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User Guide and Specifications for Electrically Isolating Non-Asbestos Gaskets for High-Temperature Service

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Foreword

This study was conducted for the U.S. Army Corps of Engineers Installation Support Center (ISC) under the Facilities Engineering Applications Program; Work Unit FE7, “Dielectrically Isolating Gaskets.” The technical monitor was Malcolm McLeod, CEISC-ES.

The work was performed by the Materials and Structures Branch (CF-M) of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). Dr. Ilker R. Adiguzel is Chief, CECER-CF-M, and L. Michael Golish is Chief, CECER-CF. The CERL technical editor was Gordon L. Cohen, Information Technology Laboratory.

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Background

Army Regulation 200-1 requires that installations must exclude asbestos from all procurements and uses where asbestos-free substitute materials are available, and minimize asbestos releases to the utmost extent possible. Substitute materials are commercially available, but many do not perform adequately. Gasket materials that have been shown to perform adequately while installed in a heat distribution system (HDS) are identified in this report. It is recommended that the gaskets identified in this report be specified for use in new construction and maintenance of existing dielectric unions in HDS piping. It is also recommended that HDS dielectric unions be maintained as indicated in this report.

The associated advantages of using this technology are:

- compliance with AR 200-1
- protection of workers from asbestos as required in Technical Bulletin MED 513
- cost savings related to preventable heat loss and premature failure caused by corrosion of HDS piping.

CERL performed laboratory tests on a number of representative non-asbestos gaskets, and five were selected for field testing. CERL, in cooperation with the Directorate of Public Works at Fort Jackson, SC, then tested and evaluated the performance of these five non-asbestos gaskets on high-temperature water (HTW) systems. The number of gaskets tested was limited, but the evaluation results provide sufficient information to determine how well each type of gasket performed under field conditions.

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2 Pre-Acquisition

Description of the Technology

The U.S. Army operates and maintains approximately 2600 miles of heat distribution systems, much of which is of the direct buried, drainable/dryable, conduited design. Corrosion of the ferrous conduit often results in reduced operational efficiency and decreased service life of these systems. In aggressive soils (those having low electrical resistivity) the corrosive attack is particularly severe. Current criteria require the installation of a cathodic protection system for underground heat distribution and chilled water piping in ferrous metallic conduit in soils with a resistivity of 30,000 ohm-cm or less.* In addition, the Federal Agency Committee (FAC) on Underground Heat Distribution Systems is currently considering requiring cathodic protection for all buried ferrous conduits.

A correctly designed cathodic protection (CP) system effectively prevents corrosion. One critical element in any CP system is dielectric isolation of the protected structure. Dielectric isolation eliminates the possibility of protective current from the CP system being conducted to buried metallic structures other than the one being protected. Dielectric isolation also helps to control or eliminate the potentially severe and localized damage caused by stray-current corrosion. Stray currents are those that leave a protected structure rather than returning along the structure lead or wire connected to an anode. Dielectric isolation is achieved by introducing an electrical insulator to direct currents at a flanged mechanical joint along with a full set of insulating bolt sleeves and washers. In addition, the conduit makes electrical contact with the carrier pipe through pipe spacers, anchor plates and welded endplates. Any CP design assumes that a certain amount of electrically isolated buried conduit piping is to be protected. The specifications for rectifiers and/or sacrificial anodes that provide the protective current through the soil assume this fixed amount of

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* ETL 1110-3-474, *Engineering and Design: Cathodic Protection* (14 July 1995).

buried surface area. If the dielectric isolation fails, more surface area than intended is involved, greatly reducing or even eliminating corrosion protection.

Dielectric isolation across a carrier pipe flange is accomplished with a "flange kit" consisting of a nonconducting gasket, bolt sleeves, and additional nonmetallic washers. After the Environmental Protection Agency (EPA) declared asbestos to be a health hazard, the Army prohibited the introduction of asbestos into the work place as of April 1990 (AR 200-1). Prior to this ban, asbestos-based gaskets were used extensively and effectively by the Army. The ban has prompted the need for an effective replacement for dielectrically isolating cathodic protection flange gasket materials. Many non-asbestos-based dielectrically isolating gaskets are available commercially, but none have been systematically shown to work effectively and reliably. Because these isolating gasket/flange kits are essential for the continued effective performance of any cathodic protection system, it was necessary to identify an effective and reliable non-asbestos-based gasket material for use by Directorates of Public Works.

