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RETUBING REFRIGERATION AND AIR CONDITIONING HEAT EXCHANGERS

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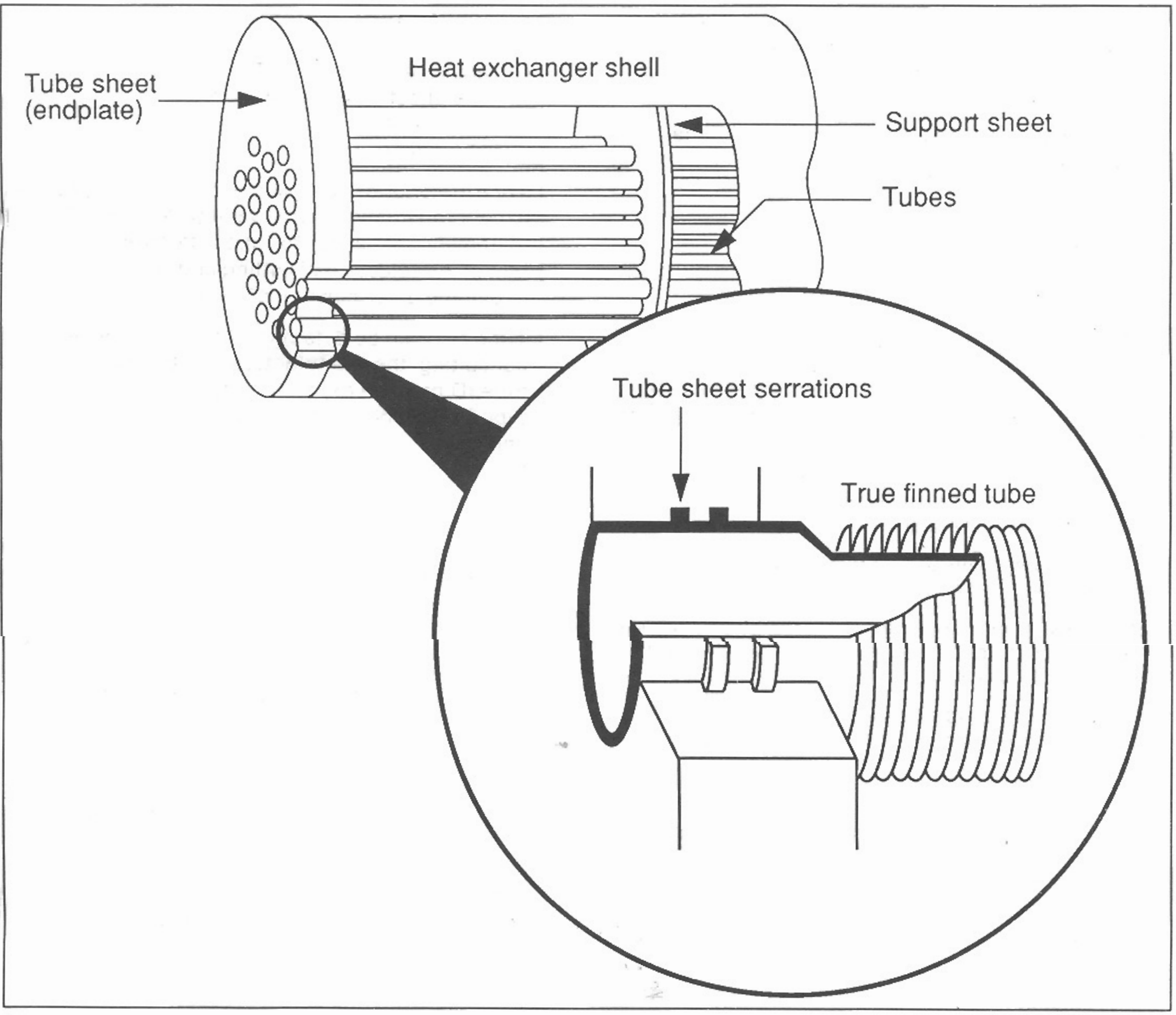
INTRODUCTION

Retubing is the process of replacing defective tubes in an air conditioning heat exchanger. This may be done on a partial tube basis or by a complete exhanger overhaul.

The determining factor for retubing is usually the loss of heat transfer efficiency affecting overall system performance.

The intention of this text is to provide overall guide lines pertinent to retubing procedures. These include:

- "State of the Art" tool descriptions and operating procedures.
- Step-by-step retubing procedures.
- Parameters involved in successful tube end sealing.



- Special application notes derived from first hand practical experience.

This text is not meant to supersede specific O.E.M. established instructional texts, although the information provided is universally applicable to all manufacturers' types of equipment.

DEFINITION OF TERMS

Prime Surface Tube: Smooth walled tube (without fins) maintaining constant ID and OD dimensions the full tube length.

True Finned Tubes: Tubes with integral fins rolled into the tube exterior to increase heat transfer surface area. The ID of the tube is greatly reduced in the fin area.

Wall Crush: The amount of tube wall reduction created by expanding the tube ID past the dimension equaling tube OD to tube sheet hole ID at metal to metal contact.

Serrations: Rings (usually ⅛" wide) machined into each tube sheet hole to "lock" the tube into position and prevent tube joint shearing due to dissimilar metal expansion variance.

OD: Outer diameter.

ID: Inside diameter.

Tube Sheet Ligaments: The metal thicknesses between adjoining tube sheet holes.

"Tenting": The spring back of the tube wall between the tube expander rolls during the tube rolling process.

Tube Joint: The mechanical seal created between the tube OD and the sheet hole ID as a result of the tube expanding process.

Lateral Sheet Hole Scarring: Scratches that go the entire length of the tube sheet hole.

BWG: (Birmingham Wire Gauge) Unit of thickness measurement used for wire and tube walls (see tube data chart for specifics).

Fin Lock: The condition existing when two adjoining tubes' finned exteriors mesh together like mating gear teeth. This "locks" the tubes together, and hinders individual tube extraction.

DESCRIPTION OF UNIT CONSTRUCTION

1. Centrifugal Units: Two (2) heat exchanger sections - Evaporator/Condenser.
   a. Finned tubes used both evaporator/condenser.
   b. Tubes rolled into support sheets in evaporator section only.
   c. Tube sheet holes are serrated to increase holding power.
   d. Tube material normally copper or copper alloy, (Stainless or Titanium used in extreme water conditions).
2. Absorption Units: Four (4) Heat Exchanger sections - Evaporator, Absorber, Generator/Concentrator, Condenser.
   a. Prime surface tubes used in all exchanger sections (except some older units).
   b. Sheet holes serrated.
   c. No support sheet expansion required.

RETUBING PROCEDURE

- Identify tube material and tube OD x wall thickness.
- Tube removal.
- Tube sheet hole preparation.
- Tube insertion.
- Tube rolling.

Tube material is usually either copper or copper alloy except in situations where the water conditions are extremely corrosive. The tube material is most important in the selection of cutting and facing tool blades and in the determination of "wall crush" values.

Tube size can be determined by one of two ways: By consulting the manufacturer or by measuring the tube ID past the expanded area and referencing the tube OD vs tube wall thickness vs tube ID (see chart at end of this chapter). Tube size is essential for sizing the retubing tools required. Tube sizing on finned tubes should be for the prime surface area to be expanded in the tube sheets. ID measurement may be difficult for finned tubes as the prime surface length on the tube ends is not uniform and may not be long enough to get a true measurement.

The tube removal process can be accomplished by several different methods: tube cutting/pulling, tube collapsing/pulling, and tube collapsing/"knocking out".

The first method is by far the most popular and efficient way of tube removal. This method involves cutting the tube inside the tube sheet, at the end of the unit posing any space restrictions to tube extraction. Then pulling the major portion of the tube from one end and the tube stub from the other using a (hydraulic) pulling device. Tube cutting alleviates the added interference caused by dragging the expanded tube end through the interim support sheets and exiting endplate in the extraction process.

The second method involves "breaking" the tube end seal at one end of the exchanger using a collapsing tool, then pulling the tube from the opposite end. The collapsing tool (See Figure 1) is a cylindrical shaped tool which is tapered and ribbed at one end. The tube end is first bent inward using a chisel to allow tool point entry (See Figure 2). The tapered/ribbed point is then hammered, either manually or via impact gun, between the tube OD and the sheet hole ID. As the tool point "peels" the tube away from the sheet hole, the rib folds the tube inward, breaking the seal. The entry point of the collapsing tool should be at the portion of the surrounding tube sheet hole having the greatest support (See Figure 3). At least two (2) collapsing locations should be used per tube end to effectively break the rolled tube end joint.

FIGURE 1

FIGURE 2

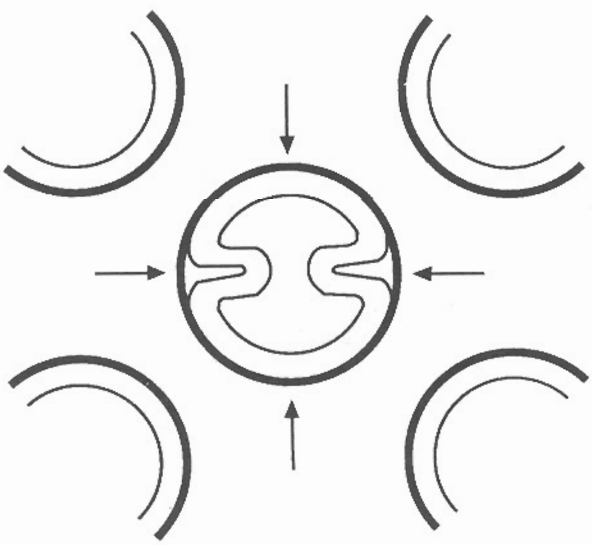


FIGURE 3

- Note: Blow any standing water out of tubes and allow exchanger tubes adequate time to air dry completely before removing exchanger tubes. Refrigerant and water create an acid condition which will cause metal corrosion.

The collapsing operation requires skill and diligence since the tool point actually "rides" on the inside of the tube sheet hole. If the tool strays off center to the sheet hole or if the tool point even slightly deforms, sheet hole scarring will occur. Lateral scarring of the sheet hole can prevent effective, leak proof, tube end sealing. It is for this reason tube end collapsing is not highly recommended.

The last method involves using the collapsing tool at both tube ends and driving the tube out of the exchanger with a knockout tool. This method, again, carries the same risks previously mentioned.

TOOL DESCRIPTION AND OPERATING TECHNIQUES IN ORDER OF USAGE

TUBE CUTTING

The most popular tube cutting tool is the "fly" type cutter. This type of tool "machines" through the tube wall gradually, from the inside out, during tool rotation (See Figure 4). This machining process results in minimal distortion to the tube OD. Since the blade extension can be controlled, and the cutting site is inside the exchanger shell, it has proved advantageous to make only a partial cut in the tube wall, approximately 75% to 90% deep. This partial cut prevents the "machined" metal chips from falling inside the exhanger. Once the cut is accomplished, the metal chips can be blown out of the tube ID. When the tube is hydraulically pulled, it breaks at the weakest portion of the tube wall, which is where the cutter scored the tube ID. This minimizes the tedious and awkward shell cleaning portion of the retubing operation.

This method is especially effective in ¾" OD finned tube replacement. A ⅝" OD cutter is used instead of the customary ¾" cutter. The blade is positioned in the tube ID under the finning. At full extension the cutter blade does not sever the complete tube wall (See Figure 4).

DRIVER: Electric or pneumatic motor with Jacobs chuck.

An alternate style cutter is the "1 Revolution Cutter". The cutting blade on this tool does not have a controlled feed. The cutter is inserted into the tube end with the blade in the retracted position. When the

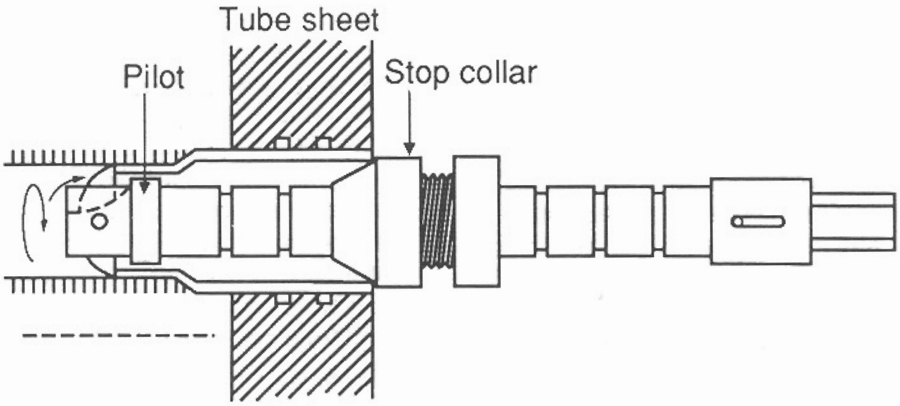


FIGURE 4

assembly is rotated clockwise in the tube, the blade immediately makes full extension, piercing the tube wall full thickness. Continued rotation "shears" the entire circumference of the tube in one complete revolution. This method is fast but it distorts the tube OD somewhat and leaves a rather large metal chip inside the exchanger.

