MCO CLOSURE TOOL: A PNEUMATIC/HYDRAULIC TOOL FOR CLOSING THE CANISTERS AT HANFORD

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ABSTRACT

The U.S. Department of Energy is retrieving spent nuclear fuel from the Hanford K Basins for storage in specially designed Multi-Canister Overpacks (MCOs). An MCO Closure Tool system was developed to close and seal the MCOs by semi-manually installing a 400 lb locking/lifting ring. The tool must apply a 70 ton force to compress a metal closure seal. The locking/lifting ring has an external buttress thread around its periphery and is installed by threading into the top collar of the MCO canister. Both the locking/lifting ring and the collar are fabricated from austenitic stainless steel, thus having potential to gall during the ring installation process. To minimize this, design criteria were established to suspend the ring in a manner that removes virtually all of the weight of the locking/lifting ring from the threads.

The tool operation accomplishes this task by suspending the closure tool and the locking/lifting ring payload assembly directly above the canister collar via a low internal friction pneumatic cylinder. The cylinder, in conjunction with a precision relieving regulator, is pressurized until the 925 lb load is precisely balanced and can extend or retract effortlessly in the vertical direction. This near-weightless condition largely eliminates the galling tendency. After the threading operation is complete, an integral hydraulic cylinder applies the 70 ton force to compress the seal while the securing operation is completed to permanently hold the sealing load.

INTRODUCTION

In preparation for the retrieval of fuel from the Hanford K Basins, Packaging Technology, Inc. (PacTec) was awarded a contract to develop and fabricate a closure tool to close and seal Multi-Canister Overpacks (MCOs) for storage in the new Hanford Canister Storage Building (CSB).

The closure tool is a fairly simple 525 lb device used to semi-manually install and/or remove the 400 lb MCO locking/lifting (lid closure) rings. A crane is required to lift and translate the tool and its payload (locking/lifting ring). However, torque is applied manually, using the integral 3 ft diameter hand wheel, to thread the locking/lifting ring into and out of the MCO collar.

The tool grips the locking/lifting ring using 18 swing clamps equally spaced around the periphery of the base weldment. Protruding dogs located at the bottom of the clamps are rotated into a groove in the locking/lifting ring.

The torque is transmitted from the tool to the locking/lifting ring via two "lock pin" bars which produce a "couple" to rotate the lifting/locking ring. The bars pass through holes in the tool to engage the ring below.

The crane attaches to the top of a pneumatic cylinder that supports the weight of the tool and its payload. The use of the pneumatic cylinder with a precision venting regulator allows the locking/lifting ring to be suspended in a near weightless condition while being screwed into or out of the MCO collar.

Sealing force is applied by a 100 ton hydraulic ram cylinder attached to the underside of the tool base. The ram pushes the MCO shield plug down, compressing its metal o-ring seal while 18 set screws are tightened to maintain the seal force after the tool is removed.

The MCOs have a unique lid closure design (Fig. 1) that requires special tooling capable of both handling and installing a locking/lifting ring and to provide the force to compress a metal seal. The MCO closure components consist of four main components: (1) canister collar, which is the top portion of the MCO and contains the sealing surface and a internal buttress thread for locking the shield plug assembly (lid) in place, (2) a metal seal that needs to be compressed with 70 ton force to provide a leaktight seal, (3) a shield plug assembly which is the main canister lid component and provides the other half of the sealing surface for the metal seal and (4) the locking/lifting ring assembly is a 400 lb stainless steel component which contains the mating external buttress thread for locking the shield plug in place. Subcomponents of the locking/lifting ring are the eighteen large diameter set screws used to lock the shield plug in place to apply pressure on the metal seal.

Because the MCO closure components are fabricated out of austenitic stainless steel, with a potential to gall when surfaces are sliding, the PacTec closure tool was designed to hold the locking/lifting ring in a near weightless condition when installing the ring into the canister collar. This weightless condition is achieved by using an air cushion via a pneumatic cylinder to minimize the load on the threads during the threading operation (Fig. 2).

