Removal of hydraulic load holding valve incident causing injury

Preface

In regards to the incident involving injury caused by an uncontrolled release of energy, I will offer several recommendations which extends to all stakeholders mentioned in your correspondence.

Included are several points which will increase awareness and understanding of hydraulic energy. Also included is background to support the associated recommendations. So not to confuse the recommendations with best, not so best and common practices; the recommendation will be clearly identified. Example photos are also included as visual references to devices that complement the recommendations.

Introduction

The primary objective is the ability to identify, and control stored residual energy. A confined fluid that is under pressure is an energy hazard. The energy in a hydraulic system comes from the following; a) the prime mover and the pump, including where some of the following is the result of the actuator (motor or cylinder) becoming the flow source from; b) supported loads which are countering the effects of gravity, c) thermal expansion, d) compressed gas such as an accumulator, e) trapped compressed air, f) induced loads from kinetic energy.

When we discuss lockout and control of hazardous hydraulic energy the above listed are branched out into an astronomical number of possible scenarios based on the details of the task being performed. Energy must be controlled for a period of time, because over time energy can form in a confined fluid from thermal expansion, of both compressible and none compressible fluids that are in a system.

To answer the question; it is possible to free the hydraulic system of 100% of its energy? As I mentioned earlier; training, knowledge, and integration of components are necessary to accomplish the zero energy state. Achieving a zero energy state can be extremely complicated. All areas of a hydraulic system where fluid is isolated should have test point connectors where a gauge can be attached. Pressure as low as 50 psi is still very hazardous and can generate extreme forces in large bore actuators. Zero psi does mean zero energy, however maintaining zero psi over time requires a procedure which includes continuous monitoring of pressure. When the flow generator (pump) is shut down and locked out, the energy generators I listed then become the hardest to identify and control. One must know the circuit and the areas where fluid can be isolated and not bled using the systems “as built” control devices. Bleeding of fluid under pressure can be complex if you don’t understand why and where the isolated pressure was or is being generated. Take for example an excavators boom, stick, and bucket components and the connecting hydraulic cylinders these components will induce pressure on the confined and isolated fluid from the force of gravity acting on them. If you cannot identify if you have each piece in a parked position or utilizing mechanical restraints which are releasing the forces of gravity from acting on the fluid, you will have an energy state. I refer to the excavator because it has the highest complexity when it comes to geometry and direction of forces. To sum this up, each task requires a procedure which suits many circumstances. Integration of components to make use of bleeding devices works well providing there is written specific procedures. The hazards of venting fluid under pressure to atmosphere are; a) burns, b) fluid injection injury, c) atomized fluid is easily inhaled which will cause respiratory problems d) slips and falls e) atomized fluid is extremely flammable, and f) environmental and property damage. Controlled bleeding must not allow fluid to vent to atmosphere, ideally controlled bleeding requires containment which will hold the volume being released and the containment must be vented to atmosphere. Containment and controlled bleeding devices will prevent the above hazards.

In large industrial systems lockable isolation devices are common, such as ball valves. Isolating in an area of a circuit to perform maintenance also requires specific procedures for isolation, lockout, monitoring, bleeding, and reintroduction of hydraulic energy. Each written procedure should include details of each of these items. Redundancy of isolation devices and monitoring is very important when energy exists beyond isolation devices.

Hose burst protection system as described is known as a counter balance valve. The valve is designed to prevent the free fall of the boom (load) in the event of a connecting hose failure. The valve is also designed to control descending (runaway) loads including overpressure relieving capabilities. To be most effective in protection of hose failure, the valve must be mounted having reduced failure points. This is commonly achieved by mounting the valve directly to the cylinder port. In some cases it is welded directly or has a connection which is of rigid pipe or tube or steel adapter. The most common are bolted pad mounted valves, which the two surfaces are sealed with and elastomeric seal (oring). The fluid between the actuator (cylinder piston in this case) and the counter balance valve is isolated and will not pass the counter balance valve until pilot pressure from the directional control valve pilots the valve to open. Without pilot pressure or over pressure the fluid remains isolated. It is this isolated volume under pressure which must be identified and controlled safely.