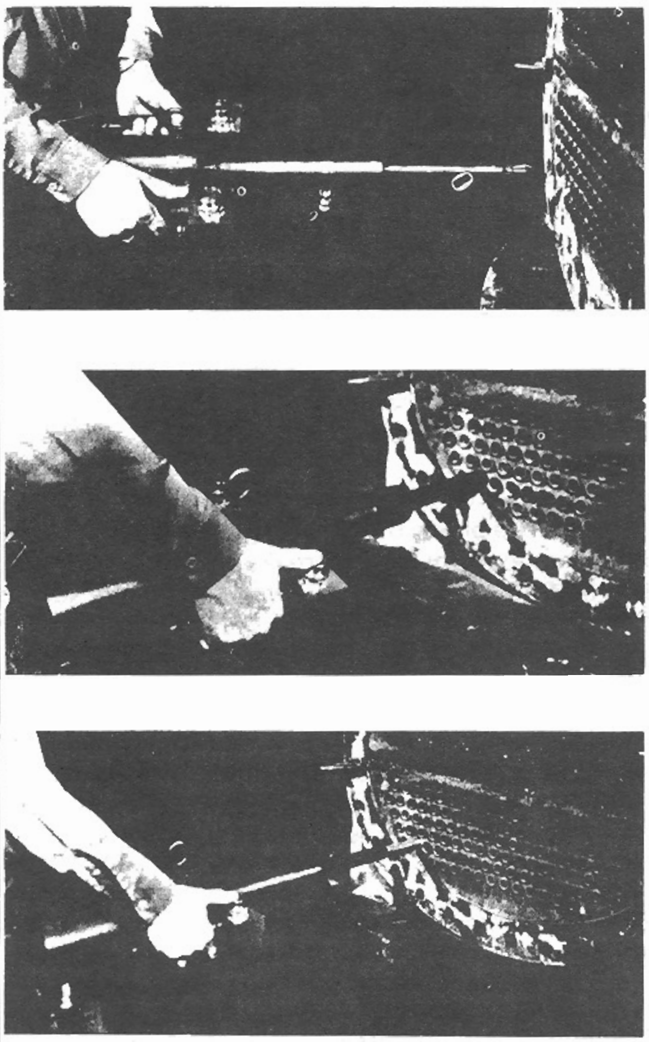


FIGURE 5
Collet-Type Puller Usage

TUBE PULLING

Tube pulling can be accomplished by several different methods:

- Pressure regulated collet type puller/continuous extractor.
- Spear type hydraulic.
- Spear type manual.

The Semi-Automatic, Pressure Regulated, Collet Type Tube Puller (see Figure 5) operates on the same basic principle as torque controlled tube expansion: Bite (or grip) the tube ID to a pressure to compensate for any variance in the tube sheet hole size or tube wall thickness. Segmented collet teeth are hydraulically expanded into the tube ID to a pressure via a tapered mandrel (draw bar) when the pull button is depressed (see Figures 6 & 7). An adjustable time on the control box then allows the collet ample time (2.0 -2.5 seconds) to take a "set" before the unit cycles into the next mode, pulling the tube 6" in a single stroke. The working end (collet/draw bar) releases the tube and reindexes for the next pull by depressing the reset button. On prime surface tube applications,

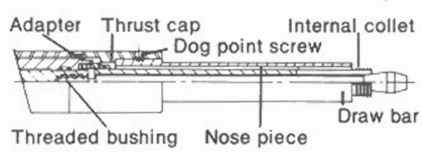


FIGURE 6

if the tube is not "free" after the maximum travel of the ram cylinder, the reindexed collet can be reinserted into the projecting tube end for another 6" pull. 36" extension pieces are optional for water box applications.

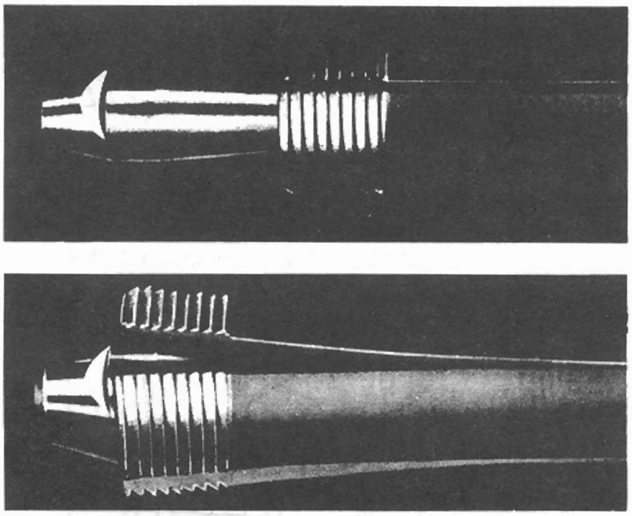


FIGURE 7

If the tube is still binding and can't be removed manually, the Continuous Tube Extractor (see Figure 8) can be used to hydraulically pull the tube completely out of the exchanger. This unit clamps on to the tube OD and simultaneously pulls the tube out in 5" strokes when the activating button is pressed. A limit switch on the extractor automatically reindexes the gripping segments for the next pull when maximum cylinder travel is achieved. Therefore the activating button need only be depressed and held once for continuous operation. The continuous tube extractor is powered by the same hydraulic pump as the collet type tube pulling ram. A switch on the control panel operates a bi-directional valve allowing easy conversion to either apparatus.

POWER SUPPLY: 110 Volt/20 Amp. Collet Style Puller Power Pak.

PULLING RATE: 10 seconds per tube (based on full 6" travel).

Continuous Extractor - 5 seconds per 5" stroke.

The Spear Type Hydraulic Tube Puller (see Figure 9) utilizes a tapered threaded spear (tap) to secure onto the tube ID. The self feeding spear/adaptor assembly is screwed (threaded) into the tube end by clockwise rotation on the adaptor shank. Once this assembly is secured in the tube a hollow centered hydraulic ram is placed over the spear/adaptor assembly and the horeshoe lock retainer is placed in its mating slot. The hydraulic ram, when activated, pushes against the exchanger tube sheet face and the horseshoe lock, simultaneously pulling the tube free. Once the cylinder has made full extension the inner cylinder can be reindexed to compact position and used as an "inertial ram" for complete tube extraction.

The tube pulling process is completed when the assembly process is reversed and the spear is manually removed from the tube end.

Power Supply: 115 Volts (110/120v) AC 60 cycle current.

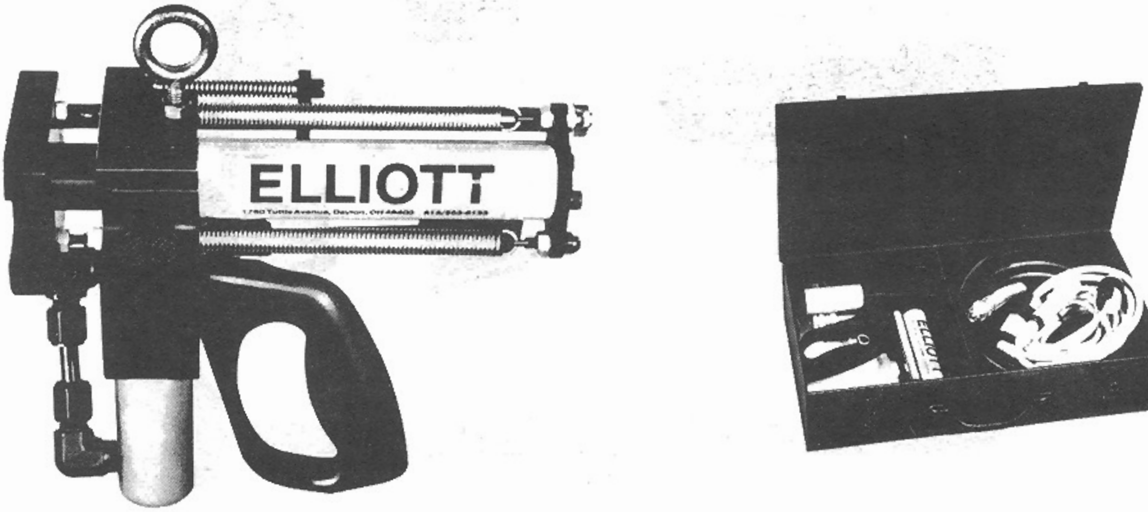
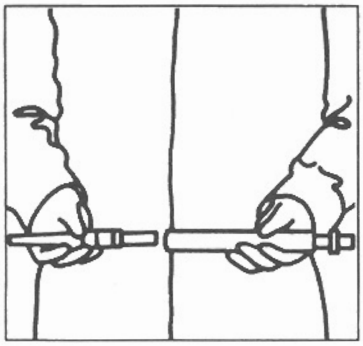
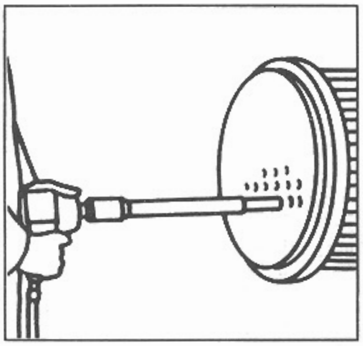


FIGURE 8

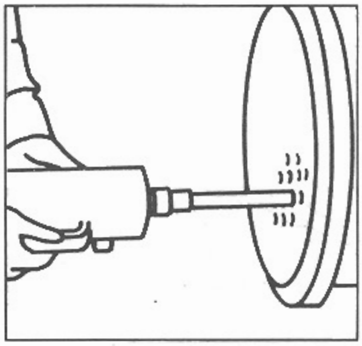
RSES



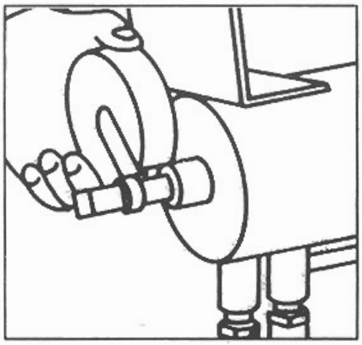
1. Thread the spear into the adapter.



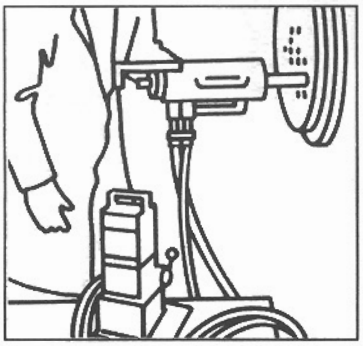
2. Using either a hand wrench or impact wrench, turn the spear into the tube.



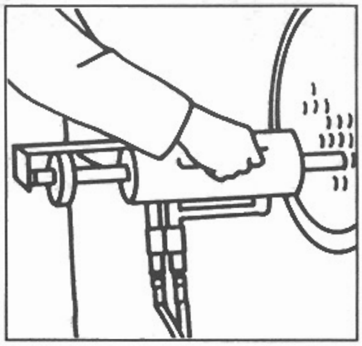
3. Place the double—acting ram unit over the spear—keep cylinder end clear of other tube ends and square against the tube sheet.



4. Lift the safety shield and place the horseshoe lock into the adapter groove.

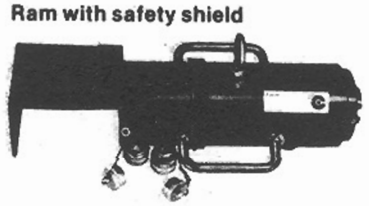


5. Drop the safety shield into working position, and apply pressure with the pump.

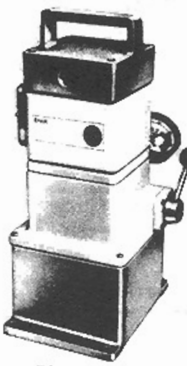


6. After cylinder pressure has pulled the tube through full stroke, pump cylinder back into the ram unit and use the double-acting ram as a battering ram to complete the job.

