1. PURPOSE

This document details the importance of ensuring the cylinder counterbalance valves (CBV's) on Knuckle Boom Cranes (KBC's) are properly plumbed and set. These cylinders have a service life of approximately 5 years and require removal to refurbish or replace. Too often, the replaced cylinders are not hooked up correctly to the crane, and the new cylinders are immediately damaged due to trapped pressure and rendered unusable. Logan recommends that in addition to standard KBC maintenance training, this document be included in that training for KBC maintenance crew members and supervisors.

2. DISCLAIMER

This document does not encompass all aspects of maintaining a KBC or its cylinders, or include all possible modes of failure of the cylinders. It is a specific-case advisory only and intended to increase safety and reduce potential downtime. This document does not supersede KBC OEM or end-user manuals; in the event of a conflict, the established manual is to take precedence. Logan is not responsible for any maintenance action on these cranes not performed by Logan.

3. BACKGROUND

Logan has been installing and maintaining KBC cylinders for 15+ years. We are aware of several cylinders that have been destroyed due to improper plumbing / CBV pressure settings. Replacing a crane cylinder can be very costly.

On more than one occasion, multiple cylinders were destroyed on the same crane, one after another. It wasn't until the counterbalance valve was configured properly that the cylinder was not destroyed.

4. CYLINDER DETAILS

KBCs typically have four boom cylinders, two Main Boom cylinders and two Knuckle Boom cylinders.

These are fairly large cylinders, with approximately 12in rods, 18in bores, and 20ft strokes. They typically have operating pressures around 340 bar / 5000psi.

The Main Boom Cylinders primarily just push, holding up the main boom. They have a counterbalance valve on the Extend port.

The Knuckle Boom Cylinders both pull and push, depending on if the knuckle boom is extended or retracted. They have counterbalance valves on both Extend and Retract ports.

5. COUNTERBALANCE VALVE INTENDED FUNCTION

The CBV's function as load holding valves; without them the cylinders would not be able to hold pressure on their own, and the boom would fall. They must be set to the proper pressure and plumbed correctly, such that when pressure is applied to the opposite cylinder port, the counterbalance valve opens and allows fluid to exit the cylinder. CBV's are connected directly to the cylinder ports.

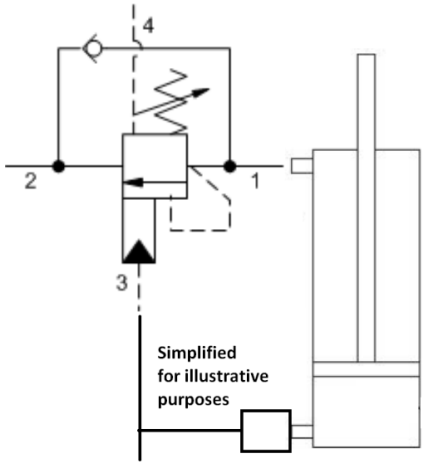
Fluid can ENTER the port without restriction, through a check valve integral to the CBV.

Fluid can EXIT the port when the CBV opens. There are two ways to open the CBV:

- Pressure at the port exceeds the pressure setting of the valve; the internal pilot causes the valve spool to shift open.
- The spool is shifted with pilot-line pressure. Typically valves have a 5:1 ratio, meaning that only 1/5th of the valve pressure setting is required from the pilot line to open the valve.

Using the Knuckle Boom Cylinder retract port as an example:

- CBV (port 1) is connected directly to the cylinder retract port.
- CBV Pilot port (port 3) is connected to the circuit such that when pressure is applied to the Extend port, the pilot shifts the valve, and fluid is allowed to exit the retract port, and return back to the system through CBV port 2.
- The CBVs also have a Vent/Drain port (port 4), which is intended to prevent buildup of pressure inside the valve, and allow it to reliably open at the set pressure.
- The CBV also has an internal pilot, such that if rod side pressure exceeds the valve setting, the valve will open (if plumbed properly), even if there is no pressure from the extend side of the cylinder.



CBV's are typically set to 10% to 30% over the working pressure. Consult the KBC manual or hydraulic schematic for specific settings. These settings are critical and should not be changed.

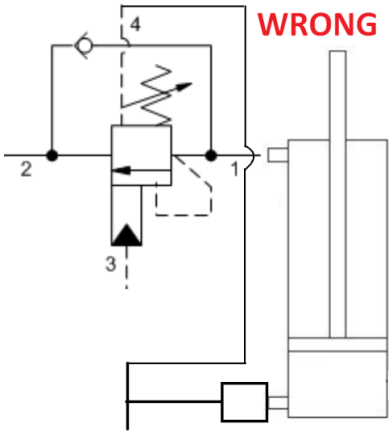
Example:

A valve's specified setting is 375 bar / 5440 psi. While this is over the MAWP rating of the cylinder, it is less than test pressure, and will protect the cylinder from damage (if plumbed properly) should overload on the crane occur.

During operation, the CBV is opened by pilot pressure. It would open at 5440 psi / 5 = 1100psi bore side pressure; cylinder pressure does not exceed MAWP.

6. CONSEQUENCES OF A MIS-PLUMBED COUNTERBALANCE VALVE

On many cranes, the pilot and vent lines have the same port sizes and line sizes. Thus it is fairly easy to accidentally connect the lines to the wrong ports. Should the CBV valve be plumbed incorrectly, with the pilot line going to the vent port, the pressure intending to operate the cylinder (opening the valve) will instead **CAUSE THE VALVE TO STAY CLOSED**. From Sun:



- Pressure at port 4 is added to the effective relief setting at a rate of 1 plus the pilot ratio times the pressure.

