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UC-81, Reactors - Power
(TID-4500, 15th ed)

DEFUELING THE S2G REACTOR

C. V. Moore

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Date

General Electric Company
KNOLLS ATOMIC POWER LABORATORY
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ABSTRACT

The defueling of the S2G Reactor which was conducted at the Electric Boat Division, General Dynamics Corporation, Groton, Connecticut during January, 1959, is reported here from the viewpoint of the participating personnel from Knolls Atomic Power Laboratory. The sequence of events is outlined, difficulties encountered during the operation are described, and conclusions of possible interest to other naval nuclear reactors are given.

CONTENTS

DEFUELING THE S2G REACTOR

C. V. Moore

INTRODUCTION

The usable uranium content of the first core of the nuclear submarine SEAWOLF (SSN575) was expended on December 12, 1958. After suitable preparation, this core was removed, cleaned, and transported to the Expended Core Facility, Scoville, Idaho for disassembly and preparation for chemical reprocessing.

The removal of the fuel was conducted by the Electric Boat Division of General Dynamics Corporation under a contract which covered the conversion of the SEAWOLF reactor plant from sodium to pressurized water. The Knolls Atomic Power Laboratory, as the prime contractor for the S2G Reactor and design agent for the reactor servicing equipment, provided technical personnel who assisted with the defueling and cleaning operations. A detailed description of the equipment used and the procedures followed is given in the referenced technical manuals.

SEQUENCE OF EVENTS

Preparation of detailed procedures for the defueling dry run was started in the Spring of 1958 and continued through the Summer and early Fall. The defueling equipment was taken out of storage and shipped to Electric Boat in the early Fall where it was inventoried and checked for any damage which might have occurred during shipment. In October, 1958, a series of lectures covering the defueling operations and the equipment to be used in the defueling was given by KAPL and Electric Boat personnel to those KAPL, EB and Navy personnel who expected to participate in the defueling proper. This series of lectures was followed by a trial or dry-run defueling operation.

The dry-run operation was performed in the north yard of the Electric Boat Division where a building was constructed especially for this purpose near a railroad siding. The building and equipment were located to simulate the placement of the reactor and equipment on the dock during the actual defueling operation. The defueling building contained a test facility which simulated one matrix hole of the reactor and the access hole located directly above this matrix hole. Also located in the defueling building was a mockup of the rotating plugs. This mockup was used for exercise of the equipment which rotates these plugs during the defueling. Components which had been previously used for testing of equipment and spare parts were utilized in constructing these mockups.

The dry run consisted of 2 weeks of trial operations of the defueling equipment conducted on a 3-shift basis. The operations simulated were insertion and removal of the secondary safety rod, filler plugs, refueling liners, and fuel rods; replacement of sodium drip cups; and rotation of the plugs. Most of the major items of equipment were exercised.

This dry-run operation not only provided training for the personnel who were to participate in the defueling, but it also offered an opportunity to perform mechanical, electrical, and fluid system checks on the defueling equipment (which had previously been stored for an extended period of time), to check out the written procedures, and to obtain realistic time estimates for use in scheduling. The operation also provided an opportunity to ensure that all the tested equipment was on hand.

The defueling dry run was followed by 6 weeks of maintenance work prior to the availability period during which the minor deficiencies discovered during the dry run were corrected.

The availability period for the SEAWOLF started December 12, 1958. During the remainder of December the reactor compartment hatch was opened and the control drive mechanisms and secondary safety withdrawal mechanisms were removed from the reactor. The defueling equipment was set up on the dock and separate weather protection shacks were constructed for the refueling console, the records, and also for the use of the attendent KAPL engineer.

During the period from January 2, 1959 through January 22, the defueling "proper" was conducted. These operations included the following:

1. Disconnection of control cylinders,
2. Sampling of reactor vent gas,
3. Installation of surface plate and reactor valve block in reactor compartment,
4. Removal of secondary safety rod and filler plugs and installation of refueling liners,
5. Thawing of reactor freeze seal,
6. Lifting and rotation of rotating plugs,
7. Removal of fuel rods and transfer to transfer casks,
8. Lowering of the rotating plugs,
9. Installation of the secondary safety rod and filler plugs and re-establishment of freeze seal,
10. Cleaning of residual sodium from defueling equipment (except transfer casks).