This technology consists of a number of different candidate gasket materials tested for suitability for sealing while also providing dielectric isolation. In order to examine only the performance of the various materials, manufacturers' recommended installation procedures were followed and identical nonmetallic bolt sleeves and nonmetallic washers were used throughout.

In order to identify non-asbestos gasket materials likely to work well, laboratory measurements of weight loss at elevated temperature and percent relaxation were made (see Table 1[*], which immediately follows this chapter). Those gaskets that performed best under these controlled conditions were chosen for field evaluation. Table 2 shows the six different gaskets selected. Five of these are made of non-asbestos material, while the sixth one is an asbestos gasket selected as the control. Table 3 provides a summary of the relevant findings.

To determine the effectiveness and long term durability of the gasket materials in the field evaluation, every attempt was made to hold other parameters constant. Nomex bolt sleeves and silicon glass washers were used throughout the field evaluation. Specific installation instructions from the various gasket manufacturers, including recommended bolt pattern, torque, and re-torque

* Relaxation measurements were made in accordance with ASTM Standard F 38-95, *Standard Test Methods for Creep Relaxation of a Gasket Material*.

values were followed. Each gasket was marked with a metal tag identifying it as part of a long-term evaluation project.

The gaskets were installed on HTW supply and return piping at nine different locations at Fort Jackson, SC. The evaluation of the performance of each gasket consisted of the following parameters:

1. Electrical Isolation – measured with a “dielectric checker” (Insulation Checker - Gas Electronic Model 601; see Appendix A for description) which measures the flow of surface current. Measurements were taken at 6 months and at 12 months.
2. Gasket Weight – the weight of the gasket was measured before installation and again after its removal in order to determine any weight loss.
3. Visual – a photographic record was made of each gasket before installation, immediately after installation, and after removal.
4. Torque Values – the torque values used were recorded. At the 6- and 12-month inspections, the values were checked again and torque adjusted as needed.
5. Flange Spacing – calipers were used to measure the flange spacing at the 12-, 3-, 6- and 9-o’clock positions. These measurements were made after installation, and at the 6- and 12-month inspections.

The evaluation procedure for each gasket immediately prior to and after removal consisted of the following:

With system energized:

1. Operating Temperature – prior to de-energizing and draining the heat distribution system, the exterior temperature of the carrier pipe (either supply or return as appropriate) were measured using both a magnetically adhered bimetallic thermometer as well as an alternative reference method (e.g., contact thermocouple, infrared pyrometer). The readings were noted, and any major changes in operating conditions were documented.
2. Electrical Isolation – measured with a “dielectric checker” (Insulation Checker - Gas Electronics Model 601) which measures the flow of surface current. Measurements were taken while the system was energized and any shorts found were recorded. If a short was found, an attempt was made to localize and identify its location.
3. Leaks – any evidence of leaking such as a faint hissing sound and/or the dripping of water was recorded.
4. Bolt Torques – the bolt torques were measured and recorded while the system was energized.

5. Flange Spacings – the flange spacings were measured and recorded while the system was energized. Measurements were taken at the 12-, 3-, 6- and 9-o'clock positions.

With system de-energized and drained:

1. Bolt Torques – the bolt torques were measured and recorded after the system was turned off, drained, and cooled to ambient temperature.
2. Flange Spacings – the flange spacings were measured and recorded after the system was turned off, drained, and cooled to ambient temperature. Measurements were taken at the 12-, 3-, 6- and 9-o'clock positions.
3. Visual Record – a photograph of each gasket immediately prior to removal was taken. A second photograph of each flange face immediately after flange separation was also taken.
4. Gasket Weight – each gasket was fully removed and weighed in the field. Every effort was made to collect the entire gasket, whether whole or in pieces, to make a valid comparison to the measurement of weight at installation. The full gasket was saved for laboratory weighing, drying, and re-weighing in order to estimate the amount of water absorption while in service.
5. Remainder of Flange Kits – the bolts, bolt sleeves, nuts, and washers for each gasket were collected and saved for further analysis.