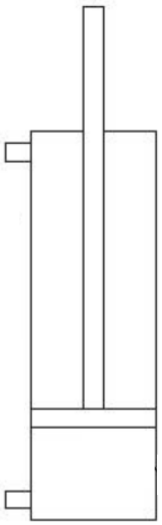
Example:

KBC Knuckle Boom Cylinder from previous example has the Retract Port CBV vent line mis-plumbed as above.

4200psi is applied to the extend port (and CBV vent port), attempting to extend the cylinder and boom out.

The CBV will not open unless the rod pressure becomes 5440psi + (1+5) x 4200psi = **30,640psi!!** This is much higher than what the cylinder is rated for; the cylinder will fail before the valve opens.

With the CBV unable to open, high pressure can build up in the cylinder. The below 3 causes of high pressure can all occur simultaneously on a knuckle boom cylinder, with example pressures:



- *Direct Intensification.* There is more area on the bore side of the cylinder than the rod side, so pressure will increase by the ratio of the areas. For example, 4200psi normal operating pressure on the bore side results in 4200 x 1.76 = **7400psi** on the rod side! The ratio will vary between different cylinders.
- *Indirect Intensification.* If only one of the two Knuckle cylinders has the CBV pilot line incorrect, then the correctly plumbed cylinder will also try to force the incorrectly plumbed cylinder to extend. Thus this can put **ANOTHER 7400psi** on the mis-plumbed cylinder!!
- *Load from the boom*. This load is unknown, but the maximum can be assumed to cause the rated system pressure, or enough to cause 4200psi on each cylinders. But if one cylinder opens correctly, the mis-plumbed cylinder would be holding the entire weight of the boom, and potentially cause **8400psi** on the rod-side of one cylinder.

With the mis-plumbed cylinder in above example, it is reasonable to assume that the rod side of the cylinder would see at least **14,800psi**, up to **23,200psi!!** Note that these pressures cannot be reached, as the cylinder would fail before this occurred. From experience, these cylinders typically fail between 10,000 and 12,000psi.

Ensure all Counterbalance Valves are Plumbed Correctly

Refer to the KBC manual or hydraulic schematic. Only a qualified, competent technician should perform this work.

Additionally, Logan recommends re-plumbing the pilot and vent lines and ports to be different sizes, so that they cannot accidentally be swapped. Especially on the Knuckle Boom Cylinders.

7. CONSEQUENCES OF AN IMPROPERLY SET COUNTERBALANCE VALVE

The cylinders on the KBC's are in pairs, with CBV's on each side of the crane.

- Should one of the paired CBV's be set LOW, it will open first, and the other cylinder may see the entire load of the boom. This can cause the cylinder to go over MAWP, up to the relief setting of the CBV. This reduces the life of the cylinder, and puts undesired twisting loads on the crane.
- Should one of the paired CBV's be set HIGH, it will open last, and cause the cylinder to see the entire load of the boom. This can cause the cylinder to go over MAWP, up to the relief setting of the CBV, which may be (much) higher than intended. This is more likely to damage the cylinder than having one valve set low.
- Should both CBVs be set LOW, the boom may uncontrollably fall, causing a critical safety issue.
- Should both CBVs be set HIGH, but equal, the crane may appear to work normally, but there is a higher risk of overpressuring the cylinders.

Ensure all Counterbalance Valves are Set Correctly

Refer to the KBC manual or hydraulic schematic. Only a qualified, competent technician should perform this work.

8. CYLINDER FAILURE MODE

The weak point of the cylinders is the barrel. When overpressured, typically the barrel will "balloon", plastically deforming to a larger diameter. The piston seals will expand to the larger diameter and eventually fail. When they fail, high pressure from one side of the piston will flow to the other side, and can blow out the wearbands/piston bearings from their grooves. With the excess pressure gone, the barrel will partially relax, potentially crushing the displaced seal and wearbands. The crushed wear bands and seals may break off and become debris in the barrel/hydraulic system. The cylinder essentially locks and ceases to function.

9. BEST PRACTICES

When removing/replacing cylinders from a KBC:

1. A hydraulic expert should be part of the maintenance crew, from rig down to rig up. Logan can provide personnel.
2. Use 2 crew members to handle the long hydraulic lines.
3. Take extreme care to mark all piping segments and ports so that they are plumbed correctly later.
4. Avoid adjusting the counterbalance valves. If in doubt, have ALL CBVs bench set prior to reinstallation on the crane. Do not just adjust one valve.
5. Ensure all lines are clean before reinstallation.
6. If pilot and vent lines and ports are the same, consider re-plumbing them to avoid accidental swapping.
7. When installing new cylinders. double check that everything is plumbed correctly to the manual / schematic before applying pressure.
8. Perform additional low-risk checks prior to full pressure operation, such as connecting gauges to test points and running at low pressure. If something is wrong it can be identified before destroying a cylinder.
9. If a cylinder is still somehow destroyed, DO NOT SIMPLY INSTALL ANOTHER CYLINDER. It will be destroyed as well.

Logan Industries sincerely hopes this bulletin can prevent future occurrences of destroyed KBC cylinders. Should you require assistance, Logan is available to help.

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