From January 22 through 31, preparations were made for cleaning the sodium which remained on the fuel rods in the transfer cask. From February 2 through 6, the actual cleaning was performed.

After cleaning of the fuel rods, the casks containing these rods were shipped from Groton, Connecticut to the Expended Core Facility at Scoville, Idaho during the period from February 8 through 11. The trip, which was by special train, was uneventful.

DIFFICULTIES AND OBSERVATIONS

Although the defueling equipment was used for the first time during this operation, it performed satisfactorily with holdup as a result of equipment difficulties in defueling operation, totaling not more than a few hours. The holdups that were caused by equipment difficulties consisted largely of time required to diagnose the difficulties and obtain general agreement as to the proper corrective action to be taken. Twenty days of 3-shift operation were required for the defueling proper. This was 3 days less than that originally scheduled for the operation.

No individuals were exposed to more than the maximum permissible daily dose, 50 mr. None of the canvas used for protection against surface contamination became contaminated during the operation. No gases or liquids in excess of permissible tolerances were released to the environment.

Nevertheless, numerous minor difficulties were encountered; these should be expected in any operation of this size and character. These difficulties together with general observations, are listed and described below:

Difficulties Encountered and Observations Made During Dry-Run Operation

Reactor Valve Hand Wheel Assembly

During unpacking operations, the reactor valve block hand wheel assembly was bent. This was corrected by straightening.

Surface Plate Lifting Eye Bolts

The eye bolts used for handling the surface plate in the reactor compartment were found on first trial to be about 1/8 in. too long to bottom properly in their fitted holes. This extra length was removed by grinding.

Refueling Console Gas Leaks

The original procedures called for performing a gas pressure drop-off test of the reactor valve block static seals by setting up a pressure in the valve block with the valve block connected to the refueling console and monitoring this pressure with the refueling console valves closed. Small leaks of inert gas in the refueling console made this procedure impractical. As a consequence, this procedure was revised to call for isolation of the reactor valve block from the refueling console by disconnecting hoses while performing the pressure test. The small leaks of inert gas in the refueling console were of no technical significance otherwise, and were not corrected.

Water in Reactor Valve Block and Transfer Casks

When the reactor and cask valve blocks were opened for inspection, traces of moisture were found inside; apparently, this moisture was the result of condensation. When the shipping domes were removed from the transfer casks, about 1 pint to 1 quart of moisture was found inside the shipping dome of one of the casks. A few drops of moisture were found beneath the dome of the second cask. This moisture did not penetrate into the rod storage region of the casks. It apparently resulted either from condensation or from rain water drawn in through a defective seal by "breathing" of the casks through the seal under the domes. During subsequent storage operations both the reactor valve block and the transfer casks were maintained with an internal inert gas pressure several psi above atmospheric to provide positive prevention of the entry of water.

Plug Removal Machine Valve Leakage

Some of the valves on the plug removal machine inert gas console leaked at the valve stem. The leaks were corrected by removing and lubricating the stems.

Ball Nuts

The refueling machine, plug removal machine, reactor valve block, and secondary safety cask were closed by sliding block-type closures. The sliding blocks were actuated by ball nuts. The torques required to move the valve blocks of the plug removal machine, reactor valve block, and secondary safety cask increased somewhat during the dry-run operation, although not sufficiently to prevent operation. These torques were reduced to normal at the end of the dry run by disassembling and lubricating the ball nuts with light machine oil.

Log Sheets for Watch Stations

Log books were maintained at the secondary safety cask, transfer cask, and simulated reactor compartment to provide a record of transfer operations and certain operating data. The formats for these logs, which were originally found to be somewhat confusing, were revised before the defueling.

Nomenclature

In giving instructions for the shutting of valves the standard Navy procedure is to use the word "shut" to describe such operations, because of the similarity of the "o" sound in "close" and "open". Wherever the work "close" was used in the operating procedures it was revised to "shut" for the defueling operation.

Cable Connectors for Refueling Machine Interlock Cable

The cable connectors on the refueling machine interlock cable and the receptacle for this cable at the refueling console were found to be both female. A male connector of the proper type was not available; therefore, both connectors were replaced with a pair (male and female) of different design.

