Combe Mill

Maintenance of Beam Engine Cold Well – Winter 2010/2011

Contents

These notes describe:

- -- The history of malfunctions in the condensing system of the Beam Engine in 2010.
- -- Work done in the winter of 2010 - 2011 to diagnose and remedy the problems.

HISTORY

From notes supplied by David Jones, 19th January, 2011.

The purpose of these notes is to put on record, as far as memory allows, the various symptoms of trouble in the condensing system and the order in which they occurred.

Symptoms

These are listed individually, although they are likely to be inter-related:

a) Zero vacuum on first start up accompanied by clouds of steam from the cold well. After 2 or 4 restarts, the vacuum begins to build and steam clouds dissipate. Thereafter OK for the day, engine being kept running with no more stops. Occurred in July (?) and certainly in August, September and, at start of day, in October.

b) Condenser and air pump moving up and down as the engine runs. Probably observable before July but not taken seriously until the wood packing blocks underneath the condenser came free and were found floating about in the cold well. It was found that the condenser + pump unit was attached to the wall of the cold well only by the bolts holding the pump against the opening to the hot well; these bolts were loose. Between the July and October steamings various remedial measures were applied.

These included tightening the bolts as far as possible, fitting new wood wedges underneath the condenser and fitting studding to (i) hang the condenser from an angle beam supported from the rim of the cold well and (ii) later, to hold this beam down, so the condenser was fully restrained vertically.

Studding supports

Wooden wedges under manifold

(c) Condenser spray valve sticking so the handle could not be turned to vary the opening. This sometimes occurred when we tried to vary the opening in response to the zero-vacuum symptom. Between the September and October steamings Eric Cooper was consulted about the design of the valve and steps were taken to ensure that the operating handle was correctly located in relation to the open/shut positions of the valve; the valve was greased and moved freely.

(d) Packing blew out of the joint between the exhaust pipe and the condenser. This happened at the October steaming. By this time (i) the condenser was firmly held in position against upward and downward movement by the studding mentioned above in (b); and (ii) the spray inlet valve could be opened and closed freely. The situation was complicated by the failure of the electric motor driving the forge blower at the far end of the forge and the decision to re-instate the belt drive from the line shaft to do its job.

The sequence of events in October 2010 is thought to be as follows:

i) On the first start we again experienced the "zero vacuum and clouds of steam" effect.

ii) We embarked on a series of re-starts.

iii) On one of these, there was a loud "pop" from the cold well.

iv) Ignoring that "pop", we went on re-starting and eventually achieved something like normal running.

v) The engine was stopped for a long period for the belt replacement in the forge. The small engines went on running and the circulation between their condenser and the cold well continued, causing the cold well water to become quite hot as there was no flow to remove the heat.

vi) On restarting after the long outage, we again got "zero vacuum and clouds of steam".

vii) In the course of this restart or a subsequent restart there was another loud "pop" from the cold well and it was clear that the packing had blown out of the exhaust-to-condenser joint. Running was abandoned.

Possible Causes

Of the four troubles listed a) and d) require explanation. The other two may well have some bearing on the causes.

As regards a), the "zero vacuum and clouds of steam" syndrome, Tony Penry suggested early on that the symptoms were consistent with the condenser being initially full of water and it is perhaps significant that when consulted in early October Eric Cooper advanced the same notion without being prompted. The idea is that if the exhaust steam cannot get into the condenser, as it is full of water, it cannot condense and escapes through the inlet pipe of the condenser spray, bubbling up through the water in the cold well. After a few restarts the air pump has lifted the water out of the condenser and normal service is resumed.

The difficulty is to explain how water could have filled the condenser. If there was a leak anywhere in the condenser+pump unit below the water level in the cold well then the practice of filling the cold well in advance would give the condenser ample time to fill up to that level.

The issue was addressed before the September steaming. A bad leak was found at the top of the air pump in the flanged joint between the barrel of the pump and the top end plate, and filling the condenser with water when the cold well was empty revealed no leaks below that level. For the September steaming the cold well was initially filled to a level below the top flange of the air pump but the symptoms recurred on the first start. However, it is possible that on that occasion the water level was above the outlet port in the side of the air pump where the gasket was inadequate and the bolts loose, so water could have got in that way. The "water filled condenser" remains an attractive hypothesis not fully explained.

