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

Donald S. Hillstrom, P.E., Donald A. Jensen, P.E., J. Greg Field
Packaging Technology, Inc., Tacoma, WA

Dan Long, Bill Anderson
Ideal Machine, Inc., Tacoma, WA

ABSTRACT

The U.S. Department of Energy is retrieving spent nuclear fuel from the Hanford K Basins for storage in specially designed canister overpacks (MCOs). A MCO Closure Tool system was developed to close and seal the MCOs by semi-manually installing a 181.4-kg locking/lifting ring. The tool must apply a 63.5 tons (metric) 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 the tendency for the stainless steel surfaces to gall, 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 419.5-kg total assembly 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 63.5 ton (metric) 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 238.1-kg device used to semi-manually install and/or remove the 181.4-kg MCO locking/lifting (lid closure) rings. A crane is required to lift and translate the tool and its payload (locking/lifting ring). However, manual torque applied using the integral 0.9-meter diameter hand wheel is used 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. 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, which in-turn, supports the weight of the tool and 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 90.8-ton (metric) 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 63.5 tons (metric) 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 181.4-kg 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. (See Fig. 2)

The metal seal compression force was 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)
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, more complex, twice as 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. (See Figure 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 9-kg 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 4.5-kg. 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 9-kg.

Fig. 3. MCO Closure Tool Details
With respect to compression of the metal seal, two approaches were considered, (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 the simplest and most efficient option. With an air operated hydraulic pump, 597.6-kg/cm$^2$ of hydraulic pressure can be developed from 7.0-kg/cm$^2$ of plant air pressure which is enough to generate 63.5 tons (metric) force from a low profile hydraulic cylinder. The small cylinder size greatly assisted in minimizing the tool size and weight. This design approach was selected.

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 to provide 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. (See Fig. 4)

**FABRICATION**

The MCO closure tool is a stainless steel or plated carbon steel assembly. This type of construction provides very low 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 combination stainless steel and carbon steel fixtures. 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 interface of the tool components. This precision was needed to facilitate the design intent of eliminating any possibility of the inherent problem 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’s functional attributes met the requirements.

**OPERATION**

**Connecting Tool to Locking/Lifting Ring**

- Move the transfer cart loaded with the closure tool assembly near a locking/lifting ring and within the coverage of a crane. The closure tool assembly is stowed on the calibration/storage fixture attached to the cart.
- Connect the crane hoist hook to the closure tool shackle located on top of the pneumatic cylinder. Assure that the hoist has been positioned directly above the center of the tool.
- Rotate all eighteen of the closure tool lever arms to the unlocked position to release all the rotary clamps from the tool calibration/storage stand.
- Activate the hoist to slowly lift the tool. Note that the pneumatic cylinder rod extends until it “bottoms-out” in the fully extended position.
- Continue to slowly lift the tool up and away from the calibration/storage stand and translate to a position directly above an MCO locking/lifting ring.
- Carefully lower the closure tool assembly to within one inch of the top of the locking/lifting ring. Check and adjust angular alignment of tool to the MCO locking/lifting ring until the set screw access holes in the closure tool assembly align with the set screws in the locking/lifting ring.
- Remove the two “lock pins” from their stowed positions and insert through two 180° opposed closure tool assembly set screw access holes and down into the hexagon sockets of the locking/lifting ring set screws.
- Lower the closure tool assembly the remaining distance until it seats atop the locking/lifting ring.
- Rotate the eighteen closure tool lever arms to the locked position.
Locking/Lifting Ring Installation

- With the lock/lifting ring connected to the closure tool, raise the ring to a comfortable working height of approximately 36-inches above the floor.
- Inspect the buttress threads of both the locking/lifting ring and the MCO collar for cleanliness and freedom of burrs.
- Lubricate both the exterior and interior buttress threads and the eighteen set screw threads as required by the MCO documentation.
- Verify that none of the setscrews protrude below the bottom surface of the locking/lifting ring.
- Connect shop airline to the air filter of the Closure tool assembly.
- Slowly adjust the pressure regulator until the pneumatic cylinder lifts the tool and payload weight to the maximum upstroke position.
- Re-adjust the pressure regulator until the cylinder just balances the load.
- Adjust the cylinder rod extension to ½-inch.
- Slowly translate the tool with locking/lifting ring to a position directly above the MCO collar and carefully lower hoist until the ring is within ½-inch of the top of the collar.
- Carefully lower the tool via the hoist until the locking/lifting ring threads are within 1/8-inch of engaging with the collar threads.
- Manually push downward and rotate the tool via the hand wheel until the buttress threads of the locking/lifting ring start engaging those of the canister collar. Continue this engagement process until the locking/lifting ring is completely bottomed-out. Torque required to engage the locking/lifting ring should not exceed approximately 100 lb-ft.
- Connect hydraulic hose from the air-hydraulic pump to the hydraulic fitting of the tool.
- Connect plant airline to the filter-regulator-lubricator of the air-hydraulic pump.
- Operate the switch on the air-hydraulic pump to the “on” position. As pressure builds, the pump pulsations will audibly slow.
- As soon as the pulsations have slowed to a constant speed, indicating that hydraulic fluid is now bypassing through the internal relief valve, rotate the foot operated switch to the “hold” position.
- As soon as the air-hydraulic pump is locked in the “hold” position, turn all the eighteen set screws until they “bottom-out” against the shield plug.
- Torque all the set screws to 18-20 lb-ft.
- Operated the switch on the air-hydraulic pump to the “retract” position.
- Remove and stow the lock pins, rotate the eighteen swing clamps to the unlocked position and lift the tool away from the installed locking/lifting ring.

Locking/Lifting Ring Installation

Locking/lifting ring removal is virtually a reverse operation to the installation.

SUMMARY

The PacTec MCO closure tool was developed and tested to establish that it will provide Hanford with an easy-to-use, reliable, low maintenance device for many years of use in the installation.
and removal of the numerous MCO lids. The tool was successfully used in December 2000 to seal the first MCO canister loaded with KBasin 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