The results of the field evaluation found that of the five types of non-asbestos gaskets evaluated, four provided both effective seals and dielectric isolation. The fifth type either did not provide effective dielectric isolation or had a seal failure.

Life-Cycle Costs and Benefits

At a replacement cost of approximately $300/ft, the Army's 2600 miles of heat distribution systems represents an investment of $4.1B. The reduction in useful life and decreased thermal efficiency is often associated with corrosive degradation in an aggressive soil environment. Even properly designed and installed CP systems can provide only partial or ineffective protection if the section being protected is not dielectrically isolated. Without CP, a conduit leak is much more likely to occur. Conduit leaks allow ground water to access the annular space, wetting insulation and lowering its thermal efficiency. If boiling occurs, the insulation will be entirely destroyed in a fairly short time. Even if the conduit is repaired and dried, heat loss will still be severe. Depending on the pipe size, heat loss can increase to three to seven times that of the design value for the remainder of the system's life, representing significant energy loss (Charles P. Marsh and Terrill R. Laughton, *Boiling Manhole Heat Loss*

Calculations, CERL TR 98/62/ADA 350373, June 1998). The excess heat loss, without boiling, for 500 ft of conduit at the current average price of $7.56/Mbtu can result in an avoidable cost of $13,200 per year. If only ten percent of all of the Army's heat distribution systems are in this condition, then $36M could be saved each year by replacing failed gaskets with dielectrically isolating ones. If the system is not repaired carrier leaks will likely result. A single carrier leak can cost anywhere from $3,000 to $15,000 to repair depending on the number of excavations needed for location and other factors. Additional costs will be associated with the interruption of service.

Table 1. Materials used in laboratory gasket testing (non-asbestos).

	Laboratory Measurements		**Manufacturers' Data**			
Material	% Wt Loss	% Relaxation	Max Temp (F)	Max Press (psi)	Max PxT	Composition
Durabla 8500	3.442	64.6	750	1500	***	NBR, aramid fiber
Durabla Black (A)	3.75	41				
*Garlock G9900**	-	-	1000	2000	700,000	Nitrile, graphite fiber
Garlock 8748 (A)	3.8	24.5				
Garlock 7228 (A)	5.9	32.5				
Garlock 3700	5.974	37.6	700	1200	350,000	EPDM
Garlock 3570	.0193	62.0	500	100	**	100% PTFE (Teflon)
*Garlock 3540**	-	-	500	1200	350,000	PTFE (Teflon)
Garlock 3400	3.021	26.2	700	1200	350,000	SBR
Garlock 3300	5.097	32.0	700	1200	350,000	Neoprene (CR)
Garlock 3200	4.778	43.6	700	1200	350,000	SBR
Garlock 3100	3.219	35.6	600	900	350,000	SBR
Garlock 3000	3.405	31.2	700	1000	350,000	Nitrile (NBR)
Garlock 900 (A)	2.85	11				
JM 1078	3.307	44.0	700	1000	350,000	NBR, synthetic fiber
JM 978 (1/16)	1.969	26.6	600	1000	350,000	Nitrile, Kevlar
JM 978-C	2.154	1.2	700	1000	350,000	Nitrile, Kevlar
JM 970	4.9	67				
JM 940	5.064	37.8	600	1000	350,000	SBR
K-Sil C81	2.194	15.8	see chart	see chart	**	Nitrile, synthetic fiber
K-Sil C4401	2.969	43.8	see chart	see chart	**	Nitrile, synthetic fiber
P-Pak White (A)	3.9	34				

*These were not tested in the laboratory

Table 2. Gaskets selected for field evaluation.

Gasket Type	Max. T(EF)	Max. Pressure (PSI)	Max. P x T	No.
Garlock 3400	700	1,200	350,000	4
Garlock 3540	500	1,200	350,000	4
Garlock G9900	1,000	2,000	700,000	4
K-Sil C81	---	---	---	4
JM978-C	700	1,000	350,000	4
Durabla Black (compressed asbestos w. styrene butadene rubber)	750	1,800	350,000	4

Note: The sizes were to be distributed such that for each material two (2) gaskets will be for piping of nominal 4" I.D. or greater and two (2) gaskets will be for piping of nominal 3" I.D. or less. In total this represents twelve (12) "large" gaskets and twelve (12) "small" gaskets. All gaskets were to be of the raised face type (no bolt holes required in the gaskets themselves). In addition, each flange face has eight (8) bolts of 3/4" diameter. Each of these will require a Nomex bolt sleeve and a silicon glass washer. Due to circumstances beyond the control of the demonstration, not all gaskets in all sizes were tested.

