



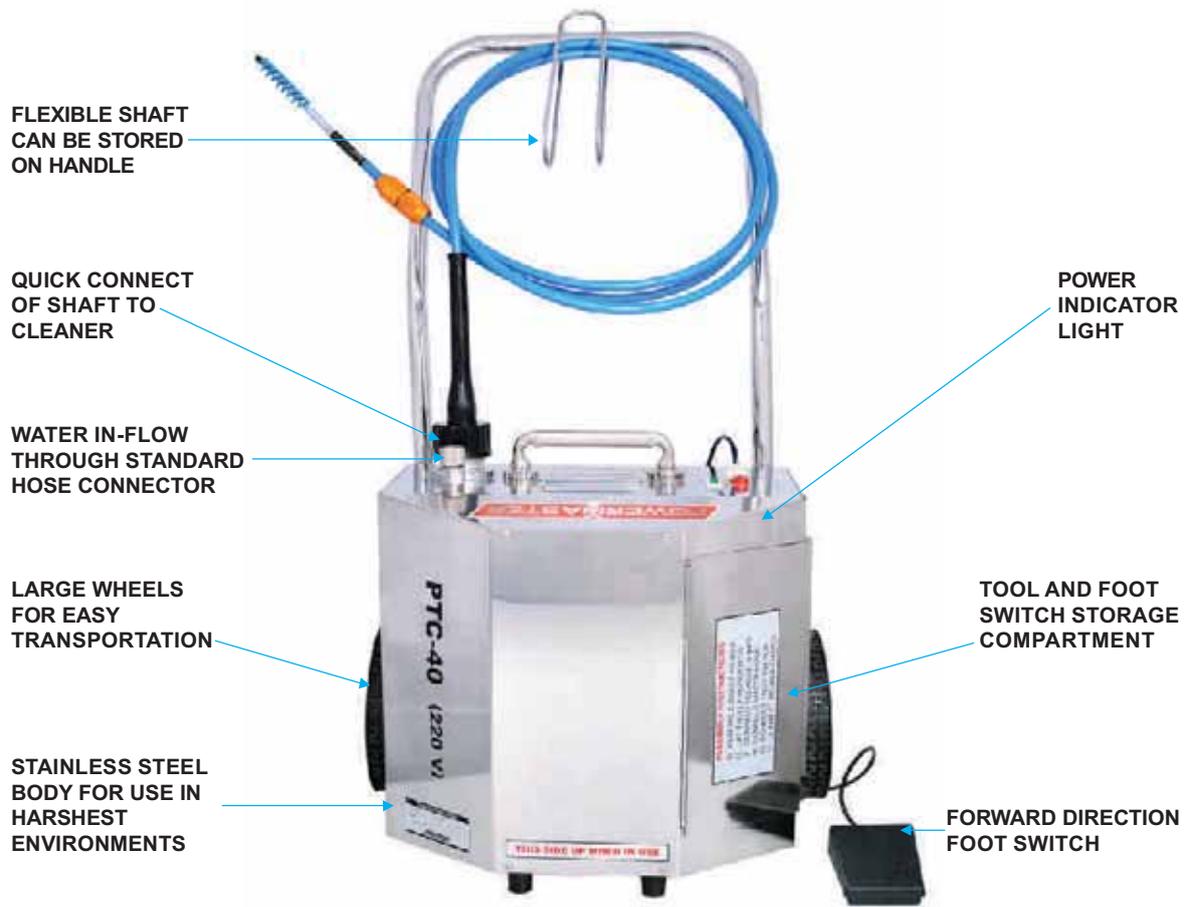
# TUBE CLEANERS

Page 93-116



1/4" & UP  
I.D.

