ON-SITE TRANSFER SYSTEM FOR REMOTE HANDLING OF LOW-LEVEL RADIOACTIVE WASTE

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ABSTRACT

Remotely operated handling systems are employed for safe processing and transfer of low level radioactive wastes at nuclear generating plants. These systems minimize or preclude personnel radiation exposure while expediting waste handling operations.

A remotely operated waste handling and transfer system containing several unique features has been designed, fabricated and installed at Southern California Edison's, San Onofre Nuclear Generating Station. The system incorporates modular subcomponents such as a waste processing shield, bottom and top loading shielded cask, transportation system and remote grappling equipment, making it adaptable to multi-task waste handling operations. The system has proven to be operationally flexible, and has contributed significantly to reducing waste processing personnel exposure.

INTRODUCTION

Increased uncertainties regarding the future availability of low level radioactive waste disposal sites has caused many commercial nuclear power utilities to investigate and implement alternatives to radwaste storage and disposal. One current methodology being explored by the nuclear power industry centers around the capability to store large quantities of low level radioactive waste on the plant site. Implementation of on-site radioactive waste storage capabilities requires well defined engineering parameters, careful project cost analysis and remotely operated equipment that insures safe, reliable handling of the radioactive containers.

Nuclear Packaging, Inc. of Federal Way, Washington, under a contract to Southern California Edison has developed a radioactive waste On-site Transfer System, (OTS), that allows shielded handling of low level radwaste at the San Onofre Nuclear Generating Station, (SONGS). The system (Fig. 1) is designed to remotely transfer multi-configured radwaste containers into shielded storage modules, on-site radioactive waste storage facilities or shipping casks. Its design and operation minimizes radiation exposure to site operation personnel and provides a flexible and efficient means for handling radwaste containers under various storage scenarios.

The waste handling system design requirements include the capability to; (1) Process variable size radioactive waste liners in a shielded environment, (2) transport liners within the confines of the site boundaries, (3) remotely transfer waste liners from the processing/transfer cask into storage modules or shipping casks, and (4) maintain personnel radiation exposure as low as reasonably (ALARA) achievable during transfer

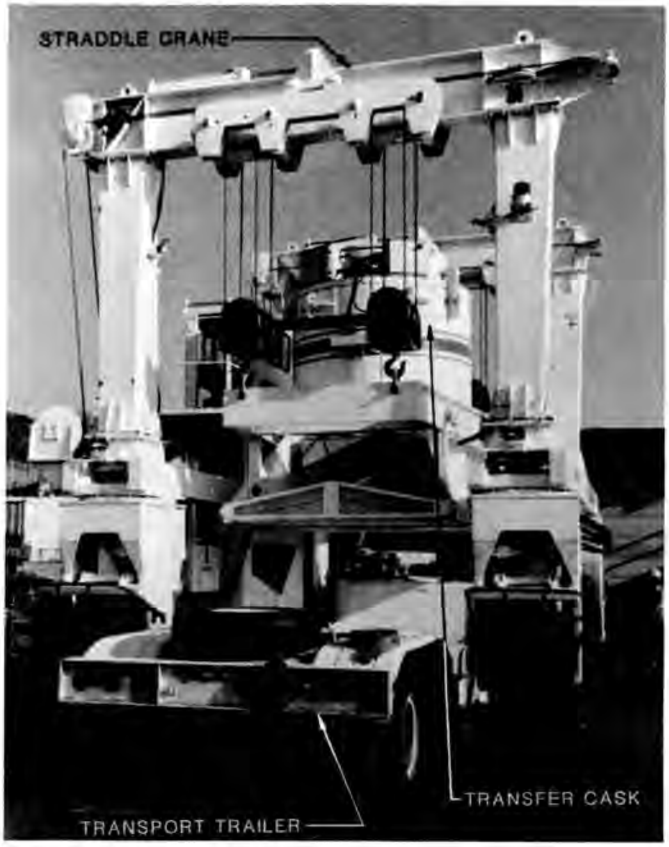

Fig. 1. On-Site Radioactive Waste Transfer System (OTS)

operations. Additionally, the OTS equipment is designed for service in an outdoor, inclement weather, salt-air environment with temperature ranges from 0°C to 49°C (32° - 120°F). Design considerations were incorporated into the OTS for equipment repair in the event of mechanical or electrical component malfunctions during "hot" transfer operations.

A modular equipment approach was adopted to meet the design requirements for the OTS. This methodology provides maximum system operational flexibility and the ability to cost effectively modify the system subcomponents for use with future waste processing liners, storage modules or shipping casks.

