ELLIOTT TOOL TECHNOLOGIES

TM-6 02-10-04

Basic Principles of Tube Expanding

Tube Expanding is the art of reducing a tube wall by compressing the O.D. of the tube against a fixed container . . . such as rolling tubes into tube sheets, drums, ferrules or flanges. To assure a proper tube joint, the tube wall must be reduced by a predetermined percentage. The following chart can be used for determining the correct tube wall reduction.

This chart shows a typical 3/4” – 16 gauge tube. Before rolling this tube you would find the proper rolling dimension as shown.

A. First determine the tube hole size.

B. Then determine the tube outside diameter.

C. Subtract the tube outside diameter from the tube hole dimension.

D. With an Elliott Tube Gauge, determine the inside diameter of the tube before rolling.

E. By adding the dimension found in “D” to the clearance between the tube O.D. and the tube hole, you will then know the tube’s inside diameter at metal to metal contact.

F. Roll the tube to what you feel is a good tube joint. This example was rolled and then the I.D. of the tube was checked with an Elliott Tube Gauge.

G. By subtracting “E” from the rolled diameter you determine the actual amount of expansion (tube wall reduction) on the inside diameter of your tube. This can be converted to a % of wall reduction by dividing the actual wall thickness (“B minus D”) .130” into the amount of roll .009.

You can use this chart to your advantage by predetermining both the % of wall reduction required and the actual inside diameter which should be rolled. After the completion of “E” you realize any additional increase of the inside diameter of the tube will result in actual wall reduction. Since the amount of wall reduction greatly determines the quality of the tube joint, you should arrive at the % required for your application prior to tube rolling.

By subtracting the tube inside diameter “D” from “B”, you determine actual wall thickness. This example would therefore be .130”. If you then take the 7% wall reduction times the wall thickness, you arrive at .0091”. Adding .0091” (“G”) to .627” (“E”) we get “F” the inside diameter of the tube after rolling (.636”).

Test Chart For Determining Proper Amount Of Tube Expansion

	Tube Test Number	1	2	3	4	5	6
A	Tube Sheet Hole Size	.757					
B	Tube Outside Diameter	.750					
C	Clearance (A Minus B)	.007					
D	Tube Inside Diameter	.620					
E	Tube Inside Diameter When Metal-To-Metal Contact is Reached (D Plus C)	.627					
F	Tube Inside Diameter After Rolling	.636					
G	Actual Amount of Roll on Diameter (F Minus E)	.009					

Note:
1) Take all measurements in thousands
2) Take “A” in middle of area to be rolled
3) Take “B”, “D” and “F” in same position as No. 2
4) Take both horizontal and vertical diameters as tubes may be out of round show mean diameter

Customer: ________________
Location: ________________
Unit: ________________
Tube Alloy: ________________
Date: ________________

Tube Expanders

Basic Principles of Tube Expanding

This technique is an excellent way to set torque rolling devices. Once you have arrived at the rolled dimension for four or five tubes, you can roll them and very simply determine if more or less wall reduction is required. Knowing how to determine wall reduction is important; however it is equally important to know the characteristics of the popular tubing materials. We should know the proper wall reduction which would apply to each metal. A simple rule of thumb is the harder the material, the less wall reduction is required to obtain a tube joint. For example, you can assign these as approximate percentages of wall reduction when rolling pressure vessels:

Tubing Material:	
Copper & Cupro Nickel	8 - 10%
Steel, Carbon Steel & Admiralty Brass	7 - 8%
Stainless Steel & Titanium	4 - 5%

These materials and percentages can be your guideline to rolling tubes of like materials.

Here is a summary of important factors in rolling certain alloys: When rolling 3003 or 4004 Aluminum you should not reduce the walls over 5%. When rolling 6061-T Aluminum, which is one of the most popular materials used in aircraft fittings, you can reduce the wall 10 to 12% for a mechanical joint.

There is a tube process called Alonizing. It is stated that Alonized steel combines the heat and corrosion resistant properties of the iron aluminum alloy with the strength and rigidity of steel. When rolling this tubing it is extremely important to lubricate each tube end and make certain that the tube expanders are kept clean. Remove all particles of the tubing materials from the expanders to decrease tool fatigue. When rolling Alonized tubing, abrasive particles are removed from the inside diameter of the tubing and gathered in the expander. It is recommended that two expanders be used. One should be cleaned and lubricated while the other is being used.

