U.S. Department
of Transportation

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Pipeline and Hazardous Materials Safety Administration

Inspection Procedure for Inspection of DOT/TC cylinder Mounting Threads

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 -

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.

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. This inspection will be performed by visual inspection after disassembly and by using Thread Pitch Gauge for measurement of the thread wear. Visual inspection requires removal of the mounting flanges. 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.

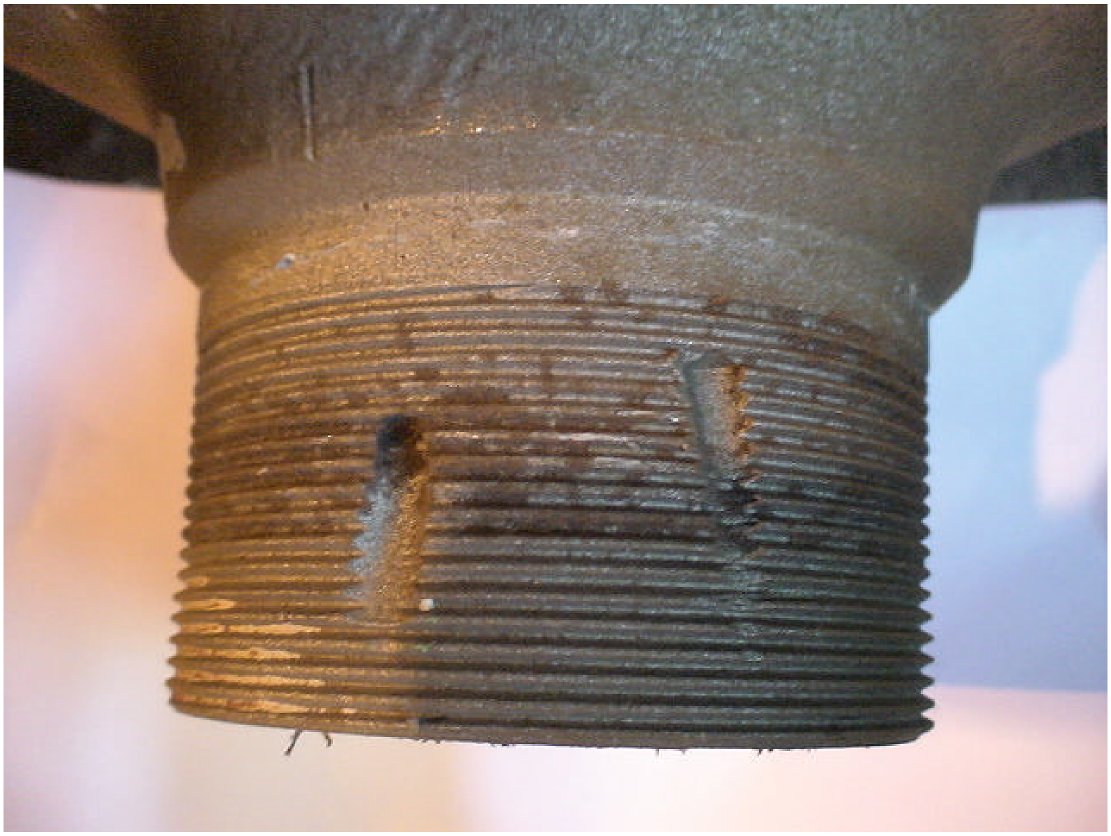


Figure 4 - Example of Isolated Damage from Anti-rotation Pins

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 to 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 retester 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.

   Note2: The requalifier must prepare a written procedure and document training personnel to perform these functions.