The metal seal compression force is achieved by using a high pressure hydraulic ram cylinder to apply a load to the shield plug. With the appropriate compression load applied, the eighteen set screws are threaded into contact with and hold the shield plug to maintain compression on the seal.

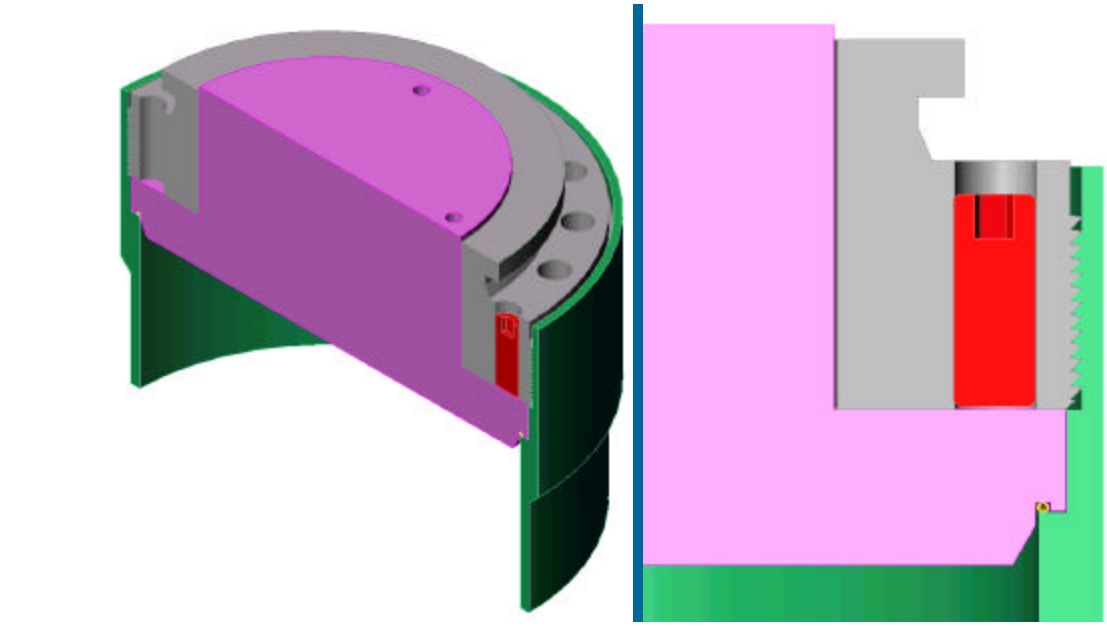


Fig. 1 Multi-Canister Overpack (MCO)