Admiralty Brass is widely used in condensers. This material should be well lubricated. The tube wall is reduced approximately 7% to 8% for optimum tube joints. In general, only a 4% to 10% reduction in wall thickness is necessary to produce a tight tube in a serrated hole. On the other hand, reduction in excess of 15% may cause leaking, splits or flaked tubes.

Carbon Steel is used in almost every type of pressure vessel built today. Tube wall reduction should be approximately 7% to 8%. Heavy lubrication is a must. If the tube is cracking or tooling shows excessive wear, tube hardness should be checked. Carbon Steel tubes should be 90 to 120 Brinnel hardness for rolling. It is possible to roll tubes up to 150 Brinnel; however, flaking and cracking are more likely to occur as the tube hardness increases.

When rolling Copper and Cupro Nickel, consider approximately 8 - 10% wall reduction to be a proper tube joint. Copper, since it is one of the softer tubes used in pressure vessels, can be easily rolled. Use plenty of lubrication because copper has an abrasive action on tube expanders.

When rolling Stainless Steel and Titanium, approximately 4 to 5% wall reduction is sufficient to produce a tight tube in a serrated hole. When rolling these alloys the entire wall reduction should be done quickly. These materials have a greater tendency to work harden; therefore, minimal or no rerolling should done.   Motor speeds should be 400 to 750 RPM.

When rolling Titanium, it is recommended to use an expander with four rolls or more. This will decrease diaphragm of a thin wall and help eliminate tube end cracking. There are, however, exceptions to the above rule.

This discussion of alloys has been related to those used in pressure vessels such as boilers, heat exchangers, and condensers. These factors would be approximately the same in a mechanical joint for industrial use. However, a greater percent of wall reduction is usually considered when making a mechanical joint. Higher quality tubes are used in industrial applications.

Major Causes of Tube Leaks

Tube rolling leakage is usually caused by one of the following: under-rolling, over-rolling, improper preparation of tube sheets and differential thermal expansion. Improper expansion can lead to serious difficulties for both the manufacturer and the repair service men.

Tube Expanders

Basic Principles of Tube Expanding

Under-Rolling

Under-Rolling as the word would imply is when the tube is not expanded to fill the tube sheet hole and the proper amount of wall reduction is not obtained. **It is better to under-roll than to over-roll.**

Over-Rolling

Over-rolling is when the expansion of the inside diameter of the tube surpasses the expansion required for the proper percentage of wall reduction for the ultimate tube joint. **Over-rolling can do considerable damage to a vessel.** Over-rolling will decrease the dimensions of the ligament between tubes and weaken this bridge. Once a ligament is weakened, it will cause a reaction in all ligaments surrounding that weak ligament. If we decrease the strength of the ligament the tube next to the tube being rolled will leak.

Over-rolling also causes distortion in tube sheets or drums, such as egg-shaped holes. It will also cause diametrical expansion which is the overall increase of a tube sheet or drum. Over-rolling has been known to cause a tube sheet to bow or warp to the point where the standard length tube could not be used in the vessel until the bowing or warpage is returned to normal. This is usually corrected by placing stay rods in the vessel and pulling the tube sheets back to their original position.

Improper Preparation of Tube Holes

Improper preparation of tube holes is another major cause in tube leakage. If the tube sheet or drum is gouged, it is extremely hard to expand the tube to fill these gouges or tears without over-rolling. The smoother the tube seat or tube hole the easier it is to roll an optimum tube joint. The ligaments and light tube walls make it more important that the finish of the tube hole be in the low micro range. We find many manufacturers today are drilling, reaming and sizing or burnishing to get the microfinish desired for tube holes.

Differential Thermal Expansion

Differential thermal expansion can result with thicker tube sheets. When the expansion due to heat varies noticeably between the thinner tube and tube sheet, a shift of the tube results. One of the most important steps for ensuring a safe and permanent tube joint is to thoroughly clean the surfaces of the tube end and the tube hole wall. These two surfaces must be clean and free of all dust, mill scale and pits or scratches. It is extremely important to eliminate any longitudinal scoring in the tube hole wall. These longitudinal lines will cause leaky tubes.