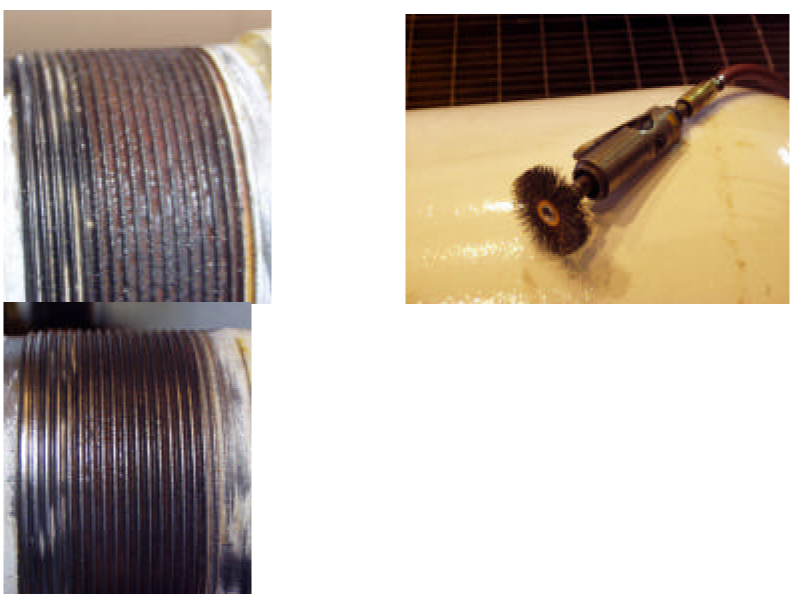


Figure 6- Typical steps in a thread cleaning process

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).

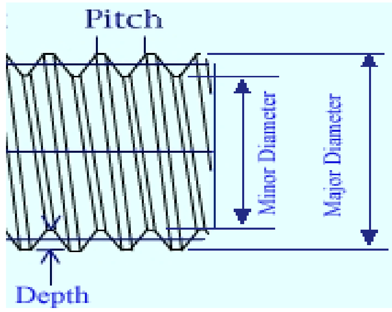


Figure 7 – Basic Details of an OD Thread

i. Thread gauges must have scribe lines that represent 35%, 50% and 75% of thread specification’s major diameter (see Figures 9, 10 and 11).
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. Threads 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 75% scribe line and document that number in column 7 of the table 3, see Appendix C.

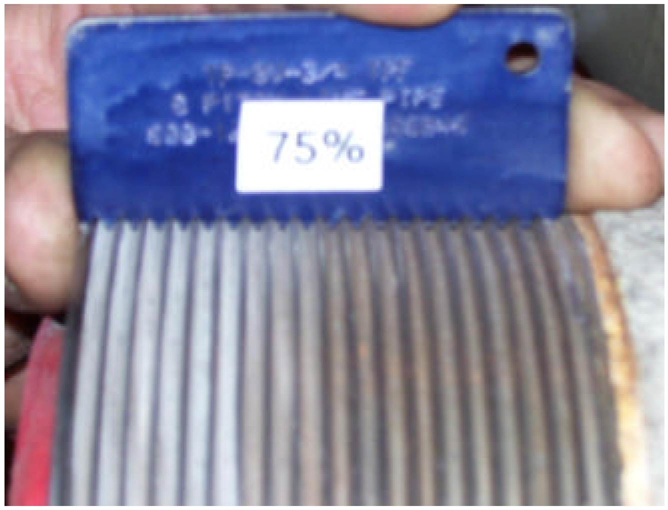


Figure 8- Inspection with thread pitch gauge having 75% scribe line

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 50% and below 75% scribe line and document line and document that number in column 6 of the table 3, see Appendix C.

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 35% and below 50%, see Table 3 of Appendix C.

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%, see Table 3 of Appendix C.

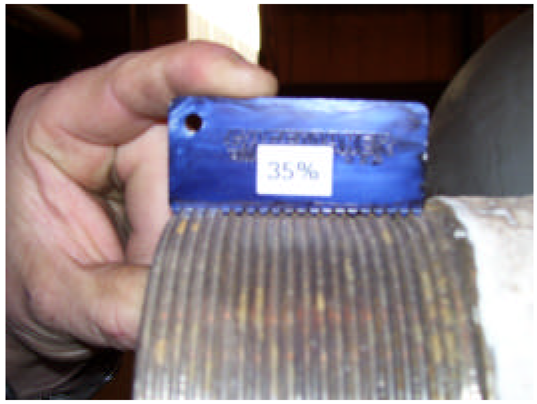


Figure 10- Inspection with thread pitch gauge having 35% scribe line

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 (See Appendix D). Upon completion of an assessment of the mounting threads, the engagement between the tube mounting threads and the mounting flange and, if applicable, the sleeve shall comply with the following acceptance criteria:

a. A minimum thread engagement of 8 consecutive threads must be available between the flange & tube when the flange is directly engaged on the tube’s neck threads or

b. A minimum thread engagement of 8 consecutive threads must be available between the flange & any intermediate part (sleeve / collar) when the flange is engaged on the tube’s neck threads with an intermediate part (sleeve / collar) or

c. A minimum thread engagement of 8 threads (either consecutive or otherwise) must be available between the tube’s neck threads and the intermediate part (sleeve / collar).

d. A minimum of 4 THREADS must be greater than or equal to 75% scribe line and a combination of threads with varying degrees of wear may be utilized provided these threads provide an equivalent thread strength of at least 8 threads when analyzed in accordance with the requirements of the Appendix E of this document. The intermediate part will be used engages all threads considered in this analysis.

APPENDIX A
(Non-mandatory)

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)

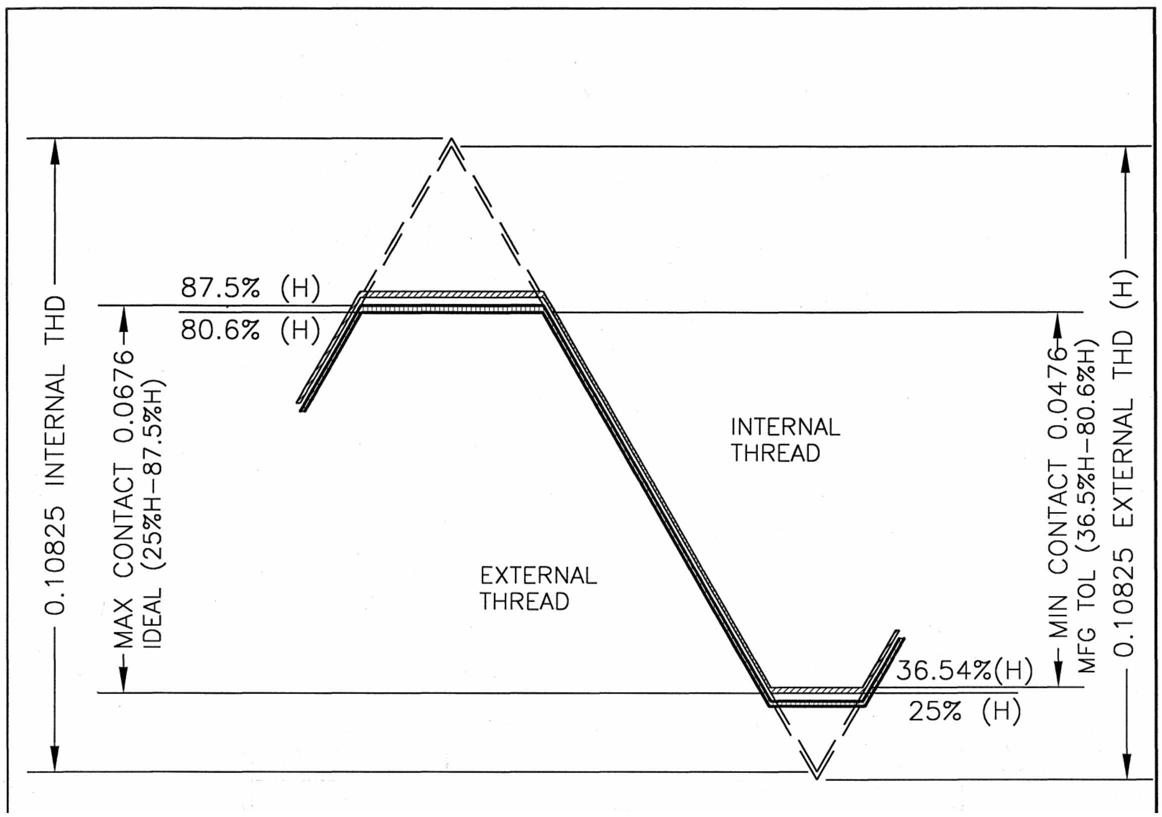


Figure 11- Thread Engagement (Ref paragraph D1 and D2)

APPENDIX B
(Non-mandatory)

E. 8-UN Class 2A Threads

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

Table 1

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 2

APPENDIX C
OD THREADS INSPECTION TABLE
(Mandatory)

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%	35-50%	50-75%	75%-100%	Total Threads
		1					
		2					
		3					
		4					
		5					
		6					
	Total		SubTotal-1	SubTotal-2	SubTotal-3	SubTotal-4	SubTotal-5

Table 3

Note1: The above table is required for each end of the tube separately.

