# IMPROVED SERVICING EQUIPMENT FOR STEAM GENERATORS

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## ABSTRACT

To help keep personnel exposure as low as reasonably achievable (ALARA) and reduce critical path outage time, most nuclear plants of Pressurized Water Reactor (PWR) design in the USA are now using improved equipment to service their steam generators (SGs) during outages. Because of the success of this equipment in the USA, three Korean plants have purchased this equipment, and other nuclear plants in the Pacific Basin are also considering procurement**.**

The improved SG servicing equipment which this paper discusses consists of the following:

- Nozzle Dams
- Segmented Multi-Stud Tensioners
- Primary Manway Cover Handling Devices
- Shield Doors
- Fastener Cleaner

This equipment is specifically designed for the individual plant application and can also be specified for replacement SG projects. All of the equipment can be used without modification to the existing SGs.

## INTRODUCTION

Utilities with PWR type nuclear plants routinely enter their SGs to perform eddy current inspection, tube plugging, tube sleeving activities, etc. These activities require entry into the SG primary channel head through the primary manway. The use of improved SG servicing equipment can help improve the performance of these activities if it can satisfy at least one of the following criteria:

1. The equipment reduces personnel radiation exposure.
2. The equipment reduces critical path outage time.
3. The equipment is safer and more reliable than existing equipment.

NES has been closely associated with the SG servicing market for many years. This close contact has allowed us to conceptualize and develop products which satisfy all of the above criteria. Sometimes, the new product is innovative and has never been used before; other times, it is simply a transfer of technology from another industrial application.

This paper will discuss the application of five pieces of equipment for SGs: nozzle dams, segmented multi-stud tensioners, primary manway cover handling devices, shield doors and fastener cleaners. The discussion will include their application, experience and how they satisfy the aforementioned criteria.

## SG NOZZLE DAMS

Many utilities are utilizing NES nozzle dams inside their SGs to temporarily isolate the SG primary channel head from the refueling pool, thus permitting refueling and eddy current testing or repair of SG tubes to occur simultaneously. NES nozzle dams are designed to fit into nozzles ranging in diameter from 30 inches (760 mm) to 42 inches (1070 mm). The only access into the SG channel head is through a manway opening, typically 16 inches (406 mm) in diameter. The NES nozzle dams are segmented to allow passage through this opening. High dose rates and contamination levels exist in the channel head; thus, the NES nozzle dam is capable of being rapidly assembled to meet ALARA objectives. Most importantly, the NES nozzle dam is safe and seals with zero leakage.

### *Nozzle Dams for Existing SGs*

Since the most common type of PWR in the Pacific Basin countries is one of either Westinghouse or Framatome design, the most common type of installed retention ring in these SGs is a flange ring with 20 threaded holes. A bolted compression seal applied against the top surface of this flange ring has been the usual method of sealing the nozzle.

The Type WR NES SG Nozzle Dam was developed for sealing SG nozzles with these flange rings. The dam, which seals within the smooth inner diameter of the flange ring, consists of two rugged pneumatic seals and a third passive seal. The dam is secured to eight of the twenty flange ring threaded holes with special threaded connections with antigalling features (that is, dissimilar material, special thread configuration, etc.). This eliminates the galling problems previously experienced with nozzle dams which sealed on the top surface of the flange ring and utilized standard threaded connections.

The Type WR NES Nozzle Dam offers the following major and proven design features:

1. Redundant, pneumatic seals with sufficient capacity and serrated face to seal against the inner flange ring surface (Figure 1).
2. Lightweight, self-aligning dam segments which allow rapid assembly within the SG primary channel head (Figure 2).
3. Requires no SG modifications.
4. Manual installation time of approximately two minutes.
5. Capable of remote installation with NSSS-supplied equipment.
6. Hydrostatic force transmitted from the dam to the flange ring via 8 special threaded connections with antigalling features.
7. Single failure proof design; that is, the failure of any one active component will not result in a breach of the dam.
8. One-piece diaphragm seal with redundant, integral pneumatic seals and a passive seal, all preattached to the middle dam segment to ease installation.
9. Backup passive emergency seal activated by hydrostatic pressure to prevent catastrophic leakage.
10. Leak detection system to verify sealing performance prior to flood-up and to continuously monitor in-service pneumatic seal performance.