Preparation of Tube Holes

Preparation of tube holes in heat exchangers and condensers is as follows:

1. Drill and ream tube sheet holes to .007” to .010” over the outside diameter of the tube to be used.
2. Be certain the ligaments are sufficient to guarantee a safe and permanent tube joint.
3. When conditions permit, utilize a sizing or burnishing tool to further assure a good finish in the tube hole. This will also increase the tensile strength of the ligament.
4. The serrations or grooves to be used will determine the holding power of the tube.
5. It is extremely important when retubing that the grooves be cleared of all metals or any foreign material.

Preparation of Tube Seats

Preparation of tube seats in drums, tube sheets, and headers are as follows:

1. Tube holes are normally drilled and reamed to approximately 1/32” larger than the nominal outside diameter of the tubes.
2. It is extremely important during this operation that there are no longitudinal scorings left in the tube seat.
3. In cases where out-of-roundness is extreme, prerolling of the tube holes is advised.
4. Be certain that the tube hole walls and the grooves in the tube walls are cleaned down to bare metal before tubes are inserted. Be certain all foreign material such as oil, grease, rust, or just plain dirt are removed. Special attention during this cleaning will prevent serious trouble later.

After tube holes have been prepared they are usually coated with a rust preventative compound. Before inserting any tube it is important to remove all traces of this coating. It is extremely important that great care be taken in handling the tubes for insertion in all of the vessels discussed above. Be certain that the tube ends are clear of any foreign material. Be especially certain that there are no chips on the tubing which may gouge the tube sheet or tube seat when the tube is placed in the vessel.

In some cases it will be necessary to force a tube into a tube hole. This should be done with extreme care. It is better to spring the tube than to try to force it with a hammer. If a tube end is kinked or damaged before rolling, the expanded end will be damaged and a leaky roll joint will result. Attention at this time to the tube ends and the tube alignment will prevent future troubles.

RECOMMENDED EXPANSION OF TUBES FOR OPTIMUM JOINT STRENGTH IN HEAT EXCHANGERS AND CONDENSERS

Use expansion listed in tube expansion column plus clearance between tube O.D. and sheet hole I.D.

Recommended expansion may be plus or minus .001”.

O.D. Size	GA	Tube Expansion	O.D. Size	GA	Tube Expansion	O.D. Size	GA	Tube Expansion
1/2”	14	.006”	3/4”	10	.008”	1-1/4”	8	.010”
1/2”	15	.006”	3/4”	11	.008”	1-1/4”	10	.010”
1/2”	16	.006”	3/4”	12	.008”	1-1/4”	12	.009”
1/2”	17	.005”	3/4”	13	.008”	1-1/4”	14	.008”
1/2”	18	.005”	3/4”	14	.008”	1-1/4”	16	.007”
1/2”	19	.004”	3/4”	15	.007”	1-1/4”	18	.006”
1/2”	20	.004”	3/4”	16	.006”			
1/2”	21	.004”	3/4”	17	.005”	1-1/2”	8	.012”
			3/4”	18	.005”	1-1/2”	10	.012”
5/8”	12	.006”	3/4”	19	.005”	1-1/2”	12	.010”
5/8”	13	.006”	3/4”	20	.005”	1-1/2”	14	.010”
5/8”	14	.006”	3/4”	21	.004”	1-1/2”	16	.008”
5/8”	15	.006”				1-1/2”	18	.008”
5/8”	16	.006”	1”	8	.009”			
5/8”	17	.005”	1”	9	.009”	2”	8	.012”
5/8”	18	.005”	1”	10	.009”	2”	10	.012”
5/8”	19	.004”	1”	11	.009”	2”	12	.011”
5/8”	20	.004”	1”	12	.009”	2”	14	.010”
5/8”	21	.004”	1”	13	.008”	2”	16	.008”
			1”	14	.008”	2”	18	.008”
			1”	15	.007”			
			1”	16	.006”			
			1”	17	.005”			
			1”	18	.005”			

ADDITIONAL SIZES

1/4” O.D. tube - expand all gauges .003” after contact with tube sheet hole
3/8” O.D. tube - expand all gauges .004” after contact with tube sheet hole

EXAMPLE

3/4” O.D. x 14 gauge tubes

Recommended expansion .... .008”
Tube sheet hole .... .760”

Therefore, expand as follows:

Tube I.D. before expanding .... .584”
Recommended expansion .... .008”
Clearance between tube & tube sheet hole .... .010”
FINISH I.D. .602”

The above recommendation is based on our experience. However, this does not constitute a guarantee because of the great variety of materials, tubes and tube sheets used. Some conditions will require experimental rolling to be certain that the rolled joints will be satisfactory.

