U.S. Department
of Transportation

Pipeline and Hazardous
Materials Safety Administration

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Inspection Procedure for Inspection of DOT/TC cylinder Mounting Threads

(Rev 3- 10/12/07)

Scope

This document provides basic guidelines for the inspection and evaluation of DOT/TC cylinder (tube) mounting threads with outside diameter greater than or equal 18".

Definitions -

Average Threads – The number of measured threads divided by the number of inspected locations (clock positions).

Bulkhead-a vertical steel plate located at one or both ends of the tube bundle on a tube trailer, ISO module and tube bundle that provides structural support for the mounting of the tubes.

Equivalent Threads – Total number of calculated threads in Table 2. Equivalent Threads are calculated by: measuring, recording, and classifying the remaining neck threads into four Wear Categories on Table 1. The average number of Table 1 threads is then derated by the values in Table 2. The totals of the derated threads are used to calculate the Total Equivalent Threads of the tube's neck.

Mounting Threads- external threads cut on the outside surface of the necks of a tube that are used to attach the tube to the support structure.

Mounting Flange- a circular disk that is threaded onto the mounting threads of a tube and subsequently bolted to the bulkhead in order to attach the tube to the trailer, ISO modules, or tube bundles. This flange arrangement is used primarily on tubes.

Major Diameter- The diameter of a thread measured across the crests of the threads for an external thread or across the roots of the threads for an internal thread. This value typically corresponds to the thread size designation for the thread.

Saddle- A clamp device used to provide structural support of a tube on the straight cylindrical portion, rather than by a mounting flange securing the tube to a bulkhead by means of mounting threads.

Sleeve (collar) -An intermediate threaded component between the flange and the tube that engages all available threads on a tube neck

Tube- a seamless compressed gas cylinder longer than 6.5 feet (2 meters) which is authorized for transportation only when horizontally mounted on a motor vehicle or in an ISO framework or other framework of equivalent structural integrity (Definition from TB-25)

Inspection Guidelines

To prevent the wear on the mounting threads of a DOT cylinder (tube) from weakening the threaded connection to a point where safety may be compromised, the mounting threads on the tube must be inspected once every 10 years. The inspection includes visual inspection and threads evaluation. This inspection will be performed by visual inspection after disassembly and by using Thread Pitch Gauge for measurement of the thread wear. To inspect the mounting threads, the mounting flange has to be removed. During mounting flange removal, a special care must be applied to prevent any damage to the tube (neck, crown or sidewall). When evaluating the mounting threads on tubes, there are two basic categories of thread degradation that should be considered: generalized thread wear and isolated thread loss.

While inspecting mounting threads on tubes, care should also be taken to follow the requirements of CGA C-6, Standards for Visual Inspection of Steel Compressed Gas Cylinders, such as examination for welds between the tube flange and the neck threads, which are not allowed.

Generalized Thread Wear -Generalized thread wear is the erosion of the mounting threads over a significant area of the neck thread due to the relative motion between the tube and the mounting flange and is characterized by a measurably shorter height of the threads in the area engaged by the mounting flange. In cases of extreme wear, such as illustrated in Figure 1, this wear has progressed to the point where the threads are completely eroded. In less extreme cases, a straightedge placed across the crests of the threads, as shown in Figure 2, can help to identify less severe general wear.