Quick-Disconnect Fitting on Refueling Machine Gas Supply Line

While the crane was moving the refueling machine, one of the quick-disconnect fittings on the gas supply line of the refueling machine came partially open, which caused a loss of gas pressure to the refueling machine. This opening apparently occurred as the quick disconnect was slid over some obstructions on the simulated dock. The fittings were reconnected, lock-wired, and taped to prevent a repetition of this incident. All other quick-disconnect fittings which were dragged around during operation were similarly secured.

Leak in Transfer Cask

A gas leak was discovered in the rotating seal area of transfer cask No. 2. After the dry run was completed, the transfer cask cover was removed and the leak repaired. The leak was found to be the result of a defective joint in a molded rubber seal. On inspection of the spare seals similar defects were found. Several of these were repaired by revulcanizing the joint and one of the repaired seals was used as a replacement.

Jog Operation of Plug Drive Motors

The gear motors which rotated the rotating plugs were provided with a continuous speed control over a range of about 50 to 100% of full speed. Operation at lower speed was obtained by driving the motors with the motor brakes engaged. This type of operation was very sensitive to brake adjustment. The motors were initially used during the dry run this adjustment was not satisfactory. It was corrected by readjusting the brakes.

Crane Breakdown

The crane used for handling refueling equipment on one occasion lost its ability to "slew" for several hours because of a rupture of gas supply lines; these were replaced.

Refueling Machine Static Seal Test

The defueling procedures called for performing a test of the static seal at the bottom of the refueling machine by pressurizing the region and checking for gas pressure drop-off. The machine was not able to pass this test because of internal inert gas leaks in a region which could not be repaired without extensive work on the machine. These leaks were, however, in a region of no technical significance.

Inserting Rod in Transfer Cask

During the first attempt to load a fuel rod in a transfer cask the fuel rod would not enter. On investigation it was found that the index setting used for rotating the rotating cover of the cask was for the wrong cask (each cask had its own index settings). The difficulty disappeared when the cask cover was rotated to the correct position.

Water in Transfer Cask Coolant Oil

During the check-out of one of the transfer casks prior to the dry run, the cover over the vent on one of the cask expansion tanks was left off for several days. It was feared that rainwater might have entered into the expansion tank; consequently, a quantity of oil was drained from the bottom of the coolant oil system and checked. A surprisingly large quantity of water was found in the oil during this investigation. It was considered that the quantity of water found (about 1 pint) was too much to have entered the uncovered vent and that the water must have resulted from condensation in the expansion tank. Consequently, all of the shield oil and coolant oil systems of both casks were drained and refilled. During the dry run and the period of storage before the defueling, the systems were kept completely full of oil to prevent condensation.

Calibration of Refueling Equipment Pressure Gages

For proper operation of the inert gas seals in the S2G refueling equipment, pressure differentials of as low as 1 or 2 psi are maintained between various portions of the equipment and between different pieces of equipment. For maintaining these pressure differentials accurate pressure gages are necessary. The pressure gages on the defueling equipment were tested and calibrated to ensure this accuracy.

Brazed Joint in Sodium Cups

The sodium cups used for catching sodium drippage from the fuel elements in the refueling machine were originally fabricated by brazing two stainless steel components together. One of these sodium cups came apart at the brazed joint during the dry-run operation; this was due either to a defective brazed joint or a joint which had been damaged by corrosion or high temperatures during sodium cleaning operations. All of the cups were modified by replacing the brazed joint with a welded joint.

Crane Exhaust Gases

The exhaust pipes of the diesel powered crane, used for equipment handling during the dry run, were aimed directly at the platforms erected about the secondary safety cask and the transfer casks, and caused considerable discomfort to personnel during portions of the operation. This condition was corrected by installing flexible metal hoses on the exhaust pipes and directing the gases upward.

Gas Leak at Electrical Penetrations of Refueling Machine

A gas leak was discovered at a point where electrical leads entered the upper machinery chamber of the refueling machine. This leak was repaired.

Sound Powered Phones

Difficulties caused by defective phones were encountered on several occasions in operating the sound powered telephones; the defective phones were replaced.

