connected.



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