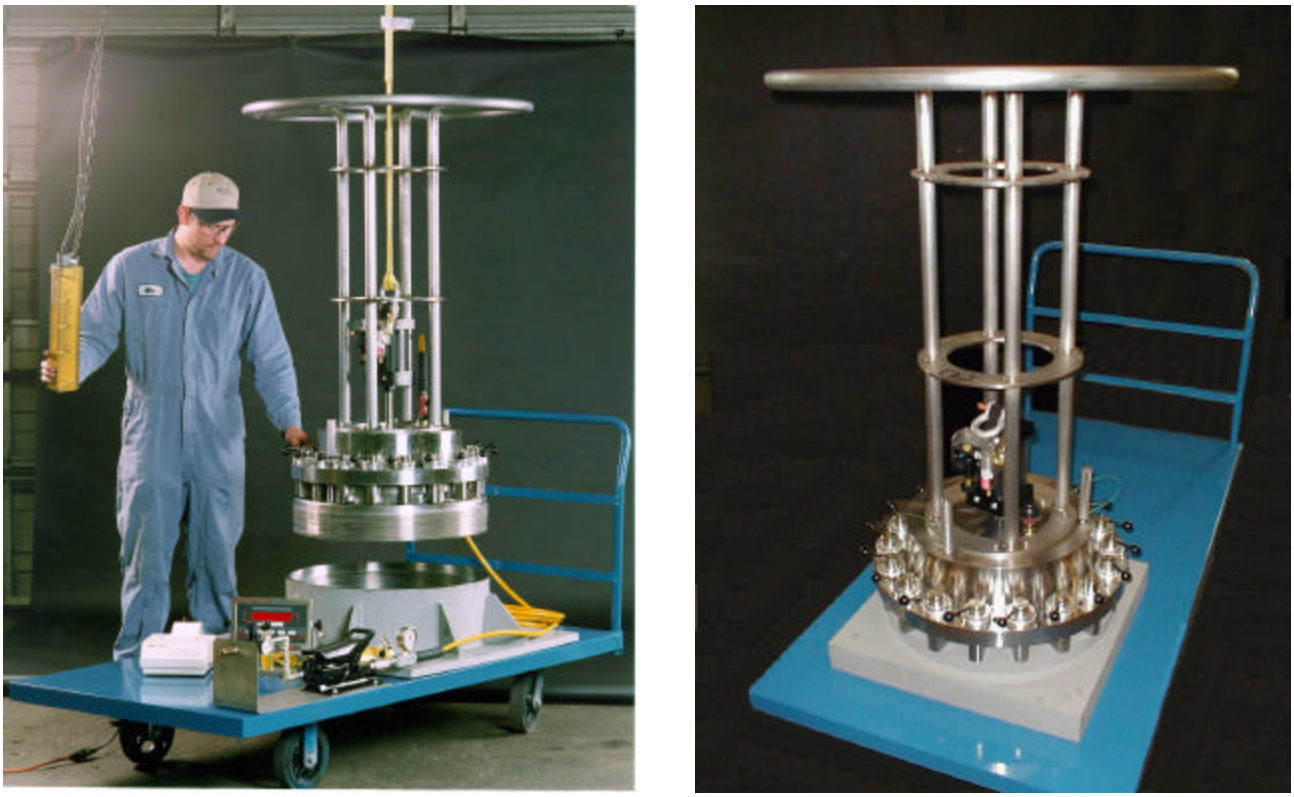


Fig. 2 MCO Closure Tool

In addition to the closure tool, additional components were required such as a transfer cart for moving the hardware, calibration equipment for routine operational checks, testing hardware for the acceptance test and hydraulic components.

