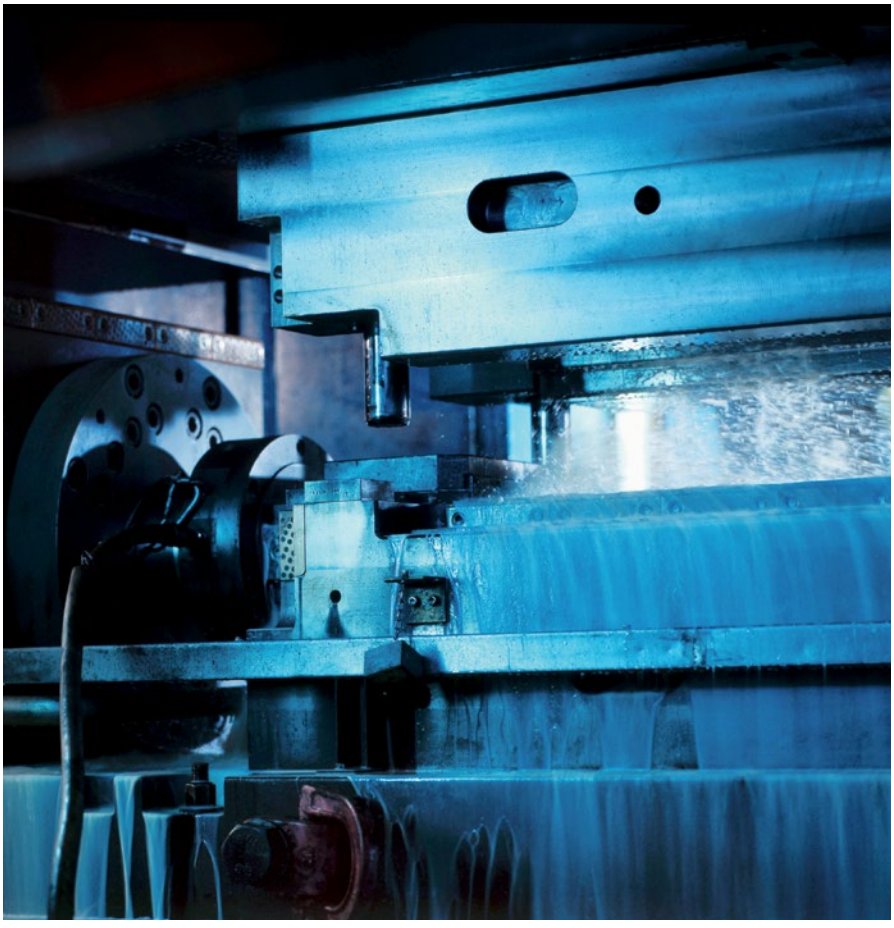
Drive & Control
profile

Safe hydraulics for hydroforming presses



Although they may be more costly than a conventional hydraulic circuit, when considering the liability involved, a safe hydraulic circuit is a worthwhile investment.

Hydroforming processes whereby complex, single-component work pieces are pressed into shape with the help of pressurized fluid, have established themselves as efficient alternatives to conventional press forming. Correctly utilizing a continuous forming process allows more finished product to be created from less raw material.

High pressure forming can produce smaller and lighter components when compared to other manufacturing processes, and features greater mechanical stability. Greater part

Safety Standard Guidelines for Hydraulic Presses

In several western regions, safety standards exist that describe how to achieve safe control for hydraulic presses.

- At least two independently controlled components arranged in series. If a safety controller detects a single failure, the press slide will stop and a new cycle cannot begin.
- When components are in their neutral position, pressure cannot build up in cylinder piston area, or the pressure in the annulus area for a down acting press cannot decay.
- Control valve spool positions must be monitored, for example, with limit switches for critical function valves.
- After each cycle, a safety control must determine whether the safe neutral positions were achieved—if not, a new cycle start must be prevented.
- Protection against press intensification in the annulus side of cylinder must be designed into the circuit.

stability, in turn, increases passenger safety in a range of automobile parts.