Figure 1- Example of Generalized Thread Wear

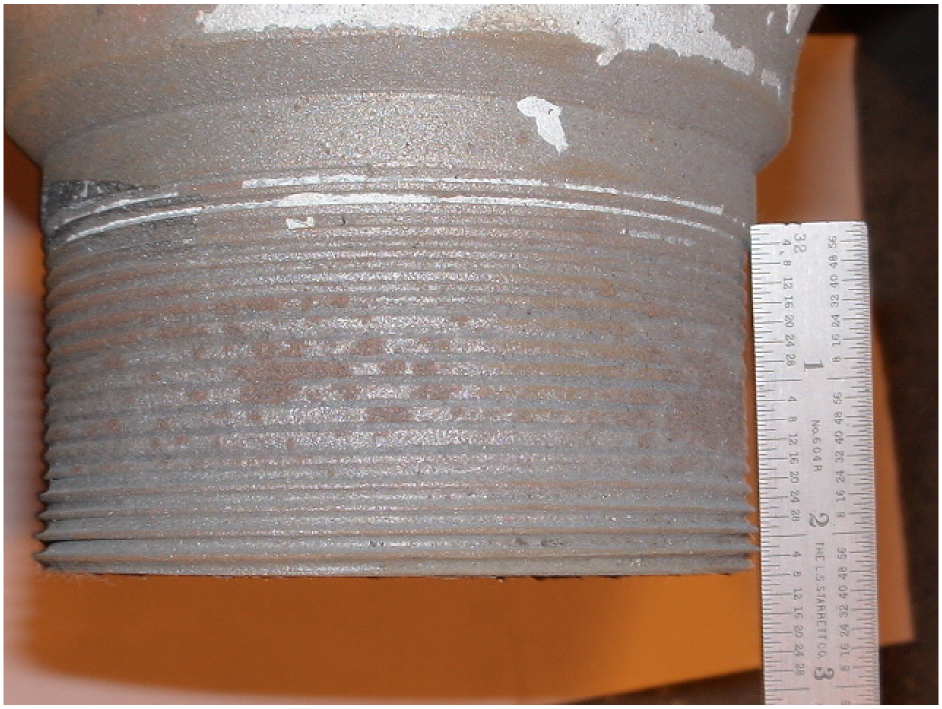

Figure 2 – Visualization of Thread Wear Using a Straightedge (Note the gap between the straightedge and the peak of the damaged threads)

To properly evaluate the thread wear, two pieces of information are required: the amount of the original thread crest that has been worn away and the number of threads affected by the wear. The effective remaining thread height can be evaluated by measuring the diameter across the crests of the worn threads using calipers, a thread gauge (see Figure 3) or a micrometer. This measurement can be compared to the major and minor diameters of the threads in the unworn condition to determine the degree of erosion that has taken place.

Figure 3-Thread Pitch Gauge

If this remaining thread height measurement is greater than 75 %, the threads with a new mounting flange should be adequate for continued service without further evaluation or modification.

Isolated Thread Wear (Deep Cuts and Gouges in Threads)

Isolated thread wear is localized damage to the mounting threads caused by setscrews or anti-rotation pins. Anti-rotation pins are cylindrical pins that are installed by drilling a hole at the interface between the threads on the tube and the threads on the mounting flange. The pin essentially locks the mounting flange in place and prevents it from rotating on the tube. Once installed in the bulkheads, the pins prevent rotation of the tube in the mounting flanges that could cause damage to the manifold piping. Since these pins resist the torsion loads imparted on the tube during transportation, it is not uncommon for the pin site to become worn after years of use. In some cases, a tube may be re-pinned several times in its lifetime prior to when the flanges are replaced (See Figure 4). The depth and number of pin sites on a tube can vary greatly depending on the methods used to drill the tube, the age of the tube and the design of the equipment. The cumulative effect of these multiple pinning locations might significantly reduce the shear strength of the threaded connection.

