TENNESSEE VALLEY AUTHORITY

NUCLEAR SAFETY REVIEW STAFF

REPORT NO. R-85-02-SQN/WBN
SEQUOYAH AND WATTS BAR NUCLEAR PLANTS
SPECIAL REVIEW OF MANUFACTURER-IDENTIFIED
POTENTIAL MISAPPLICATION OF SWAGELOK TUBE
FITTINGS AT WESTINGHOUSE REACTOR SEAL TABLES

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NSRS REPORT NO. R-85-02-SQN/WBN

SUBJECT: SEQUOYAH AND WATTS BAR NUCLEAR PLANTS - SPECIAL REVIEW OF MANUFACTURER-IDENTIFIED POTENTIAL MISAPPLICATION OF SWAGELOK TUBE FITTINGS AT WESTINGHOUSE REACTOR SEAL TABLES

DATES OF REVIEW: JANUARY 22-23, 1985 - SEQUOYAH
JANUARY 24-25, 1985 - WATTS BAR

REVIEWER: G. G. BRANTLEY — DATE 3/22/85

APPROVED BY: M. S. KIDD — DATE 3/25/85

NMS, SL 2B C-K

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I. BACKGROUND

Recent events at Sequoyah Nuclear Plant (SQN) and at least one other pressurized water reactor (PWR) involving the seal table portion of the bottom-mounted incore instrumentation system (BMIIS) have heightened the interchange of information concerning activities associated with this system. A copy of a Crawford Fitting Company (CFC) distributor information exchange addressing potential misapplication of their SWAGELOK tube fittings for seal table high-pressure mechanical seal applications was provided to the TVA Board of Directors in November 1984 by a local vendor of SWAGELOK tube fittings (references VI.A.1 and 2). The NSRS was requested to perform a review of the concerns expressed in the distributor information exchange. The review was performed in January 1985 and consisted of an evaluation of regulatory, industry, and TVA documents; inspections of seal table equipment; and discussions with industry [Westinghouse (W) and CFC] and Office of Nuclear Power (NUC PR) personnel.

II. SCOPE

This special review was performed to determine the important points of the concerns expressed by CFC about potential misapplication of their SWAGELOK tube fittings on the W designed BMIIS seal tables, if those important points are pertinent at SQN and Watts Bar Nuclear Plant (WBN), and to what extent the pertinent points had been addressed by the line organizations. Actions taken to implement related recommendations made by W were also evaluated during the review.

III. CONCLUSIONS AND RECOMMENDATIONS

The NSRS concluded that some of the concerns expressed by CFC were pertinent at SQN and WBN. There was some evidence that use of the low-pressure seals during refueling operations had caused degradation of five high-pressure mechanical seals on SQN unit 2. Both plants had high-pressure mechanical seals on their seal tables (unit 1 at both plants) that were composed of mixed fittings from different manufacturers.

NUC PR personnel at SQN with assistance from W and CFC had performed recommended inspections and evaluations and had determined that both units were safe to operate with the existing conditions. No related problems had been encountered with the seals during subsequent operation. Work instructions had been revised to include some recommendation made by CFC and W to prevent degradation of seal integrity during maintenance activities.

WBN personnel had made modifications to unit 1 to assure that all the components of the high-pressure mechanical seals were from one manufacturer (CFC) and to minimize potential for seal degradation during maintenance and outage activites. The same modification will be made for unit 2 prior to startup of that unit. The maintenance work instructions for the BMIIS were only in the initial stages of preparation.

NSRS did not identify any conditions that constitute an immediate safety concern related to the operation of SQN or the startup of WBN. While the actions taken by the SQN and WBN staffs appear to be appropriate, some specific conclusions and recommendations are offered to enhance the consistency and clarity of related maintenance instructions, lessen the probability of seal degradation, and increase the awareness of the critical and somewhat delicate nature of these seals and tube fittings in general. Those conclusions and recommendations are as follows:

A. R-85-02-SQN/WBN-01(NUC PR), Office-Wide Awareness Bulletin for Tube Fitting Maintenance Activities

Conclusion

There have been recent and significant industry events involving failures of pressurized tube fittings during maintenance activities. There are some common identified contributors to these failures and to failures of tube fittings in general (see sections IV.B, C, E, F, and G for details).

Recommendation

A NUC PR office-wide awareness bulletin or similar mechanism should be prepared and distributed to the nuclear plants. The bulletin should discuss tube fitting design; assembly, reassembly, and inspection criteria; policy on interchanging components; failure modes (including those identified by the SQN and WBN maintenance craft personnel); hazards involved in working on pressurized fittings; and should specify special precautionary measures when maintenance on pressurized fittings is necessary. The desired bulletin should be incorporated into a permanent instruction at each plant for future awareness of new employees.

B. R-85-02-SQN/WBN-02(SQN/WBN), Maintenance, Operating, and Test Instructions

Conclusion

Instructions at SQN did not contain sufficient clarity, precautions, warnings, and other measures to provide the desired level of confidence that the high-pressure mechanical seals will not be degraded during maintenance activities or to lessen the severity of the consequences of a failed seal. WBN instructions for maintenance activities on the BMIIS had not been prepared at the time of this review (see sections IV.E, F, and G for details).

Recommendation

SQN

Applicable maintenance, operating, and test instructions should be revised as necessary to provide consistent guidance for system assembly, reassembly, and inspection of all SWAGELOK and mixed

fittings; address replacement of ferrule assemblies on previously undisturbed tubing; address lubrication and inspection of fitting threads to minimize or detect wearing, galling, and cross-threading; specify limiting forces while using the low-pressure seal; add cautions and warnings against interchanging fitting components, cross-threading, turning of fitting bodies, excessive forces, working on seals while the primary system is pressurized above atmospheric, and increasing primary system pressure while thimble tubes are disconnected from the overhead path transfer system.

WBN

WBN should incorporate the recommendations discussed above into their applicable maintenance, operating, and test instructions.

IV. DETAILS

The following information is provided to facilitate an understanding of the design and operation of the BMIIS, the nature of the seal fitting manufacturer's and NRC concerns, and the actions taken or to be taken by the SQN and WBN staffs to address the concerns.

A. Incore Instrumentation System

1. System Description

The tube fittings that are the subject of this review make up the high-pressure mechanical seals in the BMIIS (see figures 1 and 3). The BMIIS was designed to measure neutron densities at 58 different locations in the reactor core. The neutron densities are measured by 6 miniature fission chamber detectors that are driven into and withdrawn from the reactor core by electric drive units and cables through 58 small (0.201-inch inside diameter) stainless steel tubes called thimble tubes. Each thimble tube (~ 103-117 feet long) is housed in its respective guide tube which is 1 inch in diameter and is essentially an extension of the reactor pressure vessel. The guide tubes terminate at a common header type device referred to as the "seal table" (see figure 2). The thimble tubes are held in place against normal reactor operating pressure by high-pressure mechanical seals made up of tube fittings consisting of two ferrule assemblies (each assembly has two ferrules), a reducer union, and two nuts (see figure 3). Each seal establishes two reactor pressure boundaries (one on the guide tube and the other on the thimble tube). Improper assembly, excessive forces, or damage to these mechanical seals can cause leakage of reactor coolant and under severe conditions can cause partial or complete ejection of the thimble tube from its guide tube. Leakage from these seals cannot be isolated and it may be necessary to shutdown, cooldown, and depressurize the reactor to allow draining the coolant level in the reactor vessel below the elevation of the seal table to

stop the leakage. Ejection of the thimble tube can result if the reactor is at some pressure (partial ejection of a thimble tube occurred at another nuclear plant with the reactor pressure at 400 psi) and separation occurs between one of the ferrule assemblies and its respective guide or thimble tube. The ejection of the thimble tube can be partial if the overhead path transfer assembly is in place and the tubing is connected up. The entire thimble tube can eject from its guide tube if the reactor pressure is high enough, the separation of the ferrule assembly from its thimble or guide tube is complete, the thimble tubes are disconnected from the overhead path transfer assembly, and the assembly is rolled back from over the seal table.