Disengaging Sodium Cup

On one occasion when an attempt was made to discharge a sodium cup into the secondary safety cask from the refueling machine, excessive force had been used in handling the cup which caused a deformation and effective reduction of the diameter of the hole on the top of the cup; this, in turn, caused the cup to adhere to the refueling grapple. The cup was repaired and the diameter of this hole inspected in all of the cups. Refueling machine operators were cautioned to use less force in handling these cups.

Portable Electric Space Heater Short

In one case, a 230-v electric space heater used on the operator's platform of the refueling machine became shorted to the machine; the operator received a severe shock. The short was corrected and a separate ground wire connected to the heaters. No lost-time injury resulted.

Weather Protection Covers for Plug Removal Machine and Refueling Machine

Weather protector canvas covers were rigged for protection of the operators of the plug removal machine and refueling machine. Several unsuccessful attempts were made to rig suitable canvas covers for these machines before reasonably satisfactory covers were obtained. The problems encountered in furnishing suitable covers were complicated by the need to disconnect the machine lifting bales from the crane hook after landing the machines on the reactor as insurance against inadvertent lifting of the machines during radioactive component removals from the reactor. After the dry run, an aluminum and plexiglass enclosure with a canvas top was constructed for the refueling machine. The canvas top of this enclosure, however, was not completely satisfactory.

Difficulties Encountered and Observations Made During Defueling

Rectifier Tubes in Rotating Plug Drive Console

The rectifier tubes, supplied as installed equipment in the rotating plug drive console, contained mercury. Although this console was capable of being sealed during operation, it was decided to replace the mercury tubes with those containing no mercury in order to comply with shipyard regulations which prohibit the use of mercury. Gas-filled rectifier tubes were procured and used as a replacement for the mercury tubes. The operation of the plug drive console with the gas-filled tubes was not completely satisfactory near the end of the defueling operation; apparently this was due to degradation of tube characteristics with life. The defective tubes were replaced by the gas-filled spares on hand.

Refueling Machine Heater Thermostat

A thermostatic switch used for controlling the temperature of the refueling machine flapper valve heater stuck in the closed position, on one occasion for about 1/2 hr. This switch was manually by-passed during this period. It subsequently freed itself and performed satisfactorily; therefore, no corrective action was taken.

Refueling Machine Plug Valve

One of the plug-type inert gas valves on the refueling machine console became leaky during operation and was replaced. The stainless steel plug and seat of the valve were found to be scored.

Control Disconnect Mechanism Screw Interference

The screws used to attach the nameplate of the control disconnect mechanism to the mechanism were found to interfere with the operation of the mechanism. These screws were removed.

Weighing of Shield Oil

As part of the operation of thawing the reactor freeze seal it was necessary to remove measured quantities of shield oil from the reactor and surrounding structure. This shield oil was measured by weighing with a balance-type scale. After the shield oil had been removed, it was discovered that the wrong balance weights had been used with the scale;

therefore, the quantities listed as the amounts of shield oil removed were in error. However, the magnitude of these errors was not significant.

Nitrogen Purity

The nitrogen purity specification initially used at the start of the defueling operation was 99.9% nitrogen. On re-evaluation, this specification was narrowed to 99.91%. A few of the nitrogen bottles which were originally planned for use in defueling could not meet this specification and were rejected. Sufficient bottles, however, were procured.

Cam Locations

The cams used on the rotating plug gears to limit this angular rotation of the rotating plugs were found to be improperly located for contacting the limit switches on the plug drive equipment. The cams were relocated.

Interference between Screws on Concentric Gear and Transmitter Unit

An interference was discovered on the concentric plug between some machine screws on the concentric gear and the concentric position transmitter. These screws were removed after causing some damage to the concentric tranmitter case and gears. This damage was repaired.

Water in Pressure Gauge on Secondary Safety Cask

The pressure gauge on the secondary safety cask was found to contain rainwater after its case had been exposed to rain. The gauge was dried out, recalibrated and a polyethylene shield case placed over it.