System Component Description

The OTS is comprised of the following modular components, (Fig. 1):

- Transfer Cask; which provides shielding from radwaste containers during waste processing and remote transfer operations.
- Cask Transport Trailer; for transportation of the transfer cask between radwaste processing facilities within the plant site boundaries.
- Mobile Straddle Crane; which provides for remote handling and positioning of the transfer cask during waste container transfer operations.

Transfer Cask

The top and bottom loading transfer cask (Fig. 2) is the primary component of the OTS. It provides shielding from radwaste containers during waste processing and subsequent transfer operations. It has an internal cavity sized to handle containers up to 5.9m^3 (210 ft^3) and is designed with a shielding equivalent of 8.8cm, (3.5 in.) of lead. Externally, it is 3.2m (10.6 ft.) high, 2.2m (7.1 ft.) in diameter and weighs 29.3 tonne (32.5 tons) empty.

Fig. 2. Shielded Transfer Cask and Transport Trailer

The cask has an integrally attached, remotely operated, 15.2cm (6 in.) thick steel closure door assembly located at its base. The door assembly enables containers to be transferred through the cask bottom and into shipping or storage vessels. The door assembly is electrically operated either from a locally mounted control panel or from the OTS remote control station. In the event of an electrical system failure the door is designed to be manually operated in order to complete or abort a container transfer operation.

Both interior and exterior surfaces of the transfer cask are designed for decontamination. The interior surface of the cask, including the doors, is clad in stainless steel. The cask exterior finish is a heavy coat of epoxy paint.

The transfer cask is equipped with two interchangeable shielding lids. The processing lid is utilized during container processing including radwaste solidification or resin drying operations. The 15.2cm (6") thick lid is clad in stainless steel. It has a 71.1cm (28 in.) diameter hole in its center that enables the processing equipment to be remotely connected or disconnected from the container inside the transfer cask. The lid is adjustable in height for processing various size containers.

The grappling lid provides for remote grappling and handling of the radwaste container. It is equipped with a 13.5 tonne, (15 ton) capacity chain hoist, grapple, load cell, grapple depth encoder and a programmable logic controller. The grapple lid is designed for quick installation and removal from the transfer cask. Keyed guide ways, quick disconnect electrical connectors and ball-lock pins enable the grapple lid to be installed or removed without personnel exposure during waste container handling operations.

The container grapple is suspended under the grapple lid (Fig. 3). It contains two grappling fingers which engage specially designed pockets on the waste container. The grapple is equipped with guides to insure alignment with the container during remote grappling operations. The guides enable positive grapple engagement with as much as a 44mm (1-3/4 in.) misalignment between the vertical axes of the container and grapple.

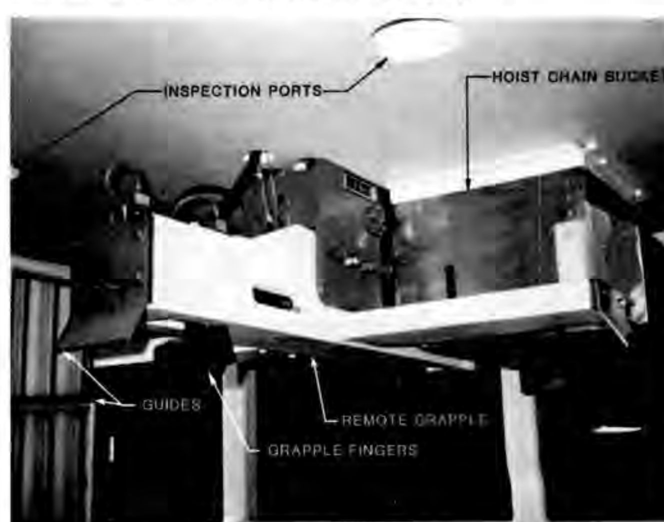

Fig. 3. Underside of Transfer Cask Grapple Lid

The grapple fingers are engaged and disengaged by a linear actuator positioned in the grapple body. Limit switches are used to indicate when the grapple is seated on the container and provide position status of the grapple fingers, (i.e., extended or retracted).

A grapple depth encoder is mounted on the grapple lid and connected to the grapple by a retractable cable. The depth encoder enables the operator to determine the grapple's vertical position during container transfer. Adjustable limit switches on the depth encoder's remote console readout allows operational set-points to be established and controlled during operation.

