ELIMINATION OF BINDING OF THREADED CONNECTIONS ON REACTOR AND SUPPORT EQUIPMENT

(Title Unclassified)

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I. INTRODUCTION

This report presents some of the causes leading to binding of threaded connections and describes action that is being taken and must be taken to eliminate seized threads between mating parts. A review of all threaded connections on reactor assembly tools and shipping containers has been performed by the writer. The review indicates some major causes of thread binding as follows:

1. Use of similar materials in mating parts, such as stainless steel, which are subject to galling.

2. Lack of conformance with specified requirements such as chamfers on bolt lead threads and countersinks on lead threads of tapped holes which lead to distorted threads.

3. Improper, or improper use of, plating or coating subject to chipping and cracking.

4. Damaged and dirty threads resulting from improper shipping, handling and storage techniques.

Section II of this report presents some principal causes of thread binding. Section III delineates action being taken by the Reactor Design Section toward minimizing binding of threaded connections. Section IV recommends corrective action to be taken by other responsible sections to reduce this problem significantly.

A tabulation containing pertinent data on the threaded connections on Reactor Assembly Tools and Shipping Containers was prepared and can be obtained from the writer. The recommendations column of the tabulation shows the action already initiated on existing threaded connections.
It should be noted that some of the comments contained herein are based on information obtained from the WANL Materials and Drafting Sections and from manufacturers literature.

It is recommended that Purchasing, Manufacturing Engineering, Quality Control, Materials, Reactor Assembly Laboratory and Reactor Design each independently implement the corrective action considered necessary to eliminate binding of threads as outlined in Section V.
II. CAUSES OF THREAD BINDING

Some principal causes leading to thread binding are as follows:

1. Galling threads on mating part:
   (a) Burrs
   (b) Excessive lead error on external thread.
   (c) Material prone to galling or not properly plated.
   (d) Surface finish on threads.
   (e) Lapped threads.

2. Distorted lead thread in nut or on bolt.
3. Nicked lead thread in nut or bolt.
4. Mating parts not the same class or size of thread.
5. P. D. and/or major diameter oversize on mating part.
6. Excessive lead error on mating part.
7. Improper thread form on fastener.
8. Improper thread form on mating part.
9. P.D. and/or minor diameter undersize.
10. Improper shipping.
11. Improper handling.
12. Improper storage.
13. Lack of proper specification.
14. Improper plating or coating.
15. No countersink on tapped holes.
16. Lack of chamfer on lead external thread.
17. High unit loading on plating causing chipping and cracking.
18. Plating added over finished threads such that the class of thread is increased over that delineated by applicable specifications. Federal
specification QQ-C-320 (Chromium Plating) requires that plating be within the specified dimensions on drawings. When Westinghouse Purchasing Department Specification PDS 12156 is specified for chrome plating, a note must be added that thread dimensions apply after plating.
III. DESIGN CRITERIA AND HANDLING PRECAUTIONS

NAVSHIPS 250-1500-3 (Design Criteria and Handling Precautions to Preclude Binding in Threaded Joints for Primary System Components in Nuclear Plant Service) dated 28 February 1961 was prepared by the Bureau of Ships as a guide for the assembly, disassembly and design of threaded joints for nuclear propulsion plant primary system components. This document can be used as a basis for design, procurement and handling precautions. The writer recommends that other responsible groups should utilize this document as an aid in establishing procedures in their particular discipline. Some excerpts from NAVSHIPS 250-1500-3 concerning design criteria and handling precautions with interpretations by the writer follow:

A. Design Factors Affecting Binding

1. Thread Pitch - The most coarse thread consistent with design requirements should be used. Fine threads are undesirable since the clearances are smaller. This increases the potential for galling, the potential for crevice corrosion and the possibility of damage due to distortion. In general, a pitch of 8 threads per inch or more coarse is recommended for diameters of 1 inch or greater.

2. Thread Class - It is desirable to obtain liberal clearances in order to reduce the possibility of binding caused by distortion. The thread class used should provide a minimum diametral clearance at the pitch line of approximately 0.003 inch for diameters less than 1 inch and 0.006 inch for diameters 1 inch and greater.
3. **Thread Form** - When the Unified thread form is used, notes should be added to the drawing specifying rounded roots and crests and minimum clearances of classes 2A and 2B. Where even greater diametral clearance is desirable, a special thread may be specified as in MIL-STD-9, to obtain a minimum diametral clearance at the pitch line of as much as 0.010 inch. Another way to obtain greater clearance than obtained with Classes 2A and 2B is to specify a Class 1A modified such that the tolerance range is the same as Class 2A while the maximum clearance is the same as Class 1A.