There are however a wide array of safety precautions that must be followed when utilizing hydroforming technology. This article will examine the basics of safe hydraulics for hydroforming presses.

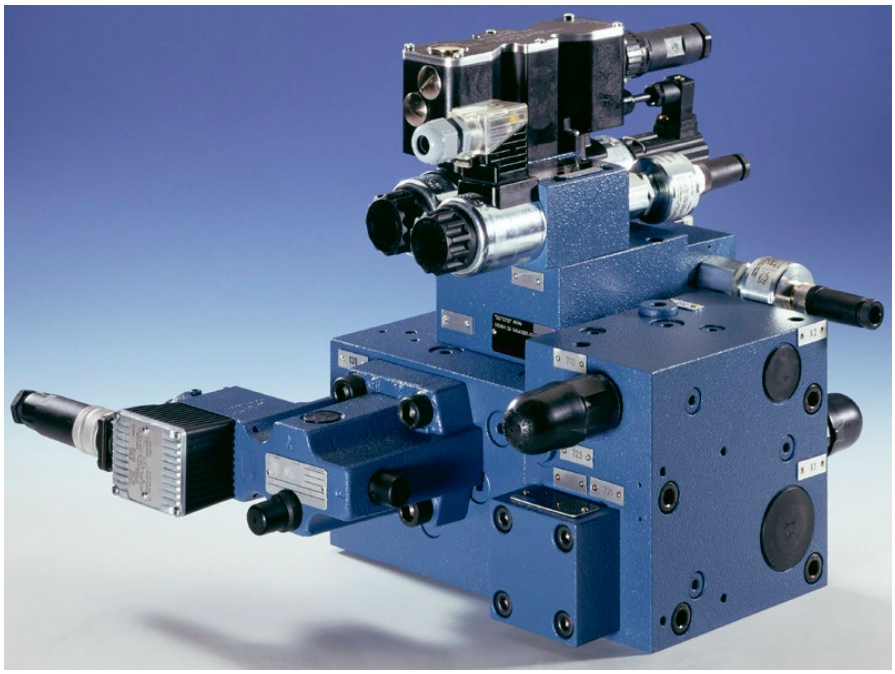
Existing Safety Standards

In several western regions, safety standards exist that describe how to achieve safe control for hydraulic presses. For example:

- United States: ANSI B11.2 “Hydraulic Power Presses— Safety Requirements for Construction, Care and Use”
- Canada: Z142-02 “Code for Power Press Operation: Health, Safety and Guarding Requirements”
- Europe: EN 693 “Safety— Hydraulic Presses”

All of these standards have the same basic requirements for safe press control. While the ANSI standard only scratches the surface, the Canadian and European standards go more in depth. The Canadian standard was largely influenced by the European standards, which have more demanding requirements. The European safety standards are more accepted worldwide as customary engineering practices, and comply with a broader range of regulations. Therefore, our emphasis will largely be on the European standards, but the goal of all three standards is to avoid a dangerous closure of the press due to a fault.

The standard EN 693 strives to accomplish a level of security



Picture 1: Standardized Rexroth Press Control Size 6

within hydraulic controls. Some requirements include:

- A minimum of two independently controlled components, arranged in series (redundancy). All of the standards referenced above assume that the probability of two components failing from independent causes, during a press cycle, is very small. If a safety controller detects a single failure, the press slide will stop and a new cycle cannot begin. The probability that a second independent failure will occur after the press is stopped, allowing the press to stroke again, before the first failure is detected, is also very low.
- When the components are in their neutral position, pressure must not be allowed to build up in the cylinder piston area, or the pressure in the annulus area (for a down acting press) must not be allowed to decay.
- Control valve spool positions must be monitored, for example, with limit switches for critical function valves.
- After each cycle, a safety control must determine whether the “safe” neutral positions were achieved. If not, a new cycle start must be prevented.
- Protection against pressure intensification in the annulus side of the cylinder must be designed into the circuit.
- When a drop in pressure could lead to an unintended dangerous motion of the ram, rigid pipe and appropriate connections shall be used in place of hoses. In Europe, even banjo type fittings are not allowed on critical press piping.
- A safety control conforming to the above standards is not required only in the following press applications:
- Forging and other presses where the material cannot be manually handled