QUICK REFERENCE CHART FOR RETUBING TOOLS

			Tube Size													
			5/8" O.D. x 18 Ga.		5/8" O.D. x 20 Ga.		3/4" O.D. x 16 Ga.		3/4" O.D. x 18 Ga.		3/4" O.D. x 20 Ga.		3/4" O.D. x 22 Ga.		1" O.D. x 17-18 Ga.	
			Prime	Finned	Prime	Finned	Prime	Finned	Prime	Finned	Prime	Finned	Prime	Finned	Prime	Finned
Tube Cutters	Power Driven Type	1 Assembly PTTC	625	625	625			625	750	625	750		750			1000
		Pilot PTTC	625P18	625P18	625P20			625P18	750P18	625P20	750P20		750P22			1000P14
		Cutter Blade PTTC	25186	25186	25186			25186	25186	25186	25186		25186			25199
	One-Rev. Type	1 Assembly 9060-	123	123	131			123	153	131	163		163			205
		Cutter Blade 9060N	625-2	625-2	625-2			625-2	750-2	625-2	1000-1		1000-1			1000-2
Tube Pullers	Collet Type	Collet M5285	C5	C5	C6			C8	C9	C9	C10		C10			C16
		Draw Bar M5285	DB2	DB2	DB2			DB2	DB3	DB3	DB3		DB3			DB4
		Thrd. Bushing M5223-	2	2	2			2	3	3	3		3			4
		Nose Piece M5759-	00508	00508	00508			00304	00304	00304	00304		00304			10000
	Ram Type	Spear 80-	062-1822T	062-1822T	062-1822T			075-16	075-1822T	075-1822T	075-1822T		075-1822T			100-16
	Hand Type	Assembly	516700	516700	516700			516800	516800	516800	516800		516800			517000
		Mandrel	5167M	5167M	5167M			5168M	5168M	5168M	5168M		5168M			5170M
Tube Gauges 876200-		For Sheet Hole	750	750	750			875	875	875	875		875			1250
		For Tube I.D.	625	625	625			750	750	750	750		750			1000
Accessories		Collapsing Tool	8637-10T6	8637-10T6	8637-10T6			8637-12T6	8637-12T6	8637-12T6	8637-12T6		8637-12T6			8637-16T6
		Knockout Tool	8496-53T6	8496-53T6	8496-53T6			8496-75T6	8496-77T6	8496-77T6	8496-79T6		8496-79T6			8496-109T6
		Sheet Hole Brush	P5252-10	P5252-10	P5252-10			P5252-12	P5252-12	P5252-12	P5252-12		P5252-12			P5252-16
		Tube Pilot	5304-542	5304-542	5304-573			5306-638	5306-674	5306-674	5306-703		5306-730			5310-912
Rolling Tools	Electric Rolling Motor		440KET22	440KET2	440KET2			440KET2	440KET2	440KET2	440KET2		440KET2			440KER1
	Electric Torque Control		78-980	78-980	78-980			78-980	78-980	78-980	78-980		78-980			78-980
	Expanders & Acc.	Expander Assem.	113105	113105	113106			113122	113123	113123	113124		113124			113164
		Mandrel	213105	213105	213105			213121	213123	213123	213123		213123			213163
		Rolls (3/set)	2115104	2115104	2115106			2115122	2115122	2115122	2115124		2115124			2115164
		2 Recess Collar	219102R( )	219102R( )	219102R( )			219121R( )	219122R( )	219122R( )	219122R( )		219122R( )			219162R( )
		Telescoping Collar	218121	218121	218121			218141	218141	218141	218141		218141			218181
		Friction Collar	210102	210102	210102			210121	210122	210122	210122		210122			210162
Trimming Tools		End Facing Tool	ETF625	ETF625	ETF625			ETF750	ETF750	ETF750	ETF750		ETF750			ETF1000
		Spare Tool Bit (Std.)	ETF626	ETF626	ETF626			ETF756	ETF756	ETF756	ETF756		ETF756			ETF1006
		Spare Tool Bit (SS)	ETF626SS	ETF626SS	ETF626SS			ETF756SS	ETF756SS	ETF756SS	ETF756SS		ETF756SS			ETF1006SS
		Spare Pilot	ETF625P18	ETF625P18	ETF625P20			ETF750P16	ETF750P18	ETF750P18	ETF750P20		ETF750P20			ETF1000P18
Cyclgrip Continuous Tube Puller			M5630-00													
Collet Style Bafflet Expander			B9765A00												B10180-00	

Notes:
1. Tube Cutters for 5/8" O.D. finned tubes are not sized to cut in the finned portion of the tube.
2. Depth of recess in the Recess Collar is indicated in 1/64" increments (ie: 1/8" Recess Collar for 3/4" O.D. x 18 Ga. = 219122R8).