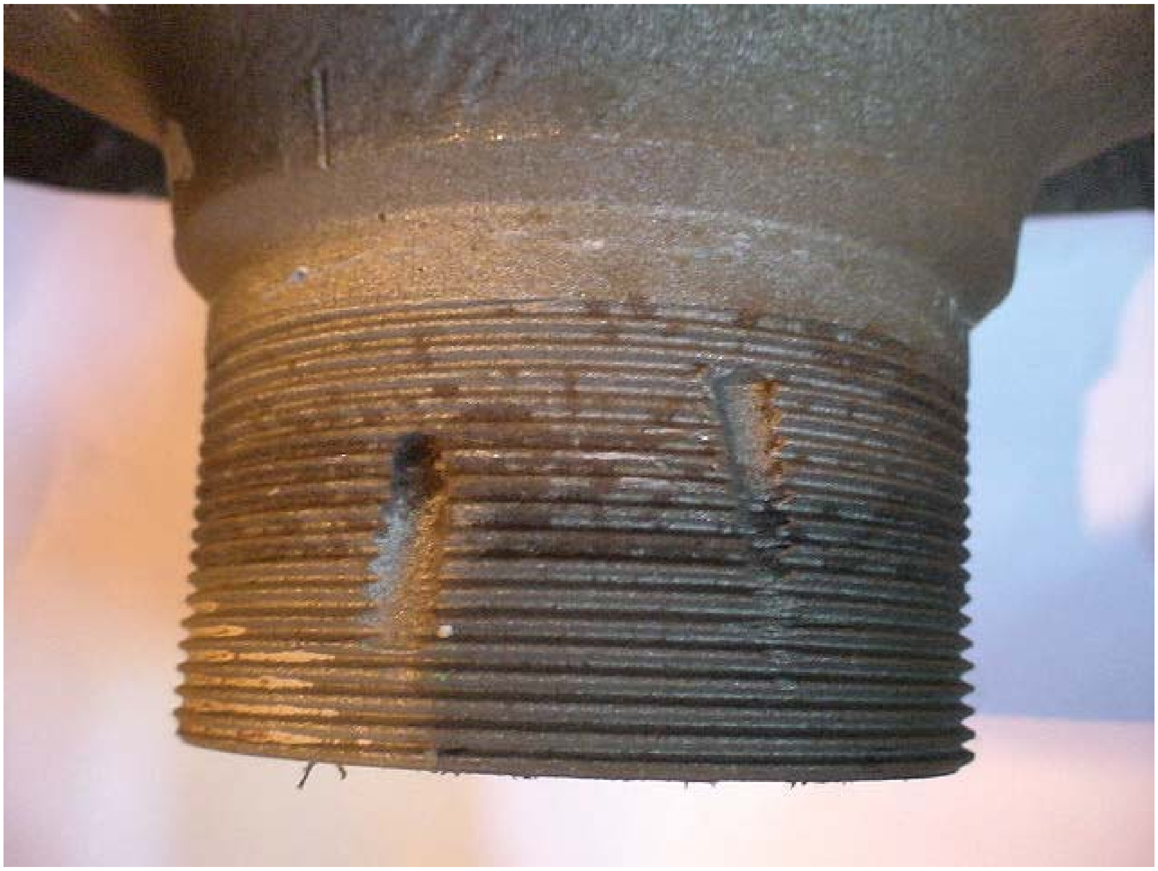

Figure 4 - Example of Isolated Damage from Anti-rotation Pins

Some older trailer designs utilized setscrews to lock the mounting flange on the tube instead of the pins described above. These setscrews were threaded through the mounting flange in a radial direction and were tightened against the tube threads to prevent rotation. Again, years of over-the road transportation and repeated tightening of the setscrews can result in localized erosion best characterized as an isolated pit in the mounting threads on the tube (See Figure 5).

Figure 5 – Example of Isolated damage from Setscrew

When evaluating areas of isolated thread wear, it is important to consider both the depth of the erosion that causes a reduction in mechanical strength at that point on the tube neck and the number of isolated locations around the neck of the tubes as these voids in the mounting threads can weaken the shear strength of the threaded joint. The allowable depth of isolated pits in the necks of the tubes due to setscrews or pins is dependent on the geometry of the tube neck and the design of the equipment.

The flaw, resulting from placement of setscrews or pins, shall be measured and assessed by the requalifier to assure the remaining bending moment is adequate for the weight of the tube and to justify the continued use of the tube.

Inspection Procedure for Measurement of OD neck threads – This procedure applies on ICC / DOT / TC / CTC cylinders (tubes) with 3AX, 3A, 3AA, 3AAX and 3T specifications with OD greater than or equal to 18” the threads are made to 8-UN class 2A thread specification (See Appendix B).

A. Pre Measurement Process

1. Remove the existing flange, collar/sleeve & any other mounting hardware with care and ensuring that the tube is not damaged.

2. Clean the OD neck threads with a wire brush or any other means that will not cause damage to the threads (see Figure 6). There exists a good possibility for the thread to be out of form due to impact from the flange (the play resulting from tolerance available in the thread classification). A die of the same thread specification (same size (maximum major diameter) or 0.001” oversized) may be required to correct the threads to give them their proper form (profile / contour). Adequate precaution needs to be taken to ensure that the lubricant used during this “chasing” operation is not allowed to get inside the tube.

> **Note:** The requalifier must prepare a written procedure and document training personnel to perform these functions.

Figure 6- Typical steps in a thread cleaning process

B. Threads Measurement tools

1. Thread Pitch gauges of the same pitch & minor diameter as the thread specification of OD neck threads (e.g. 8 UN Class 2A) must be used for determining thread deterioration (see Figure 7).

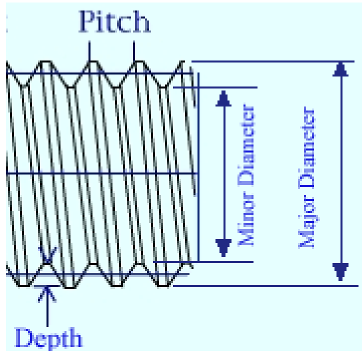

Figure 7 – Basic Details of an OD Thread

i. Thread gauges must have scribe lines that represent 35%, 50% and 75% of thread specification’s major diameter (see Figures 8, 9, and 10).

ii. To enable clear visibility no more than one scribe line is permitted on any side of the gauge.

iii. Thread pitch gauges should be purchased from gauge manufacturers along with necessary certification, see Appendix A for effective threads engagement.

