

Development of Remote Hanford Connector Gasket Replacement Tooling for the Savannah River Site's Defense Waste Processing Facility - 9457

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ABSTRACT

The Savannah River Site's (SRS) Defense Waste Processing Facility (DWPF) requested development of tooling and equipment to remotely replace gaskets in mechanical Hanford connectors to reduce personnel radiation exposure as compared to the current hands-on method. It is also expected that radiation levels will continually increase as future higher activity waste streams are treated. The facility is well equipped with compressed air, two master-slave manipulators (MSM's) and an electro-mechanical manipulator (EMM) arm for operation of the remote tools in the work cell proposed for remotely changing the gaskets.

In order to perform all of the tasks required to remotely replace Hanford connector gaskets several operations must be performed remotely, including removal of the spent gasket and retaining ring, loading the new retaining ring and gasket into the installation tool and installation of the new gasket into the Hanford connector. The Savannah River National Laboratory, SRNL developed and tested multiple tools to perform all of the necessary tasks. Removal of retaining rings from horizontal and vertical connectors is performed by separate air actuated retaining ring removal tools and is manipulated in the cell by the MSM. A new retaining ring is then placed on a platform, rotated under the conical loading tool and raised and compressed into the gasket installation tool by two linear slides actuated by air cylinders. The gasket installation tool is then pressed against the gasket sealing surface of the Hanford connector using an MSM. Actuation of a custom air cylinder overcomes the force of several different springs to align and fix the installation tool relative to the Hanford connector and seats the retaining ring and gasket. All of the tools are located on a custom work table with a pneumatic valve station that directs compressed air to the desired tool and vents the tools as needed.

On July 17 and 29, 2008 the Remote Gasket Replacement Tooling was successfully demonstrated in the Remote Equipment Decontamination Cell, REDC at the DWPF of The Savannah River Site.

INTRODUCTION

The DWPF is a facility that converts High Level Waste (HLW) from liquid form to a stable solid form by combining the waste with molten glass, a process known as vitrification. The HLW is received from the SRS tank farms in the form of a liquid-solid slurry or solution. The DWPF treats the waste so that it can be vitrified, combines the waste with solid glass frit and the two constituents are heated in a glass melter to produce a homogeneous waste form. The molten glass-waste mixture is then poured out of the melter into stainless steel canisters. The glass canisters are stored at the DWPF and will eventually be shipped to a permanent geological repository.

The DWPF glass melter and the equipment that prepares waste for vitrification are housed inside a large enclosed facility called a “canyon”. In order to perform the necessary maintenance and modifications within the canyon remotely, the canyon walls are outfitted with an array of pipe nozzles. Two nozzles within the canyon may be connected by a jumper, which is a pipe that is hung by a crane and has Hanford connectors on both ends. Each Hanford connector contains a gasket that seals to its respective canyon wall or vessel nozzle. The Hanford connector has a tapered skirt to assist the crane with placement of the connector on the nozzle and three fingers that pull against the back side of the nozzle via a remotely tightened ACME screw. There are both vertical and horizontal Hanford connectors, which vary only by connector orientation and the geometry of the connector skirt.

When a Hanford connector gasket fails, the current course of action is to remove the jumper, decontaminate it as much as possible and transport the jumper to the Contact Decontamination and Maintenance Cell (CDMC) within the canyon. In this location, maintenance personnel don protective clothing to prevent contamination and manually replace the gasket. This process requires significant planning and cost because of the risk of personnel contamination and radiation exposure.

The remote gasket replacement tooling was developed as an alternative to the hands-on gasket replacement approach. The Modular Caustic Side Solvent Extraction Unit (MCU) became operational in FY08 to process salt waste. As a result of the MCU process, an increasingly cesium-laden waste stream will be fed to DWPF over the next two years. As this waste enters into the DWPF system, hands-on replacement of gaskets will incur much higher personnel exposure rates than the current waste stream, thus making remote gasket replacement even more advantageous.