2. Westinghouse Design of the High-Pressure Mechanical Seals

a. SQN

The reactor seal table and its associated high-pressure mechanical seals were designed and the components supplied to TVA by W. The W drawings supplied to TVA specified that the high-pressure mechanical seals at SQN were to be composed of SWAGELOK tube fittings manufactured by CFC (references VI.A.14 and 15). The systems at SQN were initially assembled using W specifications (reference VI.A.12).

b. WBN

The BMIISs including the seals at WBN had not been completely assembled. The W drawings supplied to TVA specified that the high-pressure mechanical seals could be constructed of SWAGELOK tube fittings manufactured by CFC or equivalent GYROLOK fittings manufactured by Hoke, Inc. (reference VI.A.16). The drawings indicate that the system is to be assembled in accordance with W specifications (reference VI.A.12). These specifications address SWAGELOK tube fittings only.

Following this review NSRS determined that assembly of the WBN unit 1 high-pressure seals was completed as of March 12, 1985, and consists entirely of SWAGELOK components.

3. Retraction and Reinsertion of Thimble Tubes During Refueling Operations

Before the irradiated nuclear fuel can be removed from the reactor vessel during refueling operations, it is necessary to fill the reactor vessel and refueling cavity with water to provide shielding against radiation and cooling for the fuel. The thimble tubes must be retracted from the reactor core region 15-20 feet into their guide tubes before any nuclear fuel is moved to prevent damage to the thimble tubes

or to the nuclear fuel. To accomplish this operation the water level in the reactor is lowered below the elevation of the seal table. The overhead transfer assembly is disconnected from the thimble tubes at the union flare fittings (see figure 3) and the overhead assembly is rolled from over the top of the seal table. The 5/8- or 3/4-inch (1/2-inch for WBN) range nuts that form the lower reactor pressure boundary seals and hold the ferrule assembly in place on the guide tubes are loosened and approximately 15-20 feet of each thimble tube along with the 5/16-inch reactor pressure boundary seal is pulled out of its respective guide tube. A low-pressure seal supplied by W and consisting of a slotted plug (must be slotted to fit around the thimble tube), two half-metal washers, and a rubber castrate ring not supplied by W are then installed around each thimble tube. The slotted plug is threaded into the 5/8-, 3/4-, or 1/2-inch range nut and tightened to form the low-pressure seal (see figure 4). The reactor water level can then be raised to fill the reactor vessel and the refueling cavity and movement of irradiated and new nuclear fuel can begin. The low-pressure seals prevent the water in the refueling cavity (higher than the seal table) from leaking at the seal table. Following refueling operations the low-pressure seals are removed, the thimble tubes are reinserted, and the high-pressure mechanical seals are reassembled for normal operation. Final integrity of the high-pressure seals after reassembly cannot be demonstrated until the primary system is repressurized after the refueling outage.

B. NRC IE Information Notice No. 84-55, "Seal Table Leaks at PWRs"

IE Information Notice No. 84-55 was issued by the NRC on July 6, 1984, to notify licensees of a potentially generic problem involving reactor coolant leaks from the BMIIS seal tables. The notice contained information relating to events involving leaks at SQN and at another nuclear plant. The following is a brief summary of the information contained in the notice relating to these two events.

1. SQN

Workers were in the seal table room brush-cleaning thimble tubes while the reactor was at 30 percent power. The thimble tubes were disconnected from the overhead path transfer assembly such that the high-pressure mechanical seal fittings (referred to as a "SWAGELOK fitting" in the notice) were the only devices restraining the thimble tubes. While one of the thimble tubes was being brushed a fitting broke loose ejecting the thimble tube from its guide tube.

2. Other Nuclear Plant

It was believed that slight bowing of a thimble tube caused the fitting (referred to in the notice as a "SWAGELOK fitting") making up the high-pressure mechanical seal to be

improperly seated, thus causing a leak of reactor coolant. When support devices holding the fitting in place were removed in an attempt to straighten the tubing the fitting "broke loose" at the guide tube causing an unisolatable reactor coolant leak of 18 gallons per minute (gpm). Subsequent examination of the fittings found that the ferrule assemblies on all but seven of the guide tubes had been displaced from their original positions. Review of the procedure for assembly of the high-pressure and low-pressure seals revealed that the low-pressure seal fittings could have displaced the ferrule assemblies toward the end of the guide tube (see figure 4) causing improper reassembly of the high-pressure mechanical seals resulting in the initial leak. Overtorquing the fittings while attempting to stop the leak probably overstressed the ferrule assembly and allowed the seal to break loose when the support devices were removed.

The NRC notice indicated that in both cases maintenance was being conducted on a high-pressure system with what was equivalent to single valve protection. The NRC recommended that licensees review their maintenance procedures to ensure that maintenance of any system under hot, pressurized conditions should be thoroughly evaluated before allowing personnel to perform the work and to ensure that maintenance under those conditions is minimized.

C. CFC Concerns as Expressed in the Distributor Information Exchange and Other Documents

1. CFC Distributor Information Exchange, "Westinghouse Nuclear Plant Seal Tables"

The CFC information exchange was sent to distributors of CFC SWAGELOK tube fittings in October 1984. In the information exchange CFC indicated that the problems that had been occurring at seal tables at several nuclear plants were not the result of SWAGELOK fitting failures, but had resulted from fitting modifications made by the reactor designer (W). The following is a summary of the CFC specified contributing factors to problems at the seal tables:

a. Use of the Low-Pressure Seal During Refueling Operations

Use of the W modified and supplied low-pressure seals had forced ferrule assemblies on the guide tubes out of their sealing position. Over-tightening of the range nut and the slotted plug could cause the range nut to act as a gear puller thus displacing the two-piece ferrule assembly out of its original position and up toward the end of the guide tube increasing the probability of seal failure when the system is pressurized after the refueling operations. The low-pressure seals were not standard SWAGELOK components but were SWAGELOK components modified and supplied by W.

b. Wall Thickness of the Guide Tubes

Heavier than recommended wall thickness of guide tubes could result in inadequate "SWAGEING" action (see figure 5) on the tube resulting in improper sealing and holding functions. When the SWAGELOK fitting is tightened on tubing, the two-piece ferrule assembly deforms the tubing in a manner that causes a slight indention of the tubing and a slight increase in the outside diameter of the tubing above the leading edge of the ferrule assembly. This action forms the seal and secures the ferrule assembly in place on the tubing.

c. Hardness of the Guide Tubes

Machining down the guide tubes from larger outside diameter (od) heavy wall tubing may increase the hardness of the tubing thus prohibiting proper "SWAGEING" as discussed above.

d. Interchanged (Mixed) Fitting Components

Fitting components had been mixed and resulted in other than all SWAGELOK components. According to CFC this violates the basic design of the SWAGELOK fitting as their fitting components are designed and manufactured to exact angles and close tolerances and are not designed to be used with components supplied by other manufacturers as those fittings' angles and tolerances may be different. CFC indicated that their position against mixing or interchanging parts of tube fittings was longstanding and had been clearly defined in their product literature. Additionally they include a "caution" card (see figure 6) stating their position in every box of fittings they ship.

e. Thimble Tube Expansion

The thimble tubes are made from undersized tubing which is expanded in order to use standard sized fittings. The expansion results in work hardening of the tubing which could prohibit proper "SWAGEING" of the tubing.

f. Replacement of Ferrule Assemblies

Ferrule assemblies had been cut from the guide tubes and replaced in exactly the same position where previous ferrule assemblies were when jacked out of position by the low-pressure seals. According to CFC this could prohibit proper "SWAGEING" action of the new ferrule assembly.

g. Misaligned Thimble Tubes and Cross-Threaded Nuts

Thimble tubes had been misaligned and installed with nuts cross-threaded on the smaller end of the reducer union. As many as three threads had been torn off the body.