As stated in your correspondence. “I developed a safe work procedure to release the energy by loosening the mounting hardware of the valve away from the body so that the release happens in the opposite direction.”

This procedure is not a safe procedure. Mentioned above “hazards of venting fluid under pressure to atmosphere are;”

Hydraulic fluid is compressible by approximately 2% at 5000 PSI. An actuator with the load removed from it and providing there is no compressible fluid such as air entrained in the fluid, the fluid to be displaced (removed) to reduce the pressure from 5000 psi to 0 will be equivalent to 2% of the volume contained (isolated). This can assist in determining how much volume that needs to be controlled (released safely)

Recommendation;

Make recommendations to the manufacturer to engineer and integrate means of verification and control of hazardous hydraulic energy.

Integration of test point connectors in the hydraulic circuit where fluid is isolated where no current means of safely venting the fluid into the low pressure leg of the circuit also known as the return fluid lines that are returning to the reservoir which has a vent open to atmospheric pressure.

Once integration has taken place, utilize the test point connector and bleeding equipment for verification, monitoring, and venting of isolated volume under pressure.

Write a safe work procedure specific to each task to include details on;

-Supporting components to prevent movement when fluid is vented

-Instruction for safe use of integrated monitoring and venting devices

-Monitoring of energy hazards throughout the duration of the task

-How to perform a hazard assessment specific to the task

-PPE requirements

Hydraulic safety awareness training

HSAC consultant to assist in writing a specific procedure for a specific one time event

Example of best practice

Bleed tools and equipment used which where designed for identifying and venting hydraulic fluid for controlling energy as part of a lockout procedure.

This only represents an example and is specific to an application utilized in a particular facility on specific equipment.

This section stands as examples of best practices and not be understood as part of the recommendations or procedures.

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INSTRUCTIONS FOR USING BLEED DOWN KIT

Instructions for using the Bleed Down Kit and Portable Receiver Tank
This kit is designed to test for hydraulic pressure, and control the bleeding down, and venting of hydraulic volume under pressure.

Bleed Down Kit Items:

A) 3 0-2000 PSI gauges c/w female test point connector
B) 3 bleed down assemblies
C) 2 24 inch hoses
D) 2 40 inch hoses
E) 2 78 inch hoses
F) Receiver Tank
G) 1 carrying case

C

B

A

PHOTO 1

E

D

THE INSTRUCTIONS MUST BE FOLLOWED TO PREVENT INJURY AND ENVIRONMENTAL EXPOSURE.

Hydraulic placards on equipment throughout the Plant will identify the use of this equipment and will be referred to as Section "B" & "C".

Identification and control of hazardous hydraulic energy can be achieved using the items in this kit.

Hydraulic fluid is not compressible, and venting a small amount of volume will rapidly decay pressure.

CAUTION: THE RECEIVER TANK WILL HOLD APPROXIMATELY 2 GALLONS OF FLUID, AND MUST BE ISOLATED FROM THE HYDRAULIC POWER UNITS WHEN CONNECTED TO ANY TEST POINT.

Follow the machine hydraulic isolation procedures located on the associated placard at each machine.

Containment and disposal of hydraulic fluid must meet Plant Policies and Procedures.

The fluid level in the Receiver Tank can be viewed in the sight glass on the side of the tank (Photo F). Empty the receiver after each use.

F

Sight Glass

TESTING USING GAUGES ONLY (Photo 1)

Gauges can be connected to test points by removing the test point safety cap and threading the gauge onto the test point.

Threading can be done by hand and does not require a wrench, if a wrench is used, do not over tighten.

The test points have built in isolation checks. The check is pushed off it's seat by the female half of the connector.