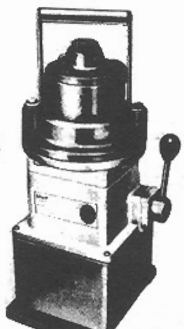
Ram with safety shield



Hydraulic pumps



Electric



Air

For pulling ½″ thru 2″ tubes

3055 spear

3055-3 adapter

3055-4 horse shoe lock

FIGURE 9

Pulling Rate: 2 minutes per tube.

The Manual Spear Style Tube Puller (see Figure 10) utilizes the same spear type tube gripping principle as the aforementioned puller. However, the pulling force is created manually. The spear is screwed into the tube end via the drive square on its shank. Once the spear is secured, two (2) spacer sleeves are slid over the tool's exterior. The tube is pulled when a hollow centered threaded cap is screwed over male threads on the spear's shank, pushing the spacer sleeve against the tube sheet face.

The manual puller is only applicable to small retube jobs (under 50 tubes) or sample tube pulling for analysis purposes.

Power Supply: Manual.

Pulling Rate: 3 minutes per tube.

APPLICATION NOTES - TUBE PULLING

The SEQUENCE OF TUBE PULLING should minimize the possibility of internal support sheet bending. This is especially important in retubing centrifugal chillers (evaporators) since the tubes are expanded into the support sheets. This internal expansion will cause added support sheet drag during tube removal.

The internal tube support sheets are usually tack welded on their perimeter to the exchanger shell. The exchanger's tubes serve to hold and position these

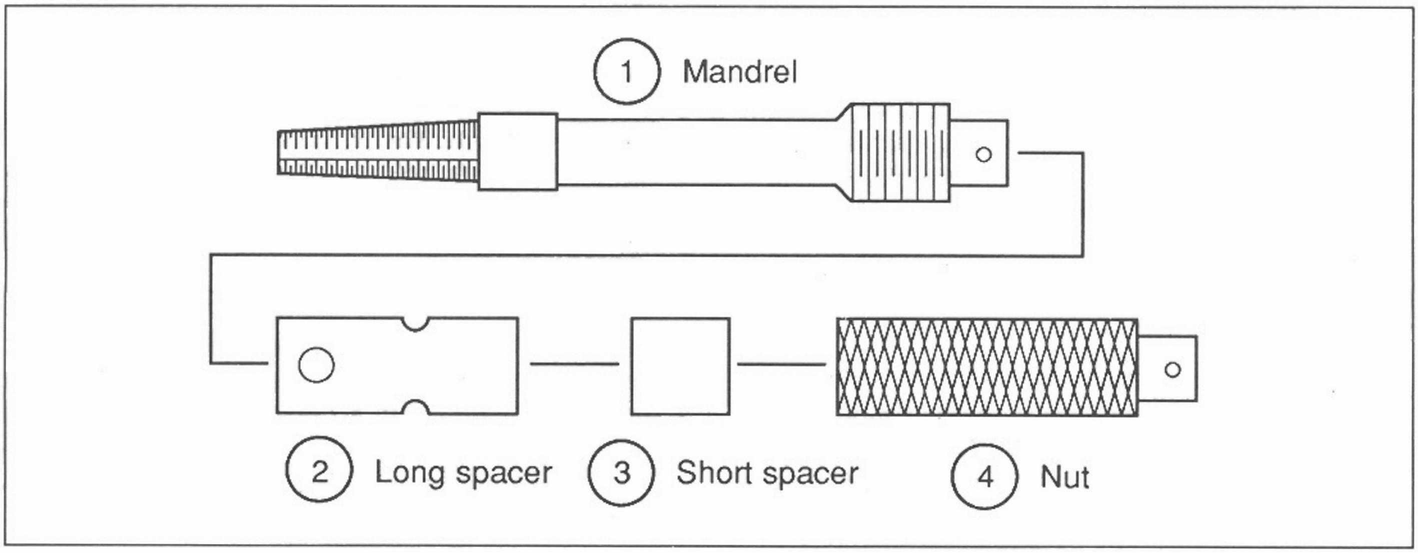


FIGURE 10

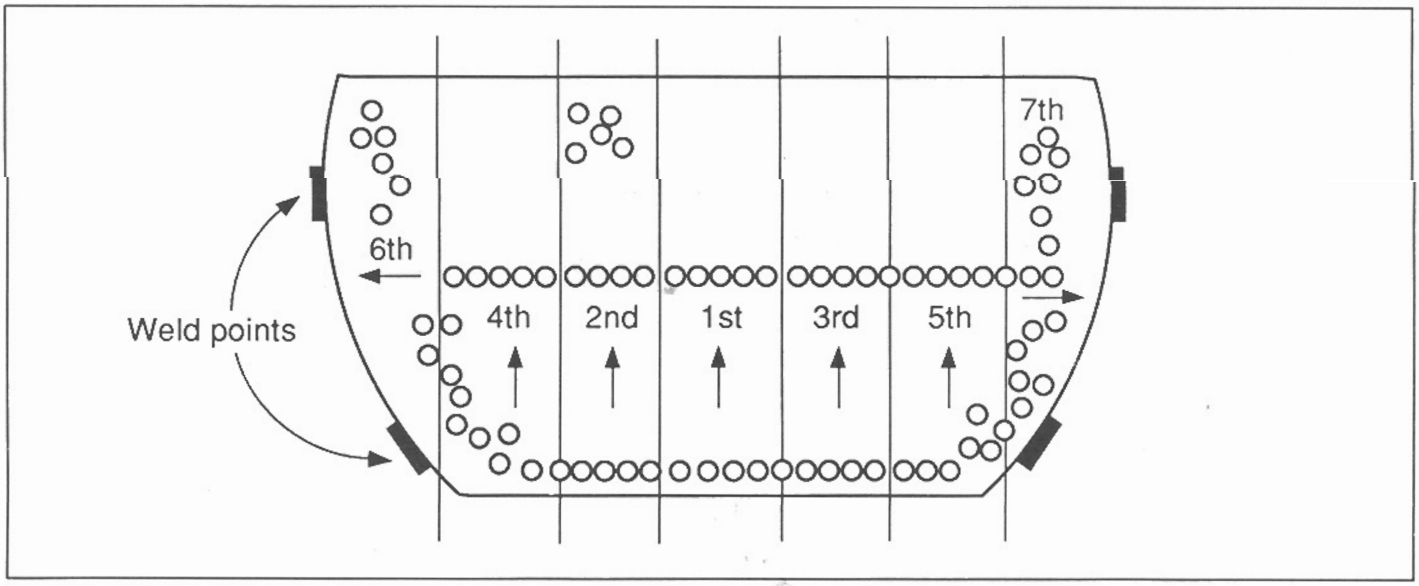


FIGURE 11

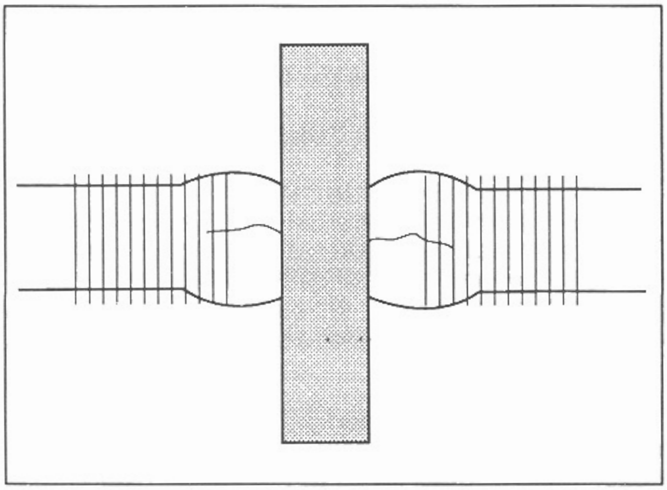


FIGURE 12

supports during the pulling process. Therefore it is highly recommended that the center quadrant of tube be removed first, working always from bottom to top to minimize fin lock (see Figure 11). Consecutively alternate quadrants right and left of center line until all the tubes have been removed.

This utilizes the adjacent quadrants of tubes to hold the support sheet fixed in position until the well-supported perimeter row of tubes is reached.

FREEZE BULGED TUBES represent one of the worst case situations experienced in a retubing application. Freeze bulges usually occur in the area of the tube immediately adjacent to the support sheets (see Figure 12). This area of the tube is annealed for support sheet expansion and is weaker than the finned portion which is not annealed.

The water inside the exhange tube has frozen and has expanded the OD of the tube, virtually locking the tube into the support sheet. Normally this condition would necessitate cutting "windows" in the exchanger shell and cutting the tubes out between the supports rather than attempting to pull them through the supports and end plates. However, these tubes can occasionally be pulled successfully. A tube, when stretched past the yield point, will break at the weakest area of its exterior (which would be the frozen bulge). The bulged area has already weakened the tube wall by expanding the tube past its yield point. Stake the tube in one sheet using a tube pulling spear so that the tube is forced to stretch. Pull the tube from the other end using a hydraulic tube pulling device. The tube will stretch until it snaps. Since the tube is staked at one end, support sheet bending will be kept to a minimum. Pull the broken tube length out using a continuous hydraulic tube pulling device, then pull the remaining portion of the tube. This method is not 100% successful, but it offers a viable alternate to cutting into the exchanger shell.

ABSORPTION UNITS utilize Lithium Bromide as a medium in the heat exchanging process. This liquid when combined with air is very corrosive to metal (steel) surfaces, which includes tube sheet and support sheet holes. Once the tubes are extracted,

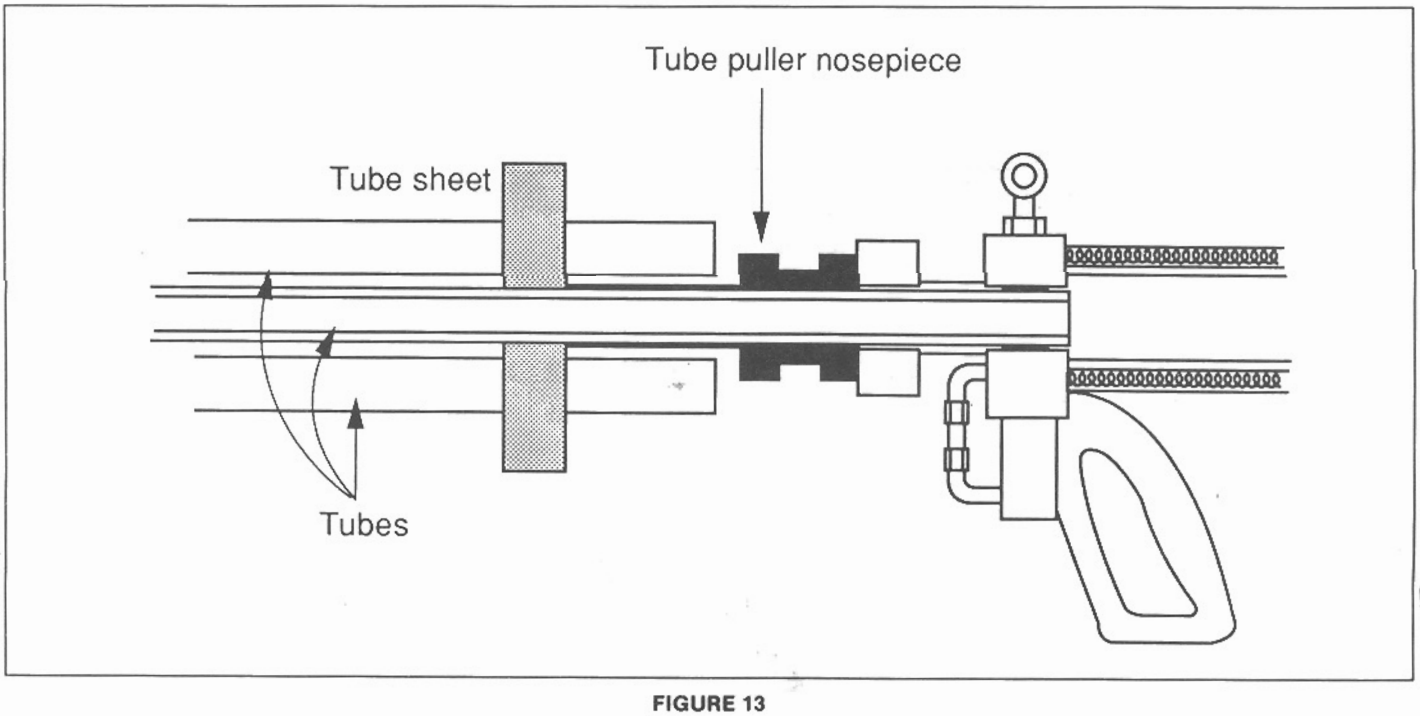


FIGURE 13

corrosion will start in both the support sheets and end plates. If gone unchecked, the rusting will effectively reduce the ID of the holes, making tube reinsertion difficult if not impossible. Rinse Lithium Bromide deposits from end plate holes with water and dry each thoroughly at the finish of each day's work. This will minimize seal surface corrosion damage.