The notes by John Ross below suggest that the clouds of steam could have been leaking past the loose packing in the exhaust-to-condenser joint and that the poor vacuum could be explained by the leakage of air inwards past the loose packing [*Sorry, JR should have said these effects would not be **simultaneous** !].* It would not be surprising if the packing had been loosened by the up and down motion of the condenser, but there is no other evidence that it had been. It survived 3 or 4 steamings after that motion was first observed before it blew out in October and then it blew out explosively with loud "pops". That suggests that up to that point it had been firmly in place doing its job.

The zero vacuum and clouds of steam occurred simultaneously and we can't claim that a leak was letting steam out at the same time as allowing air in to spoil the vacuum. Moreover the zero vacuum occurred only in the early stages of the day's run. When everything had settled down the vacuum was pretty good and it was steady, not fluctuating as it would be if it depended on the action of the air pump.

Trouble d), the packing blow out, remains to be explained. If as has been suggested we can't invoke loosened packing in the exhaust - condenser joint to explain the zero vacuum, etc., and up to October that packing was still in place, why did it blow out then? If the blow out was in some way linked to the other troubles, why had it not happened before?

One step taken between the September and October steamings was the attention to the condenser spray valve. This was now fully under our control and Davie Jones thought that if the clouds of steam were coming from the spray inlet pipe then we would suppress them by closing the valve. He remembers that he tried this but he can't recall if it was closed at the time of the blow out. It may well have been closed and if it was and the condenser was indeed full of water then the exhaust steam would have had nowhere to go and could well have forced out the packing with the explosive "pops" we heard. [*But JR doubts if we would see any steam emerging via the spray inlet pipe as he expects it to be fully condensed before it could reach the water surface.]*

Tony Penry has made a further observation about our troubles at the October steaming. He points out that in the long interval while the belt to drive the forge blower was being fitted, the water in the cold well was still being circulated through the condenser for the small engines but was not being cooled by fresh water from the river. As a result it became hot and would have been much less effective at cooling the exhaust steam from the beam engine when the engine was restarted.

Conclusions

Since the above symptoms were observed a great deal of dismantling and remedial work has been carried out as described below. In the process, the packing around the exhaust-condenser joint has been replaced and the possibility of water leaking into the condenser from the cold well has been addressed by extensive renewal of gaskets.

It remains to test the condensing system in steam. If the zero vacuum etc., syndrome recurs we shall have to think again, but it is suggested that it is important that the spray inlet valve be kept open to provide an alternative escape route for the exhaust steam.

Also, we should in future bear in mind Tony Penry's point about the effect on the temperature in the cold well of prolonged running of the small engines in the forge, when the beam engine is stopped.

A further point for consideration concerns the supports for the condenser. Its weight was borne on wooden blocks jammed under it until, as noted above, they floated out in July. The blocks were replaced but after that the arrangement of studding was installed which suspended the condenser by its top flange. When this was mentioned to Eric Cooper in August he said he thought it undesirable that the whole weight of the condenser should be carried by the top flange. Perhaps we should, when the opportunity arises, make sure that the wood blocks are doing a share of the work.