REMOTE TOOLING HISTORY

When the DWPF customer first requested SRNL to develop remote gasket tooling, the goal was less ambitious. The original goal was to develop tools that would allow gasket replacement from several feet away from the jumper to eliminate hands-on contact with the jumper to reduce radiation exposure. Increasing the distance from the jumper during gasket replacement could also minimize the need for jumper decontamination prior to gasket replacement. The tools developed were designed to use a hands-on approach to load snap rings and gaskets onto an installation tool. The installation tool would then be attached to an extension arm and transported into the CDMC, where the gasket and snap ring would be installed in a Hanford connector. The goal was to develop a low cost disposable design so that decontamination between uses would not be necessary. The introduction of more highly radioactive waste to DWPF necessitated a fully remote solution.

REMOTE EQUIPMENT DECONTAMINATION CELL (REDC)

As the name indicates, the REDC is an area of the DWPF canyon equipped for remote equipment decontamination. The cell has a large shielded window for viewing the decontamination processes. Below and in front of the window on the cell side is a 91 cm x 183 cm platform for placing items to be decontaminated or in our case, gasket replacement tooling. Available for operator use are an MSM (right and left hands), an electro-mechanical manipulator (EMM), an overhead bridge crane and 700 kPa compressed air supply. The MSM's are capable of handling up to 5 kg at full reach. The EMM is capable of handling up to 50 kg. The gasket replacement work table and all associated tooling will be placed on the REDC platform during gasket replacement activities (See Fig. 1).

GASKET REPLACEMENT TOOLING

Several tools were developed to perform the gasket replacement task. Two snap-ring-removal tools were developed, one for the horizontal and the other for the vertical Hanford connectors. An installation tool was developed that installs both a gasket and snap ring in a vertical or horizontal Hanford connector. A snap-ring-loading tool was developed to load a snap ring into the installation tool in preparation for installation of the snap ring and gasket into the Hanford connector. The installation tool storage platform is used for gasket loading onto the installation tool. All of the tools are stored and deployed off of a stainless steel work table that has a lifting attachment that allows a crane to carry the work table in and out of the REDC as needed. On the work table is space for a removable caddy which carries nine gaskets and nine snap rings. The caddy is equipped with a separate lifting bail. Ideally, several caddies can be built and used to resupply the table with new snap rings and gaskets. On the left end of the work table is a valve station that includes all of the pneumatic valves needed to run the various tools.

Before any gaskets can be replaced the gasket replacement work table and associated tooling, shown in Figure 1, must be lowered onto the REDC platform by the bridge crane. The bridge crane is then used to transport the jumper into position over the work table. The EMM is used to orient the jumper so the appropriate Hanford connector is directed toward the viewing window for optimum visibility. The EMM is also used to stabilize the jumper during gasket removal and installation operations. For this task, a special EMM attachment has been designed by DWPF engineering to slide over the ACME nut of the Hanford connector.