2. If additional lighting is required to supplement ambient light then it must be made available to the inspector to complete the cylinder inspection

C. Thread Measurement Procedures

1. Visually inspect the circumference of the mounting thread and identify the worst affected area (using a clockwise orientation). Mark a minimum of six equidistant clock positions including the worst affected area and repeat steps 2 through 5 for all identified clock positions.
2. Use the thread pitch gauge (at least 2” long) with 75% scribed line and count the number of threads in that clock position that are above the 75% scribe line and record that number in column 7 of the table 1.

Figure 8- Inspection with thread pitch gauge having 75% scribe line

3. Use the thread pitch gauge (at least 2″ long) with 50% scribed line and count the number of threads in that clock position that are above the 50% and below the 75% scribe line and record that number in column 6 of the table 1.

Figure 9- Inspection with thread pitch gauge having 50% scribe line

4. Use the thread pitch gauge (at least 2″ long) with 35% scribed line and count the number of threads in that clock position that are above the 35% and below the 50%, and record that number in column 5 of the table 1.

5. Use the thread pitch gauge (at least 2″ long) with 35% scribed line and count the number of threads in that clock position that are below 35%, and record that number in column 4 of the table 1.

Figure 10- Inspection with thread pitch gauge having 35% scribe line

OD THREADS INSPECTION TABLE

COL-1	COL-2	COL-3	COL-4	COL-5	COL-6	COL-7	COL-8
Tube No	End Identification	Position	Number of threads in each classification				
			Below 35%	35-49%	50-74%	75%-100%	Total Threads
		1					
		2					
		3					
		4					
		5					
		6					
	Total		SubTotal 1	SubTotal 2	SubTotal 3	SubTotal 4	
	Divide subtotal by 6 or "n"	Average No of Threads					

Table 1

Note 1: The above table is required for each end of the tube separately.
Note 2: Subtotals are divided by the number of clock positions measured.
Note 3: A minimum of 6 measurements are required for each tube neck/end.
Note 4: Some tubes have multiple pin marks from flange change process. Since the number, depth, diameter and angle play an important role, abnormal cases may need additional threads and or other means of engagement and support than what is prescribed in this procedure. Older tubes with set screw design may require similar treatment.

Equivalent Thread Strength Calculation

Col 1	Col 2	Col 3	Col 4	Col 5
Thread Wear Category	Average No. of Threads from Table 2	Derating Factor	Equivalent Threads	Comments
Threads Greater than or equal to 75%		0.75		Average No. of threads from column 2 shall not be less than 3
Threads 50% to 74%		0.5		
Threads 35% to 49%		0.35		Average No. of threads from column 2 shall not exceed 9
Threads Below 35%		0		
Total Equivalent Threads				Total Equivalent Threads must be ≥ 6 threads

Table 2

1. Record in Column 2, Table 2, the average number of threads from Table 1 that fit into each of the four categories shown in Table 2.

2. Multiply the number of threads in each category by the derating factor in Column3 of Table 2 and enter the value in Column 4 (the Equivalent Threads Column).

3. Add the values recorded in the Equivalent Threads Column 4 to determine the Total Equivalent Threads. The total number of threads may also be useful to ensure that all threads present have been considered.

4. The threads present are adequate for installation of an intermediate part (sleeve/collar) provided all of the following criteria are satisfied:

   a. The Total Equivalent Threads is at least 6;

   b. The number of average threads ≥ 75% is at least 3; and

   c. The Number of average threads between 35% and 49% used in the calculation does not exceed 9 threads

D. **Accept/Reject Criteria -**The accept/reject criteria have been determined based on threads strength (shearing) calculation, pulling tests data, industry practice and shared experiences of all major re-testers. Upon completion of an assessment of the mounting threads (see Tables 1 & 2), the engagement between the tube mounting threads and the mounting flange and, if applicable, the sleeve shall be a minimum of 6 equivalent threads.

E. REPLACEMENT MOUNTING FLANGES – This inspection requires that all mounting flanges are replaced with NEW flanges during reassembly.