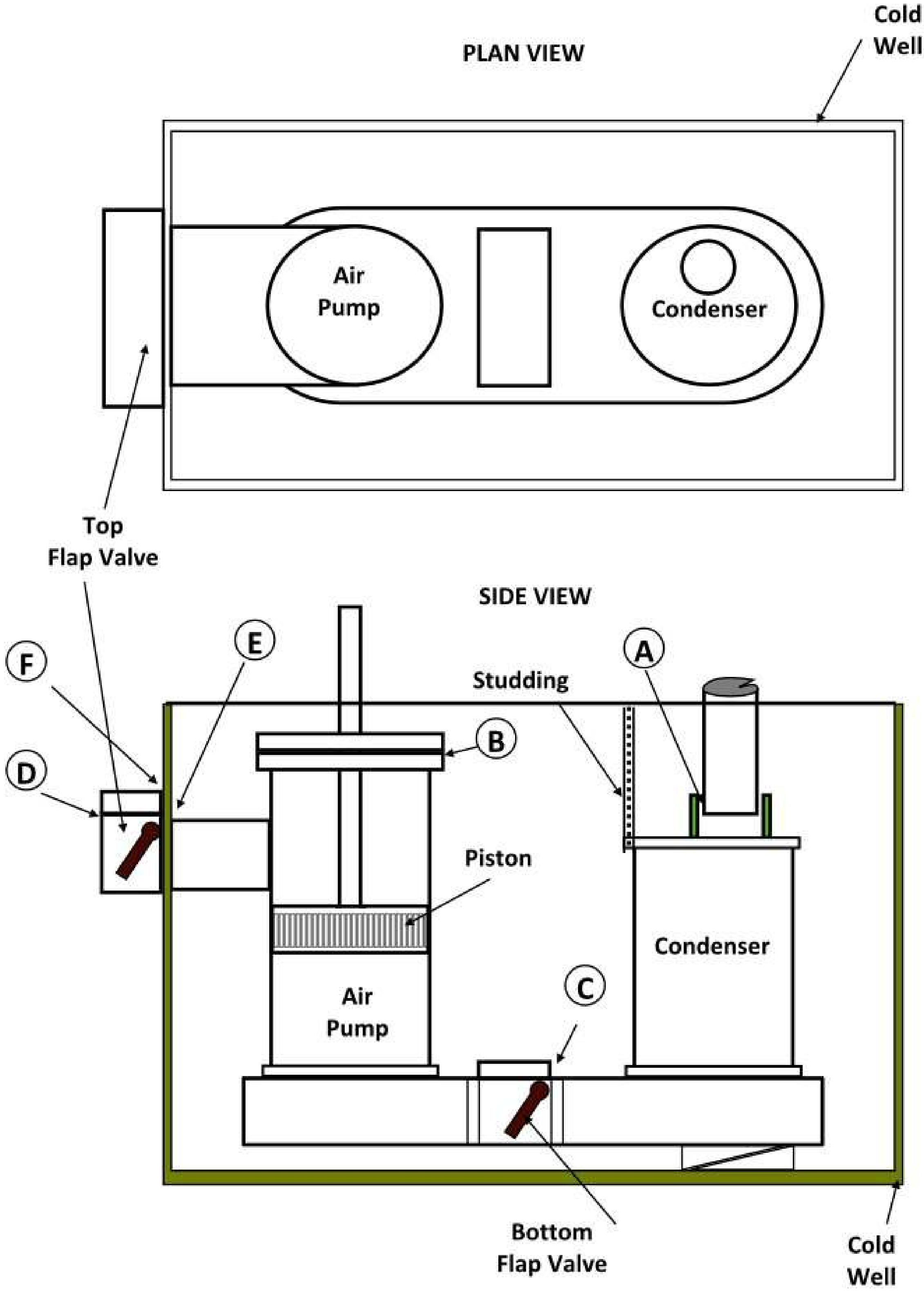


Diagram of Cold Well items referred to in the text

WORK DONE

From notes written by John Ross between 22nd Oct 2010 and 8th February 2011

These describe the repairs made to the beam engine, condenser, air pump and cold well in that period.

22 October Investigating the cold well. Last steaming, the gland packing around the steam entry to the condenser blew out and we had been having problems with water in the condenser and poor vacuum. We knew there was a big leak on the top flange of the pump which was found by filling the condenser and pump with water in August.

Removed the remnants of the gland packing and recovered most of the small wedges holding it in place; width of groove 3/4 inch, height of groove about 3 to 4 inch. See A on diagram.

Removed the top wedge in the piston rod, and checked the alignment of the rod. It was good and had not been mis-positioned when we put in the studding to lift up the condenser and restrain its vertical movement in August. Noted that to maintain good alignment of the air pump piston rod, it is important that the vertical position of the condenser is well defined as it can to some extent pivot around the wall of the cold well

Removed the bottom wedge, removed the piston rod. Removed the pump top flange: bolts were slack, the gasket was very poor and missing in parts. See B on diagram.

Missing wood strips on air pump piston

Flange has to be removed first as it is larger in diameter than the gap in the beam engine base. Removed the piston and short rod. The piston seals are axial wood strips and 25% were missing and the rest had been worn down to the steel rings above and below the strips.

All strips must be replaced and then machined down to give a good fit to the bore.

Piston flap valves were in brass and both seemed in good order.

Removed the cover plate over the bottom flap valve. Seemed in good order. Tried to lift out the valve but not possible. Left as is. New gasket needed 3 x 180 x 430 mm. See C on diagram.

Cold well bottom flap valve seen from above

24 October Filled condenser with water while jamming the bottom flap valve shut. No real leakage seen from the condenser.

Looked at bolts at the base flange of the condenser; most nuts have rusted away / broken up and JR wanted to replace them all; found that there is a problem with this. The bolts that are above the tunnel where water flows to the bottom flap valve are in fact studs with a nut above and below and the tunnel height is much less than the stud length. So to remove them we have to first remove both nuts from the stud and then pull the stud out upwards; accessing the bottom nut has to be via the tunnel!! Ron R suggested we leave as is for now and if it ever is needed we will have to fit a number of strong 'C' clamps to close the flange and make the bolts redundant.