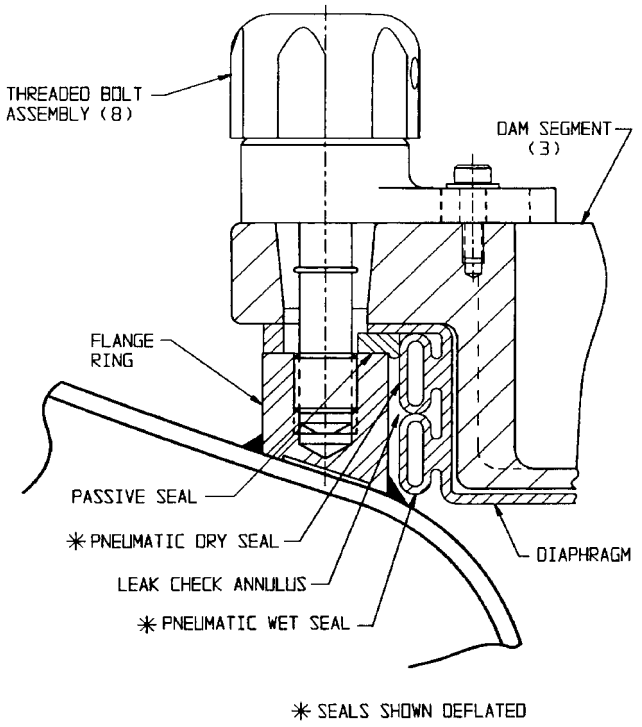


**Figure 1** NES Type WR SG Nozzle Dam Cross Section

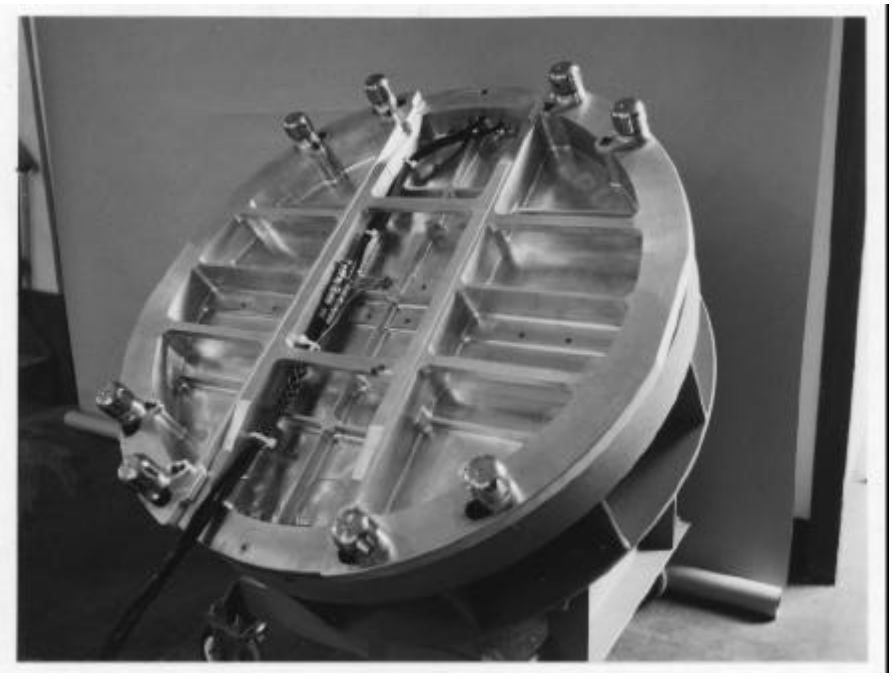

**Figure 2** Assembled NES Type WR SG Nozzle Dam

### *Nozzle Dams for Replacement SGs*

Several plants in the Pacific Basin countries are planning to, or already have, replaced their SGs. The NES nozzle dam discussed herein was developed specifically for replacement SGs and new or existing SGs with no retention rings. This state-of-the-art design replaces the traditional flange ring configuration (with its threaded holes which are susceptible to galling, misalignment and breaking of bolts) with a single, grooved retention ring that accommodates fast acting lock pins resulting in extremely short installation times.