The isolation check prevents fluid from venting. 2-3 drops may appear during the connect/disconnect transition.

If pressure exists, it will be indicated on the gauge.

G

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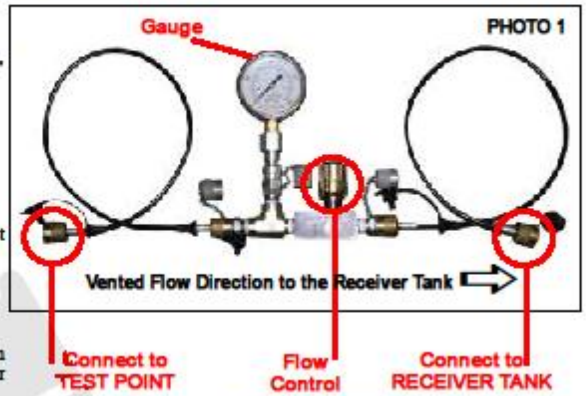
SECTION " C" - Venting to the Portable Receiver Tank

The following procedure is referred in the Hydraulic Lockout Placards as **"Section C"**.
For venting test points labelled **"Hyd Supply"**, **"Hyd Return"**, **"Hyd Cyl Rod End"** and **"Hyd Cyl Cap End"**.

NOTE: The machines that have both test points "Hyd Cyl Rod End" and "Hyd Cyl Cap End", will require two bleed down assemblies (Photo 1) to be connected. This allows volume to exit one end and enter the other, preventing the effects of negative pressure (vacuum).

This procedure will cause cylinders to move to a mechanical rest position, **caution must be taken to stay clear of moving components of the machine.**



Bleed down assemblies c/w gauge and hoses (Photo 1)

Bleed down assemblies must be connected from the test point on the machine to the Portable Receiver Tank in the following order and configuration:

A) Close the flow control by turning the adjustment knob clockwise until it stops (Photo 3)

B) Connect a test gauge to the bleed assembly (Photo 3)

C) Connect kit hoses to the bleed assembly, choose hoses long enough to reach the machine and the portable receiver tank.

D) Connect the bleed hose to the receiver tank test point (Photo 3) (the hose on the side closest to the flow control on the assembly Photo 1)

E) Connect the other bleed hose to the test point on the machine (Photo 4) (the hose on the side closest to the gauge on the assembly) (Photo 1) Pressure may be indicated on the gauge.

F) **SLOWLY** open the flow control, turning the knob counterclockwise, volume will begin to travel to the receiver and the pressure will decay to 0 psi

G) Once bleeding is complete, disconnect the hose from the machine first, then from the Portable Receiver Tank. Replace all test point safety caps.