**ELECTRIC TUBE CLEANERS**



FLEXIBLE SHAFT CAN BE STORED ON HANDLE

QUICK CONNECT OF SHAFT TO CLEANER

WATER IN-FLOW THROUGH STANDARD HOSE CONNECTOR

LARGE WHEELS FOR EASY TRANSPORTATION

STAINLESS STEEL BODY FOR USE IN HARSH ENVIRONMENTS

POWER INDICATOR LIGHT

TOOL AND FOOT SWITCH STORAGE COMPARTMENT

FORWARD DIRECTION FOOT SWITCH

*Features :*

- Water flushes through the shaft and helps remove deposits from tube.
- Forward direction foot switch enables operator to concentrate on cleaning operation without worrying about cleaner.
- Flexible shaft can be easily disconnected.
- Stainless steel body for use in the harshest environments.
- Easy interchangeability of various shafts and accessories for maximum versatility.
- Large wheels for easy transportation.
- Water consumption can be regulated as needed.

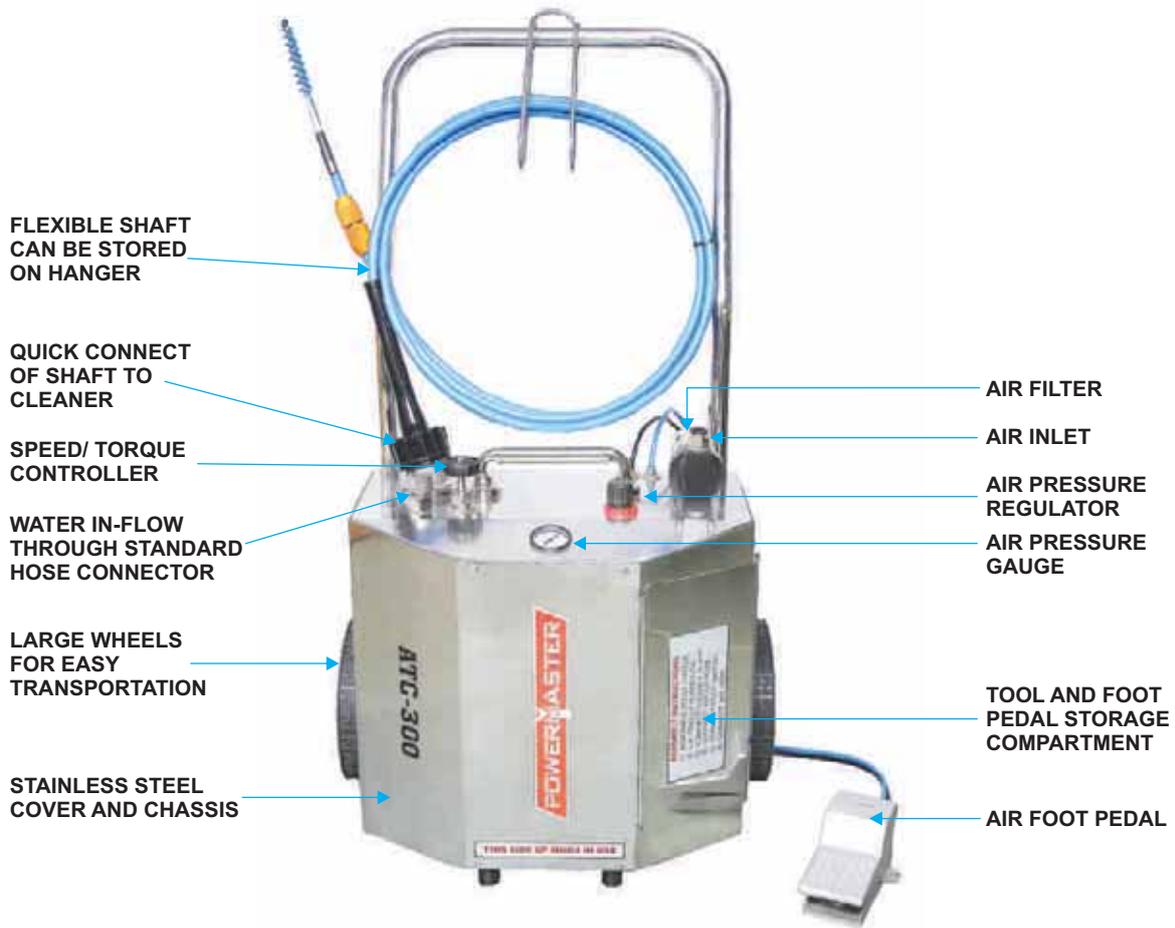
Electric Tube Cleaners are environment friendly, compact and easily maneuverable units used to clean straight and curved tubes in heat exchangers, condensers, boilers and other tubular apparatus. They work by attaching a cleaning tool (to be determined on type of deposit to be cleaned) to a flexible shaft. The Electric Tube Cleaner provides rotary motion to the flexible shaft which rotates the cleaning tool inside the tube. If needed water passes through the flexible shaft to aid in flushing out of the deposits. All Electric Tube Cleaners are supplied with forward direction foot switch. Dual direction foot switches are available on request.