A load cell is used on the grapple hoist to accurately weigh the waste container. The load cell also provides the operator with an accurate indication as to whether container transfer operation is proceeding smoothly. Sudden fluctuations in the load indicator during container transferring would indicate an operational anomaly which may require further operator attention.

Three inspection ports are provided on the grapple lid. The inspection ports can be used for insertion of sampling equipment or remote viewing equipment. The ports can also be used for releasing the grapple with long reach manual tools in the event the actuator should fail.

The modularity of the grapple lid enables it to be operated as a remotely controlled component, completely separate from the transfer cask. In this mode it can be used for placing empty containers in the transfer cask or as a remote handling device in hazardous environments within the plant's radwaste facilities.

Fig. 4. Mobile Straddle Crane, Transfer Cask & Trailer Staged for Transfer Cask Loading

Cask Transport Trailer

The transport trailer (Fig. 2) is a highway legal trailer utilized for tractor transportation of the transfer cask between in plant facilities. It also provides a working base for the transfer cask during radwaste processing. It is 10.7m (35 ft) long and has a 45 tonne (50 ton) load capacity. A specially designed suspension system provides a maximum tire ground pressure of 655k/Pa (95 psi) under full load.

The trailer is equipped with a standard fifth wheel tractor attachment and has a hydraulically actuated landing gear system for leveling of the cask during radwaste processing and long term storage. Specially designed guides are incorporated into the trailer deck to enable expedient transfer cask positioning. Tie down cables and adjustable ratchet binders secure the transfer cask to the trailer during transport.

System modularity enables the transport trailer to be used with the transfer system or as a separate trailer for highway transportation of other plant related cargo. This helps insure maximum system cost effectiveness during non-radwaste processing activities.

Mobile Straddle Crane

The mobile straddle (Fig. 4) crane provides a means for transporting and positioning the transfer cask during container transferring operations. The crane is designed to "straddle" the transport trailer, lift the transfer cask and transport it to the container transfer area. The crane has a 45 tonne (50 ton) capacity and is equipped with a hydrostatic drive system which enables precision positioning and alignment of the cask over the container transfer area, (Fig. 5).

The crane is equipped with two, 22.7 tonnes (25 ton) each, variable speed, dual hook, lifting systems to enable forward and aft leveling of the cask during transport on unlevel ground. The two individual hoists can also be used for cask leveling prior to container transfer operations.

Fig. 5. Straddle Crane positioning transfer cask over container transfer area

A lift fixture is provided for interfacing the transfer cask to the straddle crane hoists and trolley. The lift fixture is designed for quick disconnect from the cask by removal of locking pins. Ratchet binders are utilized to connect the transfer cask and lift fixture to the straddle crane's structural frame during cask transport. This prevents unwanted sway motion between the crane and cask which could cause structural damage during transit.

The crane's design includes the following additional features:

- Maximum height - 6.7m (22 ft).
- Maximum outside width - 5.4m (17ft-9").
- Minimum internal clear width - 3m (10 ft).
- Maximum ground pressure at full load 655k/Pa (95 psi).
- Capable of negotiating a 5% grade for 305m (1000 ft) under a full load of 45 tonnes (50 ton).
- Less than a 7.6m (25 ft) outside turning radius.
- Diesel powered engine with an auxiliary 10 KW A.C. generator system.
- Emergency and safety interlocks for remote operation.

In addition to the crane's standard cab controls, it has been modified to enable remote control of its engine, hoist and trolley travel functions. A 10 kw electric a.c. generator, belt driven by the diesel engine, provides self contained electrical power to the cask and control station during container transferring operations.

System Control Station

The OTS control station provides remote operation of the transfer cask and straddle crane during waste container handling operations. It is designed to operate all of the modular subcomponents of the on-site transfer system. During container transfers involving the straddle crane, the control station remains mounted to a storage/operating location on the side of the straddle crane, (Fig. 6). When the cask is trailer mounted, (such as during radwaste processing, or autonomous grapple lid operation), the control station is removed from its crane storage location and placed on a portable pedestal up to 6.1m (20 ft) from the transfer cask. The control station portability enables the operator to minimize his radiation exposure while simultaneously maximizing the system's operational flexibility.

The control station includes the following OTS controls and features:

- Master power control switch.
- Controls for raising and lowering the remote grapple.
- Grapple "extend/"retract" control and status indicators.

