



Toase-che Park Sanati Gohar Ofogh
Petrochemical Co.
**CONCEPTUAL, BASIC and DETAIL DESIGN
ENGINEERING OF STYRENE PARK OFFSITE**



Document Title: Tube Expanding Procedure

Document No.: EI027-DMF-VD-QC-PRO-026

Rev. R1

Page 1 of 11

STYRENE PARK OFFSITE

Document Title:
Tube Expanding Procedure

| Rev. | Issued Date | DESCRIPTION | PREPARED | CHECKED | APPROVED |
|------|--------------|-------------|------------|------------|---------------|
| R1 | 10-Dec.-2024 | IFA | A.Parsafar | A.Shadmand | M.Heidarzadeh |
| R0 | 06-Oct.-2024 | IFA | A.Parsafar | A.Shadmand | M.Heidarzadeh |



Toase-che Park Sanati Gohar Ofogh
Petrochemical Co.
**CONCEPTUAL, BASIC and DETAIL DESIGN
ENGINEERING OF STYRENE PARK OFFSITE**



Document Title: Tube Expanding Procedure

Document No.: EI027-DMF-VD-QC-PRO-026

Rev. R1

Page 2 of 11

REVISION RECORD SHEET

| Page | Revisions | | | | | | | Page | Revisions | | | | | | |
|------|-----------|----|----|----|----|----|----|------|-----------|----|----|----|----|----|----|
| | R0 | R1 | R2 | R3 | R4 | R5 | R6 | | R0 | R1 | R2 | R3 | R4 | R5 | R6 |
| 1 | X | X | | | | | | 41 | | | | | | | |
| 2 | X | X | | | | | | 42 | | | | | | | |
| 3 | X | X | | | | | | 43 | | | | | | | |
| 4 | X | | | | | | | 44 | | | | | | | |
| 5 | X | | | | | | | 45 | | | | | | | |
| 6 | X | | | | | | | 46 | | | | | | | |
| 7 | X | X | | | | | | 47 | | | | | | | |
| 8 | X | X | | | | | | 48 | | | | | | | |
| 9 | X | X | | | | | | 49 | | | | | | | |
| 10 | | X | | | | | | 50 | | | | | | | |
| 11 | | X | | | | | | 51 | | | | | | | |
| 12 | | | | | | | | 52 | | | | | | | |
| 13 | | | | | | | | 53 | | | | | | | |
| 14 | | | | | | | | 54 | | | | | | | |
| 15 | | | | | | | | 55 | | | | | | | |
| 16 | | | | | | | | 56 | | | | | | | |
| 17 | | | | | | | | 57 | | | | | | | |
| 18 | | | | | | | | 58 | | | | | | | |
| 19 | | | | | | | | 59 | | | | | | | |
| 20 | | | | | | | | 60 | | | | | | | |
| 21 | | | | | | | | 61 | | | | | | | |
| 22 | | | | | | | | 62 | | | | | | | |
| 23 | | | | | | | | 63 | | | | | | | |
| 24 | | | | | | | | 64 | | | | | | | |
| 25 | | | | | | | | 65 | | | | | | | |
| 26 | | | | | | | | 66 | | | | | | | |
| 27 | | | | | | | | 67 | | | | | | | |
| 28 | | | | | | | | 68 | | | | | | | |
| 29 | | | | | | | | 69 | | | | | | | |
| 30 | | | | | | | | 70 | | | | | | | |
| 31 | | | | | | | | 71 | | | | | | | |
| 32 | | | | | | | | 72 | | | | | | | |
| 33 | | | | | | | | 73 | | | | | | | |
| 34 | | | | | | | | 74 | | | | | | | |
| 35 | | | | | | | | 75 | | | | | | | |
| 36 | | | | | | | | 76 | | | | | | | |
| 37 | | | | | | | | 77 | | | | | | | |
| 38 | | | | | | | | 78 | | | | | | | |
| 39 | | | | | | | | 79 | | | | | | | |
| 40 | | | | | | | | 80 | | | | | | | |









| | | | |
|--|---|--|--------------|
|   | Toase-eh Park Sanati Gohar Ofogh Petrochemical Co. CONCEPTUAL, BASIC and DETAIL DESIGN ENGINEERING OF STYRENE PARK OFFSITE |   | |
| | Document Title: Tube Expanding Procedure | Rev. R1 | Page 3 of 11 |
| | Document No.: EI027-DMF-VD-QC-PRO-026 | | |