Table 3. Gasket performance after final inspection.

Material / Building	**Gasket Deterioration**	**Bolt Sleeve/ Washer Deterioration**	**Electrical Insulation Test**	**Torque (ft-lb)**	**Comments**
Garlock 9900 / 2601	No visual signs	No visual signs	Passed	141	Some bolt tightening required
Garlock 9900 / 2604	No visual signs	No visual signs	Passed	67	Periodic bolt tightening required
Garlock 9900 / Pit 136	No visual signs	No visual signs	Passed	70	No bolt tightening required
Garlock 3540 / 2462	No visual signs	No visual signs	Passed	105	No bolt tightening required
Garlock 3540 / 2462	No visual signs	No visual signs	Passed	105	No bolt tightening required
Garlock 3540 / 2009	No visual signs	No visual signs	Passed	141	No bolt tightening required
Garlock 3400 / 2009	No visual signs	No visual signs	Passed	141	Periodic bolt tightening required
Garlock 3400 / 2604	No visual signs	No visual signs	Passed	67	Periodic bolt tightening required
JM 978-C / 2462	No visual signs	No visual signs	FAILED	110	No bolt tightening required
JM 978-C / 2462	No visual signs	No visual signs	FAILED	110	No bolt tightening required
JM 978-C / Pit 137	LARGE LEAK	N/A (shut down)	Passed	180	Bolt tightening required
K-Sil C81 / Pit 111	No visual signs	No visual signs	Passed	200	No bolt tightening required
K-Sil C81 / Pit 111	No visual signs	No visual signs	Passed	200	No bolt tightening required
Durabla Black / 2601	No visual signs	No visual signs	Passed	70	One bolt required tightening
Durabla Black / Pit 136	No visual signs	No visual signs	Passed	70	No bolt tightening required
Durabla Black / Pit 137	No visual signs	No visual signs	Passed	70	One bolt required tightening
Durabla Black / Pit 138	No visual signs	No visual signs	Passed	70	No bolt tightening required
Durabla Black / Pit 138	No visual signs	No visual signs	Passed	70	No bolt tightening required

3 Acquisition/Procurement

Potential Funding Sources

Installation of electrically isolating non-asbestos gaskets will normally be funded by Army installations from their internal operations and maintenance budgets.

Technology Components and Sources

The electrically isolating non-asbestos gaskets described in this user guide are commercial, off-the-shelf products available on the open market. Installation of the gaskets can be performed by any mechanical contractor experienced in the installation of non-asbestos gasket materials for high temperature hot water (HTHW) service applications. To verify the dielectric isolation of pipe flanges, Army installations will need to have an instrument that can accurately test and locate electrical short circuits between adjacent pipe sections of a complex low-resistance pipe network. An alternative is to contract with a service company specializing in cathodic protection to perform both the gasket installation/replacement and dielectric isolation work.

Proper installation of the gasket, bolt sleeves, and nonmetallic washers is critical in order to achieve both sealing and dielectric isolation. Therefore, installation must comply with manufacturer's recommendations and instructions. Particularly important for achieving uniform gasket compression and good overall performance is the specific bolt-tightening sequence and torque values used.

Procurement Documents

Refer to ASME/ANSI B16.5, *Pipe Flanges and Flanged Fittings* for further information. This standard contains information regarding bolt circle dimensions, number of bolt holes, and comparisons of raised-face and full-faced pipe flanges. Two guide specifications published by the U.S. Navy Public Works Center, San Diego, PWCGS-13110, *Cathodic Protection by Galvanic Anodes*, and

PWCGS-13111, *Cathodic Protection by Impressed Current*, contain guidance useful in selecting and installing isolating gasket/flange kits (see Appendix B).

Procurement Scheduling

Normal, noncritical replacement of electrically isolating gaskets for high temperature service should be scheduled shortly after heat distribution systems have been shut down following the winter heating season. This work should be considered part of the installation's normal operations and maintenance functions. Procurement of the gaskets should be done prior to shutdown to ensure that the correct types and sizes of gaskets will be readily available when the replacement work begins.