Tube I.D.		Tube Cleaner Model No.	Motor Power		Motor Speed RPM	Weight		Dimension		
mm	inch		HP	kW		lbs.	Kg.	High	Wide	Deep
6.4-25.4	1/4-1	PTC-40	1/2	0.40	890	62	28	38"(975mm)	21"(535mm)	18"(457mm)
6.4-25.4	1/4-1	PTC-60	3/4	0.60	890	66	30	38"(975mm)	21"(535mm)	18"(457mm)
25.4 & UP	1 & UP	PTC-75	1	0.75	1780	70	32	38"(975mm)	21"(535mm)	18"(457mm)
25.4 & UP	1 & UP	PTC-150	2	1.50	1780	84	38	40"(1015mm)	22"(560mm)	19"(482mm)

All units available in your choice of :  
 110v 60Hz, 110v 50Hz - 9 Amps.  
 220v 60Hz, 220v 50Hz - 4.5 Amps.  
 Please Specify when ordering.

# PNEUMATIC TUBE CLEANERS

1/4" & UP  
I.D.



## Features :

- Shock Resistant - Excellent for applications where using electric equipment is hazardous.
- Corrosion Resistant - Stainless steel cover and chassis for long life.
- Versatile - Interchangeability of different size flexible shafts and cleaning tools.
- Speed/Torque control - Shaft rotation can be set at optimum speed for each application.
- No Tooling - Quick disconnect of flexible shaft.
- Easy Maneuverability - Large Wheels.
- Time Saving - Simultaneous water flush to remove deposits from tubes.
- Cleanliness - Foot pedal for operator convenience to activate shaft rotation and water flow to reduced water consumption and cleaner working area.

Powermaster Model ATC-300 Extra Heavy Duty Pneumatic Tube Cleaning Machine includes air filter, regulator, lubricator, adjustable speed/torque control, mobile dolly, tool storage box and air foot pedal.

The ATC-300 uses a cleaning tool mounted to the tip of a flexible shaft, which is available in different lengths and diameters to fit the size of the tube to be cleaned. For wet applications as the shaft rotates inside its watertight nylon casing, the unit feeds water through the casing to the cleaning tool. A foot pedal controls shaft rotation and water flow. While the operator feeds the rotating shaft assembly through the tube, the water flushes out deposits as they are loosened.

Tube I.D.		Tube Cleaner Model No.	Motor Power		Motor Speed RPM	Weight		High	Dimension	
mm	inch		HP	KW		lbs.	Kg.		Wide	Deep
6.4 & UP	1/4 & UP	ATC-300	4	3.00	300-3000	64	29	38"(975mm)	22"(560mm)	16"(406mm)



**ELECTRIC TUBE CLEANING SYSTEMS**

**MODEL TCS-40 CHILLER TUBE CLEANING SYSTEM**

**MODEL TCS-40** Chiller Tube Cleaning System is the most common package used for cleaning 5/8" I.D. tubes of Trane, Blue Star, Thermax, Carrier, York, and other units.