Transfer Cask Weight and Location

In order to place the fuel transfer casks within the reach of the crane used for defueling, it was necessary to move these casks to the ends of their flat cars during the loading procedure. When located in this position, however, the 55-ton casks placed a load on the railcar trucks above the capacity of the portion of the Electric Boat dock near the shore (Pier D). As a result, the casks were located in the centers of the flat cars on special steel plates during transport on to the portion of the dock used for defueling. The casks were subsequently pulled to the ends of the flat cars.

Safety Rod Adapter

The adapter attached to the secondary safety rod for its lifting from the reactor was found to be radially eccentric. This eccentricity was corrected by remachining.

Portable Boiler

A portable boiler was used for supplying hotel load steam to the SEAWOLF during the defueling and subsequently for steam cleaning operations on the defueling equipment. This boiler was out of service on occasion for periods up to several hours. The outages were, in several cases, caused by freezing of sensing lines used for control of the boiler. To eleviate this condition, the boiler was subsequently enclosed in a wooden structure.

Hose Identification

The hoses used for inert gas and vacuum service during defueling were found initially to be laid out improperly. This was corrected by relocating the hoses and adding color coded stripes to the identification marking on the hoses.

Low Pressure Regulators on Gas Bottles

During storage of the defueling equipment between the dry run and the defueling, pressure of several psi was maintained on the equipment to prevent entry of atmospheric moisture. The regulators normally used on nitrogen supply bottles were found to be inadequate for maintaining pressures this low. Special regulators were procured; these gave satisfactory service.

Internal Gas Leaks in Reactor Valve Block and Refueling Machine

Several of the spaces inside the reactor valve block and refueling machine which were nominally independent were, in fact, connected by inaccessible leaks. These were technically of no significance, but did require changes in testing procedures.

Guying Plug Removal Machine to Dock

The plug removal machine was tied down by cables and attached to 5-ton concrete blocks when not in use during the defueling. It was found that the concrete blocks shifted on the dock when the guy wires were tightened. As a result, the blocks were tack-welded to the railroad rails on the dock.

Rotating Plug Jack Interference with Water Connections

A mechanical interference was discovered between the concentric jack beams and the water connections to the concentric plug. These water connections supplied hot water to the concentric plug during the operation and could not be removed. The condition was corrected by fabricating new supporting columns of sufficient height to raise the jack beams above the water connections.

Dock Steam Freeze-Ups

With the exception of the operator's platforms on the plug removal machine, the refueling machine, and the secondary safety cask, dock steam was used on the dock for space-heating purposes. During cold weather, the freezing of the steam and drain lines caused this steam supply to be intermittently out of service. When this occurred the frozen lines were thawed with steam "lances".

Locating Dowel Positions

Prior to the jacking of the rotating plugs, their angular position was checked by attempting to insert dowel pins which should have been possible to insert with the plugs in the bolted down position. These dowels could not be inserted, apparently because of a slight misalignment of the plugs. No corrective action was required.

Dowel-Pin Actuation

When the rotating plugs were rotated to the proper position for dowel insertion, one of the dowel pins still could not be inserted. The cause of this was found to be a binding in the dowel-pin actuation screw which was corrected by reworking the screw with emery paper and then lubricating it.

Cracked Securing Bolt

During loosening of the securing bolts for the rotating plugs (which had previously been tightened with 1300-ft-lb torque), one of the securing bolt heads was cracked. An extension piece was welded onto this bolt head and then the bolt was successfully removed.

Oil in Inert Gas Panel

During initial operation of the reactor inert gas panel, oil was discovered in an inert gas flowmeter. This was traced to residual oil left in some of the pressure gages on this panel which had been calibrated with an oil-type dead weight tester in preparation for the defueling. The oil was removed.

Telephone Talking Procedures

During the series of lectures prior to the dry run most of the personnel who would be participating in the defueling were exposed to a lecture on telephone talking procedures. A few others were not so instructed; therefore, during their first experiences with the telephone system some of these personnel failed to acknowledge instructions and confirm performance of instructions. These personnel were then instructed and proper procedures were subsequently used.

Frost and Moisture Condensation on the Plug Removal and Refueling Machines

When the plug removal machine and the refueling machine were brought into the reactor compartment, first frost and then liquid water condensation occurred on the machines. The frost turned to liquid in about 1/2 hr in each case. To cope with this, a piece of polyethylene was laid over the top of the reactor during initial landing of each of these machines after storage periods on the dock. After the moisture stopped condensing, it was wiped off, the machine raised, and the polyethylene removed.