The CFC summary of their concerns was that their SWAGELOK fittings were not being used as designed.

In a letter to the NRC in November 1984 (reference VI.A.3), CFC indicated that their concerns involving expanded thimble tubes and the hardness of the guide tubes had been resolved during discussions with W and that their SWAGELOK fittings when properly assembled per the recommended instructions in their catalog are compatible with and suitable for use in the W designed seal table. CFC indicated that the fitting that was involved in the thimble tube ejection at SQN had only a SWAGELOK body (union) with nuts and ferrules from another manufacturer. They took strong exception to the use of the term "SWAGELOK fittings" in the NRC Information Notice No. 84-55, in that the fitting involved was not entirely comprised of SWAGELOK components.

2. Nuclear Operations and Maintenance Information Service (NOMIS) Report 3298A, "Instrumentation, Incore Detectors, Experience with Wear and Galling of SWAGELOK Fittings"

CFC provided NSRS with a NOMIS report (reference VI.A.7) in which four nuclear plants had reported problems with wear and galling of threads of the high-pressure fittings at the seal table to the extent that some of the fittings had to be replaced.

CFC informed NSRS that some of their fittings are lubricated with a silver-based lubricant that provides permanent lubrication on the threads for the life of the fitting to minimize wear and galling, but the fittings used for W seal table applications were not supplied with this lubricant. This was confirmed by W during a discussion with NSRS. Both CFC and W recommend that a lubricant (W recommends Neolube) be used on the male threads for initial assembly and each subsequent reassembly to minimize wear and galling of the threads.

D. Westinghouse Technical Bulletin NSID-TB-84-09, "Primary System Leaks at Seal Tables"

A W technical bulletin (reference VI.A.8) was issued in October 1984. It discussed the two events relating to the PWR and seal tables. Additionally, it indicated that subsequent to the thimble tube ejection at SQN it was reported that in many of the seal table tubing fittings, nuts, and ferrules from one fitting manufacturer were being used with fitting bodies (unions) from

another manufacturer. It was pointed out that one plant had operated in that configuration since initial startup (2-3 years) with no leakage and that the fittings had experienced approximately 25 temperature and pressure cycles, including refueling outages and trips at power.

In the bulletin W recommended or indicated the following:

1. Recommended that thimble tubes be cleaned during a scheduled outage with the primary system depressurized.

2. Recommended that fittings always be reassembled per the manufacturer's instructions and cautioned that if the fitting body is turned the sealing surface of the fitting body and/or the ferrule assembly may be damaged, and the pressure retaining capability of the fittings could be degraded.

3. Indicated that the intended design was for the mating components of the seal table pressure retaining fittings to be from the same manufacturer. W indicated that they did not recommend operation with mixed fittings but that operation with mixed fittings was not a safety concern for the following reasons:

   a. One plant had operated with mixed fittings for 2-3 years with no leaks.

   b. No leakage was found during limited hydro testing conducted by W in 1972 on mixed fittings at 1.7 times the normal system pressure.

   c. The fittings experience only pressure loading during normal operation.

   d. Adequate safety systems exist to safely shut a plant down in the event the system malfunctions.

   e. There was no apparent connection between the mixed seal table fittings and the SQN thimble ejection incident.

4. Recommended that the ferrule assemblies on the guide tubes be inspected for signs of displacement at the next outage when the thimbles were retracted as a routine part of the refueling operations.

5. Recommended that if displaced ferrule assemblies were found that they be replaced and that they should be installed on a previously undisturbed surface of the guide tube.

6. Strongly recommended against any tightening or loosening operations on the seal table reducer union fittings while the primary system is pressurized.

E. Pertinent Points Raised by CFC, Westinghouse, and the NRC

The important points raised by CFC, W, and the NRC that are considered pertinent to the integrity of the high-pressure mechanical seals at the reactor seal tables and to safety while performing maintenance on tube fittings in general, along with the plant responses to them, are as follows:

1. Use of the Low-Pressure Seal During Refueling Operations

SQN, in accordance with W recommendations, inspected the ferrule assemblies on the unit 2 guide tubes during the recent refueling outage after the low-pressure seal plugs had been removed. They found some seal degradation (loose or displaced ferrules) on five guide tubes that could have been caused by use of the low-pressure seal cap. These ferrule assemblies were subsequently inspected by a CFC representative and the plant staff and were determined to be satisfactory for service. No problems were encountered with these seals during the startup of unit 2.

A guide tube ferrule assembly inspection step had been added to MI-1.9, "Bottom-Mounted Instrument Thimble Tube Retraction and Reinsertion," that should be effective in preventing reassembly of the high-pressure seals with displaced ferrule assemblies on the guide tube. However, step 5.1.16 of SQN MI-1.9 implies that for a newly installed ferrule assembly on the guide tube the ferrule assembly can be SWAGED with the low-pressure seal cap. It is doubtful that the low-pressure seal cap can properly SWAGE the newly installed ferrule assembly as it is not designed for that purpose. Step 5.1.17 allows snugging the low-pressure seal with a wrench if leakage occurs while raising the water level in the reactor cavity, but no maximum torque value is specified to prevent displacing the ferrule assemblies on the guide tubes.

MI-1.9 should be revised to clarify that the low-pressure seal cap cannot be used to properly SWAGE newly installed guide tube ferrule assemblies. Reference should be made to SMI-0-94-3, "Seal Table High-Pressure Seal Repair," for high-pressure mechanical repair or proper replacement of new ferrule assemblies on the guide tubes. Some maximum value past handtight should be specified for the low-pressure seal and a caution should be added to prevent exceeding the maximum value which could cause displacement of the ferrule assemblies on the guide tubes.

The above recommendation should be incorporated into the appropriate instruction for retraction and reinsertion of the thimble tubes at WBN as their instructions are prepared.

2. Interchanged (Mixed) Fitting Components

a. High-Pressure Mechanical Seal Makeup at the Seal Table

W had supplied the high-pressure mechanical seals for SQN and WBN seal tables. These seals were a mixture of SWAGELOK and GYROLOK, and the W drawings and specifications did not contain any precautions against mixing components.

SQN personnel had inspected the high-pressure seals on units 1 and 2. On unit 1 at least 37 of 58 high-pressure mechanical seals had a mixture of SWAGELOK and GYROLOK parts. Based upon engineering evaluations, SQN and W personnel concluded that operation with mixed fittings on unit 1 is not a safety concern. All the fitting components inspected on unit 2 were SWAGELOK, and there is reasonable assurance that the fitting components not inspected (ferrule assemblies on the thimble tubes) were also SWAGELOK.