TUBE BINDING is resistance to manual tube extraction caused by deposits on the tube OD, tube warpage or tube exterior fin locking on adjoining tubes. Tube binding may be sporadic or by whole banks of tubes. The cyclegrip continuous extractor is the most effective way of removing these tubes. The cyclegrip normally references off the tube sheet face when pulling tubes. However, it can be used in conjunction with the collet puller nosepiece in situations involving tube projection restrictions.

If a quadrant of tubes has been pulled 6" before tube binding is evident, an additional 6" pull can be accomplished by re-inserting the collet into the projecting tube end and pulling again. Finned tube applications require a change in collet size to one that will fit in the reduced ID under the finning. Slide the tube puller nosepiece (alone) over the 12" projecting tube end and use the nosepiece shank as a reference for the cyclegrip to pull against (see Figure 13).

BROKEN TUBE PULLING can be accomplished with the collet style puller if the broken end is within 5" to 6" of the tube sheet face. Remove the nosepiece from the thrust cap and reduce the collet "biting" pressure with the collet pressure control valve. A sample tube from the exchanger is used to determine the maximum acceptable pressure before tube OD exceeds the sheet hole ID. Starting at 100 psi, insert the collet in the tube sample and press the ram pull button and reset button consecutively, allowing ample time (2

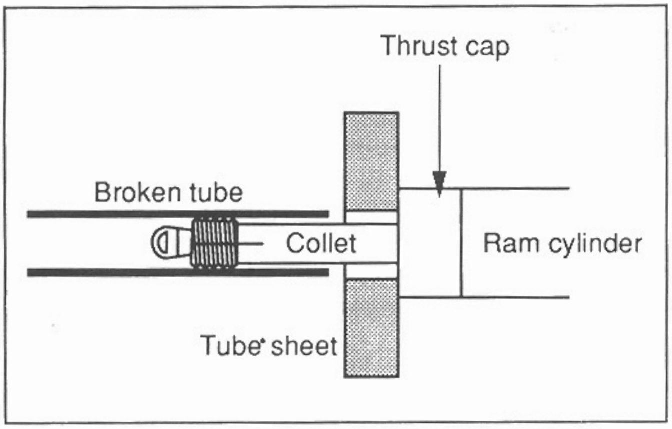


FIGURE 14

seconds) for the collet to reach full set pressure before resetting. Remove the tube sample from the collet and attempt to reinsert it in the tube sheet hole. Increase the collet pressure until mild interference is met between the tube OD and sheet hole. IMPORTANT: A new sharp collet must be used for this process. Care must be taken to center the collet in the tube sheet hole so that the inner sheet hole corner does not restrict the tube end travel (see Figure 14).

SHEET HOLE PREPARATION

The tube sheet holes should be thoroughly inspected and cleaned before inserting the new tubes (see Figure 15). Outer sheet hole corners should be checked for burrs which may have occured during the tube collapsing procedure. Burrs can cause tube OD scarring which could affect the tube to tube sheet seal. Hole ID surfaces should be free from lateral scars caused by improper collapsing tool usage. Scars can prevent effective tube joint sealing by providing a trough which cannot be filled by standard tube rolling procedures. Over expansion is usually the result of

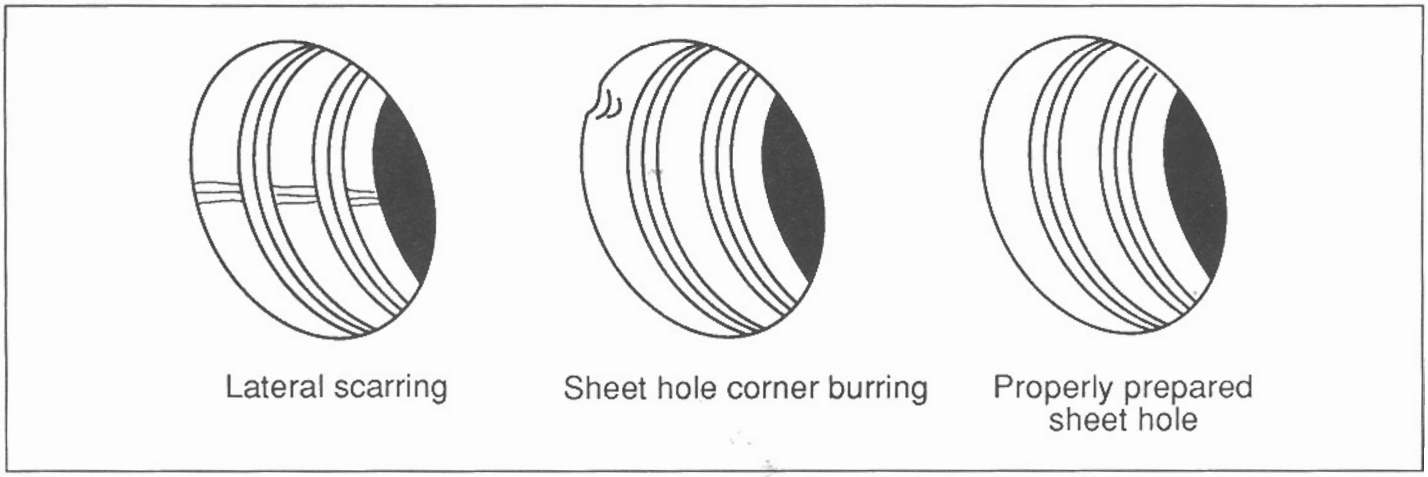


FIGURE 15

tube sealing attempts when adequate scar repairs are not effected.

Over rolling can cause sheet hole ligament distortion disturbing the tube seals in the surrounding holes. Sheet hole scars can be removed using an adjustable reamer. Care should be taken not to remove too much ligament metal; consult the exchanger's manufacturer for relevant guidelines. (.090" to .100" is a good guideline for minimum ligament thickness).

Sheet hole preparation should include wire brushing of all hole surfaces to remove all rust and foreign matter. A tube sheet hole brush is used for this purpose (see Figure 16). The brush is driven with a hand held reversible drill motor. Alternate brush rotation reindexes bent bristles for extended brush life. Finally, solvent should be used to remove any residual oily deposits from the sheet holes prior to replacement tube insertion.

FIGURE 16

Tube metal may be left in the tube sheet hole serrations in the form of rings. The metal forced into the serrations by tube expanding shears off when the tube is hydraulically pulled. There is no quick and easy way to remove these "rings". A dentist's "pick" has proved to be a very effective tool for this purpose.

Sheet hole brushing should follow this operation to "buff-out" any burrs or scratches resulting from "ring" picking.

Once the sheet holes have been brushed, the inside of the exchanger shell should be thoroughly vacuumed. This is especially important with hermetic units where the shell side refrigerant directly cools the drive motor and bearings. A bent piece of ⅝" tubing allows shell cleaning through open tube sheet holes.

TUBE INSERTION (STUFFING)

All air conditioning centrifugal and absorption type heat exchangers have internal tube support sheets spaced throughout the shells' length. The support holes are closely sized to the tube OD and can be difficult to locate with the flat end of the tubes being inserted. Tube pilots (see Figure 17) are available to simplify this operation. The pilot consists of an aluminum, tapered, bullet nose piece whose base diameter

FIGURE 17

is the same as the tube OD, with a removable nylon brush fixed to its shank. The nylon brush is over sized to the tube ID and is used to secure the bullet nose in the tube end. The pilot body translates the flat tube end into a bullet nose which assists in support sheet hole location during the "stuffing" process.

APPLICATION NOTES - TUBE STUFFING

If support sheet corrosion prevents new tube insertion, use a 3 or 4 fluted drill on an extension rod to re-size the holes. The drill should be approximately .005" oversized to the tube OD. An 11/16" steel rod bored to accept a ½" round drill shank is used as an extension with the driver being an impact wrench. Weld both the drill to the rod and the rod to the impact drive socket.

It is possible to "jump" support sheet holes in the stuffing process. The tube end may be slightly bent and the tube loses its hole alignment. The results may not be immediately evident, but at some point there will be a tube without a support sheet hole to go through. To minimize tube misalignment, tubes should be stuffed by horizontal rows, starting with the bottom row corner tube and progressing upward by consecutive rows (see Figure 18).

This procedure allows the two adjoining lower tubes to act as a support/guide between support sheets for the tube being inserted.

Absorption machines have floating tube sheets in the concentrator section, meaning the supports are not secured to the shell interior. If all the tubes are removed at once, the supports will fall out of position.

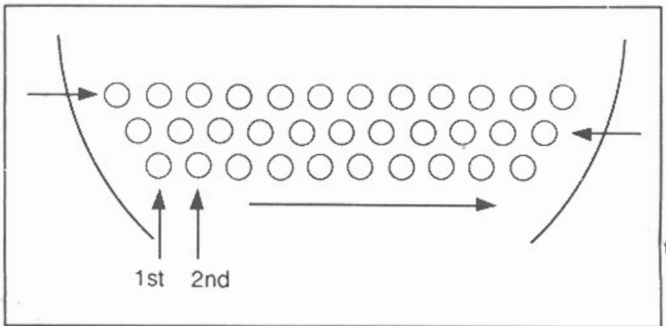


FIGURE 18

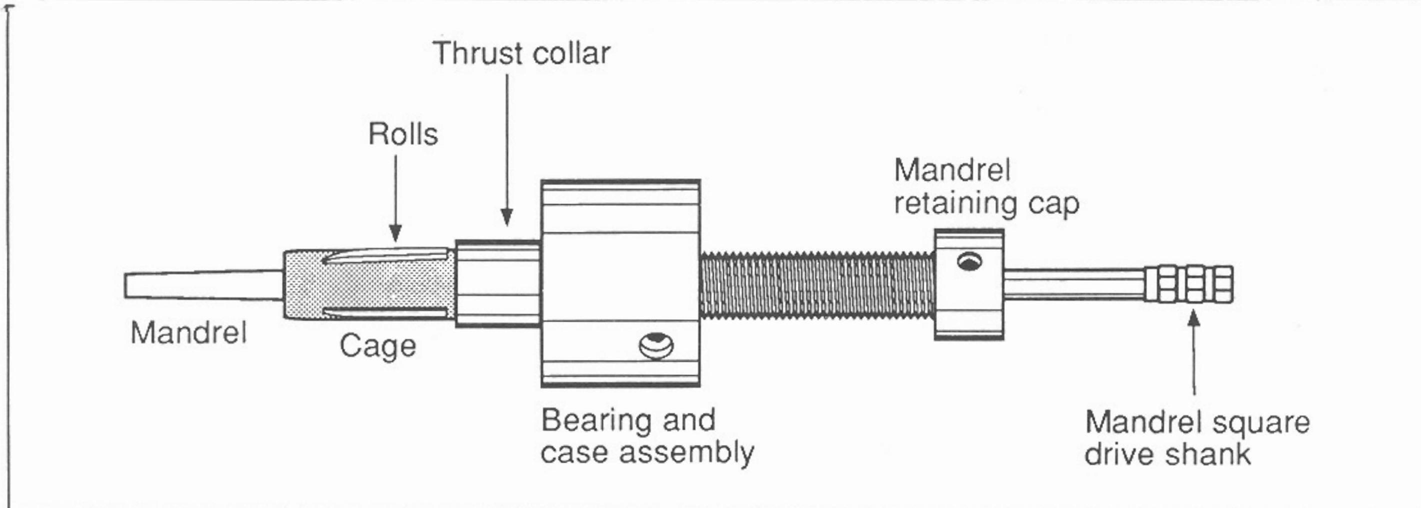


FIGURE 19

If spot tubes are left in the four quadrants of the bundle, floating supports will be held in position until replacement tubes are inserted.