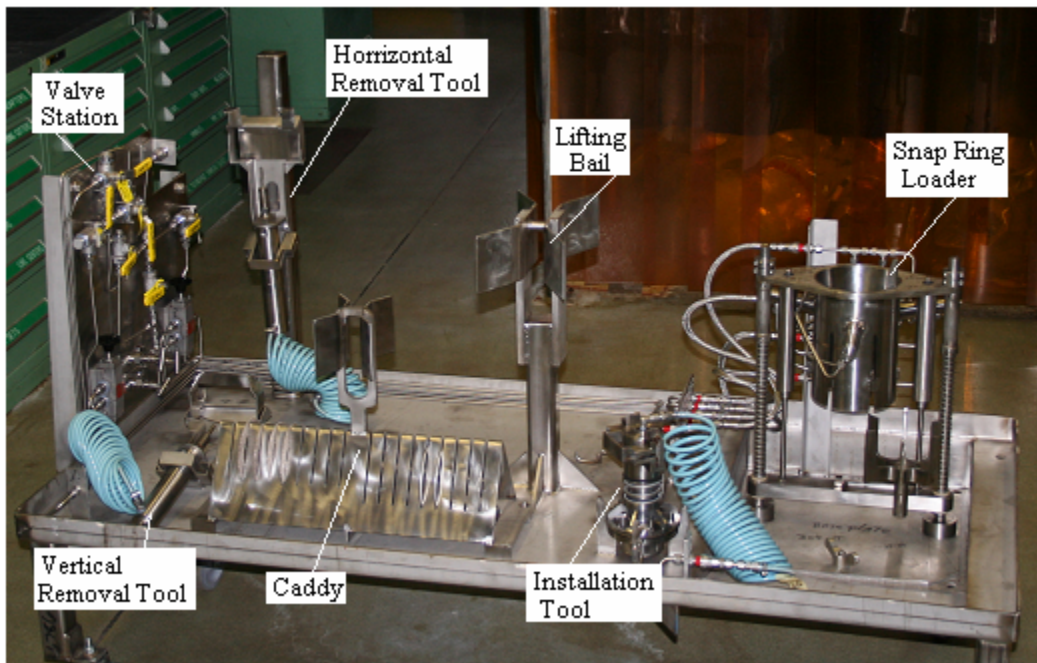


Fig. 1. Gasket Installation Work Table w/ Valve Station and Tools

SNAP-RING-REMOVAL TOOLS

The first operation that must be performed during remote replacement of a Hanford connector gasket is removal of the snap ring, which is used to retain the gasket against the Hanford connector block. The Hanford connector skirts on DWPF jumpers have three holes spaced 120° apart that allow direct access to the snap ring. A punch can be placed in any one of the holes, which are angled such that a hammer-blow to the punch will eject the ring from its groove. These design features were utilized in development of the

snap-ring-removal tools, which use an air cylinder extension to “punch” the snap ring out its groove. The only difference between the two removal tools is that one of brackets is designed to conform to a horizontal Hanford connector and the other to a vertical Hanford connector.

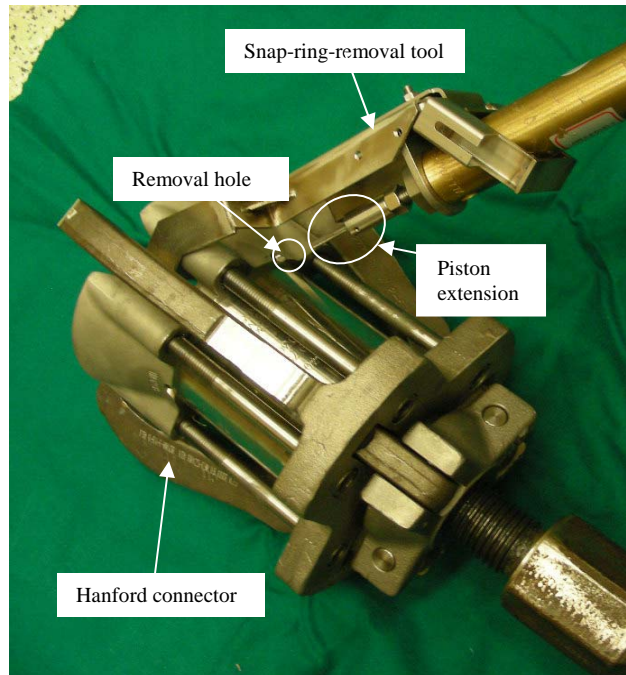


Fig. 2. Snap-Ring-Removal

In order to use the snap-ring-removal tool, the operator must position the tool where the removal tool cylinder and bracket straddle the Hanford connector skirt and align the cylinder axis as well as possible with the axis of the connector hole (see Fig. 2). Once the tool is in position, another operator opens a valve to supply pressurized air to the removal tool. This air pressure actuates the tool piston, forcing the pin through the connector hole and ejecting the snap ring. The cylinder is then vented so that the piston retracts. At this point, the snap ring has been removed and the gasket usually falls away from the jumper. If the gasket remains in the jumper, it is scraped off of the jumper with the MSM fingers.