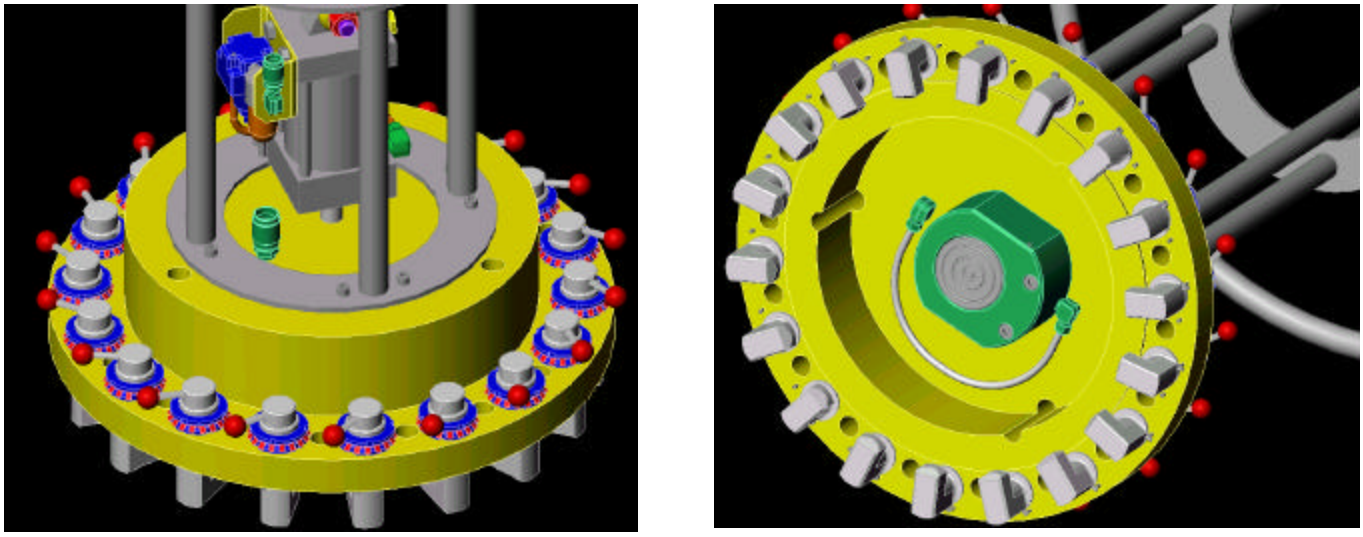
DESIGN

During the development phase of the contract PacTec engineering considered two ideas for meeting the near-weightless requirement for the threading operation of the locking/lifting ring: one a mechanical counterweight and pulley system, and the other a pneumatic system. The mechanical counterweight system was discarded because it was physically cumbersome, complex, heavy and difficult to adjust for variations in the locking/lifting ring weight.

The pneumatic system approach involved hanging the tool and the locking/lifting ring (payload) from the rod end of a low friction pneumatic cylinder and connecting the cylinder housing end to a crane hook (Fig. 3). Air pressure is supplied to the rod side of the cylinder piston and regulated with a precision pressure regulator to maintain neutral buoyancy. As the ring is threaded into the collar, the self-relieving regulator maintains a maximum load of 20 lb as defined by the contract parameters. The pressure regulator is a high precision unit with a high accuracy and pressure setting repeatability. This allows tool operators to set the pressure such that the load on the threads, whether performing threading or unthreading, is less than 10 lb. An additional feature of the regulator is that the closure tool can be installed onto a ring already threaded onto an MCO, and a

trained operator can adjust the pressure and observe when neutral buoyancy occurs prior to removal of the ring without damage to the stainless steel buttress threads.

The cylinder selected has a Teflon impregnated nitrile seal material and chrome plated cylinder wall. The reason behind this selection is that even though the cylinder rod motion is smooth during the extension/retraction motion, the breakaway force from a static condition would otherwise exceed the specification requirement of 20 lb.