Table of Contents

| | |
|------|---------------------------------------|
| 1.0 | PURPOSE |
| 2.0 | SCOPE |
| 3.0 | REFERENCES |
| 4.0 | DEFINITION |
| 5.0 | EQUIPMENT SPECIFICATION |
| 6.0 | TUBE HOLE GROOVING |
| 7.0 | Expanded tube-to-tube sheet joints |
| 8.0 | CLEANING BEFORE EXPANSION |
| 9.0 | EXPANSION CRITERIA |
| 10.0 | CHECKING OF THE EXPANSION |
| 11.0 | WORK SEQUENCE |
| 12.0 | Appendix I: sample inspection report, |

| | | |
|--|--|--|
|   | Toase-ehe Park Sanati Gohar Ofogh Petrochemical Co. CONCEPTUAL, BASIC and DETAIL DESIGN ENGINEERING OF STYRENE PARK OFFSITE |   |
| | Document Title: Tube Expanding Procedure | |
| | Document No.: EI027-DMF-VD-QC-PRO-026 | Rev. R1 Page 4 of 11 |

1.0. PURPOSE

This procedure describes the practical application of the strength expanding operation for tube-to-tube sheet of Air-cooled heat exchangers Project: “Toase-ehe Park Sanat Gohar Ofogh Petrochemical Co. CONCEPTUAL, BASIC and DETAIL DESIGN ENGINEERING OF STYRENE PARK OFFSITE”.

2.0. SCOPE

This method is used for the expansion of tubes in a standard air-cooled exchanger when the yield strength of the tube sheet is superior to the yield stress of the tube. Therefore, the plastic deformation of the tube during the expansion process includes BWG 10 to BWG16, which are categorized according to the outer diameter and wall thickness-refer to Appendix Table1. This procedure shall provide essentially uniform expansion throughout the expanded portion of the tube without a sharp transition to the unexpanded portion.

3.0. REFERENCES

API 661: Air-Cooled Heat Exchangers

4.0. DEFINITION

B.W.G: Birmingham wire gauge

d_i = inner diameter of the tube after expansion

d_0 = inner diameter of the tube before expansion





H= diameter of the tube sheet plate hole

D = outer diameter of the tube before expansion

%ER= expansion ratio%

5.0. EQUIPMENT SPECIFICATION

TROUVAY & ARUVIN LE HAVRE FRANCE TYPE:
TCM3

| | | |
|--|--|--|
|   | Toase-eh Park Sanati Gohar Ofogh Petrochemical Co. CONCEPTUAL, BASIC and DETAIL DESIGN ENGINEERING OF STYRENE PARK OFFSITE |   |
| | Document Title: Tube Expanding Procedure | |
| | Document No.: EI027-DMF-VD-QC-PRO-026 | Rev. R1 Page 5 of 11 |

6.0. TUBE HOLE GROOVING

All tube sheet holes for expanded joints in tube sheets less than 1inch (25mm) thick shall be machined with one groove approximately 1/8 inch (3 millimetres)wide by 1/64 inch (0.4millimeter) deep. A second groove shall be provided for tube sheets 1inch (25millimeters) or greater in thickness.

Grooves shall be located at least 1/8 inch (3mm.) plus corrosion allowance from the process face of the tube sheet and at least ¼ inch (6millimeters) from the airside face of the tube sheet.

Tube-hole grooves shall be square-edged, concentric and free of burrs.

7.0. Expanded tube-to-tube sheet joints

Tubes shall be expanded into the tube sheet for a length at least the smaller of the following:

- a) 50 mm (2 in)
- b) The tube sheet thickness less 3 mm (1/8 in).






In no case shall the expanded portion extend beyond the air-side face of the tube sheet.

The ends of tubes shall extend at least 1.5 mm (1.6 in) and not more than 10mm (3/8 in) beyond the tube sheet.

8.0. CLEANING BEFORE EXPANSION

The tube sheet bores must be cleaned before tubing and must be free from barbs at the level of the expansion grooves.

The inner bore of the tube must be smooth, free from barbs and swellings which would jeopardize the good expansion process.

| | | |
|--|---|--|
|   | Toase-eh Park Sanati Gohar Ofogh Petrochemical Co. CONCEPTUAL, BASIC and DETAIL DESIGN ENGINEERING OF STYRENE PARK OFFSITE |    |
| | Document Title: Tube Expanding Procedure | |
| | Document No.: EI027-DMF-VD-QC-PRO-026 | Rev. R1 Page 6 of 11 |

9.0. EXPANSION CRITERIA:

To obtain the permissible expansion range in the inner diameter of the tube, we consider the internal expansion of the tube in the plastic range.

so that the tube sheet is still elastic and after removing the expansion force, it is closed by returning to the original state.