WBN personnel had inspected the portion of the high-pressure mechanical seals that had been installed on unit 1 for cold hydro testing (guide tube ferrule assemblies, range nuts, and cold hydro caps). These fittings were a combination of SWAGELOK and GYROLOK components. A modification was accomplished on March 12, 1985 using all SWAGELOK components that will enable the seals to be disassembled and reassembled during and following refueling outages without disturbing the ferrule assemblies on the guide and thimble tubes that form the high-pressure seal boundaries. The fittings on unit 2 had not been installed. It is planned to install all SWAGELOK components with the modification on unit 2.

b. Maintenance Activities on Tube Fittings in General

NSRS interviewed mechanical maintenance engineering and craft personnel at SQN and WBN to determine their thoughts and experiences concerning interchanging (mixing) components of tube fittings. From the interviews NSRS determined that there was no formal policy established addressing mixing components of tube fittings. Maintenance craft personnel (steamfitters, foremen, general foremen, and a maintenance planner) indicated that they were aware that components should not be mixed but they were not the only craft that worked on fittings. They identified some common contributors to tube fitting failures that were encountered in their corrective maintenance activities on tube fittings. These contributors included mixed fitting components, ferrules installed backwards, no ferrules, ferrule assemblies made up of ferrules from different

manufacturers, fittings cross-threaded, and tubing not inserted properly to seat against the fitting body. The craft personnel interviewed recommended that some type of training be provided for all crafts involved in tube fitting maintenance activities. NSRS concurs with the craft personnel and recommends that the training be in the form of a NUC PR awareness bulletin to be shared with all the nuclear plants.

3. Replacement of Ferrule Assemblies

Review of SQN maintenance instructions associated with the BMIIS revealed that where replacement of defective ferrule assemblies was discussed there were no provisions in the instructions to assure that the new ferrule assemblies would be installed on previously undisturbed tubing. Where replacement of defective ferrules is addressed in maintenance instructions it should be specified that new ferrules should be replaced on previously undisturbed tubing or a special evaluation should be required to determine that replacement in the previous position is acceptable. Guidance for the evaluation and acceptance criteria should be given.

4. Wearing, Galling, and Cross-Threading of Seal Table High-Pressure Mechanical Seals

The SQN Maintenance Instruction (MI-1.9) used for retraction and reinsertion of the thimble tubes during refueling operations and which also provides instruction for disassembly and reassembly of portions of the high-pressure seals did not require the application of a lubricant during reassembly of the seals nor did it contain a caution to warn against cross-threading. A suitable lubricant should be selected and specified for use on the high-pressure seal during reassembly applications to minimize wearing and galling and a "caution" should be added to warn against cross-threading. Inspections for wearing, galling, and cross-threading should be required before reassembly of the seals.

5. Maintenance on Thimble Tubes and Seals While Pressurized

SQN had incorporated a prerequisite into their maintenance instruction for cleaning thimble tubes that will assure that cleaning activities are initiated only while shutdown with the primary system depressurized. The portion of MI-1.9 that allowed tightening of the high-pressure seals to stop leakage while the primary system was pressurized had been removed from that instruction.

6. Manufacturer's Reassembly Instructions (Criteria)

See section IV.F of this report.

F. High-Pressure Mechanical Seal Initial Assembly, Reassembly, and Inspection Criteria

1. CFC Criteria

CFC had established in their product literature (reference VI.A.5) initial assembly and reassembly criteria for their SWAGELOK tube fittings for normal applications and additional assembly criteria for their fittings used for high-pressure application/high safety factor systems. They provide a "gap inspection gage" (see figure 7) to be used to assure proper pullup on both applications (normal and high safety factor systems) for initial assembly only. Their criteria and the inspection gage can only be used on fittings made up of all SWAGELOK components and is not applicable for fittings made up with mixed components or fittings made up entirely with components from another manufacturer.

2. Westinghouse Criteria

The criteria specified by W (see references VI.A.12 and 13) for initial installation of the high-pressure mechanical seals was very similar to the CFC criteria for high safety factor systems and made reference to the SWAGELOK catalog. There was no initial assembly or reassembly criteria specified for all GYROLOK fittings or mixed fittings of SWAGELOK/GYROLOK components supplied by W. The criteria for cold hydro caps which initially establishes the seal on the guide tube is not in accordance with the CFC criteria for high safety factor systems even though once installed the initial and permanent seal on the guide tube is established. No criteria was specified for the GYROLOK hydro caps that were supplied to WBN and subsequently installed on unit 1.

The reassembly criteria is inconsistent with the CFC criteria in that a "snugging" step to assure that the nut is tightened past the previous position is omitted.

The W criteria omits the gap inspection gage to insure proper fitup on initial installation.

3. SQN and WBN Criteria

The criteria specified in instructions for a new thimble tube installation and high pressure mechanical seal repair is based upon the W initial assembly specifications and repair procedures which are in some cases inconsistent or have omissions. There are no criteria specified for the mixed component seals. SQN is currently considering replacing the mixed component high-pressure mechanical seals with all SWAGELOK components to allow use of the applicable CFC criteria.

The SQN instructions for maintenance activities on the high-pressure mechanical seals at the seal tables should be reviewed and clarified to establish consistent criteria for initial assembly (high safety factor system), reassembly, replacement of new ferrule assemblies on previously undisturbed tubing (or an alternative evaluation), and gap inspection gage testing for initial assembly and reassembly. It should be made clear that the gap inspection gage has only limited value on reassembly applications and would only identify a grossly loose fitting. Before the next refueling outage reassembly criteria should be specified for the seals with mixed components and if different from the CFC criteria for SWAGELOK tube fittings, the seals with mixed components should be uniquely identified in the instructions. An alternative would be to change out all the mixed seals to seals made up of components from one manufacturer using criteria specified by that manufacturer.

G. Other Precautions, Warnings, and Measures to Prevent High-Pressure Mechanical Seal Degradation

Some cautions and measures had been added to SQN instructions to prevent degrading the seals during maintenance activities. However, sufficient cautions and warnings had not been added to provide a high degree of confidence that the seals would not be degraded during maintenance activities. The following cautions or measures should be incorporated into applicable plant instructions at SQN and appropriate existing or new instructions at WBN to warn against causing damage to the high-pressure mechanical seals and to minimize the consequences of a severe seal failure:

1. The W caution note (from reference VI.A.8) to prevent turning of the fitting body while tightening fitting nuts should be included in SMI-0-94-3 and SMI-1-94-5, "Thimble Tube Installation."

2. A caution note should be added to MI-1.9, MI1.10, "Incore Flux Thimble Cleaning and Lubricating," SMI-0-93-4, and SMI-1-94-5 that indicates that excessive forces on the high-pressure mechanical seals at the seal table can cause seal degradation and subsequent failure at pressure. The nature of the forces should be identified (e.g., bending, torque, etc.).

3. A caution note should be added to the four instructions addressed in item 2 that warns against any maintenance on the seals while the primary system is pressurized above atmospheric pressure. The caution should indicate that any tightening or loosening of the seals with the primary system above atmospheric pressure requires an unique procedure reviewed by PORC and approved by the Plant Manager on a case-by-case basis.

4. MI-1.9 should be revised to require an inspection of the threads of the fittings for galling, wearing, or cross-threading, and application of an approved lubricant to the male threads on the high-pressure seal fittings before reassembly.

5. A precaution should be added to SQN's GOI-1, "Plant Startup from Cold Shutdown to Hot Standby," SI-146, "Reactor Coolant System Leak Test," and SI-250, "Reactor Coolant System Hydrostatic Pressure Test," which warns against increasing reactor pressure above atmospheric with the thimble tubing disconnected from the path transfer unit. If a seal fails during pressurization of the primary system causing ejection of a thimble tube, the consequences should be less severe with the path transfer unit connected to the thimble tube.