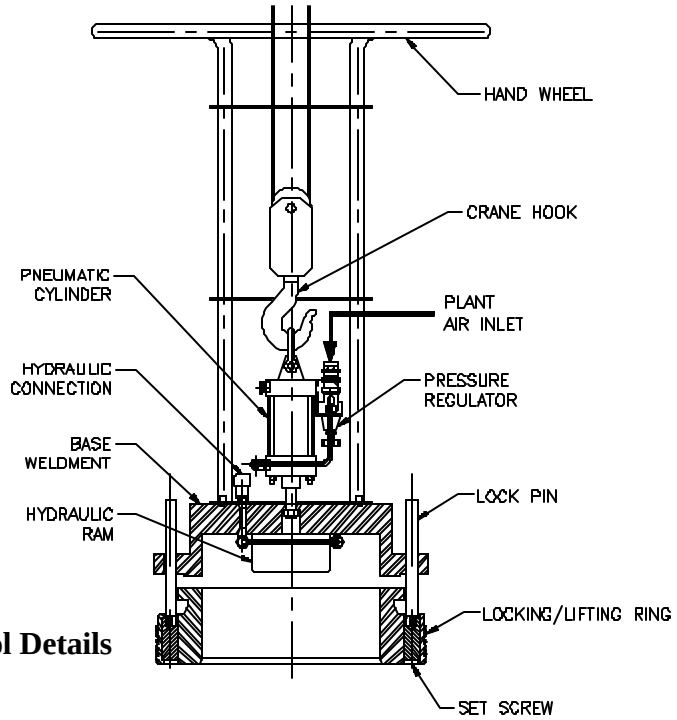


Fig. 3 MCO Closure Tool Details

Two approaches were considered to compress the metal seal: (1) mechanical threading of the 18 set screws and (2) hydraulic ram cylinder compression. The mechanical thread technique option was found to be labor intensive, required the application of high torque values to the 18 set screws and involved manual operation in a confined location.

The hydraulic ram cylinder was selected as the simplest and most efficient option. With an air operated hydraulic pump, 8,500 psi hydraulic pressure can be developed from 100 psi plant air pressure. This is enough to generate a 70 ton force from a low profile hydraulic cylinder. The small cylinder size greatly assisted in minimizing the tool size and weight.

One of the program requirements for the MCO Closure Tool system was a means of easily calibrating the hardware with respect to the metal seal compression load. PacTec selected a force measurement system that consists of a low profile load cell, digital read-out meter and a compact strip chart recorder. This provides the operator and the quality assurance organization with a hard copy printout of the force generated by the hydraulic ram cylinder. The stand required to perform the force measurement test also serves as a storage stand when the tool is not in use (Fig. 4).

FABRICATION

The MCO closure tool is fabricated of stainless steel and plated carbon steel. This type of construction requires very little maintenance because the end user will not have to worry about paint flaking off in the operation area or contamination of components by iron oxide.

The calibration/storage stand and the MCO test fixture are also constructed of stainless steel and carbon steel. All carbon steel components are painted.

The fabrication of the MCO closure tool was subcontracted to IDEAL Machine and Manufacturing, Inc. in Tacoma, WA. IDEAL performed the machining, welding, assembly and acceptance test support of the closure tool. The fabrication included GTAW[a] (stainless/stainless), SMAW[b] (stainless/stainless) and FCAW[c] (stainless/carbon) welding per PacTec design requirements. These welded items were machined to very close tolerances to accommodate precise interfaces between the tool components. This precision was needed to eliminate any possibility of surface galling when threading stainless steel components together.