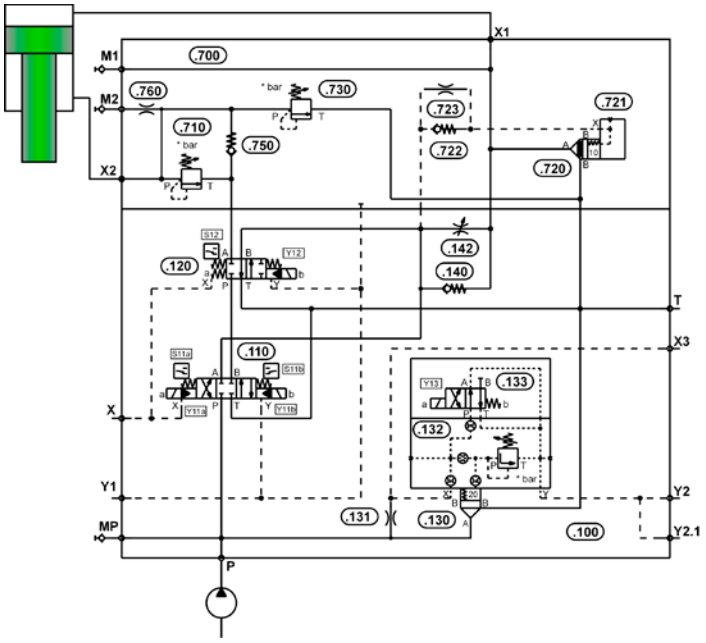
- Machines running in automatic mode with closed working areas, although a safety control may still be required for maintenance and machine set-up
- Closing speed of the press slower than 0.4 inches/second (10 mm/s)
- Stroke of the ram less than 0.24 inches (6 mm)

Characteristics of a Safe Hydraulic Circuit

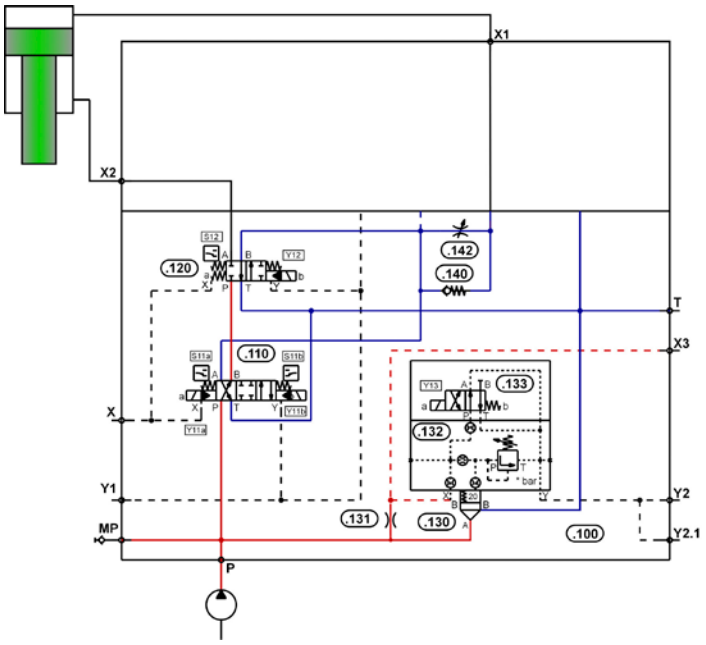
Many suppliers offer a wide variety of standardized press controls meeting the requirements for safe hydraulic control. Ours are designed for up to 800 gallons-per-minute and we offer a program of hydraulic controls to solve the most common tasks using standard components **(picture 1)**.