V. LIST OF PERSONNEL CONTACTED

A. Industry

1.	L. L. Dietz	Ridge Valve and Fitting Company
2.	B. Flusche	Crawford Fitting Company
3.	W. D. Wilson	Crawford Fitting Company
4.	K. A. Kloes	Westinghouse
5.	R. U. Mathieson	Westinghouse
6.	S. Groth	INPO

B. Office of Nuclear Power

1. Division of Nuclear Services

a.	J. H. Fox	Metallurgical Engineer

2. SQN

a.	H. L. Abercrombie	Site Director
b.	R. E. Alsup	Compliance Section Supervisor
c.	G. S. Boles	Mechanical Maintenance Engineering Supervisor
d.	R. D. Bates	Steamfitter Foreman
e.	M. R. Harding	Engineering Group Supervisor
f.	G. B. Kirk	Acting Compliance Section Supervisor
g.	J. B. Krell	Maintenance Superintendent
h.	K. E. Lewis	Mechanical Maintenance Engineer
i.	D. L. Love	Supervisor Mechanical Maintenance Section
j.	J. Leighton	Steamfitter
k.	M. D. Pickard	Steamfitter
l.	D. C. Queen	Mechanical Maintenance Engineer
m.	P. R. Wallace	Plant Manager

3. WBN

a.	S. M. Anthony	Compliance Section Engineer
b.	E. A. Elam	Mechanical Maintenance Engineer

c.	G. W. Hurley	Mechanical Maintenance General Foreman
d.	S. E. Jenkins	Assistant Power Storeroom Supervisor
e.	P. C. McCulley	Power Storeroom Supervisor
f.	C. D. Nelson	Acting Mechanical Maintenance Supervisor
g.	K. L. Reed	Mechanical Maintenance Planner
h.	R. C. Sauer	Compliance Section Supervisor

VI. REFERENCES (DOCUMENTS REVIEWED)

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3. Letter to Edward L. Jordan, USNRC, from William D. Wilson, Crawford Fitting Company, dated November 16, 1984

5. Swagelok Tube Fitting Catalog No. C-983, Crawford Fitting Company, 1983

6. Swagelok, "A Report on Initiation and Interchange," Crawford Fitting Company," 1984

7. Nuclear Operations and Maintenance Information Service Report 3298A, "Instrumentation, Incore Detectors, Experience With Wear and Galling of Swagelok Fittings," November 1, 1983

8. Technical Bulletin NSID-TB-84-09, "Primary System Leaks at Seal Tables," Westinghouse Nuclear Service Divison," October 11, 1984

9. Westinghouse letter number MED-PTE-1108(84) to R. Mathieson from G. J. Ohare, "TVA Memo From P. R. Wallace Dated 12/10/84," dated December 14, 1984

10. Westinghouse letter to R. Mathieson from R. Howard, "Seal Table Fittings Intermix - SEQ 1," dated May 2, 1984

11. Westinghouse letter number MED-PTE-1029(84) to R. Mathieson from G. J. O"Hare, "Seal Table Fitting Inspection," dated November 14, 1984

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13. Westinghouse Procedure No. MP 2.3.1, "Seal Table High Pressure Seal Repair," Revision 1, May 19, 1983

14. Westinghouse drawing number 113E516, Sheet 1 of 4, "TVA (Sequoyah Unit No. 1) Instrumentation - Bottom Mounted," TVA Approved February 16, 1972 (As-Designed)

15. Westinghouse drawing number 113E767, Sheet 1 of 4, "TVA (Sequoyah Unit No. 2) Instrumentation - Bottom Mounted," TVA approved August 26, 1980

16. Westinghouse drawing number 1096E91, sheet 1 of 4, "WAT-WBT (Watts Bar Units 1 and 2) Instrumentation Bottom Mounted"

B. Regulatory

1. USNRC IE Information Notice No. 84-55, "Seal Table Leaks at PWRs," July 6, 1984

C. TVA

1. NSRS

a. Memorandum from H. N. Culver to W. F. Willis, "Response to Board Comment - Sequoyah and Watts Bar Nuclear Plants - Manufacturer-Identified Misapplication of Swagelok Tube Fittings at Westinghouse Seal Tables," December 10, 1984 (GNS 841210 050)

b. Memorandum from K. W. Whitt to J. P. Darling, "Sequoyah and Watts Bar Nuclear Plants - Manufacturer-Identified Potential Misapplication of Swagelok Tube Fittings at Westinghouse Reactor Seal Tables - Nuclear Safety Review Staff (NSRS) Report No. R-85-02-SQN/WBN," January 15, 1985 (GNS 850115 050)

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a. Division of Operations Support

(1) Central Laboratories Report No. M86-84-0110A, "Tube Fittings for 1/4-inch O.D. SS Tubing, Sequoyah Nuclear Plant, Unit 1 - N191," dated October 10, 1984

b. Office of Nuclear Power

(1) Division of Nuclear Services

(a) Draft Report, "Sequoyah Nuclear Plant Unit 1, D-12, Traveling Incore Probe Thimble Tube Separation Special Tests," May 17, 1984

(2) Sequoyah Nuclear Plant

(a) MI-1.9, Revision 4, "Bottom Mounted Instrument Thimble Tube Retraction and Reinsertion," December 14, 1984

(b) MI-1.10, Revision 1, "Incore Flux Thimble Cleaning and Lubrication," December 12, 1984

(c) SMI-1-94-5, Revision 1, "Thimble Tube Installation," May 25, 1984

(d) SMI-0-94-3, Revision 0, "Seal Table High Pressure Seal Repair," November 12, 1984

(e) SI-146, Revision 12, "Reactor Coolant System Leak Test," May 1, 1984

(f) SI-250, Revision 2, "Reactor Coolant System Hydrostatic Pressure Test"

(g) GOI-1, Revision 50, "Plant Startup from Cold Shutdown to Hot Standby", January 7, 1985

(3) Watts Bar Nuclear Plant

(a) GOI-1, Revision 38, "Plant Startup from Cold Shutdown to Hot Standby Unit 1 or 2," January 31, 1985