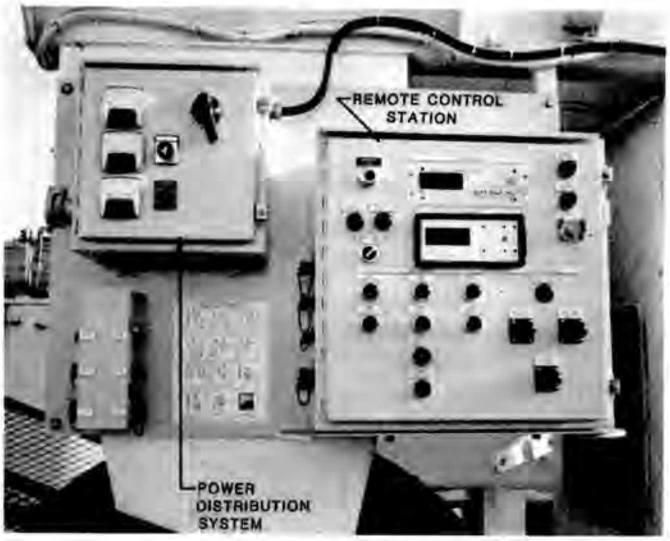

Fig. 6. OTS Remote Control Station mounted on straddle crane

- Grapple "seated" indicator.
- Cask door "open"/"closed" control and status indicators.
- Grapple depth readout with adjustable set points.
- Grapple load readout with maximum/minimum load indicators.
- Isolated, manual interlock over-ride switch.
- Emergency system shut-down switch.
- Crane, forward trolley/hoist control.
- Crane, aft trolley/hoist control.
- Master crane trolley/hoist control.

A programmable logic controller (PLC) located on the grapple lid of the transfer cask provides the interlock logic for the OTS operation. It aids in assuring that waste container grappling, hoisting and transfer functions are properly sequenced so that operator and equipment safety is not compromised.

The following provides a representative example of the interlock functions controlled by the PLC:

- Cask doors will not open or close if grapple is not in the full up position.
- Automatic hoist shut-down if preset maximum load on grapple is achieved or exceeded.
- Automatic hoist shut-down if preset negative load on grapple is achieved.
- Grapple fingers will not operate if grapple is not fully seated on waste container.

- o Grapple fingers will not retract if grapple is not fully seated on the waste container and the load cell weight is not at or below preset limits.

All control system wiring is interconnected via quick disconnect electrical connectors. This enables continued system modularity and ease in start up and maintenance under adverse field conditions.

System Startup

The OTS was received at Southern California Edison's (SCE) San Onofre site in January 1985 and placed into operation in August 1985. Between receipt and actual use, on-site acceptance testing and personnel training was conducted. During this time SCE maintenance personnel and operators were familiarized with the system and were trained in it's operation by a Nuclear Packaging representative. The plant personnel verified system design parameters and gained operating proficiency by positioning and transferring mock waste containers into a shipping cask.

Following equipment assembly and initial assembly verification testing, the OTS was taken into the plant for operational testing. Upon equipment staging, power was connected to the OTS system in preparation for removal of an empty High Integrity Container (HIC) utilizing the remote grapple lid. Following electrical power-up all control panel indicators were found to be functioning appropriately. However, operator attempts to raise or lower the grapple lid hoist containing the test container were unsuccessful. After several trouble shooting attempts failed, system operators disregarded warnings about use of the "interlock over-ride" switch, and placed the grapple lid controls in the manual mode. (Switching to the "over-ride" mode bypasses all safety system interlocks and defeats the protection against improper equipment operation). With the controls in this mode, the operator inadvertently retracted the grapple and partially released the test container. Though there was no damage to equipment or personnel, it clearly and graphically demonstrated how important the safety interlock features of the system are. As a result of this incident, use of the interlock over-ride function is severely limited and its use must be authorized by department supervision.

Further investigation into the hoist motor problem revealed the truck bay power supply was incompatible with the hoist motor's phase protection circuitry. This prevented the hoist motor from operating. Minor wiring changes quickly corrected the problem and the grapple lid hoist motor began operating as designed.

Also identified during operational testing was the need for a remote CCTV system for the grapple lid in order to get a positive view of the grapple position and operation. (Inspection ports were provided on the grapple lid for CCTV installation, however the remote viewing system was not provided with the original equipment). The lack of viewing perspective was compensated for by placing an individual in an elevated position to direct the OTS operator when necessary. This however, did not significantly affect the system operability.

As the test program continued, further operational procedures were established to ensure that containers were attached to the grapple device during transfer cask transport. This ensured container/cask concentricity, thus avoiding potential grapple misalignment or misengagement following transfer cask movement.