Eccentric Jack Screw Shafts

The eccentric jack screw shafts were found to be slightly oversize for the proper operation of their jacking nuts. The threads on the shafts were turned down and subsequent operation was satisfactory. (The jacks were not tested during the dry run.)

Quick-Disconnect Fittings

The quick-disconnect fittings used on the dock were difficult to operate. In some cases this was aggravated by slight corrosion of cadmium-plated quick-disconnects. The condition was partially alleviated by lubricating the fittings with silicone grease.

Electrical Connectors on Refueling Machines

On two occasions, electrical connectors in the cable supplying the refueling machine became disconnected as a result of the motion of these cables and the dragging of the cables over obstacles. After the first accidental disconnection the connectors were taped with paper tape; however, this tape was too weak and after the second break occurred, a cloth tape was used.

Plug Drive Jog Operation

In operating the plug drive motors, the jogging operation could not be performed satisfactorily during most of the defueling. This was apparently due to wear of the motor brakes and possibly to changes in motor characteristics caused by the use of gas-filled rectifier tubes in the plug drive console. By the time the difficulties occurred, however, the operators of the plug drive motors had become sufficiently skilled to operate the motors satisfactorily without the use of a jog-type control; therefore, no corrective action was taken.

Rewinding of Crane Cables

On two occasions, the cables on the crane, used for handling the defueling equipment, became improperly wound on the cable drum. On the first occasion the cables were unwound and rewound in a more satisfactory manner; this, however, was found inadequate to correct the difficulty. Later a section was removed from the cable to permit satisfactory winding action.

Portable 230-Volt Space Heater

On one occasion a portable 230-v space heater used for personnel on the refueling machine operating platform became grounded. The heater was repaired.

Lowering of Fuel Rods in Transfer Cask

On several occasions, fuel rods could not be completely lowered into the fuel transfer cask by about 1.7 in. In each such case the hole in the transfer cask in which difficulty was encountered was left vacant and one of the spare transfer cask holes was used instead. It is thought that these difficulties resulted because of incorrect calibration of the transfer cask rotating covers.

In one case difficulty was encountered in seating a rod below about 1.3 in. from complete seating. In this case, the cause was thought to be difficulty in grappling and ungrappling either because of the buildup of sodium in the machine or because of some difficulty in the grapple actuating mechanism.

Seating Transfer Cask Excess Plug

When a row of fuel rods in a transfer cask was filled the transfer cask access plug for this row was placed back in the cover of the cask. In one case, difficulty was encountered in seating this plug in the cover. Seating was accomplished by pushing down on the plug with one's foot.

Transfer Cask Valve Block Protective Cover

A weather cover was placed over the transfer cask valve block when the refueling machine was away from the cask. This cover was normally removed for landing the machine. In one instance, it was inadvertently left in place during an attempt to land the refueling machine. The cover was secured by means of two wing nuts located on top of the cover. These wing nuts left an impression in the bottom of the refueling machine which apparently caused no significant damage to the refueling machine. The wing nuts were, however, severely damaged and were replaced.

Rain Protection of Transfer Cask Valve Block

On one occasion a hard driving rain interfered with the landing of the refueling machine on the transfer cask valve block because it was necessary to maintain dry mating surfaces between the refueling machine and the valve block. Landing on the reactor was less difficult because of the weather protection afforded by the SEAWOLF hull.

Orientation of Transfer Cask Valve Block

In placing the transfer cask valve block on the transfer cask, on one occasion the transfer cask valve block was placed so as to interfere with some of the stationery structure of the transfer cask. As a result, it was impossible to load a fuel rod in one of the holes in the transfer cask. This hole was left empty (each transfer cask was provided with 5 spare holes).

High Winds

Operations were severely handicapped during one 3-day period because of winds with velocities of 40 to 50 mph with gusts to 75 mph. These winds were accompanied by temperatures from 0 to 15°F. In general, winds below 20 mph caused no difficulties. Winds above 40 mph caused complete cessation of crane operations. Winds between 20 and 40 mph caused varied degrees of interference. These high winds were from the West and had relatively little effect on the motion of the SEAWOLF. During one (different) 3-day period, southeast winds were encountered and swells and vessel motion did develop.