PHOTO 2

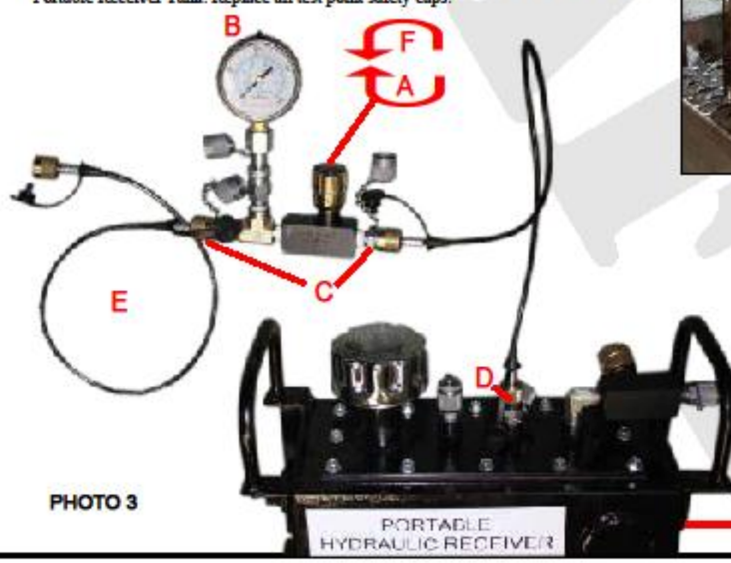
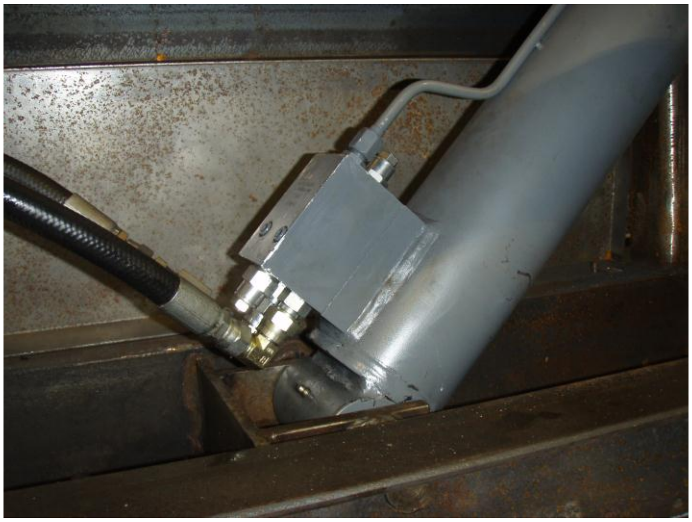


PHOTO 3

PHOTO 4

A



This photo **A,** shows a counterbalance valve which is pad mounted directly to the hydraulic cylinder. This too has no means integrated to identify and safely vent the isolated fluid. Making modifications to integrate test/bleed points requires engineering and may also include recommendations and acceptance by the equipment manufacturer. There would be a shift in liability and warranty if not done by the manufacturer when done by a modifier/integrator.

A catch 22 will exist if the integration is not made by the manufacturer at the point of manufacture. A post manufacture modification still puts the modifier/integrator at risk in order to make previsions for safety devices. If a modifier/integrator chooses to make post manufacture changes, the procedure would require very detailed instruction to reduce risk.

Due to the exponential number of variables, one written safe work procedure will not effectively capture the highest risk reduction methods for each task or event. Although some tasks and events are similar they vary enough that risk can be lessened in some cases. A hazard assessment should be utilized to determine the controls for the lesser.

Conclusion;

Primarily safety devices on mobile equipment are designed with the operator in mind also including public and environmental safety. Maintenance and repair personnel generally are working at greater risk due to equipment design. Maintaining and repairing equipment requires significant knowledge and skills to reduce risk. Risk becomes considerably higher when safety devices are not integrated into equipment to identify and control hazardous energy.

Until standards and codes are developed and enforced, which increases safety for maintenance and repair personnel, many procedures will be deemed unsafe. In Canada in most provinces the under Occupational health and Safety Acts and Legislation; one can be charged for failure to provide a safe work environment and or procedure. Where an injury takes place from not controlling hazardous energy the province will lay heavy fines. On equipment manufactured where maintenance procedures are unsafe or there is no hierarchy of controls to mitigate a hazard and the procedure is deemed high risk, work should not be carried out. Buyers of equipment must consider this, as under most acts and regulations, the owner of the equipment can be included in litigation where a worker was injured. In Ontario all equipment purchased must undergo a prestart health and safety review, which is designed to determine the safety of the equipment and in most cases integration of safety devices and procedures prevail. The owner of the equipment in most cases an employer is fully responsible for the safety of personnel exposed to equipment therefore the equipment must be safe. Manufacturers in some countries are required to meet certain standards and codes which are designed to increase safety of equipment, however not all equipment meets safety standards that are recognized by Canada.

This particular incident is not so isolated and until standards and codes are developed and enforced or intervention on the part of all stakeholders this matter of manufacturers design and integration to increase maintenance and repair safety will remain unresolved.

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