SNAP-RING-LOADING TOOL

Before the gasket installation tool can be used, a snap ring must be “loaded” into a groove on the installation tool with geometry similar to that of a face seal o-ring groove. This is required because when the snap ring is ejected from the installation tool into the Hanford connector, the ring must already be compressed or its diameter will be too large to fit in the connector groove (see Fig. 3).

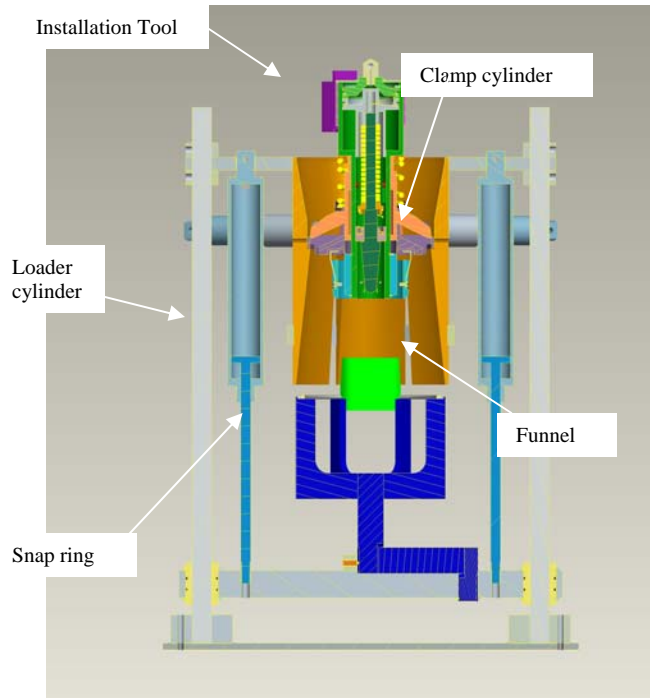


Fig. 3. Snap ring loader staged for loading

The snap ring loader loads a snap ring into the installation tool by performing the following steps (see Fig. 4).

1. A snap ring is placed on the snap ring loader fingers.
2. The fingers are rotated under the loading funnel until the hard stop is hit.
3. The installation tool is placed in the funnel.
4. The clamp cylinders are actuated to lock the installation tool in position.
5. The loader cylinders are actuated to raise and compress the snap ring into the installation tool.

After the snap ring has been loaded in the installation tool, a gasket is placed on the installation tool storage mount and the installation tool is placed on top of the gasket. Six custom springs are mounted on the head of the installation tool to retain the gasket on the installation tool (see Fig. 5).

