





	<b>Toase-eh Park Sanati Gohar Ofogh Petrochemical Co.</b> <b>CONCEPTUAL, BASIC and DETAIL DESIGN ENGINEERING OF STYRENE PARK OFFSITE</b>		 
	Document Title: Tube Expand Procedure		
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# STYRENE PARK OFFSITE

**Document Title:**  
**Tube Expand Procedure**

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<b>Rev.</b>	<b>Issued Date</b>	<b>DESCRIPTION</b>	<b>PREPARED</b>	<b>CHECKED</b>	<b>APPROVED</b>

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## 1. Purpose

Expanding the end of tube in tube sheet hole, in order to make a tight mechanical joint that provide a metal to metal seal by creating circumferential and radial stresses between the tube and the tube sheet.

## 2. Scope

This procedure is applicable for carbon steel, stainless steel, super duplex stainless steel and non-ferrous heat exchangers.

## 3. References

-Heat exchangers selection, design and construction by E.A.D SAUNDERS.

-API 660 standard.

-TEMA.

(2015 ) / Addendum 1 (2020)

TEMA 2015 Tenth Edition

Definition (project, owner, contractor, ...) shall be added after references and before description.

## 4. Description

### 4-1. Expanding Equipment & Process

The expansion process is roller expansion that is most common. In this method a torque is transmitted from the expansion machine via an axis to the conical mandrel of the tool. 3 hardened rolls are mounted symmetrically around the mandrel. During expansion the conical mandrel is moved in the axial direction and the rotating rolls will plastically deform the tube radially into the tube wall. In the roller expansion process the forward movement of the mandrel causes the rollers to move outwards to press against the tube; subsequent friction between the rollers and rotating mandrel induces the rollers to turn and squeeze the tube against the hole. When the forces from the tool are equal to the deformation forces from the tube / tube sheet the process stops and a joint is created. This operation normally takes 5-10 seconds.

The initial expansion of the tube merely closes the annular space between tube and tube hole but metal-to-metal contact, which provides sealing, is made by more cold-work.





Once the yield point of the tube is exceeded additional expansion causes it to extrude longitudinally in both directions. It has been estimated that 60-75% of the extrusion is in the direction of the bundle and the remaining 25-40% of the extrusion proceeds away from the bundle towards the operator.

Tubes should be expanded into the tube sheet for the length, ~~As per approved drawings.~~

Notes:

at least the smaller of the following: (As per approves drawings)

1. 50 millimeters
2. The tubesheet thickness minus 3 millimeters

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1. Expanding district for full expansion is from the beginning of the tube to the end of tube expanding length. In this case 1R roller can be used.
2. When tube to tube sheet is seal welded or strength welded, the expanding portion should be started 8~10mm beyond the weld.
3. In order to close the annular space between hole and tube, the tube may be expanded for the full thickness of the tube sheet but in no case shall the expanded portion extend 3mm beyond the shell-side face of the tube sheet.

#### 4.2 Preparing For Expanding

In order to achieve roller expanded joints of high integrity, the tubes and holes must be free of scale, dust, dirt and scratches or toolmarks. As the tubes are fed through holes in the baffles and tube sheet, the holes must be free from burrs in order to avoid scratching. The expander itself must be cleaned regularly and discarded once there are signs of wear.

#### 4.3 The Value of Expanding Torque

The optimum amount of tube wall thinning (i.e. tube-wall thinning) depends on several factors such as the surface finish of the tube, annular clearance between the tube and hole, mechanical properties of the tube and tube sheet, diameter and wall thickness of tubes & length of expanded joint.

Experience shows that a tube-wall thinning of 5~8% covers many industrial application with specific value of 8~10% for copper and cupro-nickel, 7~8% for carbon steel and admiralty brass, 4~5% for stainless steel, titanium, and super duplex stainless steel.

For light expansion and strength weld, the tube-wall thinning normally is 1~3%. In this case 2R roller can be used.

The percentage of tube wall thinning is calculated from the following formula:

$$\% \text{ wall thinning} = \left( 1 - \frac{(d_h - d_r)}{(d_o - d_i)} \right) \times 100$$





Where

$d^h$  = measured tube hole diameter before expansion.

$d^o$  = measured tube outside diameter before expansion.

$d^i$  = measured tube inside diameter before expansion.