This same design applies to the corresponding bolts (studs) at all flanges on the condenser bottom and the pump top and bottom flanges, so take care not to shear or slacken these particular bolts !

Small engines' condensate system pipes

Identified the pipes on flywheel side of cold well tank: Steel pipe through wall of cold well supplies cooling water to the small engine condenser via the Weir pump or, alternatively, via the small green pump driven by the Bradford. 2" copper pipe over the side returns cooling water from that condenser. Plastic pipe delivers condensate coming from that condenser via the grey pump driven by the Bradford.

With water filling the bottom flap valve recess (cover plate off) there was no drop in water level in 30 to 45 minutes, so no leakage below this height.

Next: Survey bore of pump and entry diameter. Fit gasket and bottom flap valve cover plate; fit packing and wedges to exhaust - condenser joint; make good piston and re machine; look at top flap valve; refit piston and top flange.

Suggest: The clouds of steam in the cold well on start up were from the top entry packing which had worked loose when the condenser was jumping up and down. When we do get a slight vacuum, this outflow of steam is killed and air enters in lieu and when the water level in the condenser drops low enough the air is removed by the bottom flap valve and the piston action. Water gets in the condenser from the pump top flange, past the very worn piston and slowly by back flow through the bottom flap valve over say a few hours.

It is very likely that the vertical movement of the condenser in summer/autumn 2010 was caused by the very worn piston packing coming loose. falling down to jam in the gap between the piston bore and the lower flange of the piston and creating a very substantial upward force on the pump, sufficient to lift the pump and condenser.

27 October

We measured the bore of the cold well pump: North is the valve box, east is the door.

NB In the photograph north is to the right and south to the left.

Inside of air pump

	N - S	E - W	NE-SW	NW-SE
Top of pump				
Dial gauge readings	0.150	0.143	0.150	0.160 ins
Actual diameters	13.098	13.105	13.098	13.088 ins
	332.69	332.87	332.69	332.44 mm
Bottom of pump				
Dial gauge readings	0.145	0.150	0.145	0.150 ins
Actual diameters	13.103	13.098	13.103	13.098 ins
	332.82	332.69	332.82	332.69 mm

(Note: Roughness of the bore means that diameters cannot be accurate to better than 0.005 ins or 0.1 mm) Mean diameter = 332.7 mm

Removed the top flap valve; gasket in very poor state, flap valve not flat so needs dressing and the pivots for the hinge are broken and need repositioning to get an acceptable seal on the flap valve; preferably the hinge position needs to be well defined so as to get a good face seal from the flap valve to the opposing face. Assembly removed to JR's for fixing. See D on diagram.

10 November

Gasket material and gland packing received from I B S. Cleaned up faces of bottom flap valve cover plate, refitted it. Needed double gasket (2 x 3mm) to seal properly – see C.

Filled pump housing and condenser to brim: no leakage shown.

Measured the O.D. of the pump piston flanges (above and below the wood packing) circ was 1040 mm by taping, giving approx diameter of 331 mm and radius of 165.5 mm. The thickness of the very worn wood packing was 10 mm, giving the radius of the piston where the packing fits as 155.5 mm. Taking the piston bore as about 333 mm and radius as 166.5 mm, shows the radial thickness of the wood packing when finish machined as 11 mm. If we are to finish machine the rebuilt packing, this says the wood packing when assembled to the piston should be say 12.5 mm minimum.

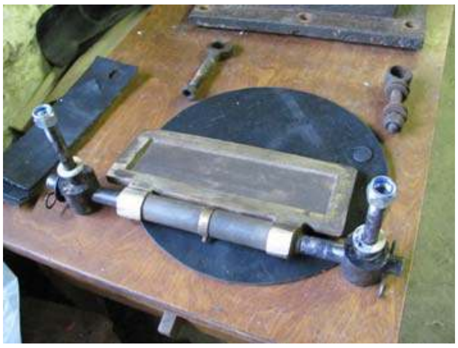
17 November

Discussed with Ken Crawford the repacking of the piston. Suggested using ash but later Ken proposed teak so amended to teak. Noting that several of the strips were worn tapered (thin end at the bottom) and we had lost 1/4 of them, it seems likely that the lost ones had become so worn that they had jammed between the piston OD and the bore, causing high friction, more wear and more load. This may have been the prime cause for the condenser vertical movement noted this summer. KC / JR agreed a time between repacking of say 8 years might be right. The present strips had lasted 15 years but were now thumb-nail indentable (a bit too soft).