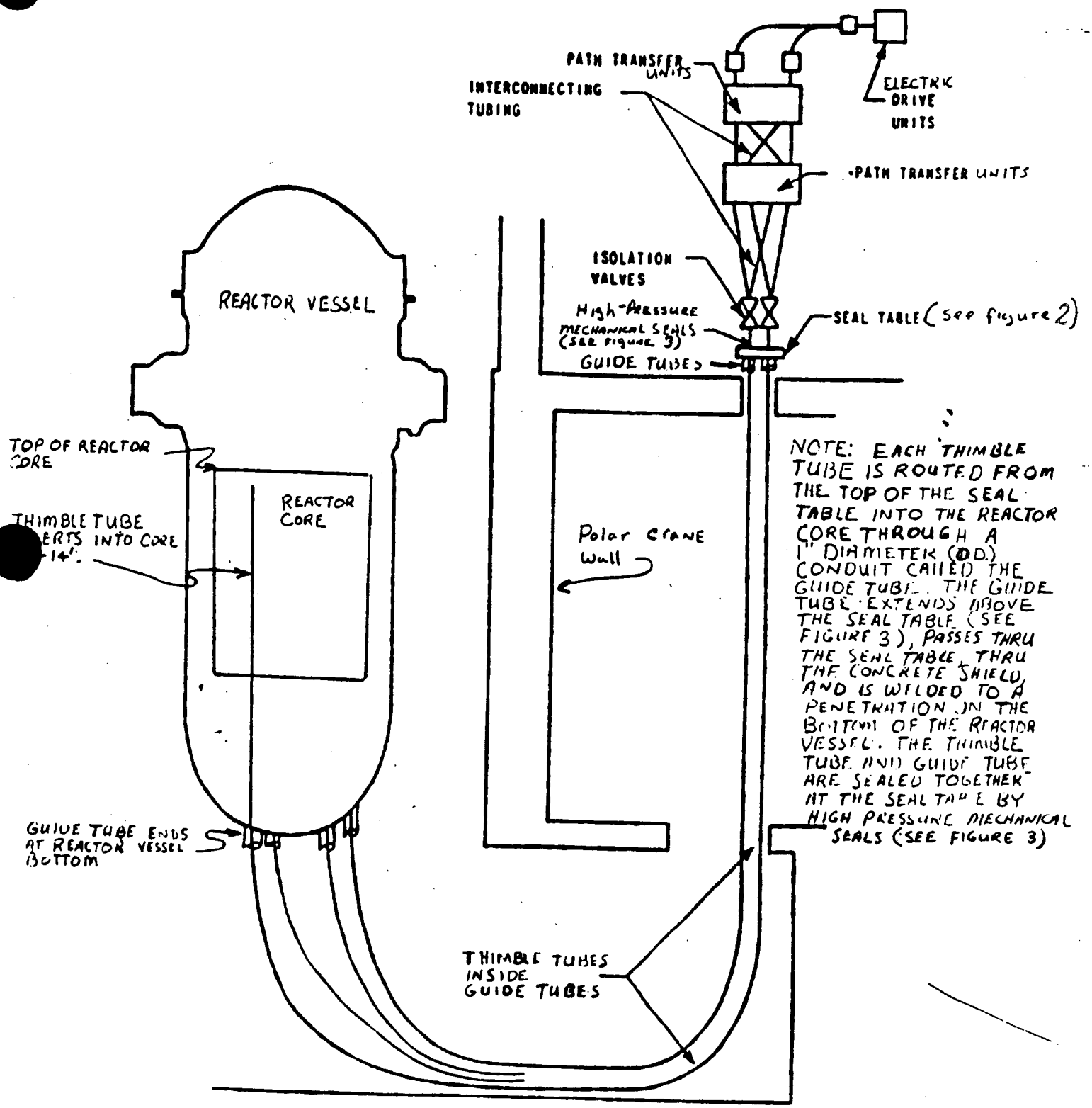


FIGURE 1 BOTTOM MOUNTED INCORE INSTRUMENTATION SYSTEM (BMIIS)

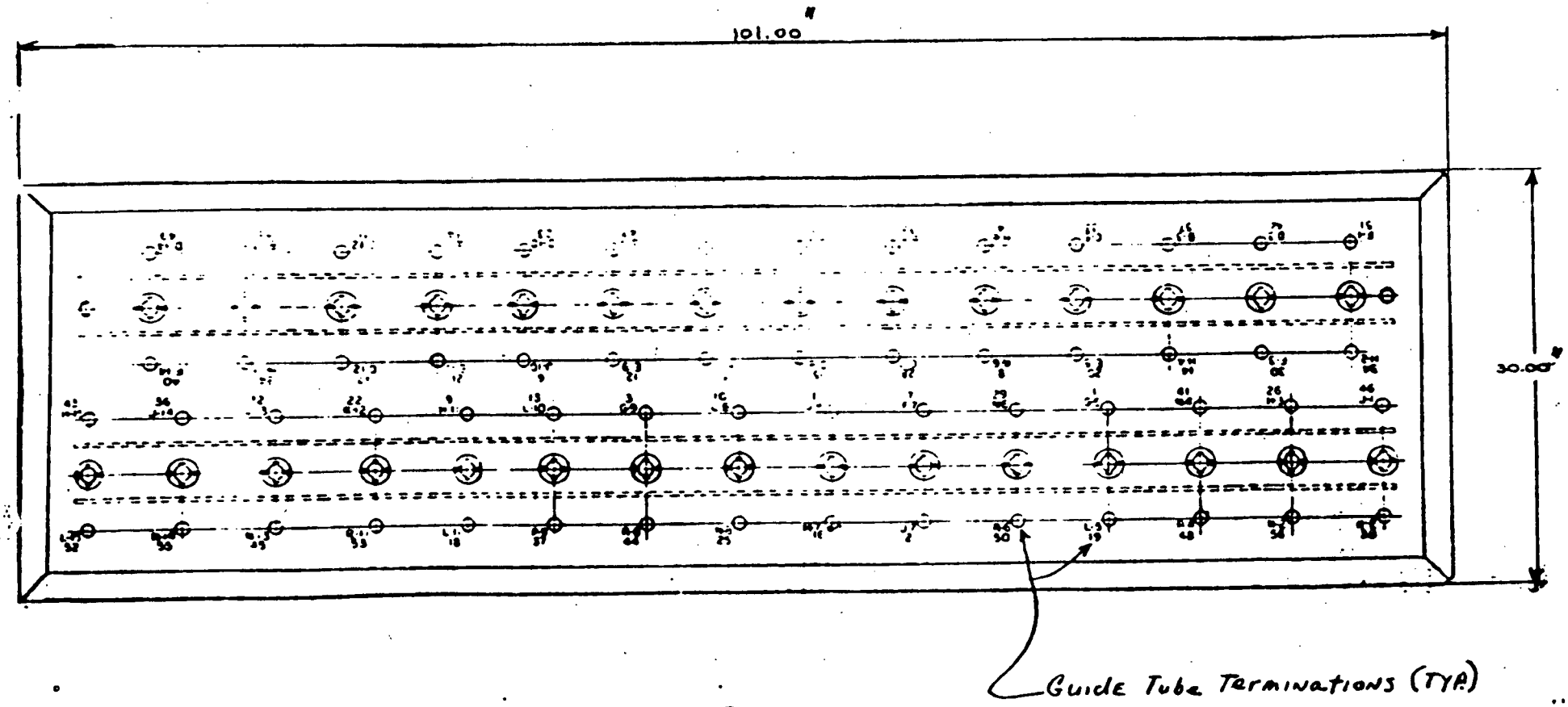
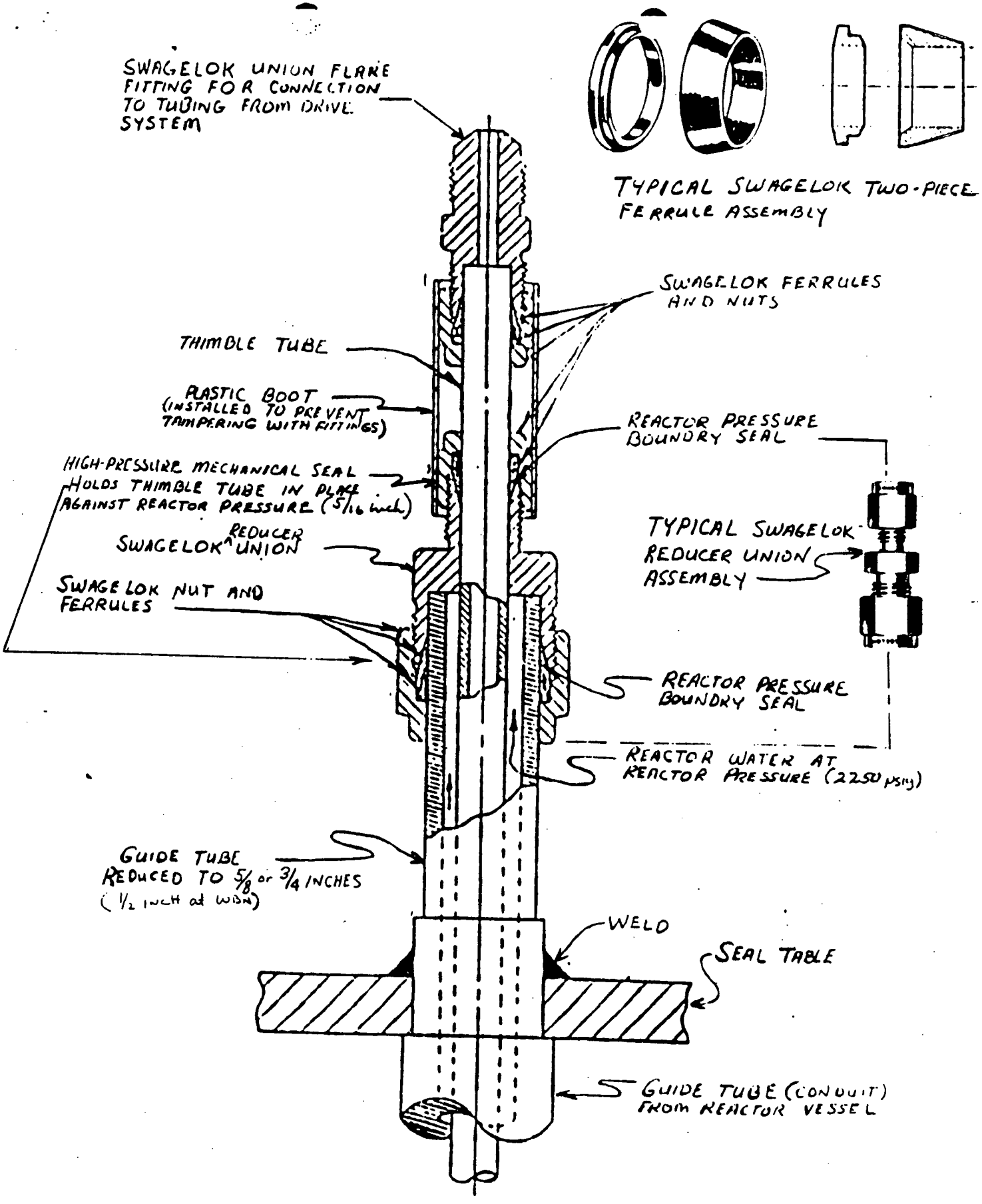