The NES nozzle dam for replacement SGs offers the following major and proven design features:

1. Hydrostatic force transmitted from the nozzle dam to the retention ring via quick-throw lock pins (Figure 3).
2. Lightweight, self-aligning dam segments which allow rapid assembly within the SG primary channel head (Figure 4).
3. One-piece diaphragm seal with redundant, integral pneumatic seals and a passive seal, all pre-attached to the middle dam segment to ease installation.
4. Specially designed pneumatic seals with sufficient throw and serrated face to seal against the clad nozzle surface.
5. Backup passive emergency seal activated by hydrostatic pressure to prevent catastrophic leakage.
6. Manual installation time of 1 minute.
7. Capable of remote installation with NSSS-supplied equipment.
8. Single failure proof design; that is, the failure of any one active component will not result in a breach of the dam.
9. Leak detection system to verify sealing performance prior to flood-up and to continuously monitor in-service pneumatic seal performance.
10. Maximum clearance between the nozzle dam and tube sheet; that is, the dam does not project above the retention ring and does not have any abrupt hang-ups.

### *Operating Experience*

NES has supplied over 250 types of SG nozzle dams to most types of PWRs. The NES SG Nozzle Dam has been employed since 1985 to support over 150 outages at 40 nuclear plants. Its utilization has saved these plants millions of dollars in critical path outage time. Although most nozzle dam applications have been in the USA, the Kori 1 and Ulchin 3,4 Nuclear Plants in Korea have also chosen the NES nozzle dam.

## SEGMENTED MULTI-STUD TENSIONING SYSTEM

The NES Segmented Multi-Stud Tensioning System (SMTS) is a portable system designed to simultaneously tension all studs on system closures such as SG primary and secondary manways, and handhole and valve covers. This state-of-the-art system applies a predictable and accurate preload to all studs simultaneously, thus eliminating the problems normally associated with conventional torque tightening techniques (that is, uneven gasket preloads resulting in closure leakage, galling, broken fasteners, etc.).

The SMTS enables the installation and removal of system closures to be completed rapidly in high radiation areas. Therefore, its application meets ALARA objectives.

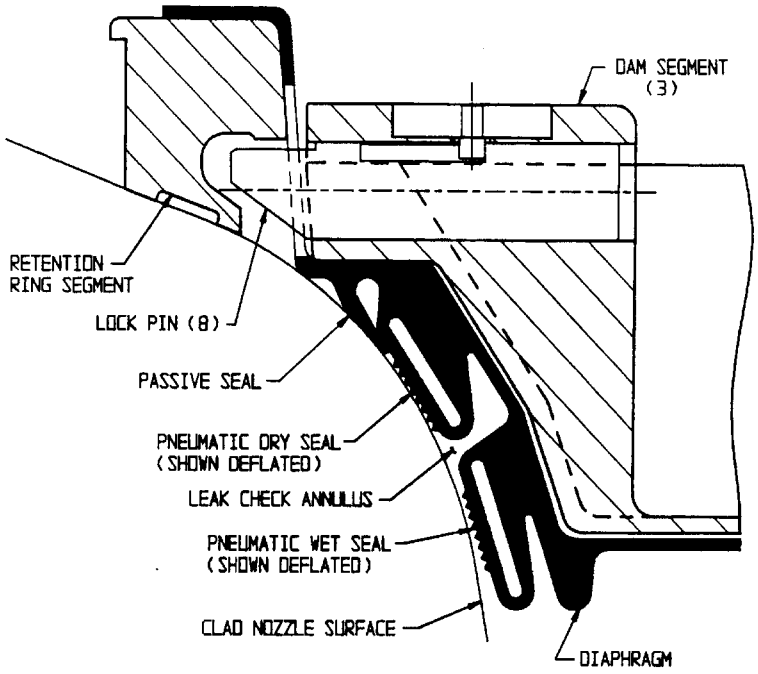


**Figure 3** NES SG Nozzle Dam Cross-Section (for replacement Sgs)

**Figure 4** Assembled NES SG Nozzle Dam (for replacements Sgs)

The SMTS consists primarily of several ring segments (that is, two, four, etc. depending upon the number of studs), an air-operated hydraulic control unit and interconnecting high pressure hoses with quick couplings. Each segment contains hydraulic load cells that are interconnected to allow their simultaneous pressurization from one hydraulic port in each segment. The hydraulic load cells are fitted with self-energizing lip seals that snap-fit into the piston housing to ease replacement. The hydraulic load cells are designed to work with ethylene glycol or oil based hydraulic fluids. Each segment has a handle for ease of handling by one person.