APPENDIX A

Effective Thread engagement

1. Ideal- Approximately 25 % to 87.5 % from root.
2. With consideration to manufacturing tolerances- Approximately 36.5 % to 80.6 % from root (see Figure 11)

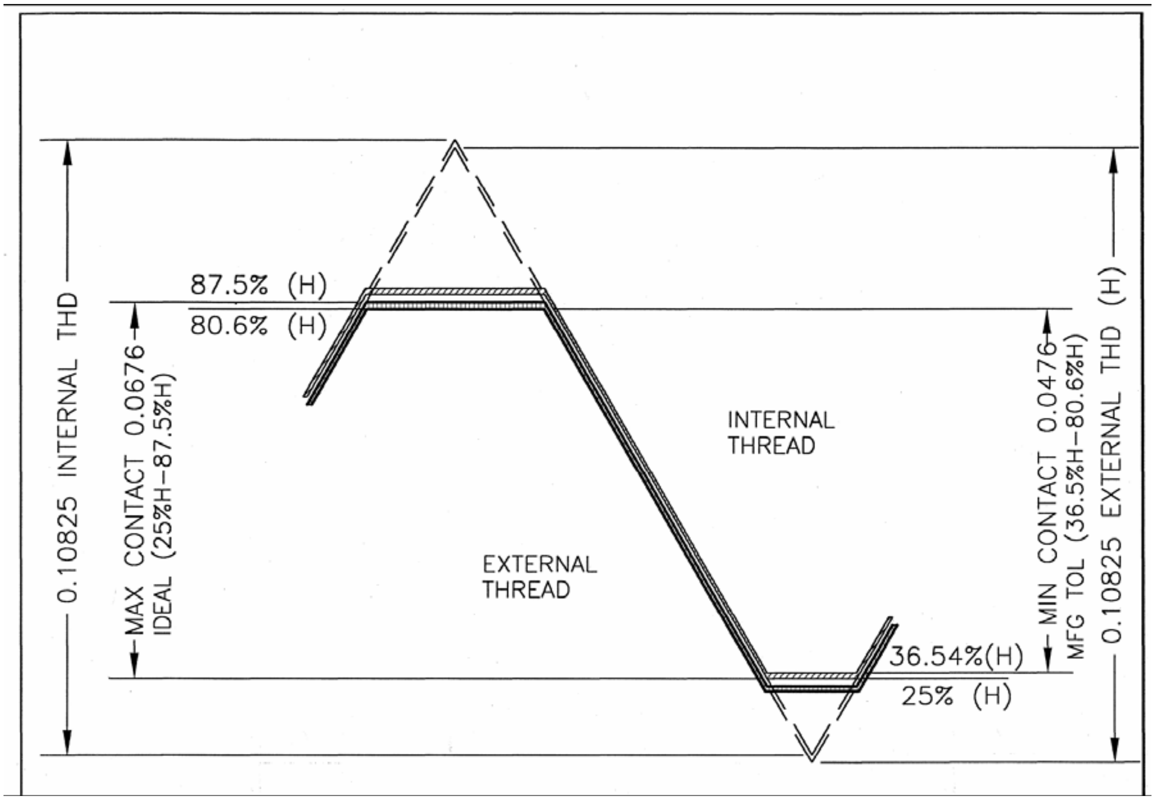

Figure 11- Thread Engagement (Ref paragraph D1 and D2)

APPENDIX B

8-UN Class 2A Threads

DOT Tube Specifications	Nominal Size (Typical)	External (major)				Internal (minor)			
		Max.	Min.	Diametric Differ	Thread Height Differ	Max.	Min.	Diametric Differ	Thread Height Differ
3AAX	4.7500	4.7471	4.7321	0.0150	0.0075	4.6400	4.6150	0.0250	0.0125
3T	4.5000	4.4972	4.4822	0.0150	0.0075	4.3900	4.3650	0.0250	0.0125

Table 3

Description	Formula	Value	% of thread height	Notes
Pitch (P)	1/Threads per inch	0.125″	NA	
Height of a V-thread (H)	P x Cos 30	0.10825″	100%	Sharp V-thread.
EXTERNAL				
Crest flatness Height (Ext.)	0.125 x H	0.01353″	12.5%	
Thread height Tolerance (Ext.)	(Major(max)-Major(min))/2	0.0075	6.92%	Based on tolerance in major diameter
INTERNAL				
Crest flatness Height (Int.)	0.250 x H	0.0270625″	12.5%	
Thread height Tolerance (Int.)	(Minor(max)-Minor(min))/2	0.0125	11.54%	Based on tolerance in minor diameter

Table 4