APPENDIX D
(Non-mandatory)

Thread Strength Indicator Computation

1. A factor is assigned to each classification as indicated in the following table

Remaining Thread Height	Factor
Below 35%	0
35%-50%	1
50% - 75%	2
Above 75 %	3

Table 4 - Threads Strength classification Factors Based on Representative Pull Tests

a. For 6 position measurement
   Thread Strength Indication = SubTotal2 + (2 x SubTotal3) + (3 x SubTotal4)

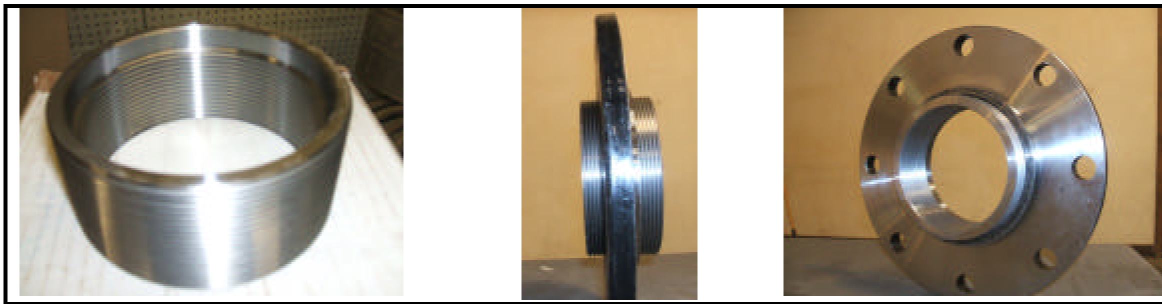
b. For ‘n’ number of positions measurement
   Thread Strength Indication = (n/6) x (SubTotal2 + (2 x SubTotal3) + (3 x SubTotal4))

c. 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.
d. Based on the computed Thread strength Indication refer to table below for decision making for continued service of the cylinder

Scenario	Total Count (6 positions)	Total Count for n positions	Decision
1	0 to 100	0 to 100 x (n/6)	Rethread / Saddle
2	100-250	100 x (n/6) to 250 x (n/6)	Sleeve + Flange
3	250 and above	Above 250 x (n/6)	Flange only

Table 5 - (See Figure 12)

Continuation of APPENDIX D



SLEEVE / COLLAR	FLANGE & SLEEVE/COLLAR	FLANGE & SLEEVE/COLLAR

Figure 12-Typical arrangement & usage of sleeve / collar

APPENDIX E
(Mandatory)

Equivalent Thread Strength Calculation

1. Using the thread measuring technique outlined in Section C of this document, measure and record the number of threads that fit into each of the four categories shown in the table below.

Thread Wear Category	No. of Threads	Derating Factor	Equivalent Threads	Comments
Threads Above 75%		0.75		Must be at least 4 threads
Threads 50% to 75%		0.5		
Threads 35% to 50%		0.35		Cannot exceed 9 threads
Threads Below 35%		0		
Total Threads				
		Total Equivalent Threads		Must be > 8 threads

Table 6

2. Multiply the number of threads in each category by the derating factor shown in the next column and enter the value in the Equivalent Threads column.

3. Add the values recorded in the Equivalent Threads column 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 8;

   B. The number of threads above 75% is at least 4; and

Continuation of APPENDIX E

   C. The Number of threads between 35% and 50% used in the calculation does not exceed 9 threads (3.15 equivalent threads).

5. This procedure should be repeated at a minimum of 3 additional equidistant points around the circumference of the thread.