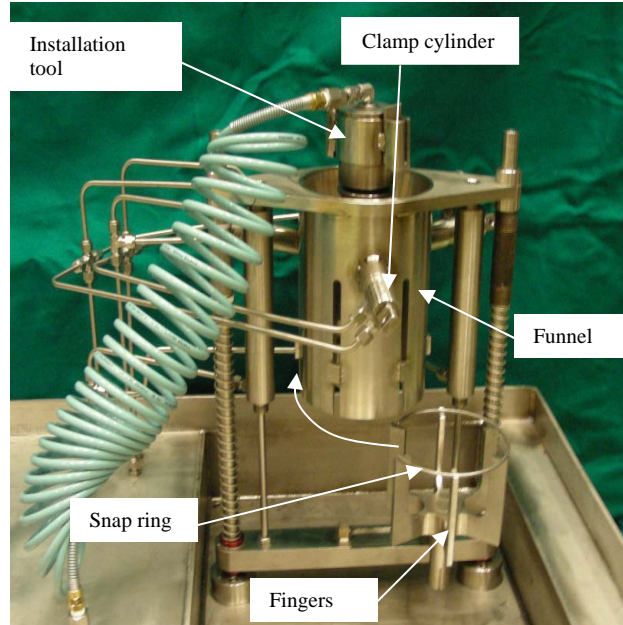


Figure 4: Snap-Ring-Loading Preps

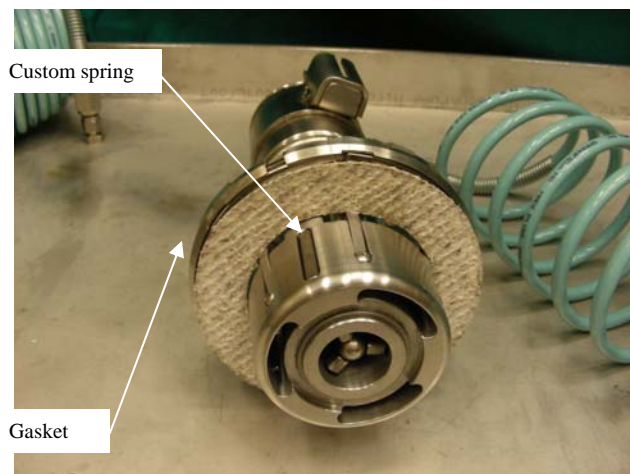


Fig. 5. Illustration of loaded gasket

GASKET INSTALLATION TOOL

The gasket installation tool is designed to replace 3” diameter gaskets, which represent approximately 60% of the Hanford-style gaskets in service in DWPF. However, 80% of the gasket replacements during the last several years were performed on 3” Hanford connectors.

To use the gasket installation tool, an MSM operator first places the tool against the sealing face of a Hanford connector. With the tool in this position, 700 kPa compressed air is provided to the tool. The air actuation causes the following:

1. The tool locates itself concentrically with the connector block center hole.
2. The tool anchors itself to the connector.
3. The tool advances both the gasket and the snap ring into position.

4. The snap ring expands into its groove in the connector firmly fixing the gasket.

Fig. 6 shows a cross section of the installation tool inserted into a Hanford connector. In this view the tool is retracted (not pressurized). Features of interest in this view are: the MSM grips, snap ring ejector fingers, gasket, snap ring, gasket retainer clips, and the Hanford connector.

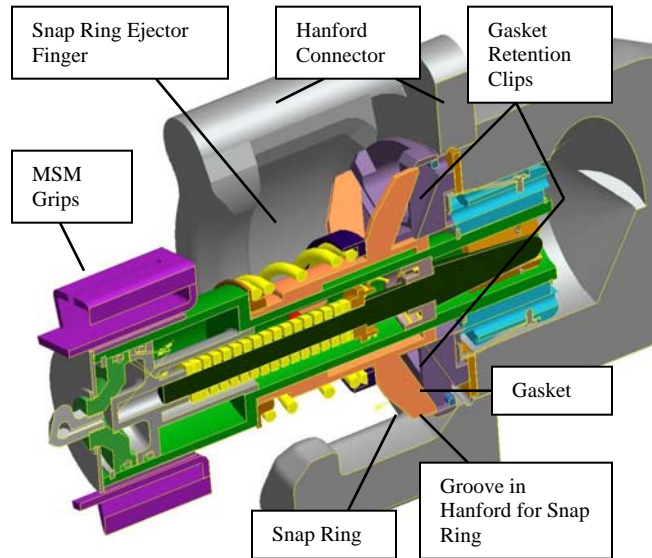


Fig. 6. View 1 of Installation Tool in Hanford Connector (3-D Model)

The Hanford connector is illustrated in gray and the installation tool is shown in multi-color format. The MSM (not shown) is positioning the installation tool as shown against the Hanford connector. When compressed air enters the tool (discussed later) the snap ring is forced forward into the Hanford connector groove by the snap ring ejector fingers. The gasket thickness is such that the snap ring bears against the gasket allowing it to maintain its position in the connector.

Fig. 7 shows another cross-section of the installation tool. Items of interest in this figure are: dogs, wedge, pins, piston, springs and the compressed air inlet port.