4. **Thread Surface Finish** - The optimum surface finish depends on the relative hardness of the mating materials. A rough surface may lead to ploughing; for instance, when a hard material is moved against a soft material, any projections on the hard material will plough into the softer material with a resulting metal pile-up. In contrast, an extra fine surface finish may lead to galling because of the many surface contact points if two soft mating materials are used. A compromise surface finish of 32 to 63 micro-inches is suggested on both internal and external threads to minimize the occurrence of ploughing or galling. All chatter marks and burrs should be removed from mating surfaces, to reduce the tendency for ploughing and subsequent binding.

5. **Thread Loading** - A relatively high thread load increases the possibility of galling by increasing the tendency for self-welding. Therefore, it is desirable to specify limits on the amount of torque used in the assembly of threaded closures; these limits on torque should be based on design considerations such as required preload for pressure containment, etc. Consideration should be given to the use of bolt heaters and pretensioning devices where a large preload is necessary. Furthermore, high local thread load intensities which contribute to galling can be reduced by
providing a high degree of thread accuracy thus increasing the thread surface contact area.

6. **Chamfer** - Threads which extend to the end of the member should be chamfered to the depth of the thread to facilitate assembly and to reduce the possibility of damage to the end thread. Care should be taken to prevent the internal thread chamfer from causing a point loading on the external thread as this may result in thread failure.

7. **Materials for Threaded Closures** - Identical metals and combinations of metals that exhibit a tendency to self-weld because of their solid state solubility, metallographic structure, and relative hardness should be avoided for mating parts in threaded joints. It should also be noted that some metals which are not soluble in each other have a tendency to gall when used as mating parts.

8. **Plating Materials** - A common method for preventing crevice corrosion and for achieving dissimilar metal contact is to plate one of the mating parts with another material. The most common plating material is chrome which gives a hard, corrosion resistant, low friction surface. However, if the relatively soft subsurface (stainless steel) deforms under load, the hard thin chrome plating may crack as it becomes unsupported, resulting in hard jagged chrome particles flaking off and causing thread binding by gouging the mating surface. Therefore, it is desirable to limit the load on chrome-plated surfaces. Chrome plating should always be done in accordance with approved procedures.

9. **Lubrication** - Lubricants tend to prevent galling by providing separation between mating metal surfaces. The only lubricant approved for use in
areas of primary coolant systems in nuclear reactor plants, which are within pressure boundaries and could thus contact primary coolant during plant operation is a colloidal suspension of graphite particle size B, dispersed in alcohol (Neolube). This lubricant may be used to facilitate assembly and disassembly but its use should be limited to prevent excessive amounts of it from entering the primary system.

10. Operating Conditions - The design should be predicated on the conditions under which the threaded joint will have to be operated, to insure that the clearances and thread loadings will be within desirable limits when the mating parts are subjected to operating conditions, i.e. temperature and pressure effects.

11. Determination of Bolt Torque for Bolted Joints - The size and number of bolts required in a bolted joint and the set up torque shall be determined in accordance with letter Serial 00:00:08-31L dated 4/17/64 by Mr. G. Downs.

B. Field Handling Procedures for Threaded Closures

While satisfactory design criteria are of fundamental importance in reducing the frequency of binding of threaded closures, the effectiveness of a good design can be nullified by improper handling in the field. In addition to the careful handling normally given to parts in the field, the following are desirable precautions:

1. General -
   (a) Where special tools, such as torque wrenches are required, no attempt should be made to start work without these tools.
(b) Only tools properly sized to minimize the possibility of over torquing the closure or damaging the part on which the tool fits should be used for assembly or disassembly of a threaded closure.

(c) Impact wrenches should not be used to loosen or tighten a threaded joint except in certain applications, where they are specifically approved for spinning on or off stud nuts. Even in these cases they should not be used for the final tightening or initial loosening.

(d) Torque should be applied only on the wrench flats and should be applied with a minimum amount of lateral force.