TUBE ROLLING

Tube rolling is the process used to secure replacement tubes into the heat exchanger tube sheets (end-plates). The tube OD is forced into the surrounding tube sheet hole, creating a leakproof mechanical seal or joint. This is accomplished by expanding the tube ID past the dimension equaling metal to metal contact between the tube OD and the sheet hole ID. This additional wall "crush" forces the tube metal to flow into the tube sheet hole and serrations, resulting in a sound mechanical joint. The amount of wall crush is extremely important and will be explained further in this text.

The tool used in this procedure is aptly called a tube expander (see Figure 19). The tube expander is comprised of the following parts: rolls, mandrel, cage, and thrust collar. The cage houses the rolls and positions them on a slight angle to the tool's center line. This is referred to as the feed angle. The mandrel is the driving mechanism for this tool. The rolls ride on the tapered portion of the mandrel exterior. When in the retracted position, the mandrel collapses the rolls and allows tool/tube ID insertion. Clockwise rotation, after mandrel - roll - tube ID contact is made, causes the mandrel to self-feed forward, due to the feed angle. This causes the rolls to expand further with each rotation. Counter clockwise rotation reverses the expanding process, releasing the tool from the tube ID.

The thrust collar positions the rolls in relation to the tube sheet face and the tube end (except in the case of the friction collar). The thrust collar is adjustable and is used to position the rolls only in the area of the tube sheet.

A variety of thrust collars are available to suit different tube end requirements: Recessed Collars (see Figure 20) to insure equal tube end projections past tube sheet face, Flush Collar (see Figure 21) to roll tube ends even with tube sheet face, Telescoping Collars (see Figure 22) which will accept a variety of different tube end projections, and Friction Collars (see Figure 23) used to expand tubes in restricted quarters where standard diameter collars are not acceptable.

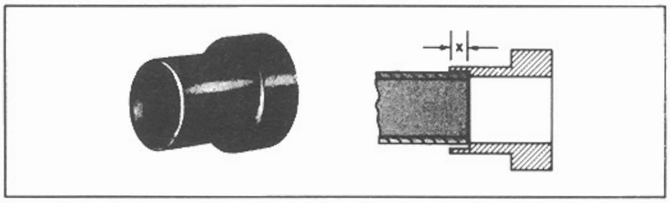


FIGURE 20

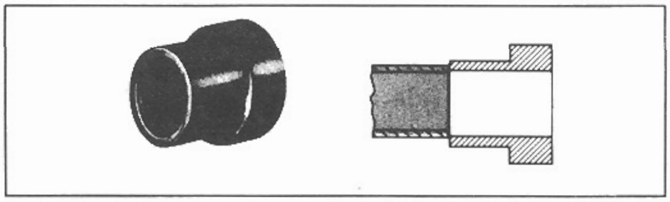


FIGURE 21

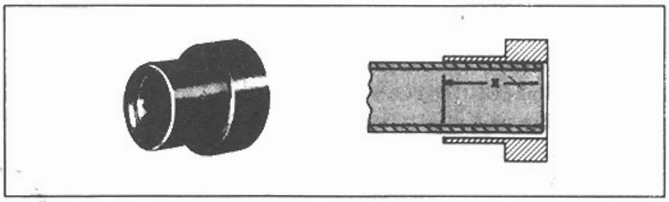


FIGURE 22

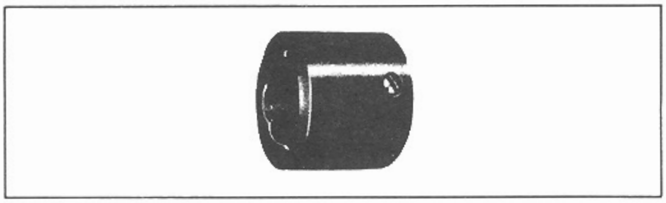


FIGURE 23

Tube expander rolls have a generous radius on the lead end to prevent sharp creases in the tube ID as a result of the expanding process (see Figure 24).

The rolls are tapered (½ taper to that of the mandrel) so that the tube wall is expanded equally the full tube sheet thickness. The effective roll length is measured from the crescent of the radius at the roll lead end to the thrust collar face. Roll length adjustment is accomplished by loosening the thrust collar locking screw and threading the cage either clockwise or counter clockwise in the thrust collar (referencing the shank end of tool). Clockwise rotation increases the effective roll length and counter clockwise rotation decreases the effective roll length. Once the desired roll length is achieved, (⅛" shorter than tube sheet thickness) lock the thrust collar in position with the locking screw.

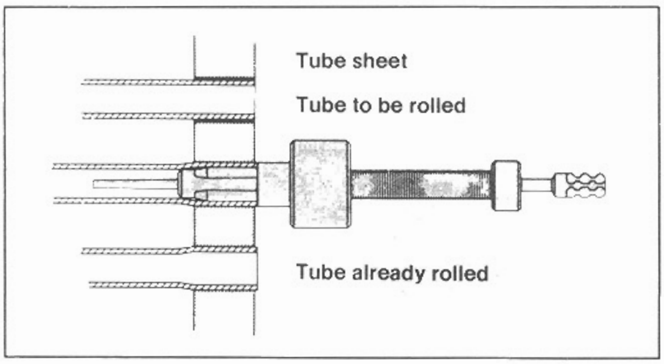


FIGURE 24

The flush collar, recess collar, and friction collars are basically used to roll the inlet end of the exchanger bundle. They provide an edge for the tube end to reference against. These collars dictate tube end positioning, in regards to the tube sheet face. The recessed collars are available with counter bore depths in 1/16" increments from 1/16" to ½".

The Telescoping Collar is basically used for rolling the discharge end of the exchanger tubes. The collar is bored (full length) oversized to the tube OD and will accept any variety of tube projections up to 1". It allows accurate roll positioning when inconsistent tube projections exist due to tube length variance. The standard expander has three (3) rolls. The triangulapositioning of the rolls, in the tool cage, facilitates equal perimeter wall crush in situations where tube sheet hole ovalness is present. Five (5) roll expanders are available for expanding extremely thin walled (.028" and thinner) stainless tubes where wall "tenting" is most prevalent.

APPLICATION NOTES

Over-rolled Tubes (see Figure 25) represent the worst case scenario of tube rolling situations. The tube wall is compressed to the point that it loses its elasticity (becomes excessively work hardened). The tube sheet ligament distortion is a result of further tube joint sealing attempts. The tube sheet metal actually yields to the excessive expanding force, resulting in tube hole enlargement. The domino effect is the ovalling of the surrounding sheet holes. "Dimension" rolling is the most effective method for sealing over-rolled tubes. The size dwelling effect "irons out" the tube wall without additional, excessive wall crush.

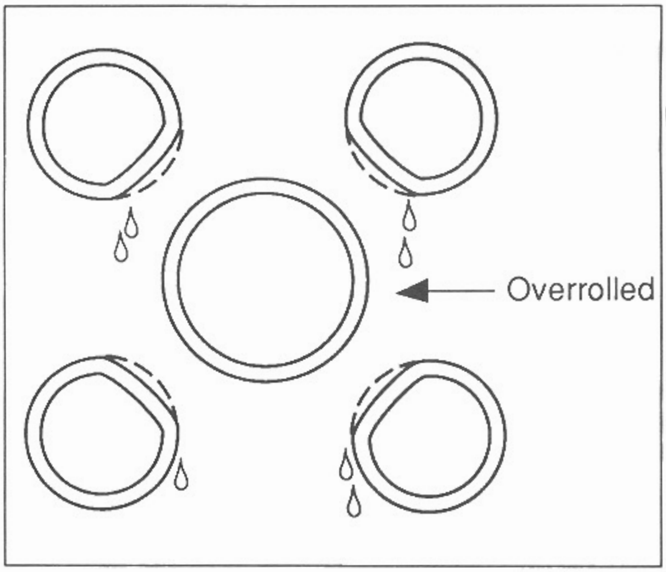


FIGURE 25

The tube expander can be used to dimensionally expand tubes or to expand tubes to a pressure. Dimensional Expanding means to expand to a fixed consistent size tube after tube. This method involves creating a restriction on the mandrel to stop its forward travel at the same point time after time. Washers are usually stacked between the mandrel square drive shank and the mandrel retaining cap for this purpose. This method has merit in sealing over-rolled tubes where sheet hole distortion is present.

Tube re-rolling is sporadically required to retighten tube joints where the seal has failed or the tube was under-rolled. Insert the appropriate tube expander, tap the mandrel forward until firm mandrel-roll-tube ID contact is made, then rotate the mandrel clockwise until the cage of the expander rotates 1 revolution. Recheck the seal and repeat the process if leakage is still detected. If more than three (3) re-rolling operations are required, plug the tube rather than risk overrolling. The tube expander must be driven by a reversible type Tube Rolling Motor (air or electric). Electric motors are most commonly used in AC heat exchanger field repairs because of the availability of electrical power. The tapper head motor is widely used due to its speed and ease of operation. This motor combines the speed and operation of semi-automatic forward/reverse switching with a 5.2 amp power capability in a lightweight (6 lb.) motor.

Torque controlled tube rolling (expanding the tube to a tightness) is a preferential method for rolling tubes. This method adjusts for sheet hole ID and tube wall variances by controlling the amount of wall crush after metal to metal contact is made (tube OD to hole ID). The Electronic Torque Control (see Figure 26) is the tool used for this purpose. This unit monitors the amperage draw of the rolling motor in 1/50 amp increments. When the tube OD contacts the sheet hole ID, the amperage draw of the motor increases drastically due to the increased resistance.

Adjustable tumblers on the control box determine the amp rating the torque control will accept before terminating current flow to the motor. Solid state circuit controls compensate for initial motor surge requirements and reapply power for motor reversal once the expansion cycle is completed.

It should be noted that each electrical motor has different operating characteristics. To properly set your torque control/motor package, a set procedure should be followed which takes these characteristics into account. This will be discussed in the section entitled "Tube Expanding Techniques and Procedures".

In the expanding process, tube wall metal is "extruded" toward the tube sheet face due to a self-feeding nature of the tool. This will cause a certain amount, although minimal, of tube projection past the tube sheet face even when flush expander collars are used. This projection will hinder gasket face sealing on units where division plates are used. Tube End

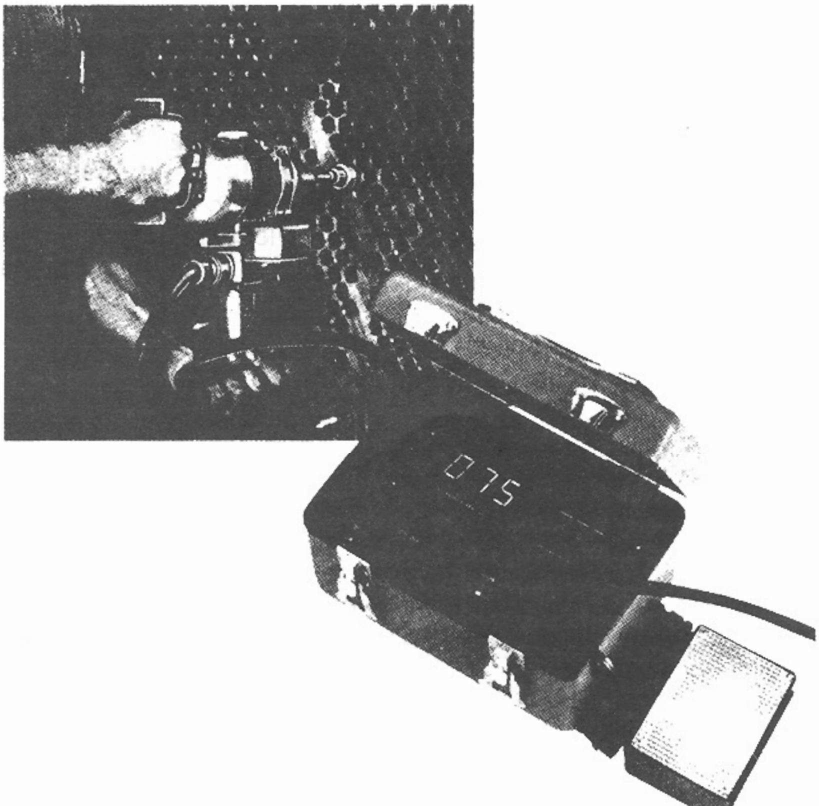


FIGURE 26
Setting of 50 Represents 1 Amp Draw

Facing Tools are used to trim the unwanted portion of the tube flush to the tube sheet face (see Figure 28). This tool has a pilot ring which centralizes the cutter body in the tube ID, an adjustable stop collar to insure accurate blade to sheet face positioning, and a cutter body with round shank drive configuration for rapid tube end removal.