This condition is created when the expansion ratio ER % is defined as the following relationship:

$$\% ER = \frac{(d_i - d_o) - (H - D)}{(D - d_o)} \times 100$$

% ER Is situated in the following range: 3 % ≤ ER% ≤ 10 %

for tubes with gauge BWG 12 to 16

10.0. CHECKING OF THE EXPANSION

Due to the application of tube-to-tube sheet weld in the connection of tube and tube sheet: the expansion of tube sheet to tube is done in two stages:






The first step is a small expansion to help escape the welding fumes and fix the tube to the hole in the tube sheet, and there is no need to measure the corresponding amount.

The final expansion rate after full expansion is measured and reported according to **Table 1**.

The expansion operation inside the tube goes back to the first 10 samples.

As a result, the normal value of the expansion force is determined by adjusting the ampere device.

The obtained result is applied to all tubes. Finally, the inner diameter of the pipes after expansion is measured and recorded. This diameter should be within the range of parameter "di" in **Table 1**.

| | | | | |
|--|---|--|--|--------------|
|   | Toase-eh Park Sanati Gohar Ofogh Petrochemical Co. CONCEPTUAL, BASIC and DETAIL DESIGN ENGINEERING OF STYRENE PARK OFFSITE | |    | |
| | Document Title: Tube Expanding Procedure | | | |
| | Document No.: EI027-DMF-VD-QC-PRO-026 | | Rev. R1 | Page 7 of 11 |

| ITEM No.'s | BWG | Min. Wall THK. | OD | H(mm) | Range Of heavy exp% | d0 | Range of di |
|------------|-----|----------------|------|-------|---------------------|--------|-------------|
| Air cooler | 16 | 1.651 | 25.4 | 25.7 | 3~10 | 22.098 | 22.49~22.79 |

Range of Expanding L (light), H (Heavy)

Range of di: The limits of "di" values are calculated according to the percentage of permissible expansion from 3% to 10% using the ER% relationship.

The suitable mandrel model is selected according to the thickness of the tube wall and the outer diameter of the tube according to the BWG table.

The expansion on the tubes and the holes of the tube sheet is done according to the ampere and power settings of the device.

The final expansion efficiency is checked during the hydrostatic test, and in case of leakage from the expanded area, by re-expanding up to the maximum allowed range, the sealing of the area is ensured. The results obtained will be reported in the inspection report.

11.0 work sequence

According to the connection plan (picture 1) and work chart (picture 2), first the tube is welded to the tube sheet and then EXPAND is done.

According to NDT Map (EI027-DMF-VD-QC-PRO-023), NDT tests are not possible in this type of connection.

Leak test according to Hydrostatics Procedure. is done.

Air leak t to be done also.

PT to be done.



Toase-eh Park Sanati Gohar Ofogh
 Petrochemical Co.
**CONCEPTUAL, BASIC and DETAIL DESIGN
 ENGINEERING OF STYRENE PARK OFFSITE**



Document Title: Tube Expanding Procedure

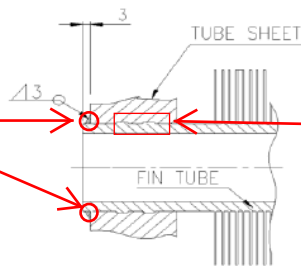
Document No.: EI027-DMF-VD-QC-PRO-026

Rev. R1

Page 8 of 11

picture 1

8
Tube To Tube Sheet



It is not compatible with tube bundle detail. please recheck it.

To be compatible with tube bundle. tube sheet with 20mm can not have two grooves.

WPS & PQR for Pressure Part and Structure: EI027-DMF-VD-QC-WPS-022(Page 3)

| Weld No. | WPS NO : | PQR | ITEM NO. | WELD DIScription | Designation | Material | Thk (mm) |
|----------|--------------|------|-------------------------|--------------------|--------------------|-------------------------------------|------------|
| 8 | DS11-W025/01 | P052 | EI027-DMF-VD-ME-DWG-005 | TUBE SHEET TO TUBE | FILLETWELD-T-JOINT | ASME SA334 GR.6 TO ASME SA516 Gr.70 | 1.65 TO 20 |



Toase-eh Park Sanati Gohar Ofogh
Petrochemical Co.
**CONCEPTUAL, BASIC and DETAIL DESIGN
ENGINEERING OF STYRENE PARK OFFSITE**