$d^{i'}$  = measured tube inside diameter after expansion.

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The measured tube inside diameter after expansion includes the enlargement of the hole, itself and the above formula provides apparent percentage of wall thinning. Subject of normal tube expansion is not one which can be treated readily on a highly scientific basis, but is best left to the skill and experience of fabricator.

An expander torque value, which provides the required amount of expansion, and at which the expander will automatically cut out must be determined from bellow procedure. Select 10 holes randomly, mark them from 1 to 10, then measure tube ID, tube OD, and tube sheet hole ID of each marked hole and fill in the form below.

<b>Setting the Expanding Tool</b>					
Project No.:		Item No.:		Front Head: <input type="checkbox"/>	Rear Head: <input type="checkbox"/>
<b>Reference Holes Dimensions</b>					
Hole No.	Tube ID	Tube OD	Tube sheet hole ID	Tube ID after Expanding	Expanding tool's Torque
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
				Average Torque	





Next, by using the "wall thinning" formula and an average value of tube wall thinning, calculate the "tube ID after expanding" and fill in the related column.

Now, start from the first hole and increase the torque of the expanding tool gradually to achieve the desired "tube ID after expanding" and record the torque value in the last column.

Repeat this sequence for all of the 10 holes.

Finally, calculate the average value of the 10 recorded torques, set the torque of the expanding tool to this value and proceed with expanding the other tubes.

During production, frequent random check is made to ensure that the procedure established by the obtained torque from the test is being followed.

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*Torque check is made particularly at the beginning of a shift or operator change.*

#### **4.4 Expansion Recommendation**

*-To decrease friction during expansion, a lubricant should be used e.g. a ball –bearing oil or lubricant especially design for expansion purposes .When using the lubricant, try to avoid it getting into the tube/tube sheet annular space as this can affect the joint negatively.*

*-The tool will despite good lubrication, heat up during expansion, for longer tool life the tool should be cooled regularly between expansion operation.*

*-A higher torque setting is needed for expanding into higher strength materials.*

*-Since the torque setting on the machine to produce a certain degree of expansion very much depend on the tube/tube sheet dimension, the tool and the machine efficiency, each fabricator should do their own trials to establish the exact settings.*

*-It is important to have equipment with rather high ability when expanding super duplex stainless steel into high strength tube sheet materials .If the machinery and the tool have the right ability, there should be no problems, even when the tube sheet has a proof strength exceeding 500 MPa.*

*-A higher tooling wear is to be expected for duplex stainless steel compared to austenitic steel, due to the superior mechanical properties of the duplexes.*

*-Expansion to the desired degree of wall reduction should normally be done in one step .If the tube sheet has very high strength and the machine/tool ability is at its limit, it is possible to do the expansion in two steps, either by reducing the tool length 1/2 or by expanding twice in the hole with the same machine parameters.*

#### **5. Inspection**





*Measurement equipment: Inside diameter Caliper or Micrometer.*

*Amount of measurement: after expanding of all tubes measurement shall be done by operator and reported to Q.C. inspector and then %10 of tubes shall be randomly checked by inspector and along with filling out TUBE EXPANDING REPORT.*

*Amount of actual expanding rate is defined as follows based on actual thickness of tubes and also tube hole inside diameter in tube sheet according to assigned tolerance:*

$$\%wall\ thinning = \left(1 - \frac{(d_h - d_r)}{(d_o - d_i)}\right) \times 100$$

*Where*

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$d_i = d_o - 2t$  --then  $d_i' = \%wall\ thinning \times 2t - 2t + d_h$

Nominal  $d_i'$  --- ' $d_i'$ ' will be defined nominally where  $t$ =nominal thickness,  $d_h$  =nominal diameter.

Minimum  $d_i'$  --- ' $d_i'$ ' will be defined minimum where  $t$ =maximum thickness,  $d_h$  =minimum diameter.

Maximum  $d_i'$  --- ' $d_i'$ ' will be defined maximum where  $t$ =minimum thickness,  $d_h$  =maximum diameter.

Finally all tubes inside diameter shall be within above mentioned limit.

## 6. Documentation

After satisfactory performance of tube expanding and dimensional control, the tube expanding report shall be approved and signed by FPA QC inspector, purchaser and client representative inspector.

Please attach the " Tube Expansion Report" as an attachment in the continuation of this document.