4 Post-Acquisition

Initial Implementation

For each flange kit, the correct size of non-asbestos gasket needs to be specified, procured, and inspected upon receipt. Proper tools and equipment are needed to remove the existing gasket and install the new one. The tightening of flange bolts is not done randomly, but in a pattern, and using the correct torque, as specified by the gasket manufacturer. After the gasket has been properly installed, it must be checked for leaks and electrical isolation. The flange bolts should be retorqued and the gasket rechecked to verify its seal and dielectric integrity 24 to 72 hours after the heat distribution system has been energized.

Proper installation of the gasket, bolt sleeves, and nonmetallic washers is critical in order to achieve sealing and dielectric isolation. Therefore, installation must comply with the manufacturer's recommendations and instructions. Particularly important for achieving uniform gasket compression and good overall performance is the specific bolt-tightening sequence and torque values used.

Operation and Maintenance of the Technology

Gaskets should be inspected annually. The torque of the flange bolts should be checked, and bolts retightened if necessary, and the electrical isolation of the gaskets should be checked as well. If the inspection finds that gaskets must be replaced, note that valve gaskets must be replaced in pairs. Replacing a single gasket on one side of a valve may result in leaks occurring in the other side's gasket because the physical effort to spread one set of flanges apart may induce stresses that can adversely affect the integrity of the seal between the other set of flanges.

Service and Support Requirements

Directorate of Public Works operations and maintenance personnel must know how to correctly use a dielectric checking instrument to verify electrical isolation of gaskets.

Performance Monitoring

Monitoring the performance of the electrically isolating non-asbestos gaskets with a dielectric checker is straightforward. The gaskets must maintain

electrical isolation for the CP system to work effectively, and must also maintain a seal to prevent leaks in the heat distribution system. This is done through visual observation for leaks, and also by verifying that the flange bolts are at the correct torque.

Table 3 shows that four of the five non-asbestos based gasket materials tested provided good service for both mechanical sealing and dielectric isolation. The asbestos-based Durabla gaskets were included as a control group only; their performance is rated for comparison purposes. These gaskets are not to be used in distribution systems. Following the manufacturer's installation instructions precisely will help guarantee long, trouble-free service.

Appendix A: Model 601 Insulation Checker – Principle Of Operation

The Model 601 insulation checker was invented as an instrument for testing and locating electrical short circuits between adjacent pipe sections of a complex low-resistance pipe network.

The DC resistance of the metallic pipe is so small that it is virtually impossible with existing measuring apparati to accurately determine where adjacent pipes are shorted together. This problem is exacerbated by the fact that other pipe and insulators, either in series or parallel and in close relationship, are inter-connected with the pipe under study. This forms additional short circuits that the usual DC measuring devices are unable to distinguish from a short circuit around the insulator of interest.

The basic concept on which the Model 601 insulation checker is based involves the substitution of radio frequency energy for direct current energy in the measuring of small DC resistances associated with structures having considerable RF (skin effect) resistance but very small DC resistance. Radio frequency electromagnetic signals do not travel through the pipe (conductor) but ride completely on the surface — thus the term "skin effect."

In utilizing this basic concept a radio frequency voltage is applied between normally insulated adjacent portions of the pipe. The skin effect of the pipe to which radio frequency is applied results in a substantial resistance to radio frequency current flow. This produces a substantial and easily measured radio frequency voltage between the adjacent insulated points to which the radio frequency voltage is applied. If, however, a DC short circuit occurs directly between the pipe sections to which the RF voltage is applied, the radio frequency resistance is quite small, causing a virtual zero RF potential difference between the normally insulated points. In this manner the location of a short circuit between the normally insulated sections of a complex pipe system may be easily determined.

The Model 601 insulation checker is a radio frequency oscillator producing electromagnetic signals of a specific frequency which are fed to the test probes. A detector circuit is tuned to the same frequency generated by the oscillator. The radio frequency voltage is rectified to DC voltage. A micro-ammeter for determining the DC voltage is employed which indicates RF voltage between the test probes.