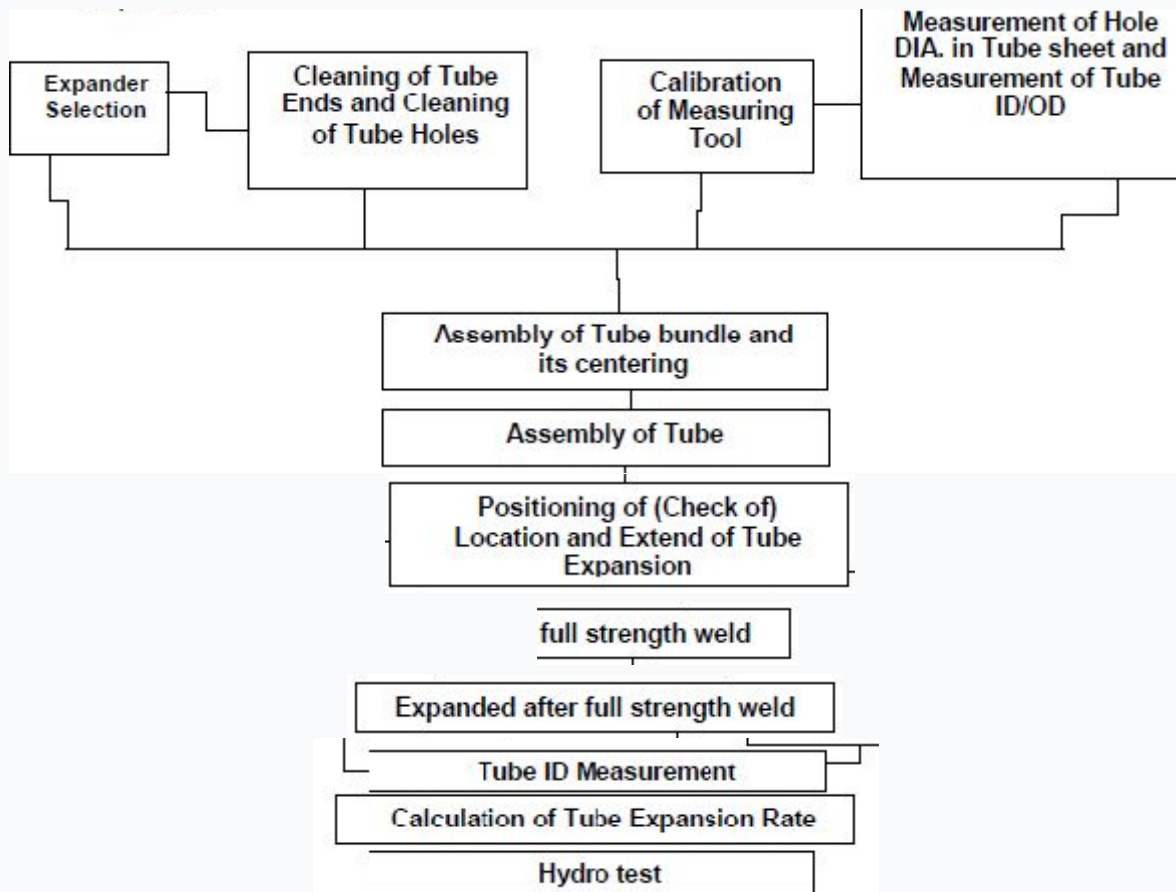
Document Title: Tube Expanding Procedure

Document No.: EI027-DMF-VD-QC-PRO-026

Rev. R1





Page 9 of 11

work chart



Air leak test to be added also. (before hydro test)

12.0 Appendix I: sample inspection report,

| | | |
|---|---|---|
|   | <h2 style="margin:0;">Tube Expanding Report</h2> |   |
| Project Name / Dtt Job No : | Toase-ehe Park Sanati Gohar Ofoh Petrochemical Co. | |
| Reference Document Name / No | Tube Expanding Procedure EI027-DMF-VD-QC-PRO-026 | |
| Item no : | Air Cooler | |

| Tube Bundle No : | | | | | | Standard Dimensions | | |
|----------------------|---------------------|-----------------|-------|------------------|---|---------------------|--------|-----------|
| Front Tube Sheet No: | Rear Tube Sheet No: | Number Of Holes | B.W.G | Expansion Rate % | D | d0 | H (mm) | di (rate) |
| | | | | | | | | |