The stud tensioning load is applied to the studs via reaction nuts that are supplied with the system. The system is also supplied with round, nut rotating sockets (NRSs) to facilitate the initial, uniform tightening of the closure nuts with an NES-supplied in-line torque wrench and square torque adapter bit. The NRSs incorporate magnets so they will be self-supporting when assembled over the closure nuts.

NES has supplied 24 SMTSs to ten nuclear plants in the USA and 12 SMTSs to the Kori 3,4 and Yonggwang 1,2 nuclear plants in Korea.

## PRIMARY MANWAY COVER HANDLING DEVICE

The NES Manway Cover Handling Devices (MCHD) provide a safe and positive means of removing and replacing SG primary manway covers quickly to meet ALARA objectives. Two types of MCHDs are available, the Manway Cover Handling Tool Set and the Manway Cover Elevator.

### *Manway Cover Handling Tool Set (MCHTS)*

The NES MCHTS requires no external power source (that is, failure-prone hydraulics or pneumatics) for operation. Operation relies only on existing features of the manway itself, and the tool set can be used with studs or bolts. The MCHTS is hand-operated and is totally independent of the variables and interferences that normally make the operation and handling of floor-supported machines difficult. The NES MCHTS has been designed to handle primary manway covers weighing up to 1,750 lbs (800 kg).

The MCHTS consists primarily of two guide rods, one jackscrew and two hoist bar studs (Figure 5) and one chain hoist support bar and two chain hoists with cover support brackets (Figure 6). With additional tools, the tool set can also be used to handle a stud tensioning ring.

NES has supplied 48 MCHTSs to 13 nuclear plants in the USA.

### *Manway Cover Elevator (MCE)*

The NES MCE consists of a simple electrically-operated dual winch which can be remotely operated to meet ALARA objectives. Operation relies only on existing features of the manway itself and requires no floor space. The MCE is also totally independent of the variables and interferences that normally make the operation and handling of floor-supported machines difficult.

The MCE consists of two electric winch assemblies of a worm gear design. The operation of the MCE is performed by two technicians (Figure 7).

NES has supplied 4 MCEs to the Kori 3,4 and Yonggwang 1,2 nuclear plants in Korea.

## SHIELD DOOR

The NES Shield Door is designed to help meet ALARA objectives by reducing the amount of radiation emitted from open SG channel head manways, thus allowing SG maintenance activities to be performed at a reduced exposure rate. The door can be locked to restrict entry of unauthorized personnel into the channel head and includes ventilation features.