System Operating Experience

The primary waste processing area at San Onofre is a common truck bay at the Units 2 and 3 Radwaste Building (RWB). Liners or HICs are filled in the truck bay area with either solidified waste, dewatered waste or dry solid wastes. These wastes normally read 5 to 50 rem/hour on contact.

In August of 1985 and in February 1986 the OTS was used very beneficially in support of resin dewatering/drying. The resin dewatering/drying system components were assembled for this activity on the loading dock area in the truck bay. The OTS trailer/transfer cask was staged alongside the dock as a process shield with an HIC inside the cask. When the container was filled, processed and capped, the remote grapple lid was installed on the transfer cask and the grapple was engaged to the HIC for transport. The electrical power was disconnected from the transfer cask and control panel then the trailer/cask was removed from the truck bay using a hydraulic fifth wheel tractor.

After removal from the radwaste truck bay, the transfer cask could be moved to the on-site storage facility or the HIC could be transferred into a shipping cask. If the transfer cask is transported to the on-site storage facility, the following sequence of events occurs.

The trailer is backed into the storage facility truck bay and power/controls are connected to the transfer cask from the facility bridge crane. A lifting device is attached between the transfer cask and bridge crane. The crane is then made ready for automatic/remote operation. The crane is operated from the facility control room and is monitored through video cameras mounted on the crane and in the facility. When the crane reaches the appropriate destination coordinates the cask shield doors are opened and the grapple lid hoist lowers the container into its designated location. The entire transfer evolution is performed without exposing or touching the container.

As an alternative to transferring the container to the storage facility, it may also be transferred into a shipping cask using only the grapple lid. This is the method used in the ALARA comparison which follows.

ALARA Benefits

An example of the ALARA impact of the OTS can be seen from a comparison of the exposure received during handling of solidified resin liners in 1984 versus the handling of dewatered/dried resins in 1985.

In 1984, without the OTS, a concrete process shield was used alongside the loading dock on which the radwaste processing system was staged. This provided adequate shielding but containers were required to be lifted out of the shield with a mobile crane and carried, unshielded, out of the truck bay to another shield or a transport cask. This evolution required a rigger to physically climb onto the container to connect and disconnect the crane hook in addition to guiding the container to it's destination. The average exposure for such an evolution involving a 190 cubic foot container with a dose rate of approximately 10 rem/hour was 150 millirem. (This number varied slightly depending upon the condition of the rigging cables, the dexterity of the workers and the actual dose rate of a given container).

An example of the exposures received by the individuals involved is as follows:

rigger	115 millirem
health physics	15 millirem
mobile crane operator	20 millirem
Total	150 millirem

By comparison, in 1985 a processing campaign was undertaken generating seven HICs of dewatered/dried resin. The OTS trailer-mounted transfer cask was used as a process shield. Upon completion of each processing evolution, the transfer cask and trailer were driven out of the truck bay and staged next to a shipping cask or storage module. Using the remotely operated grapple lid and a mobile crane, the container was moved a short distance to the shipping cask or module with minimal exposure. In this situation the container was handled remotely and unshielded, leaving the transfer cask on the trailer.

The exposure resulting from one such movement of a 210 cubic foot HIC reading 8 rem/hour on contact with this method was 61 millirem.

The exposure distributed among the personnel involved was as follows:

crane operator	3 millirem
overhead checker	5 millirem
health physics	20 millirem
Radwaste Specialist	15 millirem
load rigger	18 millirem
Total	61 millirem

SUMMARY

The On-site Transfer System is continuing to perform its intended function without incident and has significantly contributed to reductions in personnel radiation exposure. It has exhibited a high degree of reliability under rigorous field operating conditions. The modular system design approach has demonstrated the ability to be flexible and adaptable to changing operational parameters and interfaces. The system design has been shown to be readily adaptable to reconfiguration to meet future demands in radioactive waste processing, handling and storage requirements.

Additionally, the OTS has demonstrated cost savings to SONGS due to an overall reduction in equipment lease time, contract personnel time and utility labor time spent transferring and handling radwaste. The reduced exposure has resulted in fewer Health Physics controls, fewer support personnel and simply, less time to accomplish the same task. By comparison, it now takes approximately two hours to perform a task that once took up to eight hours to complete.

In summary, the On-site Transfer System has demonstrated the ability to:

- reduce personnel exposure resulting from waste handling.
- reduce overall costs resulting from routine waste handling.
- provide new methods of handling waste at SONGS by meeting plant-specific design considerations.
- meet the design and engineering requirements to interface with the plant's recently completed on-site storage facility.