- CONTENTS**
- PTC - 40 Tube Cleaner - 1 no.
  - PFS - 500-79 Flexible Shafts - 2 nos.
  - Nylon Brushes (specify size) - 25 nos.
  - PBT-1, 2, 3 or 4 Buffing tools (specify size) - 2 nos.
  - Replacement blades for Buffing Tools - 8 nos.
  - Repair kit for flexible shaft PFS-500 consisting of 4 drive end couplings, 4 tool end couplings, 1 shaft repair tool with hammer, 1 flexible shaft lubricator and 2 bottles of lubricant.



**PTC-40 TUBE CLEANER**



**FLEXIBLE SHAFT**



**NYLON BRUSH**



**BUFFING TOOL**



**REPLACEMENT BLADES**



**SHAFT REPAIR TOOL**



**REPAIR KIT**

**MODEL TCS-60 CHILLER TUBE CLEANING SYSTEM**

**MODEL TCS-60** Chiller Tube Cleaning System is similar to the TCS-40 Tube Cleaning System, but uses a more powerful 3/4 HP motor for tougher deposits. A dual direction foot switch is provided for cleaning internally grooved tubes.

- CONTENTS**
- PTC - 60 Tube Cleaner - 1 nos.
  - PFS - 500 - 140 Flexible Shafts - 2 nos.
  - Nylon Brush (specify size) - 25 nos.
  - Repair kit for flexible shaft PFS - 500 consisting of 4 drive end couplings, 4 tool end couplings, 1 shaft repair tool with hammer, 1 flexible shaft lubricator and 2 bottles of lubricant.