In addition to the safety functions, some other press-specific functions are built-in. **Picture 2** shows a schematic of the hydraulic circuit. Within this circuit, valve #110 is a direction control valve equipped with limit switches. It is used to control the up and down press movement, and acts as the first safety valve. Valve #120 is the second safety valve, while valve #730 is the pressure intensification protection required by the safety standards.

The neutral position of valve #110 shuts off the pump, and the neutral position of valve #120 vents the bore side of the cylinder to the tank. The same valves are used to prevent a pressure drop in the annulus area of the cylinder. The connection from the annulus area of the cylinder to tank is blocked by two valves. Pressure cannot build up in the bore area, nor can pressure decay in the annulus area of the cylinder unless both valves are activated.



Picture 2: Hydraulic Press Control with Safety Circuit



Picture 3: Valve #110 is stuck in the crossed position

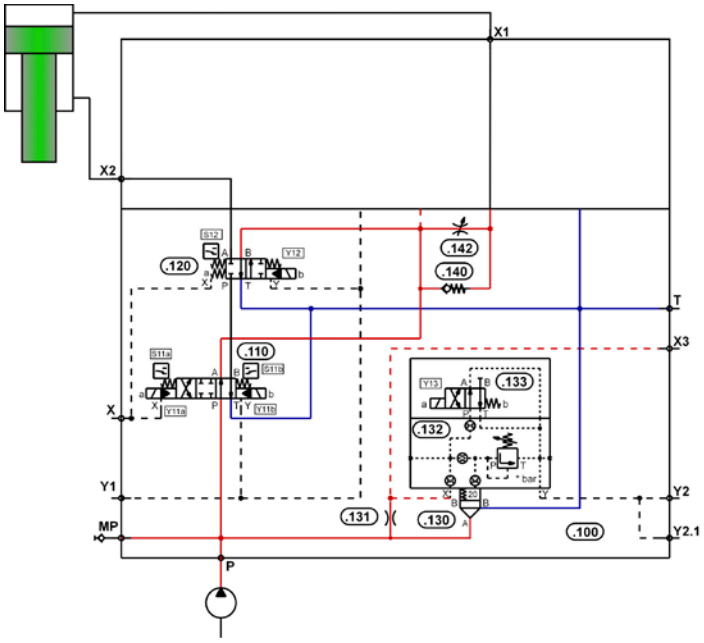
In the unlikely event that one of the two valves fails, the other will take over the safety function. **Pictures 3, 4 and 5** show this example of failure. (Please note these pictures do not show a counterbalance function or the pressure intensification protection valve.)

The bore side of the cylinder is still vented to the tank through port B to T of valve #120. Hence,

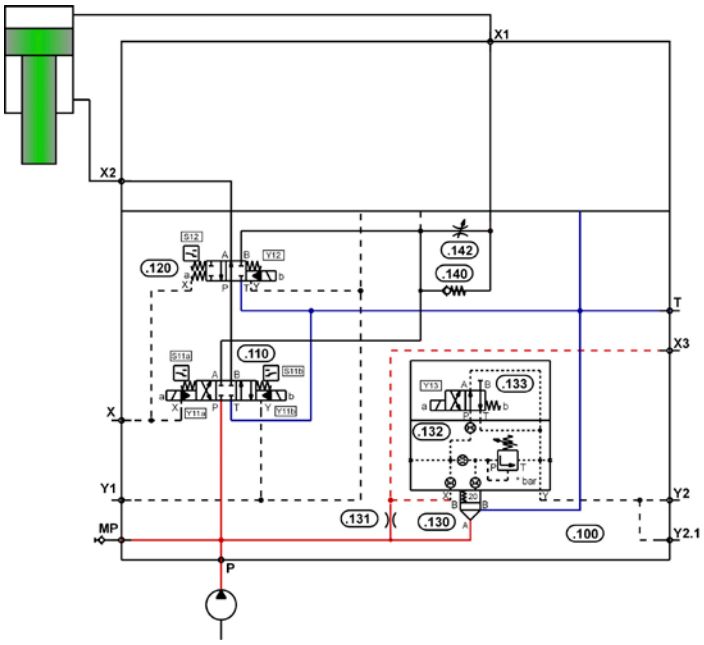
there will be no pressure built up. The annulus area of the cylinder is still blocked and pressure decay is avoided. In conformance with the safety standards, there will be no dangerous movement.