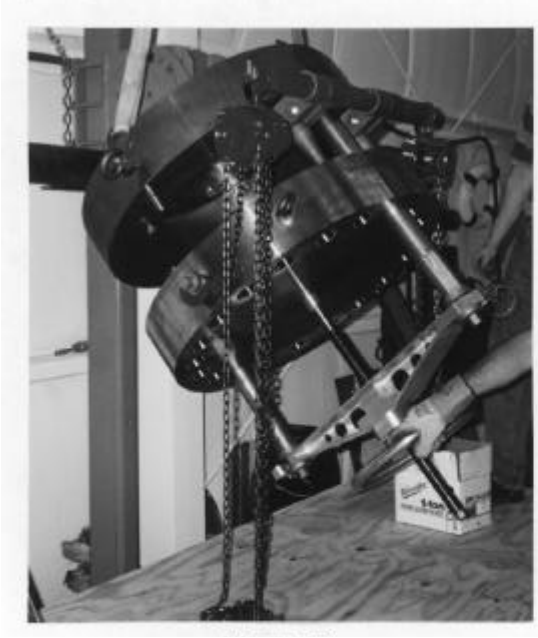

**Figure 5** Jackscrew Operated by Handwheel to Translate Cover to and from The Manway Flange

**Figure 6** Chain Hoists Operated Simultaneously to Lower and Raise the Manway Cover

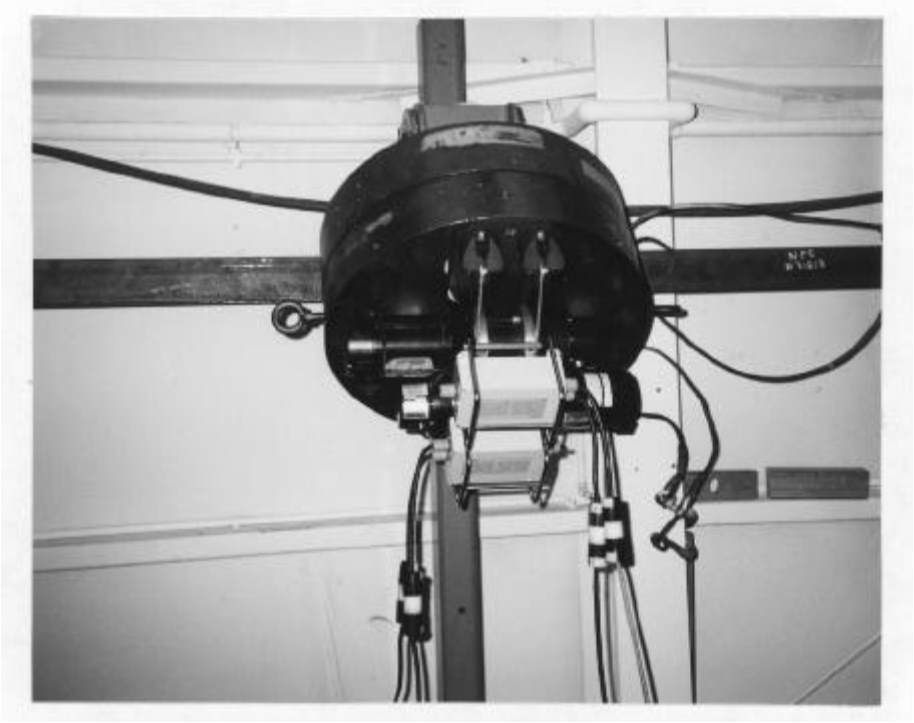

**Figure 7** Manway Cover Elevator

The shield door consists of a support ring, an inner and outer shield (the door) and four support bolts. The support ring attaches directly to the manway flange with the four support bolts. The ring is split to allow shield door removal with hoses and cables passing through the manway. The bolts are fabricated from aluminum to preclude galling. The support ring will protect the manway sealing surface since its opening corresponds to the manway opening. The support ring includes clearance holes to facilitate maintenance of the tapped manway cover and diaphragm fastener holes. The support ring is also compatible for mounting with various manufacturers' NDE equipment (for example, Zetec, Framatome, etc.).

The lead shield and ventilation opening are integrated into the floor of the NES design. This is accomplished by separating the radiation shield to create an annulus for air flow between the manway and the inner shield. A circular opening through the middle of the door allows quick movement of air between the hot and cold leg manways. Also, the door incorporates a hinged, shielded opening for hoses and cables.

NES has supplied 113 Shield Doors to 15 nuclear plants in the USA.

## FASTENER CLEANER

Threaded fasteners (that is, studs, nuts and bolts) used to secure primary and secondary system closures must be cleaned each outage to ease visual inspection and NDE testing and ensure optimum fastener performance. Thread cleaning is usually performed manually with wire brushes in a low dose area away from the closure. The operation is time consuming and could result in the spread of radioactive contaminants in the area and on personnel performing the operation.

The NES Fastener Cleaner is portable and rapidly cleans studs, nuts and bolts of any lubricants, oxides or other chemical deposits. Its use eliminates the spread of contaminants and will help utilities meet ALARA objectives.

The NES Fastener Cleaner incorporates a reversible, air motor driven receptacle which engages the hexagonal projection on the fastener (stud or bolt) while the fastener is laterally supported on a V-way in the cleaner housing. The cleaner housing has a hinged cover that supports two rows of wire brushes and can be quickly latched. The housing incorporates a vacuum suction outlet to direct all contaminants to a plant vacuum and HEPA filter system. The nut cleaning brush projects from one end of the cleaner. Operation is controlled from a control box which includes a pressure gauge and regulator.

NES has supplied 14 Fastener Cleaners to 10 nuclear plants in the USA and one Fastener Cleaner to Sizewell B in Great Britain.

## ACKNOWLEDGMENTS

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|---|---|
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## KEY WORDS

PWR, steam generator, SG, nozzle dam, seals, stud tensioner, manway cover, shield door, fasteners, ALARA.