**PTC-60 TUBE CLEANER**



**FLEXIBLE SHAFT**



**NYLON BRUSH**



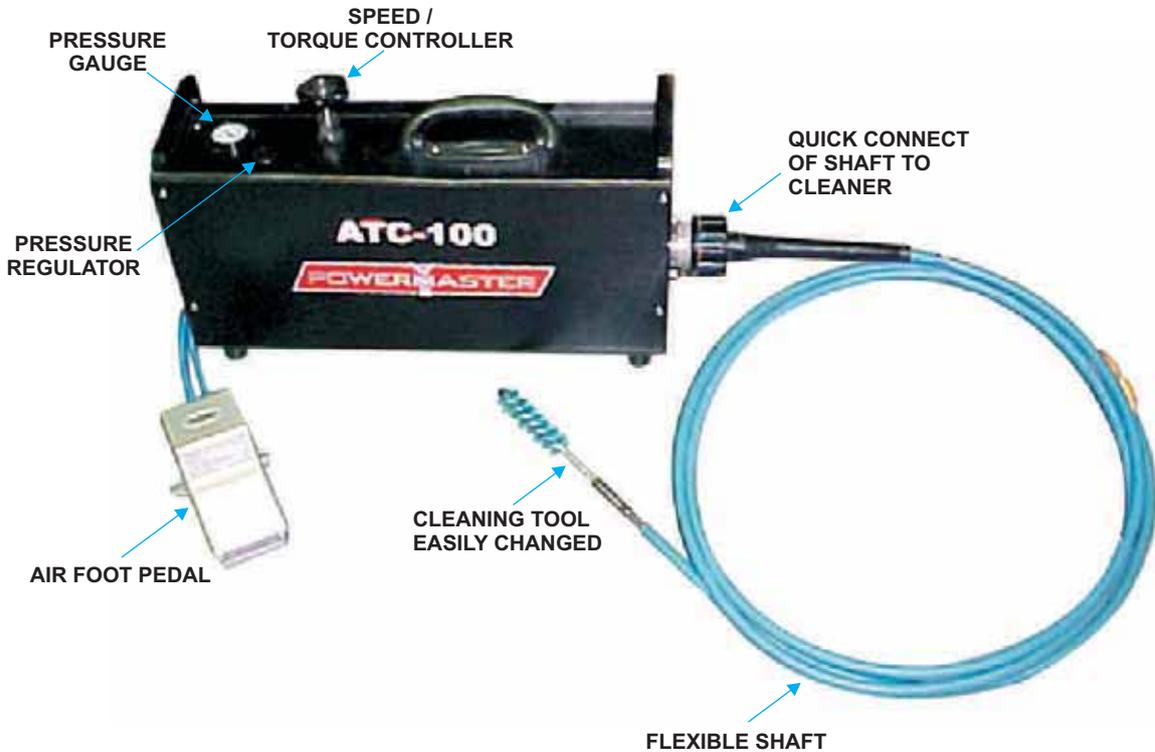
**SHAFT REPAIR TOOL**



**REPAIR KIT**

# PORTABLE PNEUMATIC TUBE CLEANERS

1/4" & UP  
I.D.



## Features :

- Shock Resistant - Excellent for applications where use of electric equipment is hazardous.
- Versatile - Interchangeability of different size flexible shafts and cleaning tools.
- Speed/Torque control - Shaft rotation speed can be set at optimum for each application.
- No Tooling - Quick disconnection of flexible shaft.
- Time Saving - Simultaneous water flush to remove deposits from tubes.
- Cleanliness - Foot switch for operator's convenience to activate both shaft rotation and water flow to reduce water consumption and making working area clean.
- Compact - Light weight easy to operate inside drum.

Model-ATC-100 Portable Pneumatic Tube Cleaning Machine includes FRL unit, adjustable speed/torque control, and air foot pedal. The ATC-100 uses a cleaning tool mounted on the tip of a flexible shaft, which is available in different lengths and diameters to fit the size of the tube to be cleaned. For wet applications, as the shaft rotates inside its watertight nylon casing, the unit feeds water through the casing to the cleaning tool.

A foot switch controls shaft rotation and water flow. While the operator feeds the rotating shaft assembly through the tube, the waterflow softens the deposits before cleaning and flushes them out during cleaning.

Tube I.D. mm	Tube I.D. inch	Tube Cleaner Model No.	Motor Power		Motor Speed RPM	Air Supply		Weight		Dimension		
			HP	KW		Min	Max	lbs.	Kg.	High	Wide	Deep
6.4 & UP	1/4 & UP	ATC-100	1.7	1.1	300-3000	60psi @ 15cfm	100psi @ 70cfm	26	12	10.3/8"(655mm)	6"(152mm)	19"(483mm)



**'PORTO' PORTABLE ELECTRIC TUBE CLEANERS**



*Features :*

- Compact and portable for use in multiple locations.
- Easy connect and disconnect of various shafts and cleaning tools.
- Foot Switch enables operator to concentrate on cleaning operation.
- Water moving through shaft flushes out deposits already dislodged by cleaning tools.

The 'PORTO' is built for users to whom a small size and easy transportation means they can clean more tubes faster. Used to clean 1/4" - 1" I.D. tubes in chillers, condensers, evaporators and heat exchangers. The flexible shaft rotates at 1760 rpm as water feeds through the nylon casing to the cleaning tool. As the tool removes the deposits, the water flow flushes them out. A solenoid valve ensures that water flows only when the machine is running. Water consumption can be regulated as needed.

Tube I.D.		Tube Cleaner Model No.	Motor Power		Motor Speed RPM	Weight		High	Dimension	
mm	inch		HP	KW		lbs.	Kg.		Wide	Deep
6.4-25.4	1/4-1	PORTO	1/2	0.40	1760	36	16	10"(254mm)	11"(279mm)	18"(457mm)

All units available in your choice of :  
 110v 60Hz, 110v 50Hz - 9 Amps. 220v 60Hz, 220v 50Hz - 4.5 Amps.  
 Please Specify when ordering.