Although pump flow from P to A of valve #110 is possible, there will be no pressure build up in the bore side of the cylinder because the flow is vented to tank over valve #120. Again, the annulus area of the cylinder is still blocked and decay in pressure is avoided. Hence there will be no dangerous movement.

Picture 5 shows how the pump is blocked at the P port of valve #110, and no pressure build up will occur in the bore side of the cylinder. Although valve #120 allows a pressure build up at the B port of valve #110, the annulus area of the cylinder is still blocked. Again, there is no uncontrolled movement of the press and the redundancy requirements are met.



Picture 4: Valve #110 is stuck in the parallel position

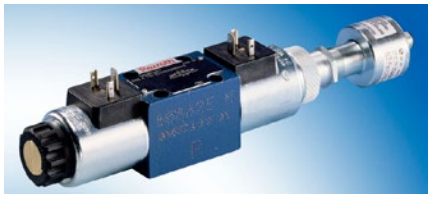


Picture 5: Valve #120 is stuck in the activated position

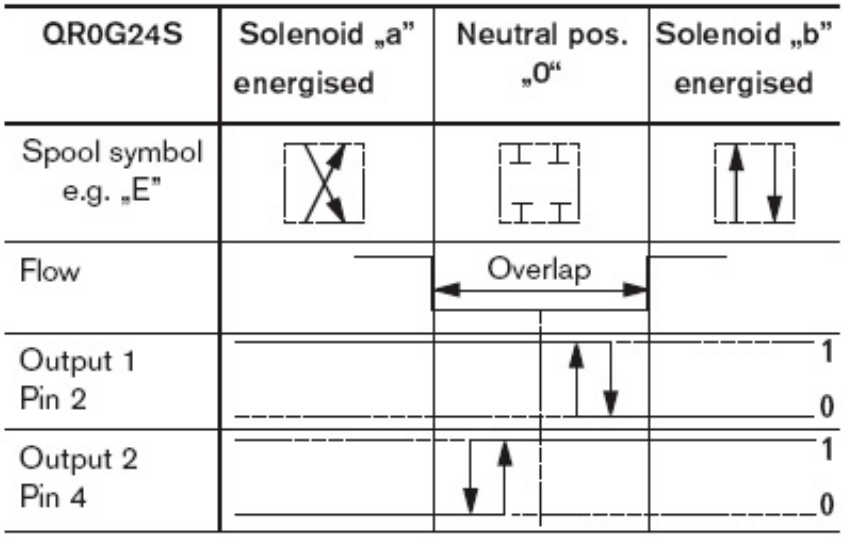
Characteristics of a Hydraulic Safety Valve

The safety standards have special requirements for the hydraulic valves used in the press safety circuit. Hydraulic valves should feature a safe design that contains adequate spool overlap, is spring centered and has durable springs. The pressure intensification protection valve should be direct operated and sealed and locked against unauthorized adjustment. If a break in the spring of either valve occurs, the space between the spring windings should be less than one wire thickness to prevent “winding” of the spring which would drastically affect operation. The (safety) directional valves are equipped with a limit switch that indicates the actual position of the valve spool **(picture 6)**.