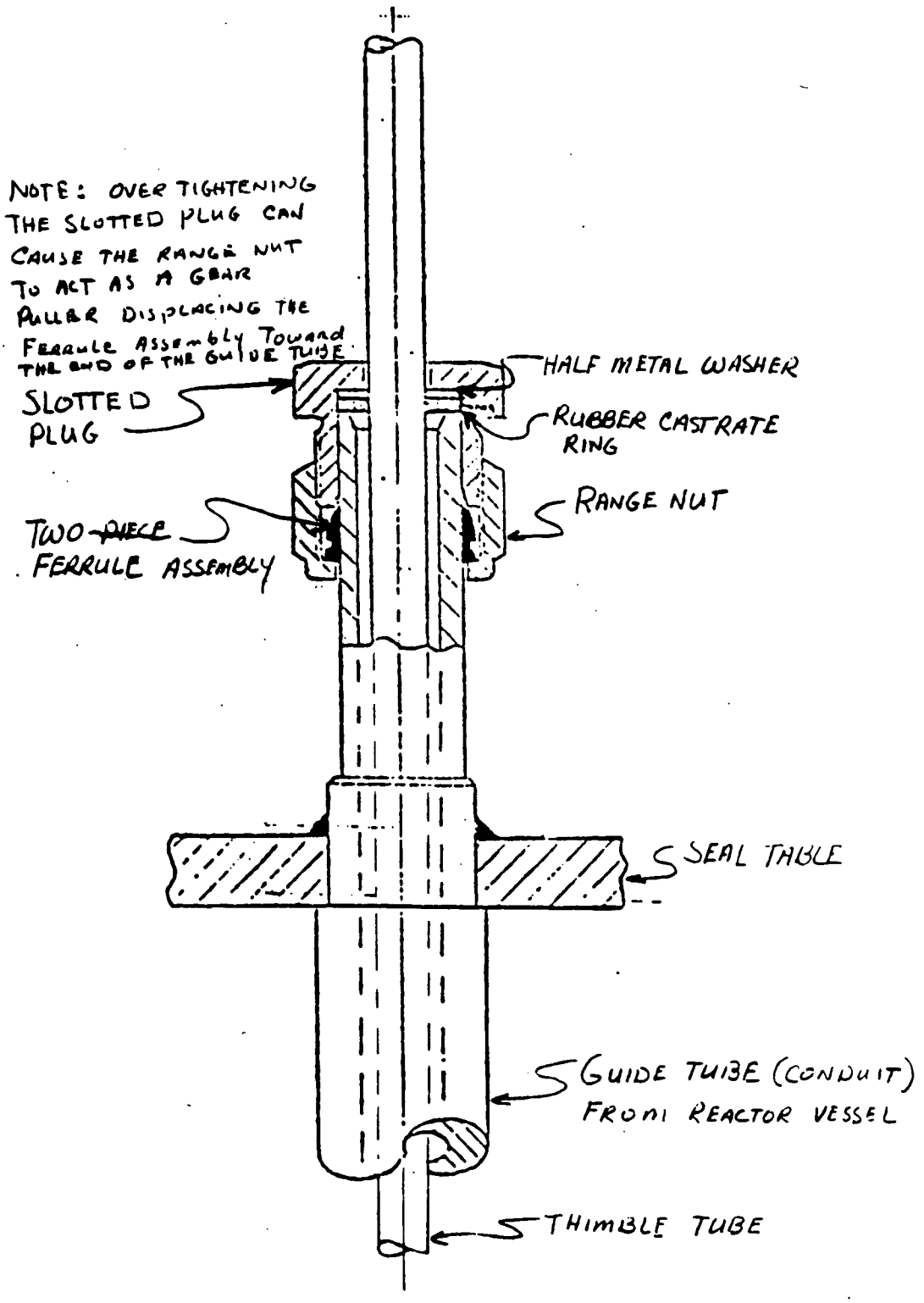
FIGURE 2

REACTOR SEAL TABLE



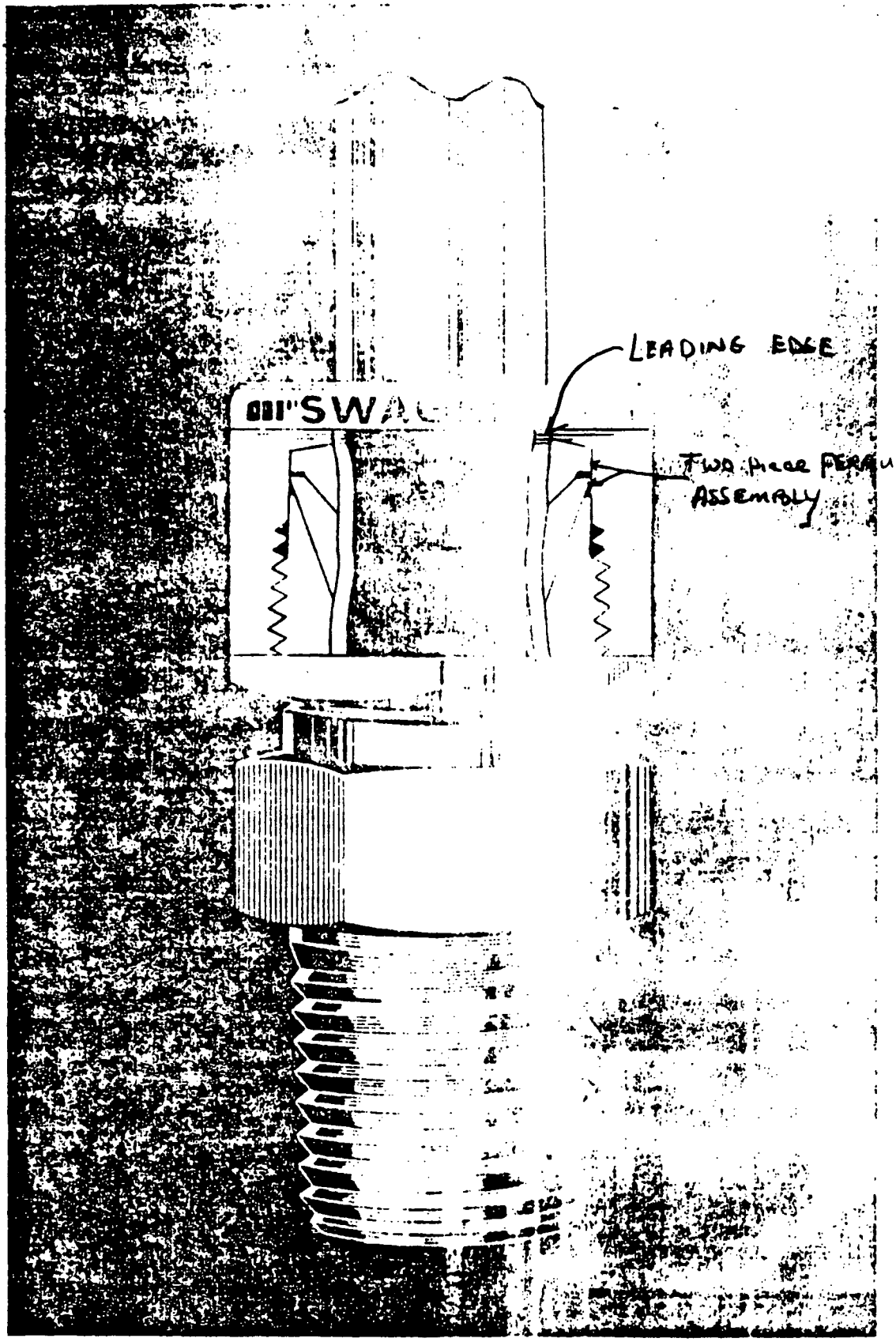
SEAL TABLE HIGH-PRESSURE MECHANICAL SEAL ASSEMBLY (TYPICAL 1 OF 58)

FIGURE 3



LOW-PRESSURE SEAL USED DURING REFUELING OPERATIONS WHEN THIMBLES ARE RETRACTED

FIGURE 4



"SWAGEING" ACTION OF A SWAGELOK FITTING ON TUBING.
FIGURE 5

CAUTION

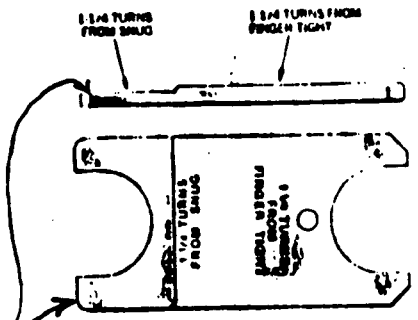
DO NOT MIX OR INTERCHANGE PARTS OF TUBE FITTINGS MADE BY OTHER MANUFACTURERS.

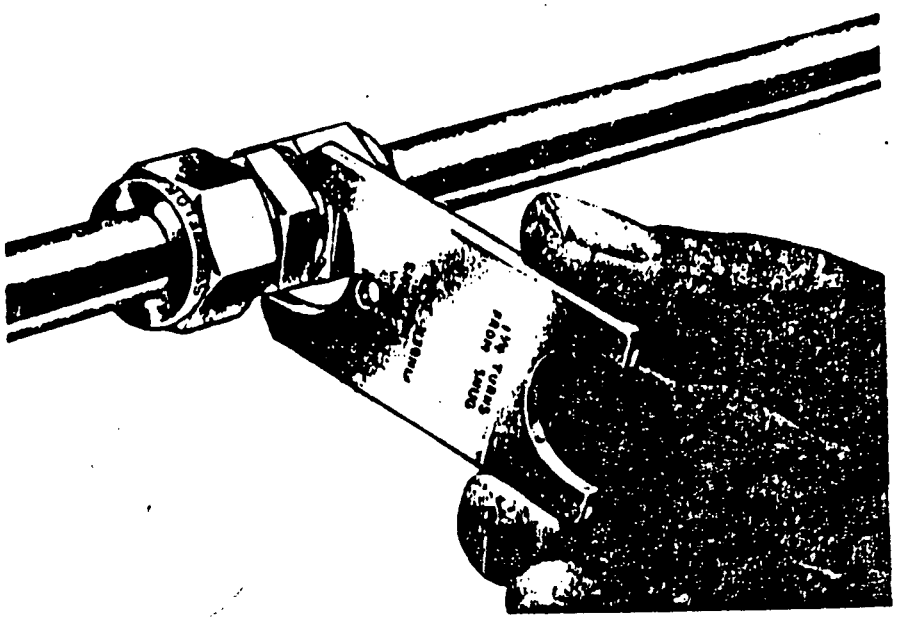
SWAGELOK Tube Fittings are manufactured to exacting tolerances. The critical interaction of precision parts as designed is essential to reliability and safety. Using parts of fittings