**'TCS-PORTO' PORTABLE ELECTRIC TUBE CLEANINGS SYSTEM**

**MODEL TCS-PORTO CHILLER TUBE CLEANING SYSTEM**

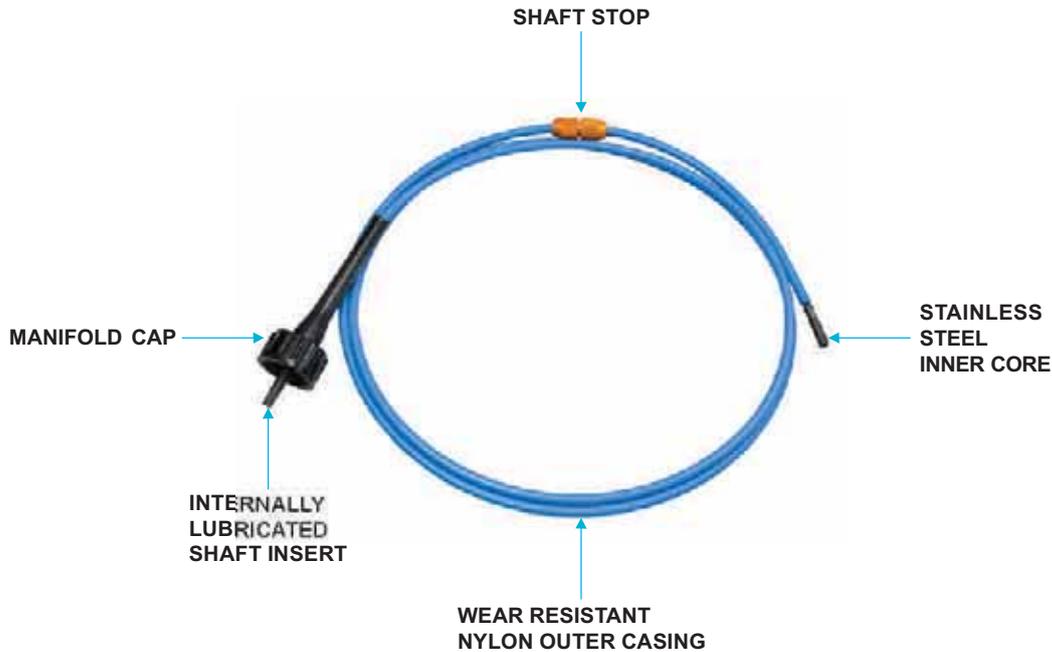
**Model TCS-PORTO** Chiller tube cleaning system is the most common system for cleaning chillers by users to whom size and portability is paramount.

- CONTENTS**
- 'PORTO' Portable Tube Cleaner - 1 no.
  - PFS - 500 - 140 Flexible Shafts - 2 nos.
  - Nylon Brush (specify size) - 25 nos.
  - Repair kit for flexible shaft PFS-500 consisting of 4 drive end couplings, 4 tool end couplings, 1 shaft repair tool with hammer, 1 flexible shaft lubricator and 2 bottles of lubricant.



# FLEXIBLE SHAFTS

1/4" - 1"  
I.D.



## For PTC-40, PTC-60 FLEXIBLE SHAFTS WITH STAINLESS STEEL INNER CORE

When ordering flexible shafts and accessories, each item should be ordered for specific tube/pipe size or size range. Shafts have color coded shaft stops for easy identification. Stainless Steel inner cores ensure our shafts have longest life, flexibility and resistance to corrosion. Since the inner core of the shafts are the heart of the system and take most of the strain, stainless steel inner cores cause our shafts to last longer than the competition.

To order Flexible Shaft(s), determine tube I.D.(s) and length of the longest tube(s). Order Flexible Shaft(s) to correspond with tube I.D.(s) and lengths. Please ask us for special or longer lengths.