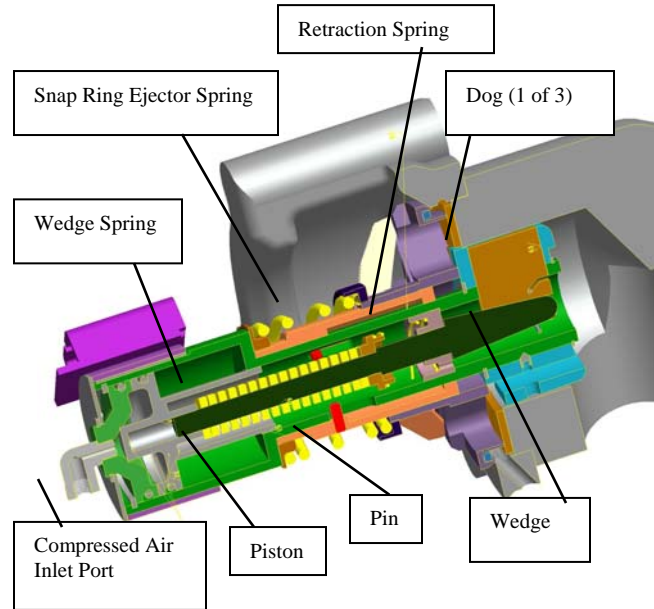


Fig. 7. View 2 of Installation Tool in Hanford Connector (3-D Model)

When compressed air is introduced to the inlet port the piston begins to move to the right (Fig. 7 shows the piston fully to the left position) which begins a chain reaction of motions internal to the tool. The wedge is forced rightward, which causes the dogs (shown in orange in Fig 7) to bear against the bore of the process hole in the connector. The dogs serve to lock the tool in place relative to the hanford connector. Once the dogs are in full contact with the bore no further motion is possible for the wedge. Any further motion of the piston will cause compression of the wedge spring; which further loads the dogs ensuring anchorage and alignment of the tool with the connector. The leading edge of the piston makes contact with three red pins (radially oriented) that are part of the snap ring ejector, causing the pins to move to the right with the piston. The snap ring ejector spring resists motion of the ejector to avoid accidental snap ring ejection due to inadvertent motion of the snap ring ejector fingers during tool movement. The spring is compressed until the snap ring is ejected from its groove and delivered into the connector. The retraction spring is present to encourage dog retraction into the tool after the air pressure has been isolated from the tool. A garter spring (not annotated) retains the three dogs when the tool is removed from the connector bore.

The proportioning of the total load provided by the piston to the wedge and pins is dictated by the spring choice and the extent of any preloading in the snap ring ejector spring. The springs are chosen so as to devote a large percentage of the available piston force to anchorage and alignment of the tool axis to the connector axis. The geometry of the installation tool is designed to minimize the gap between the installation tool and the Hanford connector skirt to ensure that the snap ring enters the Hanford connector groove.



Fig. 8. Installation Tool in Hanford Connector

Use of the MSM required that the tool weight not exceed 10 lbs due to MSM load limitations. The load limit required custom design and engineering optimization during development of the tool.

CONCLUSIONS

The Hanford connector gasket replacement tooling has been successfully demonstrated using MSM's to manipulate the various tools. Nitric acid is used in many of the decontamination processes performed in the REDC, where the tooling will be deployed. Although most of the tool components were fabricated/purchased with nitric acid and radioactive service in mind, some of the prototype parts have been replaced with parts that are more compatible with nitric acid/radioactive service. Several modifications to the various tools were performed to facilitate maintenance and replacement of failed components. Development of installation tools for replacement of 1", 2" and multi-hole gaskets is planned. On July 17 and 29, 2008 the Remote Gasket Tool was successfully demonstrated in the REDC cell using a process jumper. Deployment of the existing system in the DWPF REDC for system jumper maintenance is expected during FY09.