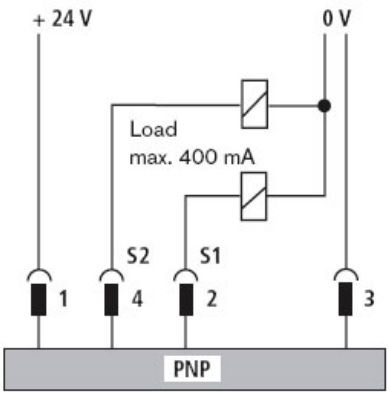
The switch is typically an inductive type with two switched outputs. Before the final monitored position



Picture 6: Directional valve with inductive limit switch



Picture 7: Switching logic of a limit switch

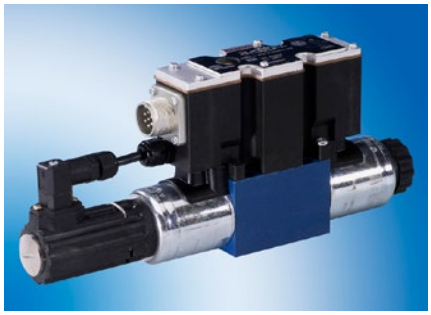


Picture 8: Pin Assignment

is reached, one output goes high, the other low, or vice versa. This means that one switching output will be open (N/O), the other is closed (N/C). **Picture 7** highlights the switching logic and **picture 8** details the pin assignment.

Proportional valves are often used to meter the oil flow in the system. Thus, cylinder speeds can be varied, and acceleration and deceleration can be controlled. Proportional valves can be equipped with internal feedback for the actual spool position to achieve high accuracy. This position feedback is also used for monitoring in press safety systems. **Picture 9** shows a direct operated proportional valve, while **picture 10** shows a pilot operated proportional valve.

The spool monitoring is integrated into the valve's onboard electronics. In order to get a redundant signal, three electrical signals are used. **Picture 11** shows the switching logic, and **picture 12** shows the spool-signal logic.

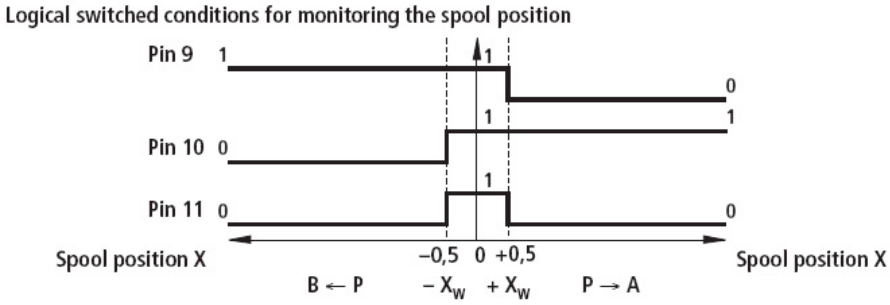


Picture 9: Direct operated proportional valve w/ spool monitoring

Picture 10: Pilot operated proportional valve with spool monitoring

How are the signals used?

The press has to be equipped with a safety control or safety relays to implement proper press safety. Each limit switch or the onboard electronics of a proportional valve's position feedback must be hardwired to the control. A fault detected by the safety control must immediately stop the press and prevent a new cycle until the problem is fixed. All safety valves should be switched off.



Picture 11: Switching logic of spool monitoring in proportional valve

Logical signal linkages

Spool position	Flow direction	Logical switched conditions Pin 9	Pin 10	Pin 11
$X < -X_W$	B ← P	1	0	0
$-X_W \leq X \leq X_W$	–	1	1	1
$X > X_W$	P → A	0	1	0

0 ≙ 0 V
1 ≙ 24 VDC (19.0 V to 35 V)

Picture 12: Spool-Signal Logic

Conclusion

Safe hydraulics is available. Although they are more costly than a conventional hydraulic circuit, when considering the liability involved with personal health and safety, a safe hydraulic circuit is a worthwhile investment. For more information on Bosch Rexroth industrial hydraulics, visit www.boschrexroth-us.com/brh-i.

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