The expanded ID of the tube and the sheet hole are measured with an Internal Tube Gauge (see Figure 27) to insure that adequate wall reduction is achieved. This tool uses three (3) steel balls situated in a triangulated pattern in the tool housing to measure the tube ID. A tapered center shaft presses the balls to the tube inside. The shaft travel transmits the measurement to the calibrated gauge face, indicating the tube ID in thousandths of an inch. A stop collar on the tool casing positions the balls in the area to be measured.

SUPPORT SHEET TUBE EXPANDING

This is usually only required on centrifugal unit evaporator exchangers. The purpose of this operation is to prevent tube OD metal loss, at the supports, due to tube vibration during operation. Light metal to metal contact, tube OD to support hole ID, is all that is required. The tubes should only be expanded in the support sheet hole surface. The most widely used tools for this purpose are the collet type and the roller type support sheet expanders.

The Collet Type Support Sheet Expander has a segmented expanding collet similar to the one used in the collet style tube puller. However, the tube expanding surface is smooth and radiused (see Figure 29).

The collet is expanded hydraulically by a tapered draw rod and is used in conjunction with the collet puller ram and hydraulic power pak. The adjustable collet pressure control valve is used to determine the tube expansion pressure. Modular collet and draw rod extension pieces are used to determine the length of its reach (approximately 50" in length each). The collet only expands the tube surface at the crescent of its radiused surface.

Driver (powered by): Collet style puller power pak/ram.
Expansion time/support: 10 seconds (based on double expansion with 30 degrees rotation).

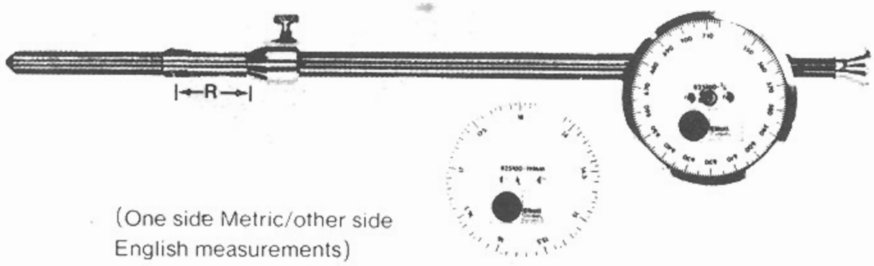
The Roller Type Support Sheet Expander works on the same principle as the expander described previously. However, this tool has a larger expansion range than the standard expander, to compensate for the great difference between the tube ID under the fins and the tube ID at the support sheets. The tool length is also radically different, reaching lengths of 14'. Tool expansion can either be controlled dimensionally or by torque control as described later.

Driver: Reversible hand held motor (same as used for end plate expansion).
Expansion time/support: approximately 60 seconds, including tool and stop collar repositioning.

APPLICATION NOTES: SUPPORT SHEET EXPANDING

The collet style expander does not have the lateral thrust forces that the roller type does, therefore a stop/thrust collar is not required. A reference mark on the collet extension piece is all that is required for collet positioning and tool operation. The roller type tool requires stop collar positioning/repositioning and repetitive lubrication (as does the standard expander) to cool and clean the rolls and mandrel. The collet type does not require any lubrication due to the negligible tool surface interaction/heat build up.

Support Sheet Location is accomplished by inserting a rod through the tube sheet hole and marking on its exterior when the end hits each consecutive support sheet. The mark is placed on the rod to reference the tube sheet face to support sheet face dimension. Support sheet thickness varies from approximately



(One side Metric/other side English measurements)

FIGURE 27

¼" to ½". Add half the support sheet thickness to the the measured distance sheet face to sheet face to detercollet mine or roll positioning. Rod measurements should be taken in each of the four (4) quadrants of the exchanger. Reposition the expander in accordance with any variances in support sheet distances.

FIGURE 28

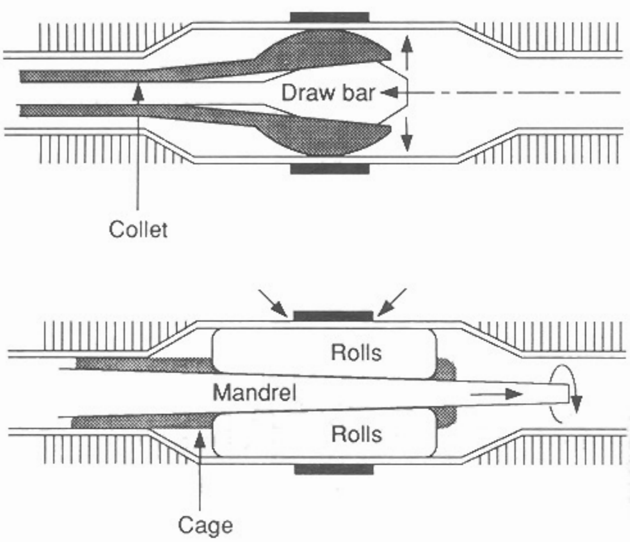


FIGURE 29

As previously mentioned in the expander section, tube rolling is expansion of the tube ID to a dimension producing adequate tube wall reduction to create a leak proof mechanical joint.

Tube wall reduction (or crush) is the key factor in this formula. Tube wall reduction does not effectively take place until the tube OD meets the tube sheet hole surface (ID). The difference between the starting tube OD and the sheet hole ID is referred to as clearance. The clearance factor is added to the starting measured ID of the tube to determine ID of the tube at metal to metal contact (tube OD to sheet hole ID). This portion of the formula is universal to all heat exchanger tube expanding formulas. It gives a reference point for the next factor which is wall crush. Wall crush is determined by a percentage of the total wall thickness (single wall thickness × 2) based on the material of the tube. This value is added to the previous metal to metal ID value to determine final rolled ID.

The following table consists of the Industry Standards for the percentage wall crush based on tube material.

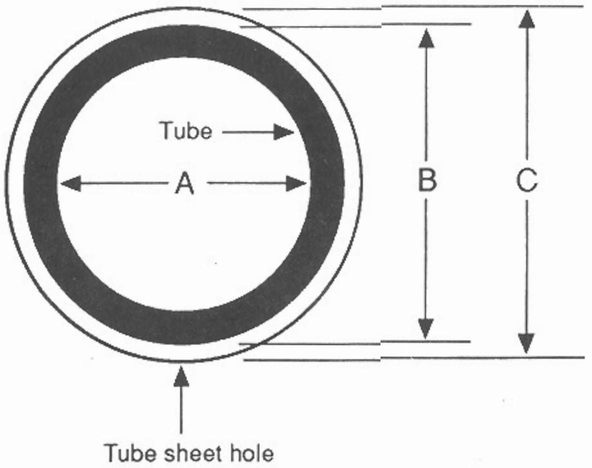
Copper & Cupro Nickel	8 - 10%
Steel, Carbon Steel, & Admiralty Brass	7 - 8%
Stainless Steel & Titanium	4 - 5%

These materials and percentages can be your guideline to rolling tubes of like materials. As you will note, the harder the material, the less wall reduction required. The following is a "cook book" formula to determine finished rolled ID. The following example is for a ¾" OD × 18 BWG copper tube.

Measured sheet hole ID	.760"
(-) Tube starting OD	- .750"
(=) Clearance	.010"
Clearance	.010"
(+) Measured starting tube ID	+ .652"
(=) Tube ID @ metal/metal contact	.662"
Tube OD	.750"
(-) Tube ID	- .652"
Overall wall thickness	.098"
Overall wall thickness	.098"
(×) 10% wall reduction	× . 10"
Wall crush	.0098"
Metal to metal tube ID	.662"
(+) Wall crush	+ .0098"
Finished rolled tube ID	.6718" (or .672" ID)
Overall wall thickness	.098"
(×) 8% wall reduction	× . 08"
Wall crush	.00784"
Metal to metal tube ID	.662"
(+) Wall crush	+ .00784"
Finished rolled tube ID	.66984" (or .670")

Acceptable finish rolled tube ID range is .670" - .672"

TABLE 1



% Wall Crush

- Copper and cupronickel — 8-10%
- Steel, carbon steel and admiralty brass — 7-8%
- Stainless steel and titanium — 4-5%

Tube material ______________

Tube sheet thickness __________

Wall crush calculation

(B-A) = x .0_ _ / x .0_ _

Example: (B-A) (Copper): .098 x .010" = .0098" (10% / 8%) / .098 x .008" = .0078

WORKSHEET

	*Example	Sample 1	Sample 2	Sample 3	Sample 4
A Measured tube I.D.	.652"				
B Measured tube O.D.	.750"				
C Measured sheet hole I.D.	.760"				
C Minus B = (Tube clearance)	.010"				
A (Starting I.D. tube)	+ .652"	+	+	+	+
I.D. tube @ Metal/Metal contact	= .662"	=	=	=	=
Tube wall crush (Round off)	+ .008" + .010"	+ ____ +	+ ____ +	+ ____ +	+ ____ +
Finished rolled tube I.D. range	= .670" = .672"	= ____ =	= ____ =	= ____ =	= ____ =
Torque control setting					
Actual rolled I.D. measured					

*Exam[illegible]aken from section labeled "Tube expanding guidelines" A = .652" B = .750" C = .760"

TUBE EXPANDING TECHNIQUES AND PROCEDURES

TORQUE CONTROLLED tube expanding is by far the most popular method for tube rolling because it self compensates for variables which the operator/technician cannot control, those being sheet hole ID variance and tube wall thickness variance.

The Electronic Digital Torque Control monitors the power required by the rolling motor to properly expand the tube. This is done by controlling the amperage (amp) draw of the rolling motor. The motor "bears down" during the rolling operation, with the added resistance of crushing the tube wall. As this resistance increases, the motor's amperage usage increases. Adjustable tumblers on the torque control allow the operator to establish a cut-off point which, when reached, will stop the electrical power to the motor. Power is reapplied to the motor after the trigger is released and depressed a second time to allow motor reversal/tool release. A LED readout on the control indicates the actual amperage usage of the rolling motor during all phases of the operation.

Since this process references motor power requirements after metal to metal contact (tube to sheet hole), any variances in tube or sheet hole dimensions are irrelevant.

Power Requirements: 105-130 V AC, 50-60 hz.

DIMENSION ROLLING on the other hand, solely relates to a fixed, predetermined size. The forward travel of the tube expander mandrel is limited by "stacking" washers between the mandrel shank and the mandrel retaining cap secured to the tool's cage.

This method allows consistent, repetitive size control tube after tube and requires only a reversible tube rolling motor.

The tube rolling sequence should be by horizontal row from the bottom row up. This will prevent the tube rolling lubricant from contaminating the unexpanded tube sheet holes.

TUBE PLUG REMOVAL

This is an integral part of the retubing process. Two piece (ring/pin) type plugs are the style most frequently used on air conditioning exchanger tubes due to their superior sealing ability. They are also the hardest to remove.

If an ample amount of the pin is protruding from the ring, a pipe wrench may be used to twist the pin out of the ring bore. The sleeve relaxes inward somewhat and may be worked loose using an easy-out or tube pulling spear.

Another method for plug removal involves drilling a hole in the pin portion and using a tube pulling spear/adaptor/horseshoe lock and inertial ram to remove the pin and ring consecutively. For ¾" tube applications, a ⅜" drill is used to bore an access hole in the pin shank. Then a ½" OD - 16 BWG spear, with a taper capable of securing in both the ⅜" pin hole and the ring's tapered bore, is secured in the tube plug component. The inertial ram (section of heavy walled steel pipe) is used to "hammer" against the horseshoe lock to remove the plug piece. After the pin is removed from the spear, the remaining ring is removed in the same fashion.

SET UP/OPERATING INSTRUCTIONS

FLY TYPE CUTTER (See Figure 30.)