QUICK REFERENCE CHART FOR TUBE MAINTENANCE TOOLS

Tube Size					Jiffy Gun		Roto-Jet		Two-Piece		Used On
Tube	Wall	Nom.	Tube	Tube I.D.	Nylon Brush	Rubber	Nylon Brush	Flexible	Ring	Pin	
1/2	23	.028	Prime	.444	472	P507006B	437	0512	455	437	
			Finned								
5/8	18	.049	Prime	.527	542	Special	500	0512	532	500	
			Finned		428	Special	375	0511	532	500	
	20	.035	Prime	.555	573	Special	562	0512	559	500	
			Finned								
3/4	14	.083	Prime	.584							
			Finned	.494			500	0512			
	15	.072	Prime	.606							
			Finned	.526	542	5370-590	500	0512	613	1	
	16	.065	Prime	.620							
			Finned	.526	542	5370-620	500	0512	631	1	17DA
	17	.058	Prime	.634							
			Finned	.543	556	5370-620	500	0512	640	1	16E, 16HA, 17DA, 17Q, 17R
	17-18	.055	Prime	.640							
			Finned	.561	573	5370-650	562	0513	640	1	17DA, 17EA, 19CB, 19EA
	17-18	.053	Prime	.644							
			Finned	.551	573	5370-650	562	0513	640	1	16JA, 17CA, 17DA, 17Q, 17R, 19C 19DA, 19EA
	17-18	.052	Prime	.646							
			Finned	.573	602	5370-650	562	0513	640	1	
	18	.049	Prime	.652	674	5370-650	625	0513	657	1	
			Finned	.557	573	5370-650	562	0513	657	1	16JA
	18-19	.047	Prime	.656							
			Finned	.568	580	5370-650	562	0513	657	1	17CA, 17EA, 17FA, 19C, 19CB, 19DG, 19EA
	19	.042	Prime	.666	686	5370-650	625	0513	670	1	
			Finned								
	20	.035	Prime	.680	703	5370-680	687	0513	695	1A	
			Finned								
	20	.028	Prime	.694	715	5370-680	687	0513	695	1A	
			Finned								
7/8	20	.035	Prime	.805	832	5370-790	812	0513	809	2	
			Finned								
1	17	.058	Prime	.884							
			Finned								
Unk.	Unk.	Unk.	Prime								
			Finned				500	0513			York S559E 46A (Cent.)
Tube Sheet Hole (Nominal)			1/2						502	500	
			5/8						631	1	
			3/4						752	1A	
			7/8						877	2A	
			1						1002	3	

DIAL SETTING TEST CHART FOR DETERMINING PROPER AMOUNT OF TUBE EXPANSION WITH AUTOMATIC TORQUE CONTROL UNIT

	Tube Test Number	1	2	3	4	5	6
A	Tube Sheet Hole Size						
B	Tube Outside Diameter						
C	Clearance (A Minus B)						
D	Tube Inside Diameter						
E	Tube Inside Diameter When Metal-To-Metal Contact Is Reached (D Plus C)						
F	Tube Inside Diameter After Rolling						
G	Actual Amount Of Roll On Diameter (F Minus E)						
H	Dial Setting						

NOTE:
1) Take all measurements in thousands
2) Take “A” in middle of area to be rolled
3) Take “B”, “D” and “F” in same position as No. 2
4) Take both horizontal and vertical diameters as tubes may be out of round show mean diameter

Customer: ______________________

Location: ______________________

Unit: ______________________

Tube Alloy: ______________________

Date: ______________________

Elliott offers a complete line of precision tube tools, including:

tube expanders

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Condenser Expanders

Refinery Expanders

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Electric

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tube cleaners

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Tube Cutters

Manual Tools

Spear Type Tube Pullers

Collet-Type Tube Pullers

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Grooving Tools

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