Made new gaskets in 3 mm rubber (2 off) for the pump to the cold well – see E - and a circular gasket for the top flange of the pump (1 off) – see B. The doubled gasket could not be fitted easily but by fitting them sequentially it was possible to fit the two 3mm gaskets. Rechecked the dial gauge diameter for the bore; all OK.

19 November

Collected machined items for the top flap valve from Mach-Tech. Reassembled the valve and progressively machined the pivots back to get a good closing of the valve plate. Actual gap when finished was around 0.005 ins or 0.1 mm. To allow the valve plate to open to 90 degrees, the material on the back of the flap valve hinge had to be relieved; if this works, it will allow the removal of the temporary wooden block, which had been added to limit the opening of the flap valve and stop it jamming open.



New flap valve components

8 December

Fitted the new items and the top flap valve to the cold well; on the cold well side - see E, two, 3 mm gaskets were used and on the flap valve side three – see F, 3 mm gaskets were needed. Not possible to fit 3 gaskets on the cold well side. Collected the piston which had been repacked by Ken Crawford, to take for machining / sanding. Tony S, Ron R and John R agreed the machining size of the wood packing should be 332 mm, c.f. the piston bore of 332.7 mm (see above).

20 December

The new teak packing on the piston was machined by Mach-Tech to 332 mm dia and at the same time the flanges at each end of the wood packing were skimmed to 330 mm dia, making the wood proud of the metal by 1mm on radius.

New teak strips with temporary retainer band

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29 December

Top flap valve completed, can now open 90 degrees so the wood block to limit the opening to prevent jamming was not needed. Piston refitted quite easily. Top flange of the air pump refitted with new gasket – see B. Filled with water, no leakage seen. Operating rod refitted to piston rod. Entered operating rod into cross-head by barring the beam: good alignment. With beam at BDC at the pump end, the rod needs lifting about 20 mm to get the locking wedge to fit in the slot. Orientation of piston is (luckily) good, otherwise we would have had to rotate it to get the top locking wedge in place (not easy!).

Split pins were added to retain the wedges as, if one wedge fell out and the operating pull rod did not re-enter the socket, there would be a major catastrophe: either the pull rod would buckle (unlikely) or the piston would punch a hole in the bottom of the air pump. This is not to be recommended!

Added split pin

8 January 2011

Re packed the seal from steam exhaust into the condenser – see A - using IBHS product 50-474-2M Klinger 49 packing, 3/4 inch square.

New oak wedges for condenser seal

Wedging it in place with oak wedges about 80 mm long x 25mm x 18 mm at thick end with short taper at top end. These wedges are used to compact the packing and are only held down by the second short wedge which is driven in from the top and follows up the main wedge as the packing is compacted.

The spares items which were used are:

a) 3mm black rubber insertion gasket; IBS part number 50-802

b) Klinger 49 Packing, 19 mm; IBS part number 50-474-2M (needs 530 mm length)

IBS: Industrial Boilerhouse Supplies Ltd. 01489 570 737. www.ibhs.co.uk

c) Oak, 25 mm x 18 mm dressed, 3 m length needed.

Conclusions by John Ross

a) Some of the air pump piston strips had become so worn that they had jammed in the gap between the piston metal flanges and the piston bore, causing sufficient friction to lift the condenser / air pump assembly on the piston upstroke. This vertical movement caused the exhaust - condenser joint to leak and eventually blow out in October.

b) The slow build of vacuum on start up was maybe due to air leakage **in** at this joint.

c) The clouds of steam on start up were from this joint, being killed as soon as there was sufficient vacuum in the condenser.

d) The bad leak on the air pump top flange allowed water to fill the condenser (over some hours) so reducing its effectiveness and several cycles were required to remove this water. This is confirmed by the great quantity of water which emerges from the top flap valve on start up, **very much** in excess of any condensate flow.

e) Comment: The gauge registering the condenser vacuum does not respond to positive pressure, so if there is any above atmospheric pressure here (e.g. on start up) it will not be indicated. A second positive pressure gauge could be a useful trouble shooting item.

f) Comment: To keep the piston rod in correct alignment, the condenser / air pump position must be well defined. The previous wooden wedges under the condenser were not really adequate for this duty.