made by other manufacturers with SWAGELOK Tube Fitting parts will not provide reliable connections. Damage or injuries may result from interchanging or mixing parts of tube fittings made by other manufacturers with SWAGELOK Tube Fitting parts.

SWAGELOK CAUTION CARD

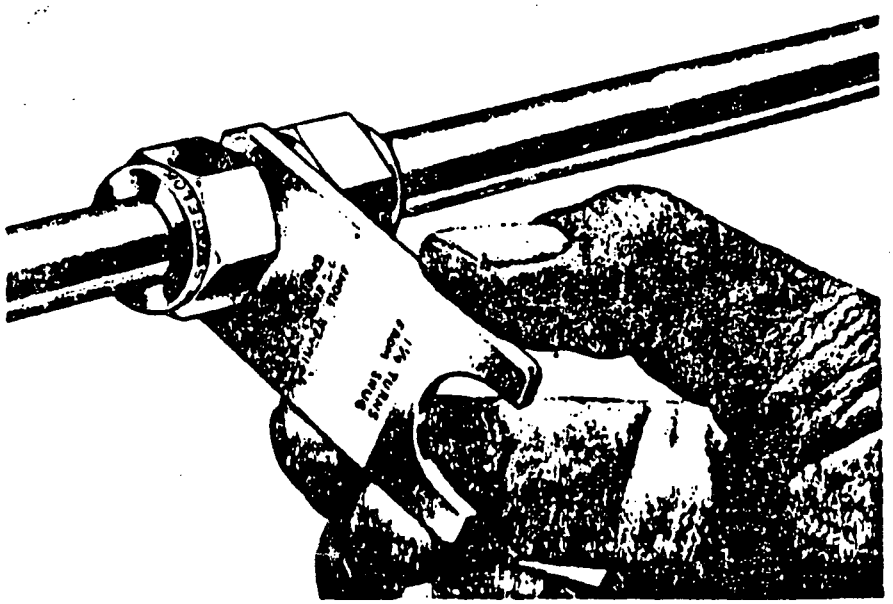
FIGURE 6

NOTE: THIS PART OF THE GAGE IS TO BE USED AFTER INITIAL ASSEMBLY OF SWAGELOK TUBE FITTINGS FOR HIGH PRESSURE APPLICATIONS, HIGH SAFETY FACTOR SYSTEMS





Gap Inspection Gage does not fit between nut and body hex. Fitting is sufficiently tightened.



Gap Inspection Gage fits between nut and body hex. Fitting is *not* sufficiently tightened.

SWAGELOK GAP INSPECTION GAGE

Figure 7