| Front Tube Sheet | | | | | | | | Rear Tube Sheet | | | | | | | |
|------------------|---------|------|--------|------|---------|-----|--------|-----------------|---------|------|--------|------|---------|------|--------|
| Item | di (mm) | % ER | Result | Item | di (mm) | %ER | Result | Item | di (mm) | % ER | Result | Item | di (mm) | % ER | Result |
| 1 | | | Ok | 11 | | | Ok | 1 | | | Ok | 11 | | | |
| 2 | | | | 12 | | | | 2 | | | | 12 | | | |
| 3 | | | | 12 | | | | 3 | | | | 12 | | | |
| 4 | | | | 12 | | | | 4 | | | | 12 | | | |
| 5 | | | | 12 | | | | 5 | | | | 12 | | | |
| 6 | | | | 12 | | | | 6 | | | | 12 | | | |
| 7 | | | | 12 | | | | 7 | | | | 12 | | | |
| 8 | | | | 12 | | | | 8 | | | | 12 | | | |
| 9 | | | | 12 | | | | 9 | | | | 12 | | | |
| 10 | | | | 20 | | | | 10 | | | | 20 | | | |

| | |
|---|--|
| <p>D: Tube external diameter before expanding d0: Tube internal diameter before expanding H: Tube sheet hole diameter di: Tube internal diameter after expanding ER: Expansion rate ER</p> | $\% ER = \frac{(d_i - d_0) - (H - D)}{(D - d_0)} \times 100$ |
|---|--|

| DTT | CONTRACTOR | TPA | CLIENT |
|--------------------------|--------------------------|--------------------------|--------------------------|
| Name : Date: Sing: | Name : Date: Sing: | Name : Date: Sing: | Name : Date: Sing: |



CHECKING OF THE EXPANSION PROCEDURE

Acceptance ranges for the inner diameter of tube after expansion (di)

| Size | BWG | Wall thk(mm) | D | H(mm) | ER% | dO | di | roller | | |
|--------|-----|--------------|-------|-------|--|--------|---|---------------|------------|---------------|
| | | | | | | | | Comp. Tool No | Mandrel No | Set of Roller |
| 1" | 10 | 3.403 | 25.4 | 25.7 | According to customer requirements bet | 18.594 | The minimum and maximum are calculated by inserting the Exp% in the formula | C1237 | CM61 | CR15 |
| | 11 | 3.048 | 25.4 | 25.7 | | 19.304 | | C1243 | CM62 | CR16 |
| | 12 | 2.768 | 25.4 | 25.7 | | 19.864 | | C1245 | CM62 | CR17 |
| | 13 | 2.413 | 25.4 | 25.7 | | 20.574 | | C1247 | CM62 | CR18 |
| | 14 | 2.108 | 25.4 | 25.7 | | 21.184 | | C1249 | CM63 | CR18 |
| | 15 | 1.828 | 25.4 | 25.7 | | 21.744 | | C1251 | CM63 | CR19 |
| | 16 | 1.651 | 25.4 | 25.7 | | 22.098 | | C1251 | CM63 | CR19 |
| 1 1/4" | 10 | 3.403 | 31.75 | 32.11 | | 24.944 | | C1263 | CM65 | CR24 |
| | 11 | 3.048 | 31.75 | 32.11 | | 25.654 | | C1267 | CM66 | CR26 |
| | 12 | 2.768 | 31.75 | 32.11 | | 26.214 | | C1269 | CM66 | CR27 |
| | 13 | 2.413 | 31.75 | 32.11 | | 26.924 | | C1271 | CM67 | CR28 |
| | 14 | 2.108 | 31.75 | 32.11 | | 27.534 | | C1273 | CM67 | CR29 |
| | 15 | 1.828 | 31.75 | 32.11 | | 28.094 | | C1275 | CM67 | CR30 |
| | 16 | 1.651 | 31.75 | 32.11 | | 28.448 | | C1275 | CM67 | CR30 |
| 1 1/2" | 10 | 3.403 | 38.1 | 38.56 | | 31.294 | | C1287 | CM 70 | CR 35 |
| | 11 | 3.048 | 38.1 | 38.56 | | 32.004 | | C1291 | CM 70 | CR 36 |
| | 12 | 2.768 | 38.1 | 38.56 | | 32.564 | | C1293 | CM 70 | CR 37 |
| | 13 | 2.413 | 38.1 | 38.56 | | 33.274 | | C1295 | CM 71 | CR 37 |
| | 14 | 2.108 | 38.1 | 38.56 | | 33.884 | | C1295 | CM 71 | CR 37 |
| | 15 | 1.828 | 38.1 | 38.56 | | 34.444 | | C1297 | CM 71 | CR 38 |
| | 16 | 1.651 | 38.1 | 38.56 | | 34.798 | | C1297 | CM71 | CR38 |

Roler model : TROUVAY & ARUVIN LE HAVRE FRANCE TYPE: TCM3