Person(s) involved: John Ross, David Jones, Peter Hirst, Ken Crawford

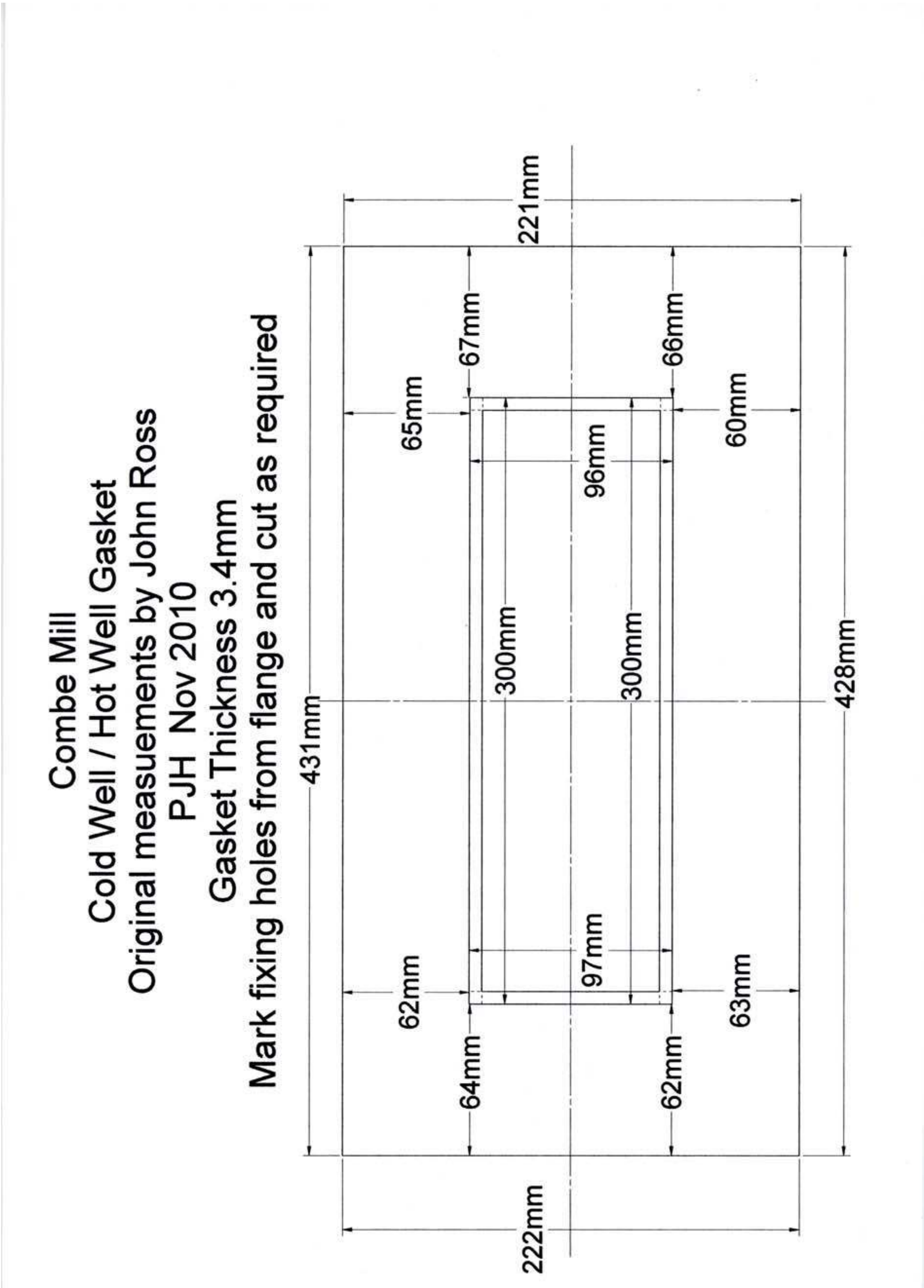
Written by: John Ross, David Jones.

8 February 2011

DRAWINGS

Cold Well/Hot Well gasket

Air pump top flange gasket


Combe Mill
Cold Well / Hot Well Gasket
Original measuements by John Ross
PJH Nov 2010
Gasket Thickness 3.4mm
Mark fixing holes from flange and cut as required
221mm
67mm
66mm
65mm
60mm
96mm
300mm
300mm
431mm
428mm
97mm
62mm
63mm
64mm
62mm
222mm

Combe Mill
Air Pump Top Flange Gasket
PJH Nov 2010
Gasket Thickness 3.4mm
Cylinder cover retaining bolts are not
concentric with the bore therefore
cut away gasket as required