2. Assembly -

(a) Prior to assembly, the threads should be protected both by careful handling and by the use of some form of thread protector such as a metal or plastic bushing, or sleeve.

(b) Both male and female threads must be clean and free from nicks and burrs. All rough edges must be removed. When there is evidence of poor chrome adhesion, the threads should be replated because the chrome flakes may cause binding.

(c) The lubricant should be applied to the thread and the threaded parts assembled until hand tight before using a tool for tightening.

(d) The final tightening torque should conform to the specific closure design torque requirements, where stated in technical manuals or
assembly procedures. In general, the requirements of WANL Process Specification PS 294507 (Installation of Threaded Fasteners) should be met.

3. Disassembly -

(a) Before resorting to force to open a closure when binding obviously exists or where specified torque limitations are being exceeded, other methods of loosening the joint, such as the following, should be attempted:

Heating the outer surface while the center section is cooled.

Forcing graphite-in-alcohol lubricant into the joint and working the thread back and forth to distribute the lubricant, however, care must be exercised in working on installed components to prevent introduction of excessive amounts of lubricant into the system.

If the joint cannot be easily disassembled after applying the graphite-in-alcohol lubricant, other approved anti-seizing compounds may be used in applications where this material is prevented from entering the system by a suitable barrier and can be completely removed from the joint after disassembly.

(b) When locking devices requiring crimping are used, it is essential to be certain that adequate uncrimping has been performed prior to applying removal torque. Small, uneven pressure loads resulting from partially crimped locking devices may cause galling when disassembling, especially on large threads.

(c) After breaking the torque with a wrench, the subsequent removal should be by hand so that any tendency toward galling can be detected by touch.
IV. ACTION TAKEN BY REACTOR DESIGN TO ELIMINATE THREAD BINDING

The following comments delineate action which has already been initiated by Reactor Design to eliminate thread binding on reactor and support equipment.

1. A tabulation listing threaded connections based on a review performed by Reactor Design was prepared. The tabulation includes data for each threaded connection such as item number, drawing number, quantity, size and class of thread, type of external thread, plating material and torque value. The tabulation includes the mating part information by item number, drawing number, material, type and class of thread. The recommendation column delineates the action already initiated for modifications on the threaded connections.

2. Threaded connections consisting of materials subject to galling as type 304 stainless steel to 304 stainless steel or aluminum to aluminum; one of the items will be replaced with silicon bronze material.

3. No plating or coating will be used on replacement hardware. Plated items subject to repeated disassembly and reassembly will be replaced with unplated parts. Plating or coating will not be specified on new drawings.

4. Where no disassembly is performed on existing threaded connections of like material which are subject to galling or are plated, no changes will be made.

5. No changes will be performed on existing connections consisting of stainless steel to aluminum.
6. Notes will be added to existing drawings covering replacement hardware and to new drawings to assure quality threads on connections which are repeatedly disassembled and reassembled as follows:

(a) Threads shall conform to the requirements of Handbook HB-H28 and WANL PS 294506 (Supplementary Manufacturing Information).

(b) **External Threads** - If the part is detailed, the lead thread chamfer will be called out at the detail. A note indicating a special finish on the threads will be included if the design requirement necessitates. For commercial hardware the following note will be added as applicable:

`External Threads - 32 to 63 AA finish. The first thread shall be chamfered 45° ± 5° X one thread depth + .010.`

All information concerning threads, chamfers, threads, reliefs, etc. can be obtained from Section 19 of the Drafting Manual.

(c) **Internal Threads** - Holes shall be countersunk 110° ± 5° included angle to the minimum major diameter + .030 - .000 and be concentric within 0.020 TIR. The information for tapped holes will be included in the thread call out in accordance with Section 19, Paragraph 19.4 - 4.8 of the Drafting Manual. Tapped holes will have countersinks on both ends where through bolts are specified.
NOTE: The practice of calling out chamfers on lead external threads and countersinks on internal threads is necessitated since parts have been furnished in the past that did not conform to specified requirements in this area. In the past, tool drawings referenced WANL Process Specification PS 294506 (Supplementary Manufacturing Information) and Handbook HB H28. WANL PS 294506 references MIL-STD-9 (Screw Thread Conventions and Methods of Specifying). WANL PS 294506 specifies the information concerning countersinks while MIL-STD-9 delineates applicable information if not otherwise covered on the drawing.