Set Up:

1. Select cutter blade type for tube material, blade #-S for stainless/alloy tubes or standard blade # for non-ferrous/steel.

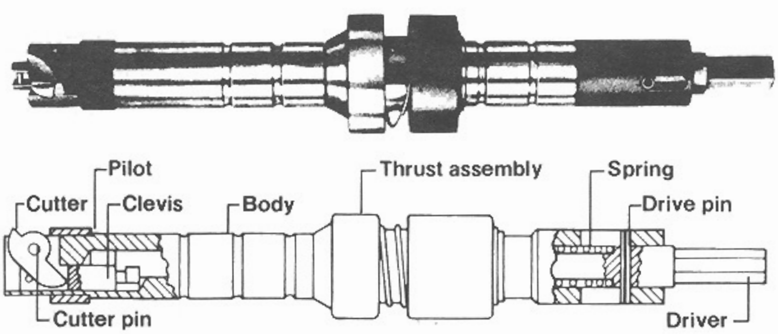


FIGURE 30

2. Select pilot ring for wall thickness of tube (in even number BWG).
3. Slide pilot over cutter body (blade end).
4. Depress cutter drive shank approximately 1/16" (to assist in blade hole and pin alignment).
5. Insert cutter blade in appropriate slot and install cutter pin in tool body.
6. Pinch two (2) halves (front and back) of positioning collar together and set cut depth from tube end desired; cutter must clear back face of tube sheet.
7. Adjust cutter reach to at least 3" for 3/4" OD finned tubes (515700-20); this will insure blade placement under fins.
8. Secure tool hex shank in drive motor chuck.

Operating Instructions:

1. Dunk-lube tool tip and blade in light oil.
2. Insert cutter in tube ID, start motor prior to stop collar contact with tube end.
3. Press drive motor/cutter forward until stop collar contacts tube end and the blade meets the tube ID.
4. Apply firm pressure until the desired cutting depth is achieved.
5. Withdraw the cutter assembly from the tube end and repeat the process until all tube ends are cut/"scored" at one end of the exchanger.
6. Periodically check blade for wear.
7. Re-sharpen or replace dull blades.
8. Applying excessive blade force or cutting with a dull blade will flare the tube OD.
9. Tube cutters should always be used with a pilot ring.

ONE REVOLUTION TUBE CUTTER

Set Up:

1. Loosen stop collar positioning set screw.
2. Adjust cutter blade/stop collar distance.
3. Cutter body is sized for tube OD × wall thickness; a pilot is not required.

Operating Instructions:

1. Lubricate cutter blade.
2. Insert cutter in tube end while turning cutter in counter clockwise rotation (this prevents blade/-tube ID binding.
3. When stop collar hits tube end, rotate cutter body clockwise via the hex drive shank with a wrench (DO NOT USE IMPACT DRIVE).
4. Rotate cutter one (1) full revolution to fully cut the tube.
5. Turn cutter counter clockwise to collapse blade and withdraw tool for next cut.

ASSEMBLY INSTRUCTIONS M-5223-00 COLLET STYLE TUBE PULLER

1. First, determine the accurate size of the tube to be pulled in either tube OD × BWG wall thickness (from tube spec.) or by a physical measurement of the tube ID.
2. Select the appropriate collet, draw bar, nosepiece and threaded bushing.
   - Consideration should be given to the material of the tube to be pulled when sizing collets and accessories. Non-ferrous materials are relatively soft, as tube materials go, and the gripping teeth of the collet sink into the tube surface deeper to attain a good grip. As the collet bites deeper, more metal is displaced into the base area of the teeth. This effectively reduces the ID of the tube in relation to the collet OD (completely collapsed) and will prevent easy withdrawal of the collet from the tube end after the pull.
3. Determine whether the RAM EXTENSION KIT M-5236-D __ (in 18", 24" and 36" lengths - as measured from the "pull and reset boxes") would be *useful due to the depth of the heat exchanger's* water box. If so:
   - A. Remove M-5223-D2-22 thrust cap and M-5223-D23 collet adaptor from the pulling ram. Also make sure that the draw bar's threaded bushing is removed from its seat.
   - B. Screw M-5236-D4 (length) inner rod extension into the inner cylinder's threaded tap (bottom out with firm pressure).
   - C. Screw M-5236-D3 (length) outer piston extension into the outer cylinder's threaded tap (bottom out with firm pressure).

D. Screw M-5236-D2 (length) onto the threads of the cylinder's outer casing.

E. Screw M-5223-D23 collet adaptor into the tap of the M-5236-D3-( ) outer piston extension.

4. Screw the threaded bushing (if required) into the tapped hole of the inner cylinder of M-5236-D4 extension piece using the screwdriver provided in the tool kit.

5. Screw the M-5285-101-( ) collet into the M-5223-D23 collet adaptor (bottom out with firm-plus pressure).

6. Screw the M-5285-102-( ) draw bar into the threaded bushing through the collet center hole (bottom out with firm pressure).

7. Loosen the two (2) set screws in the M-5223-D2-22 thrust cap and insert the nose piece until it bottoms in the cavity, then tighten set screws.

8. Screw thrust cap onto cylinder's outer casing or M-5236-D2-( ) extension piece (bottom out with firm pressure).

9. Attach pulling cylinder's three (3) hydraulic hoses to the appropriate quick connect couplings on the hydraulic pump unit (color coded for easy match up).

   - Make sure all connections are thoroughly bottomed out with firm hand pressure. If not, the spring loaded ball in the connector will restrict the hydraulic oil flow.

10. Attach electrical twist type connector from the pulling cylinder to the mating fitting off the pump control box.

11. Check hydraulic fluid level by removing vented access plug on top of the unit's sump. Fluid level should be within 1" of top. If fluid has to be added, refer to the manual for acceptable oils.

12. Select extension cord with wire gauge sufficient to handle a maximum of 20 amp draw without voltage drop.

CORD LENGTH	25	50	100	150	200	250
WIRE GAUGE	14	12	8	6	6	4

   - Electrical power to power pack should be above 150 volts AC when the motor is under full load (system pressure at 5000 psig).

OPERATING INSTRUCTION M-5223-00
COLLET STYLE TUBE PULLER

1. Collet Pressure Adjustment:

   A. Depress and hold reset button on the ram handle. Collet and system pressure gauges will register maximum set pressures because the system will essentially be "dead headed".

   B. Using silver collet pressure setting cap, located in the center of the valve block assembly, turn clockwise to increase pressure and counter clockwise to decrease collet pressure. (Recommended initial setting is 400 psig.) Release reset button.

2. Adjust time delay tumblers (located above volt meter gauge on pump control box) to an initial setting of 25. This stands for 2.5 seconds. This will allow the collet 2.5 seconds, after the pull button is pushed, to take a "set" in the tube end before the cylinder will go into the pull mode.

3. Insert the collet into the tube end until the nose piece makes contact with the tube sheet face. Care should be taken to position the nose piece square with the tube sheet face (not "cocked" to one side, up or down). Misalignment can cause damage to collet or tube end "tearing", resulting in a partial pull.

MAKE SURE THERE IS NOBODY STANDING AT THE OTHER END OF THE HEAT EXCHANGER!!!

4. Depress and hold the pull button until you either hear the "klunk" of the rolled joint being broken free from the tube sheet or until you feel the ram lower slightly, indicating the joint has been broken. If the tube sheet face is badly damaged due to corrosion, the ram will try to "cock" to one side during the pull mode. Applying pressure to the ram in the opposite direction will be beneficial to preserving collet life and insuring succesful pulls. The travel of the ram's forward hydraulic hose will indicate the distance the tube has been pulled. Release the pull button when the desired pull distance has been achieved.

5. Depress reset button until collet and draw rod completely re-index. The sound of the pump motor laboring will indicate that the system is dead-headed with the collet and draw rod completely returned for the next pull.

- If the collet broaches or scrapes the tube surface metal only, return to step number (1) and adjust the collet pressure up to 50 psig and repeat steps (3) thru (5). Continue this process, using a different tube each time, until a pressure is reached which secures the collet in the tube end without slippage - pulling the tube. Leave the collet pressure at this setting and proceed with the job.
- If the collet bites off the end of the tube without pulling the entire tube, perform the steps recommended above, reducing the collet pressure by 50 psig each try until a successful pull is achieved.

  (This unit operates on the same principal as torque controlled tube expanding - biting or expanding to a pressure to compensate for variations in tube sheet hole ID dimensions.)
- The standard nose piece positions the lead teeth of the collet approximately ⅝" from the nose piece tip. The nose piece can be trimmed to allow the collet to reach further into the tube end. You will find this extremely helpful in pulling light walled (18 BWG and lighter) non-ferrous tubes such as those found in air conditioning service. A popular procedure is to trim the nose piece to position the lead teeth of the collet ⅛" short of the inside edge of the tube sheet.

SPEAR TYPE HYDRAULIC TUBE PULLER

Set Up:

1. Attach two (2) hydraulic hoses from ram cylinder to hydraulic pump via quick connects.
2. Check hydraulic fluid level.
3. Plug pump power cord into 110 V AC outlet with 20 amp breaker.

Operating Instructions:

1. Select spear size and thread spear to adaptor.
2. Lubricate spear teeth with cutting oil.
3. Screw (thread) spear into tube end via adaptor square shank to approximately 85 ft-lbs torque maximum.
4. See Figure 9.
5. The hydraulic cylinder can be collapsed and used as an inertial ram if tube binding occurs after the initial pull.
6. Remove spear from tube end using a vice grips pipe wrench or vice to secure tube and a wrench to turn spear.

SHEET HOLE BRUSHES

Set Up:

1. Secure brush shank in drive motor chuck (Jacobs).
2. Wear protective eyewear.

Operating Instructions:

1. Start drive motor then push brush forward and back through the entire length of the sheet hole 4-5 times.
2. Inspect hole surface and repeat if necessary.
3. Alternate brush rotation will re-index bent bristles and extend brush life.

TUBE PILOTS

Operating Instructions:

1. Press nylon brush shank in tube end until the pilot body contacts the tube end.
2. Insert the tube in the exchanger.
3. Remove pilot from the tube end. Repeat.
4. If tube end "skips" a support sheet hole, exercise caution in backing the tube out - the pilot edge could catch the sheet hole corner - pull the pilot out of the tube end leaving the pilot inside the exchanger.

TUBE EXPANDERS/MOTORS

Set Up:

1. Push the newly inserted tube until the tube end is flush with one tube sheet face. Measure the tube end projection past the opposite tube sheet face. Divide the projection by two (2) and select the recessed collar that closely matches this dimension. This balances the projection value on each end of the exchanger.
2. Roll all the tubes at one end of this recessed collar and roll all the tubes at the other end of the exchanger with the friction collar. The friction collar allows the rolls to reference off the tube sheet face even if the secondary tube sheet projection varies due to tube length variance.
3. The recessed collar is replaced by removing the snap ring from the front of the case (roll side of case). This allows thrust collar removal and replacement. Replace the snap ring to complete the operation.
4. Adjust the effective roll length of the tool by loosening the clamp nut thrust collar positioning set screw with the Allen wrench provided with the tool. Leave the Allen wrench in the set screw and screw the cage clockwise (from the shank end) to

increase the effect of roll length and counter clockwise to decrease the effect of rolling. Lock the thrust collar in position by tightening the clamp nut collar set screw.

5. Assemble the expander square mandrel shank into the drive motor's quick change chuck.
6. Plug motor power cord into appropriate receptacle on torque control box.

Operating Instructions:

1. Dunk-lube the expander (effective roll area only) in a can of water soluble lubricant or light oil.
2. Retract the expander mandrel; this will collapse the rolls and insert the expander in the tube end until the tool's thrust collar hits the tube sheet/tube.
3. Press the mandrel forward and start the tube rolling motor. The mandrel will self-feed into the tool so added forward force is not required.
4. Allow the motor to rotate the tool until the torque control stops the motor. Reverse the motor by pulling back on the motor handle firmly, then starting the motor (tapper head style motor) or by reindexing the motor directional "flip" switch then starting the motor (regular reversible electric motor).
5. Dunk-lube the expander frequently - every other tube - to wash away foreign material (dirt, grit, or metal chips) out of the tool and to dissipate tool heat buildup caused by friction.
6. Excessive heat buildup will cause permanent roll/mandrel failure. If the rolls are too hot to hold in your hand, exchange the tool with another and allow tool to cool in the "dunk-lube" can of oil.
7. Inspect roll and mandrel surfaces periodically to check for surface breakdown (flaking or discoloration). Replace tool part which is damaged/worn, immediately. Further usage will cause related surface damage - rolls to mandrel/mandrel to roll.
8. Do not apply side pressure to mandrel either during operation or at rest (leaving motor hanging on mandrel in tube end during periods of inoperation). This may lead to premature failure of mandrel due to side flexing.
9. Rolls and mandrel are replaced by loosening the mandrel retaining cap set screw and unthreading it from the cage. This allows the mandrel to be fully removed from the tool, thus releasing the rolls for removal. Reverse operation for reassembly.