If an insulator is faulty, a direct current and RF short circuits exist between pipes at the points normally insulated by the insulating unit. Accordingly, the RF voltage between the test probes is virtually zero, causing the meter pointer to deflect toward or to zero. If, however, the insulator is good, a substantial RF skin-effect impedance along pipes and around insulators produces a considerable RF voltage between the test probes that is fed to the detector circuit causing little or no deflection of the meter pointer.

In this way it is possible to locate a shorted bolt in a normally insulated flange even though the bolt being examined may or may not be the only shorted bolt in the flange. The Model 601 insulation checker has been used to check flanges ranging from ¼- to 96-in. diameter. This insulation checker will not check the condition of a buried flange from remote test leads. The Model 702 insulation checker is another instrument used to check the quality of insulation of buried insulating units and between a carrier pipe and casing.

The Model 601 cannot be used to check the value of a carbon resistor because the resistance is too high for the meter to read. The radio frequency electromagnetic signal does not travel through the resistor but only on its outside surface.

Appendix B: Excerpts From Related Navy Public Works Center Guide Specifications

The following sections from PWCGS-13110, *Cathodic Protection by Galvanic Anodes* contain information on selecting the correct materials and using the appropriate procedures for installing isolating gaskets. Note that Sections 2.7 and 3.1.8 of PWCGS-13111, *Cathodic Protection by Impressed Current* contain identical information found in PWCGS-13110's Sections 2.1.5 and 3.1.6, respectively.

From Section 2, "Products":

2.1.5 Insulating Flange Kits: Insulating flange kits shall include full-faced gaskets, full-length sleeves, and double insulating and steel washers. All insulating materials shall be suitable for use in the intended service at required operating temperatures and pressures.

2.1.5.1 Gaskets:

a. Insulating gaskets for steam, condensate and high temperature water shall be not less than 1/8-in. thick and suitable for operating at not less than 450 °F.

b. Insulating gaskets for compressed air, natural gas, or water shall be not less than 1/8-in. thick neoprene or buna nitril face phenolic gaskets suitable for operating at not less than 200 °F.

2.1.5.2 Sleeves:

a. Insulating sleeves for steam, condensate or high temperature water shall be full-length nomex material suitable for operating at not less than 450 °F.

b. Insulating sleeves for compressed air, natural gas, or water shall be full-length minlon, mylar, or nomex material suitable for operating at not less than 200 °F.

2.1.5.3 Insulating Washers: Insulating washers shall be NEMA G7 rated silicon glass material 1/8-in. thick suitable for operating at not less than 450 °F. The I.D. of the washers shall be large enough to fit over the O.D. of the sleeve.

2.1.5.4 Steel Washers: Washers shall be 1/8-in. thick cadmium plated steel. The I.D. of the washers shall be large enough to fit over the O.D. of the sleeve

2.1.5.5 Heat-Treated Bolts and Nuts: Material for bolts shall conform to the ASTM Specification A-193, Grade B7. Nuts for bolts shall be semi-finished hexagon heads and made from metals conforming to ASTM Specification A-194, Grade 2H. The nuts shall conform to the American Standard "Heavy Hexagon Dimensions ASA 18.2 1955" and shall be tapped in accordance with ASA B1.1 1960 Coarse Thread Series Class 2 Fit.

From Section 3, "Execution":

3.1.6 Insulating Flange Kits: Insulating flange kits shall be installed, as shown, and at the locations indicated on the drawings by using the following installation procedures:

a. Inspect the insulating flange kit and verify that the material is as specified.

b. Cut piping accurately and square, removing all fins and burrs.

c. Work flanges into place without springing or forcing.

d. Align flange faces so that they are parallel and concentric, to within 0.01 in., without external loading or springing.

e. Align bolt holes by driving two tapered drift pins in opposite directions to each other in two diametrically opposite bolt holes.

f. Weld flanges in accordance with ANSI B16.25.

** OR **

a. Cut taper pipe threads in accordance with ANSI B2.1.

b. Apply joint compound or thread tape, in accordance with NFGS-02695, to male threads only.

c. Engage threads so that not more than three threads remain exposed.

"BACKING OFF OF THREADED FLANGES TO PERMIT ALIGNMENT SHALL NOT BE PERMITTED."

d. Work piping into place without springing or forcing.