Sound-Powered Phones

The sound-powered phones used for communication between the operating stations, in several instances, became inoperative and had to be replaced.

Vessel Heave and Drift

During the latter 3-day period noted above, some swells were present and caused a heaving motion of about 1 in. with a 10-sec period and a drift (in and out from the dock) of about 1 ft with a several minute period. These motions slowed up the landing and take-off motions of the refueling machine on the reactor and caused some banging of the refueling machine against the reactor compartment hatch. The drift actions also required special alterness on the part of the crane operator to boom (out or in) as much as necessary to match the drift before lifting the refueling machine.

Grappling Fuel Rod from Reactor

On one occasion it was necessary to grapple a fuel rod twice before it could be lifted. This difficulty was suspected to be due to wear in the grapple actuating mechanisms.

Freeze During Refueling Machine Cleaning Operation

The normal procedure for cleaning residual sodium from the refueling machine called for a steaming period followed by a water flush. This operation was conducted during subfreezing weather. During the water-flush operation the machine and cleaning station froze (despite the aid of electrical heaters installed in the cleaning station) and a return to the steaming operation became necessary for a period of several hours to remove the ice. To avoid the hazard of electrical shorts, the heaters in the refueling machine were not used.

Tools for Secondary Safety Withdrawal Mechanism

Certain special tools for removal of the secondary safety withdrawal mechanism could not be found during the period between the dry run and the defueling. Replacement tools were manufactured.

Heating of Containers for Control Drive Mechanisms

When the control drive mechanisms were removed from the reactor they were installed in tightly fitted metal containers. The containers were at a low ambient temperature of about 30°F whereas the mechanisms were at about 70°F when removed from the vessel. This difference in temperature was sufficient to cause interference between the mechanisms and the containers. As a result, it was necessary to heat the containers prior to installing the mechanisms.

Involuntary Opening of Transfer Cask Valve Block

On several occasions during the landing of the refueling machine on the transfer cask valve block, the riggers and other personnel assisting in landing the machine apparently accidently struck the handle which opens the transfer cask valve block, and thus caused a slight opening of the valve block and a loss of inert gas through the block. In each case, the incident was detected by personnel monitoring the cask pressure at the refueling console. It was immediately corrected by closing the valve block.

Leak in Inert Gas Panel

In testing the static seals of the rotating plugs after jacking down, a satisfactory test could not be obtained because of gas leaks in the inert gas panel. The test was performed by isolating the seals with a pressure gage from the inert gas panel after charging the seals with inert gas.

Installed Wiring Between Engine Room and Reactor Compartment

Permanently installed wiring between the engine room and the reactor compartment was used for connecting the plug drive equipment to the refueling console. Although it had been inspected, it was found to be improperly wired and was corrected at the time of use.

NOTES

Use of Lead-in Devices for Landing Heavy Equipment

Guides or lead-in devices to assist in landing the refueling or plug removal machines were permanently installed on the top of the secondary safety cask. Removable guides were used on the reactor valve block. No guides (except a 2-in. high rail for final positioning) were used on the transfer cask valve block.

During the dry-run operation, opinion of the personnel participating was divided concerning the value of the guides used on the reactor valve block. The guides were used on both sides of the valve block during one of the three shifts. Only one guide was used on one shift, and on the other shift no guides were used. During the defueling operation proper, both guides were used and all personnel questioned considered that the use of guides was desirable, including those persons who previously held opinions to the contrary.

The times required for landing on the reactor valve block averaged about 1 to 2 min faster than the times required for landing on the transfer cask valve block where there were no guides available. It is presumed that this time difference was due to the use of the guides.

The guides seemed to be valuable, not so much in physically guiding the machines, as in providing the personnel who guide the crane operator with the necessary confidence to land the machine more rapidly than would otherwise be possible because slight errors in guiding would be rectified by the guides.