7. Torque values will be specified for all threaded connections on drawings. WANL PS 294507 (Installation of Threaded Fasteners) shall be added to assembly drawings to cover the procedures for the installation of threaded fasteners.

8. Thread lubricant (Neolube) will be specified on the drawings by adding WANL PS 294506 (Lubrication of Threaded Joints and Pilot Fits) for lubricating male fastener threads and washer faces prior to assembly.

9. High strength alloy steel bolts will be used as required from a mechanical standpoint. However, as a general practice, fasteners for non-reactor parts will consist of stainless steel to silicon bronze where corrosion resisting materials are desirable.

10. Silicon bronze material will meet QQ-C-591 composition A (hard) on purchased hardware such as nuts and bolts. Its mechanical properties are:
Yield Strength - 50,000 psi
Tensile Strength - 80,000 psi
Elongation - 15%

Where it is necessary to provide fasteners which are not catalog items, free machining leaded silicon bronze conforming to QQ-C-591 Composition D (hard) will be specified. This material has the same mechanical properties as noted above.

11. Male threads on fasteners should be specified as rolled threads when possible.
V. PREVENTIVE MEASURES BY OTHER SECTIONS TO ELIMINATE THREAD BINDING

1. **Proper Handling** - Care must be exercised during all handling phases to eliminate the possibility of damaging parts. Parts must be removed carefully from protective wrapping for final inspection at WANL. As parts are inspected they should be installed in separate protective barriers.

2. **Storage** - Parts must be stored in suitable container to prevent damage and corrosion. Loose bolts and nuts for lifting fixtures, tools, etc. should be stored in partitioned containers which preclude nicks, scratches, etc. The container should be conspicuously marked with proper part or tool number identification to eliminate the possibility of using the parts incorrectly.

3. **Inspection** - Inspection of parts at the source and at WANL should include the following:
   
   (a) Require that a suitable finish exists on the threads free of nicks, burrs, scratches, etc.
   
   (b) Parts should be uniform in quality and condition. They should be sound, clean, free from fins, burrs, cracks, tool marks and other imperfections detrimental to their performance or defects which might affect their serviceability.
   
   (c) There should be 100% visual inspection as a minimum, accompanied by rejection or rework of defective parts.
   
   (d) Complete dimensional conformance.
(e) In general, bolts, nuts and other fasteners for tools fabricated from carbon and alloy steel should be subjected to magnetic particle inspection.

(f) Non-magnetic materials such as austenitic stainless steel should be examined by fluorescent penetrant examination or dye penetrant inspection to detect discontinuities open to the surface of the part.

4. **Packing and Packaging:**
   Require vendors to pack bolts separately to eliminate thread damage. All subsequent handling and storage must be aimed at protecting threads.

5. **Examination of Existing Fasteners:**
   All existing tooling should be examined for countersinks on tapped holes and chamfers on external threads. All items should be modified as necessary to meet drawing requirements on parts that are repeatedly assembled and disassembled. For example, distorted lead threads should be reworked.

6. **Workmanship -** Shall be consistent with the type of product, finish and class of thread specified. Product shall be free from fins, seams, cracks, tool marks and other defects which might affect its serviceability.

7. **Sampling -** Each lot of mating fasteners shall be subjected to torque requirements and be subsequently inspected for damage to threads on the mating parts. Unless otherwise specified, not less than 5% of the fasteners shall be subjected to qualification test sampling. Noticeable distortion, or scratches deep enough to reduce the efficiency of the threads are cause for rejection.
8. **Trial Fit-Up** - All mating fasteners shall be trial fitted prior to actual assembly. The bolt shall remain in serviceable condition and permit installation of a new nut freely with the fingers up to engagement of the self-locking devices.

The tabulation containing pertinent information on the mating parts of threaded connections on reactor assembly equipment and shipping containers, includes the action already initiated to replace parts subject to binding and identifies drawings which are being modified accordingly. It is recommended that procurement of replacement parts be expedited as modified drawings are released. A similar tabulation covering threaded connections on the reactor has been prepared and is available.

Lastly, it is recommended that all responsible groups take action to define procedures as necessary in their particular discipline so that the problem of binding in threaded connections will be eliminated.