Tube I.D. Range mm	Tube I.D. Range inch	Flexible Shaft Model No.	Flexible Shaft Length		Shaft Core O.D.		Shaft Casing O.D.		Tool End Thread
			feet	mtrs	mm	inch	mm	inch	
6.4-9.5	1/4-3/8	PFS-250-40	13	4.0	3.2	1/8	6.4	1/4	8 - 32 F
		PFS-250-79	26	7.9					
11.1-12.7	7/16-1/2	PFS-375-40	13	4.0	6.4	1/4	9.5	3/8	1/4 -28 F
		PFS-375-55	18	5.5					
		PFS-375-79	26	7.9					
		PFS-375-110	36	11.0					
		PFS-375-140	46	14.0					
14.3-25.4	9/16-1	PFS-500-40	13	4.0	7.9	5/16	12.7	1/2	1/4 -28 F
		PFS-500-55	18	5.5					
		PFS-500-79	26	7.9					
		PFS-500-110	36	11.0					
		PFS-500-140	46	14.0					
		PFS-500-184	61	18.4					
		PFS-500-232	76	23.2					

## FLEXIBLE SHAFTS FOR INTERNALLY GROOVED TUBES

Tube I.D. Range mm	Tube I.D. Range inch	Flexible Shaft Model No.	Flexible Shaft Length		Shaft Core O.D.		Shaft Casing O.D.		Tool End Thread
			feet	mtrs	mm	inch	mm	inch	
17.5-25.4	11/16-1	PFS-560-40	13	4.0	9.5	3/8	14.3	9/16	1/4 - 28
		PFS-560-55	18	5.5					
		PFS-560-79	26	7.9					
		PFS-560-110	36	11.0					
		PFS-560-140	46	14.0					
		PFS-560-186	61	18.6					
		PFS-560-232	75	23.2					

**Note :** PFS - 560 shafts can be supplied with Teflon<sup>®</sup> casing for when using dry. To order add suffix "T" to shaft number. Teflon is a trademark of Du Pont Company.

**Note:** See page 102 for shaft repair equipment.



## BRUSHES

**NYLON BRUSHES** Used for removing soft scales in ferrous (carbon steel, stainless steel) and non-ferrous tubes (copper, brass, plastic, etc.) and for final 'finishing' of tubes.



NYLON BRUSH

**STAINLESS STEEL BRUSHES** Used for removing soft and light scale deposits in ferrous tubes (carbon steel, stainless steel, etc.).



STAINLESS STEEL BRUSH

**BRASS BRUSHES** Used for removing soft and light scale deposits in straight, non-ferrous tubes. (Copper, brass, nickel and their alloyed tubes).



BRASS BRUSH

Brush O.D.		Nylon Brush	Stainless Steel	Brass Brush	Threading	Coupling
mm	inch					
6.4	1/4	N - 250	SS - 250	B - 250	8 - 32F	P-1 (8 - 32M x 8 - 32M)
7.9	5/16	N - 312	SS - 312	B - 312	8 - 32F	P-1 (8 - 32M x 8 - 32M)
9.5	3/8	N - 375	SS - 375	B - 375	12 - 24F	P-2 (8 - 32M x 12 - 24M)
11.1	7/16	N - 437	SS - 437	B - 437	1/4 - 28M	-
12.7	1/2	N - 500	SS - 500	B - 500	1/4 - 28M	-
14.3	9/16	N - 562	SS - 562	B - 562	1/4 - 28M	-
15.9	5/8	N - 625	SS - 625	B - 625	1/4 - 28M	-
17.5	11/16	N - 687	SS - 687	B - 687	1/4 - 28M	-
19.1	3/4	N - 750	SS - 750	B - 750	1/4 - 28M	-
20.6	13/16	N - 812	SS - 812	B - 812	1/4 - 28M	-
22.2	7/8	N - 875	SS - 875	B - 875	1/4 - 28M	-
23.8	15/16	N - 937	SS - 937	B - 937	1/4 - 28M	-
25.4	1	N - 1000	SS - 1000	B - 1000	1/4 - 28M	-

- Brushes should be ordered so that brush O.D. is marginally less than tube I.D., for it to easily enter tube with deposit.