ELECTRONIC TORQUE CONTROL

Set Up:

1. Plug torque control power cord into receptacle on control box face and also into 100V DC wall receptacle.
2. Plug tube rolling motor power cord into appropriate plug on control box face, turn on/off switch to the ON position.

Operating Instructions:

1. Measure five (5) tube/sheet hole sets, deriving the required information needed to determine finished rolled ID for each. Use specific measurements; do not average. Sheet hole measurements should be of the hole surface, not in the serrations. Tube measurements should be made in the area of the tube to be expanded.
2. Determine finished rolled ID for each set and identify tube/sheet hole samples.
3. Plug motor cord into appropriate torque box receptacle and torque box cord into wall outlet.
4. Set control box tumblers to 200. Depress rolling motor to trigger switch for 20-30 seconds, allowing the motor to warm up.
5. Note motor amperage draw on the LED readout under no-load condition.
6. Set control tumblers at the number which is fifty (50) in excess of the no-load amp draw, and expand the first tube.
7. Measure the rolled area of the tube with the tube ID gauge. If additional adjustment is needed to attain the pre-calculated ID, either raise or lower the tumbler rating (by increments of 5 or 10) and repeat the operation until successful results are achieved.

   During the control adjusting operation the same tube end should not be rolled more than once. The rolling process workhardens the tube metal.

   Further attempts to roll the same tube would result in false readings due to its pre-hardened condition.
8. Once the final setting is determined, re-roll the "test" tubes and all the rest of the tubes in the end plate. Even though the final rolled IDs may vary slightly due to sheet hole variance, the wall crush will remain consistent.
9. Log control setting and other pertinent data (tube material/tube OD × wall thickness/tube sheet thickness) for future reference.
10. Adjustments to expander effective roll length will affect the control setting/torque. The more tube area to be expanded, the higher the required torque value. If two (2) expanders are used for your retubing operation (which is standard practice due to tool heat build-up), adjust the effective roll lengths identically.

ASSEMBLY INSTRUCTIONS FOR ELLIOTT B9765-00 SUPPORT SHEET EXPANDER

TOOL RANGE: .550" to .687"
TOOL REACH: 12' (THREE 4' SECTIONS)

1. Remove tube pulling collet, draw bar, nose piece, thrust cap, and threaded bushing from M5223D2 hydraulic cylinder assembly.
2. Insert M5223-0100024 threaded bushing. Screw bushing in until bushing bottoms out.
3. Insert B9669D2 collet extension adaptor. Screw adaptor in until adaptor bottoms out.
4. Screw the thrust cap taken off in Step 1 back on hydraulic cylinder.
5. Insert pilot adaptor into thrust cap and tighten dog point set screws.
6. Assemble collet to one of the collet extensions.
7. Assemble draw bar to one of the draw bar extensions. Screw set screw into end of draw bar extension until set screw bottoms out.
8. Insert draw bar assembly into collet assembly then slide location collar over collet extension.

   Note: Tapered end of collar references off tube, bored end references off tube sheet.
9. If only one extension length desired (4') then thread this assembly to M5223D2 hydraulic cylinder. If longer reach desired, go to Step 10.
10. Screw additional draw extension to set screw on assembled tool. Screw another set screw in the back end of added draw bar extension.
11. Slide additional collet extension over draw bar extension assembled in Step 10 and screw to existing collet extension. If additional reach is desired, repeat Steps 9 and 10. If not, assemble to hydraulic cylinder.

    Note: If more than 12' reach is required, additonal draw bar and collet extensions may be purchased to obtain desired reach.

OPERATING INSTRUCTIONS B9765-00 SUPPORT SHEET EXPANDER

1. Remove the pull hose from the Elliott M5223D3A power unit. This hose is located at the lower left on the manifold block and should be color coded as Black on the manifold.
2. Measure support sheet distances from tube sheet face.
3. If there is tube projection from the tube sheet, use the location collar with the counterbored end facing the tube sheet. If all the tubes are flush with the tube sheet, the tapered end of location collar may be used.
4. Adjust the collet pressure to 500 psi.
5. Using a sample tube and section of support sheet, position the collet in the tube under the support sheet area.
6. Press the pull button on cylinder and hold for approximately two (2) seconds, then press the reset button to release the collet. Rotate cylinder thirty (30) degrees and repeat the operation.
7. Check expansion for tightness; if loose, increase collet pressure in 100 psi intervals and repeat until expansion required is met.
8. If expansion range exceeds .687" washers may be used between collet and collet extension. A 1/16" thick washer will increase tool range .010".

WARNING:

DO NOT BEND support sheet expander assembly. Bending will cause premature failure of the PC2-0100024-00304 set screws. A counterbalance and/or trolley type support mechanism is recommended.

TUBE END FACING TOOL

Set Up:

1. Select blade for tube material; blade #-S for stainless steel or standard blade number for nonferrous.
2. Select pilot ring for wall thickness of tube (in even number BWG).
3. Remove pilot screw from cutter body and reassemble with pilot sleeve (tighten firmly).
4. Unscrew positioning collar set screw and adjust collar face to blade face for desired cut and tighten set screw.
5. Secure round tool shank in Jacobs chuck of drive motor.

Operating Instructions:

1. Dunk or spray-lube blade with light oil or cutting oil.
2. Insert tool's pilot ring in tube end and initiate motor rotation prior to blade/tube end contact.
3. Press tool firmly into tube end until stop collar contacts the tube sheet face.
4. Remove tool from tube end and repeat the process, lubricating/cooling the blade frequently.
5. Excessive heat buildup in blade will cause premature dulling.
6. Inspect blade periodically for blade dulling.

RSES

Chart to determine inside diameter of tubes*

B.W.G.	Wall Thick-ness	Outside Diameter Tubes ¼″	⅜″	½″	⅝″	¾″	⅞″	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	3″	3¼″	3½″	3¾″	4″	4¼″	4½″
00	.380						.115	.240	.490	.740	.990	1.240	1.490	1.740	1.990	2.240	2.490	2.740	2.990	3.240	3.490	3.740
0	.340					.070	.195	.320	.570	.820	1.070	1.320	1.570	1.820	2.070	2.320	2.570	2.820	3.070	3.320	3.570	3.820
1	.300				.025	.150	.275	.400	.550	.900	1.150	1.400	1.650	1.900	2.150	2.400	2.650	2.900	3.150	3.400	3.650	3.900
2	.284				.057	.182	.307	.432	.682	.932	1.182	1.432	1.682	1.932	2.182	2.432	2.682	2.932	3.182	3.432	3.682	3.932
3	.259				.107	.232	.357	.482	.732	.982	1.232	1.482	1.732	1.982	2.232	2.482	2.732	2.982	3.232	3.482	3.732	3.982
4	.238			.024	.149	.274	.399	.524	.774	1.024	1.274	1.524	1.774	2.024	2.274	2.524	2.774	3.024	3.274	3.524	3.774	4.024
5	.220			.060	.185	.310	.435	.560	.810	1.060	1.310	1.560	1.810	2.050	2.310	2.560	2.810	3.060	3.310	3.560	3.810	4.060
6	.203			.094	.219	.344	.469	.594	.844	1.094	1.344	1.594	1.844	2.094	2.344	2.594	2.844	3.094	3.344	3.594	3.844	4.094
7	.180			.140	.265	.390	.515	.640	.890	1.140	1.390	1.640	1.890	2.140	2.390	2.640	2.890	3.140	3.390	3.640	3.890	4.140
8	.165		.045	.170	.295	.420	.545	.670	.920	1.170	1.420	1.670	1.920	2.170	2.420	2.570	2.920	3.170	3.420	3.670	3.920	4.170
9	.148		.079	.204	.329	.454	.579	.704	.954	1.204	1.454	1.704	1.954	2.204	2.454	2.704	2.954	3.204	3.454	3.704	3.954	4.204
10	.134		.107	.232	.357	.482	.607	.732	.982	1.232	1.482	1.732	1.982	2.232	2.482	2.732	2.982	3.232	3.482	3.732	3.982	4.232
11	.120		.135	.260	.385	.510	.635	.760	1.010	1.260	1.510	1.760	2.010	2.260	2.510	2.760	3.010	3.260	3.510	3.760	4.010	4.260
12	.109	.032	.157	.282	.407	.532	.657	.782	1.032	1.282	1.532	1.782	2.032	2.282	2.532	2.782	3.032	3.282	3.532	3.782	4.032	4.282
13	.095	.060	.185	.310	.435	.560	.685	.810	1.060	1.310	1.560	1.810	2.060	2.310	2.560	2.810	3.060	3.310	3.560	3.810	4.060	4.310
14	.083	.084	.209	.334	.459	.584	.709	.834	1.084	1.334	1.584	1.834	2.084	2.334	2.584	2.834	3.084	3.334	3.584	3.834	4.084	4.344
15	.072	.106	.231	.356	.481	.606	.731	.856	1.106	1.356	1.606	1.856	2.106	2.356	2.606	2.856	3.106	3.356	3.606	3.856	4.106	4.356
16	.065	.120	.245	.370	.495	.620	.745	.870	1.120	1.370	1.620	1.870	2.120	2.370	2.620	2.870	3.120	3.370	3.620	3.870	4.120	4.370
17	.058	.134	.259	.384	.509	.634	.759	.884	1.134	1.384	1.634	1.884	2.134	2.384	2.634	2.884	3.134	3.384	3.634	3.884	4.134	4.384
18	.049	.152	.277	.402	.527	.652	.777	.902	1.152	1.402	1.652	1.902	2.152	2.402	2.652	2.902	3.152	3.402	3.652	3.902	4.152	4.402
19	.042	.166	.291	.416	.541	.666	.791	.916	1.166	1.416	1.666	1.916										
20	.035	.180	.305	.430	.555	.680	.805	.930	1.180	1.430	1.680	1.930										
21	.032	.186	.311	.436	.561	.686	.811	.936	1.186	1.436	1.686	1.935										
22	.028	.194	.319	.444	.569	.694	.819	.944	1.194	1.444	1.694	1.944										
23	.025	.200	.325	.450	.575	.700	.825	.950	1.200	1.450	1.700	1.950										
24	.022	.206	.331	.456	.581	.706	.831	.956	1.206	1.456	1.706	1.956										

*Above table does not allow for tube mill tolerance

Table to determine pipe size and schedule number

Nominal Pipe Size (in.)	O.D. (in.)	Schedule Number for Pipe Sizes Wall Thickness / Inside Diameter (Inches)							
		40	ID	80	ID	120	ID	160	ID
⅛	.405	.068	.269	.095	.215				
¼	.540	.088	.364	.119	.302				
⅜	.675	.091	.493	.126	.423				
½	.840	.109	.622	.147	.546			.187	.466
¾	1.050	.113	.824	.154	.742			.218	.614
1	1.315	.133	1.049	.179	.957			.250	.815
1¼	1.660	.140	1.380	.191	1.278			.250	1.160
1½	1.900	.145	1.510	.200	1.500			.281	1.338
2	2.375	.154	2.067	.218	1.939			.343	1.689
2½	2.875	.203	2.469	.276	2.323			.375	2.125
3	3.500	.216	3.068	.300	2.900			.437	2.626
3½	4.000	.226	3.548	.318	3.364				
4	4.500	.237	4.026	.337	3.826	.437	3.626	.531	3.438
5	5.563	.258	5.047	.375	4.813	.500	4.563	.625	4.313
6	6.625	.280	6.065	.432	5.761	.562	5.501	.718	5.189
8	8.625	.322	7.981	.500	7.625	.718	7.189	.906	6.813
10	10.750	.365	10.020	.593	9.564	.843	9.064	1.125	8.500
12	12.750	.406	11.938	.687	11.376	1.000	10.750	1.312	10.126