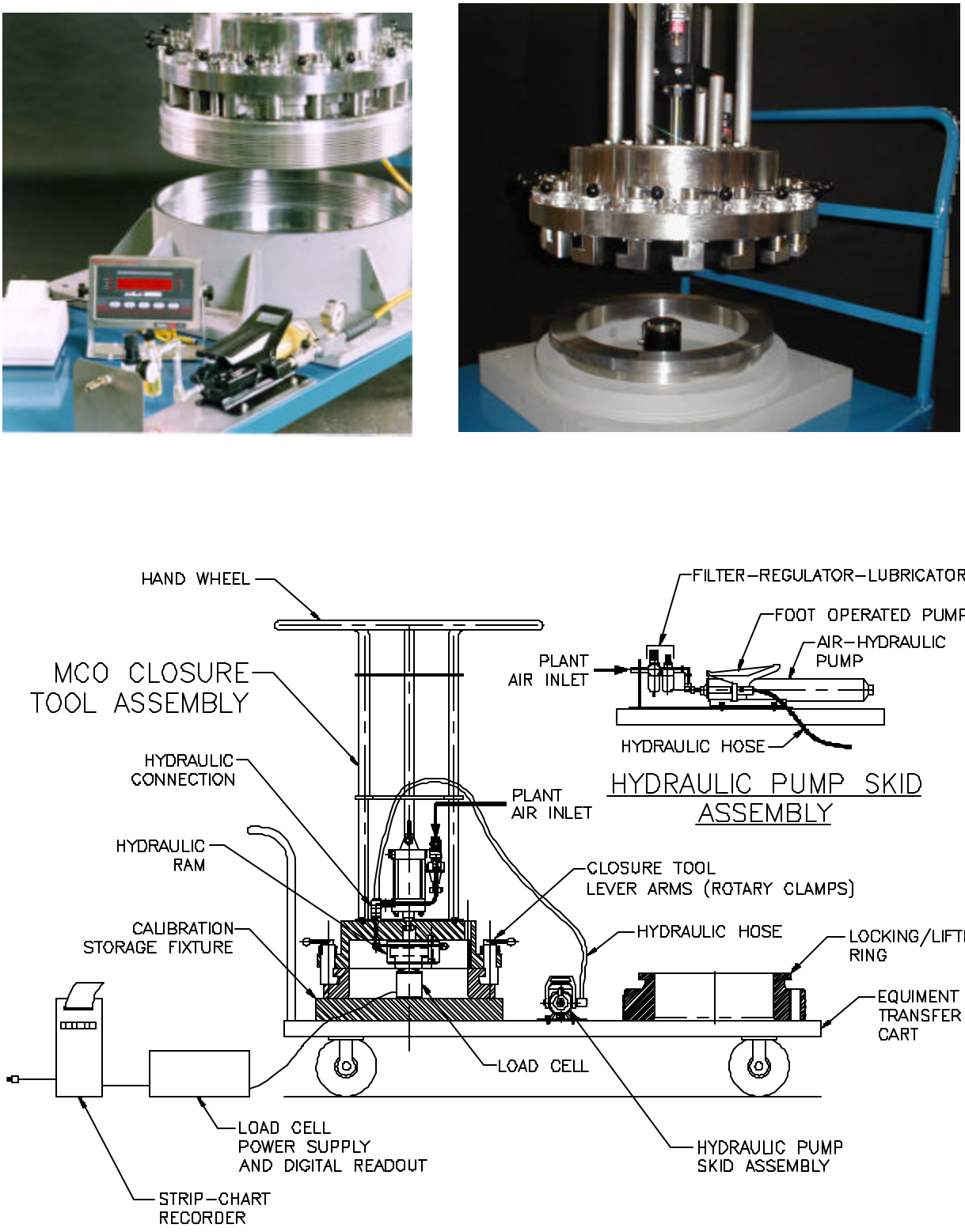


Fig. 4 MCO Closure Tool Calibration Hardware

Throughout this project, IDEAL utilized many inspection procedures and techniques to provide assurance that the MCO closure tool would perform as expected and meet all requirements of the purchase order, drawings and specifications. The inspection process began with material receipt inspections, delineating material conformance to specification requirements as well as assuring compliance with blueprint dimensional requirements. The next step included welding and machining described above. During the welding operations, inspection processes insured that welds were sound and met acceptance requirements for Visual Weld Examination by IDEAL's AWS certified weld inspector. In addition to Visual examination, IDEAL employed other non-destructive inspections such as Magnetic Particle and Liquid Penetrant Examinations. These inspections were performed by IDEAL's ASNT certified level II personnel for each of the processes. The final machined components were subjected to inspection procedures delineating all dimensional and other drawing and specification attributes, with actual objective evidence of acceptance recorded.

The MCO closure tool components were load tested to insure soundness of the fabrication processes employed. Load testing was performed in compliance with PacTec's procedures, and objective results were recorded. The completed and accepted components were further subjected to performance tests, insuring that the tool met all functional requirements.

SUMMARY

The PacTec MCO closure tool was developed and tested to provide Hanford with an easy-to-use, reliable, low maintenance device to install and remove the numerous MCO lids. The tool was successfully used in December 2000 to seal the first MCO canister loaded with K Basin spent nuclear fuel. The MCO is now in storage in the Canister Storage Building.

Footnotes

a. Gas Tungsten-Arc Weld
b. Shielded Metal-Arc Weld
c. Flux Core Arc Weld