Operating Times

Prior to the defueling operation it was estimated that about 1 hr would be required for transfer of each fuel rod from the reactor to the transfer casks. Although this amount of time was used for the first few fuel rods, after about 6 rods had been transferred the time required was reduced considerably to about 1/2 hr per fuel rod. The faster transfer of a fuel rod required 24 min for a complete round trip of the refueling machine. Some improvement was noted in transfer times during the entire operation, although the bulk of improvement was noted in the first few transfers.

The crane transfer times averaged about 7 or 8 min for transfers from the reactor to the transfer cask and about 5 or 6 min for transfers from the transfer cask to the reactor.

CONCLUSIONS

Conculsions that apply to operations of a similar nature are given as follows:

Effects of Wind Velocity

Wind velocities below 20 mph cause no significant difficulties in dockside crane operations. Wind velocities above 40 mph effectively prevent dockside crane operations. Wind velocities between 20 and 40 mph may or may not prevent dockside crane operations depending on the types of cranes available and on other local conditions.

Effects of Low Temperatures

Steam Supplies

The reliability of dockside supplies of steam and water is seriously impaired by temperatures below freezing, especially when these temperatures are accompanied by high wind velocities. Consequently, steam should not be relied upon for heating of reactor servicing equipment where loss of this heating may have serious consequences.

Adequacy of Design Calculations

Design calculations alone should not be relied upon to demonstrate the adequacy of electrical heating for protection against low temperatures. Instead, actual test results should be obtained when reliability is important.

Lead-in Landing Devices

Surfaces on which heavy reactor servicing equipment is repeatedly landed during reactor servicing operations should be provided with lead-in guides which are operative about 1 ft above the landing surface. Such devices may be relied upon to reduce landing times by about 1 to 3 min.

Inadequacy of Available Portable Cranes

To the writer's knowledge, there are no portable cranes currently being manufactured which are suitable for use in reactor servicing operations. No portable cranes are currently available with dead-man type controls; i.e., with existing cranes, if the crane operator leaves the controls during lowering operations, the load will be dropped.

This type of control is satisfactory for normal lifting operations but is undesirable when the consequences of dropping a load are extremely serious, as they may be during reactor servicing operations.

Weather Protection for Personnel

Reactor servicing equipment which is designed to be operable during inclement weather should be provided with enclosures for protection of personnel and equipment from the weather. These enclosures should be provided with permanently installed heaters with suitable grounding arrangements because the portable space heaters commonly used are hazardous when employed with this type of equipment.

Maintenance of Inventories of Servicing Equipment

Shipboard servicing equipment which is not permanently installed or listed in an accounting system (as are shipboard spare parts) is very easily lost.

All items of servicing equipment (especially small special tools and components) should be identified permanently by identification numbers which can be used for inventory and storage of equipment, even by personnel unfamiliar with the equipment. Liberal quantities of spares should be provided for such components. Containers should be designed so that items used together can be packed in one package.

Dry-run Operations

With the current frequency of reactor servicing operations and lack of any permanent service organizations for such operations, dry runs or rehearsals should be conducted for all major reactor servicing operations. During these dry runs all the servicing equipment to be used during the actual operation should be checked out by the same personnel who will perform the actual operation. The dry run should be scheduled far enough in advance of the actual operation to permit repair and replacement of equipment. Suitable mockups of the portions of the reactors involved in the actual operations should be provided.

Locking of Controls

All controls whose inadvertent operation would result in serious consequences should be provided with some protective locking device which would require actual release before the control itself could be operated.

Such controls should be located, whenever possible, where they cannot be accidentally actuated.

Weather Covers

All weather covers used for protection of the tops of the reactor service equipment should be designed so that mating equipment can be landed on top of them without damage to either component.

Vessel Motion Effects

During dockside reactor servicing operations vertical ship motion of up to 1 in. with a 10-sec period and lateral motion of up to 1 ft with a period of several minutes do not seriously interfere with reactor servicing operations involving the landing of heavy equipment and maneuvering of heavy equipment through small clearances (2 in. radial).

REFERENCES

1. NavShips-389-0019 Reactor Servicing Components, USS SEAWOLF, SSN575.
2. NavShips-341-1285 Manual for Power Plant and Supporting Auxiliaries, USS SEAWOLF, SSN575, Volume VII, Reactor Servicing.