3.1.6.1 Insert insulating gasket between flanges.

3.1.6.2 Insert insulating sleeves into bolt holes.

"DO NOT FORCE SLEEVES INTO BOLT HOLES AS DAMAGE TO SLEEVES WILL OCCUR."

3.1.6.3 Assembly of studs or bolts.

a. Run one nut on each stud so that two full threads remain showing.

b. Slide one steel then one glass washer onto each stud or bolt and insert into bolt hole.

c. On the opposite end of the each stud or bolt place a glass, then a steel washer, then the nut.

3.1.6.4 Torque the first two studs or bolts at diametrically opposite locations to a maximum value of 30% of the final torque value.

3.1.6.5 Remove drift pins and replace with sleeve and stud or bolt assemblies.

3.1.6.6 Torque the remaining studs or bolts to 30% of their final torque value in a star pattern.

3.1.6.7 Continue to torque the studs or bolts in a star pattern to 60% of their final torque value.

3.1.6.8 Repeat step 3.1.7.7 increasing torque value to 100%.

3.1.6.9 For steam, condensate, and high temperature water applications, retorquing of all studs or bolts using step 3.1.7.8 shall be done after system startup to compensate for relaxation or creep of assembly.

3.1.6.10 Test the effectiveness of each insulator.

"ALL INSULATORS THAT TEST LESS THAN 100% SHALL BE REPLACED."

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CEWES 39180
ATTN: Library

CECRL 03755
ATTN: Library

USA AMCOM
ATTN: Facilities Engr 21719
ATTN: AMSMC-EH 61299
ATTN: Facilities Engr (3) 85613

USAARMC 40121
ATTN: ATZIC-EHA

Military Traffic Mgmt Command
ATTN: MT-LOF 22041-5000
ATTN: MTE-SU-FE 28461

Fort Leonard Wood 65473
ATTN: ATSE-DAC-LB (3)
ATTN: ATZT
ATTN: ATSE-CFLO
ATTN: ATSE-DAC-FL
ATTN: Australian Liaison Office

Military Dist of WASH
Fort McNair
ATTN: ANEN-IS 20319

USA Engr Activity, Capital Area
ATTN: Library 22211

US Army ARDEC 07806-5000
ATTN: AMSTA-AR-IMC

Linda Hall Library
ATTN: Receiving 64110-2498

US EPA, Region V
ATTN: AFRC-ENIL-FE 60561

US Army Environmental Center
ATTN: SFIM-AEC-NR 21010
ATTN: SFIM-AEC-CR 64152
ATTN: SFIM-AEC-SR 30335-6801
ATTN: AFIM-AEC-WR 80022-2108

Defense Nuclear Agency
ATTN: NADS 20305

Defense Logistics Agency
ATTN: DCSC-BI 22060-6221

National Guard Bureau 20310
ATTN: NGB-ARI

US Military Academy 10996
ATTN: MAEN-A
ATTN: Facilities Engineer
ATTN: Geography & Envr Engrg

Naval Facilities Engr Command
ATTN: Facilities Engr Command (8)
ATTN: Engrg Field Divisions (10)
ATTN: Engrg Field Activities (4)
ATTN: Public Works Center (8)
ATTN: Naval Constr Battalion Ctr 93043
ATTN: Naval Facil. Engr. Service Ctr 93043-4328

416th Engineer Command 60623
ATTN: Gibson USAR Ctr

US Army MEDCOM
ATTN: MCFA 78234-6000
Fort Detrick 21702-5000
ATTN: MCHS-IS
Fort Sam Houston 78234-5000
ATTN: MCFA-PW
Walter Reed Army Medical Center 20007-5001
ATTN: MCHL-PW

Tyndall AFB 32403
ATTN: HQAFCESA/CES
ATTN: Engrg & Srvc Lab

USA TSARCOM 63120
ATTN: STSAS-F

American Public Works Assoc. 64104-1806

US Army CHPPM
ATTN: MCHB-DE 21010

US Gov't Printing Office 20401
ATTN: Rec Sec/Deposit Sec (2)

Nat'l Institute of Standards & Tech
ATTN: Library 20899

Defense General Supply Center
ATTN: DGSC-WI 23297-5000

Defense Supply Center Columbus
ATTN: DSCC-WI 43216-5000

Defense Tech Info Center 22060-6218
ATTN: DTIC-O (2)

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