## DRILL TIP DOUBLE DIAMETER BRUSHES



DRILL TIP DOUBLE DIAMETER NYLON BRUSH



DRILL TIP DOUBLE DIAMETER BRASS BRUSH

Tube I.D.		Drill Tip Nylon Brush	Drill Tip Brass Brush
mm	inch		
15.9	5/8	DTBN-625	DTBB-625

## DRILL TIP DOUBLE DIAMETER BRUSHES

These brushes are used to clean internally grooved tubes. The drill tip of brushes cleans through hard scale before the brush cleaning action takes over. The large diameter of this brush cleans into the grooves of the tubes and the small diameter into the lands of the tube's rifling.

## COLOR CODED SHOOT THRU SCRUBBERS

Tube I.D.		Scrubber O.D. (inch)	Model	Color	Type
mm	inch				
12.57-13.74	0.495-0.541	0.560	SC-560-S	Gold	Soft
13.39-14.10	0.527-0.555	0.560	SC-560	Gold	Hard
14.50-15.75	0.570-0.620	0.630	SC-630-S	Brown	Soft
15.00-16.00	0.590-0.630	0.630	SC-630	Brown	Hard
15.75-17.15	0.620-0.675	0.695	SC-695-S	Orange	Soft
16.56-17.63	0.652-0.694	0.695	SC-695	Orange	Hard
16.76-18.54	0.660-0.730	0.750	SC-750-S	Violet	Soft
18.03-19.05	0.710-0.750	0.750	SC-750	Violet	Hard
18.54-20.32	0.730-0.800	0.825	SC-825-S	White	Soft
19.74-20.80	0.777-0.819	0.825	SC-825	White	Hard
19.81-21.60	0.780-0.850	0.870	SC-870-S	Lime	Soft
20.96-22.10	0.825-0.870	0.870	SC-870	Lime	Hard
22.10-24.00	0.870-0.944	0.960	SC-960-S	Blue	Soft
22.50-24.13	0.886-0.950	0.960	SC-960-M	Blue	Medium
22.91-24.28	0.902-0.956	0.960	SC-960	Blue	Hard
25.40-27.56	1.000-1.085	1.100	SC-1100-S	Black	Soft
26.09-28.09	1.027-1.106	1.100	SC-1100	Black	Hard

In most cases hard tube scrubbers are recommended for removing light to medium deposits in condensers. They work by being 'Shot Thru' the tubes with a high pressure air gun. Order tube scrubbers by model and color.

**Features :**

- Scrubbers are shot thru tubes with a gun using compressed air and water.
- The scraping disks will not damage inside of tubes.
- Scrubbers float for easy retrieval.
- Reuseable.



## CLEANING ACCESSORIES



**BUFFING TOOL**



**REPLACEMENT BLADES**



**BUFFING TOOL WITH DRILL TIP**

**BUFFING TOOLS** are used for final polishing or removal of light and soft deposits from ferrous and non-ferrous tubes that have been previously cleaned. Used in straight or very large radius tubes in a clockwise direction only.

Tube I.D.		Buffing Tool	With Drill Tip	Replacement Blades	Adjusting Tool
mm	inch				
7.9-9.5	5/16-3/8	PBT-1	PBT-1-T	PBB-1	PBT-AT
9.5-12.7	3/8-1/2	PBT-2	PBT-2-T	PBB-1	PBT-AT
12.7-14.3	1/2-9/16	PBT-3	PBT-3-T	PBB-2	-
15.9-25.4	5/8-1	PBT-4	PBT-4-T	PBB-3	-

**CARBIDE DRILLS** for heavily choked tubes

Tube I.D.		Carbide Drill
mm	inch	
6.4	1/4	CB-250
9.5	3/8	CB-375
11.1	7/16	CB-430
12.7	1/2	CB-500
14.3	9/16	CB-560
15.9	5/8	CB-625
17.5	11/16	CB-680



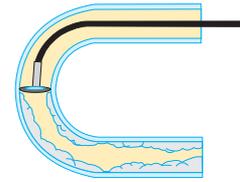
**CARBIDE DRILL**

**CARBIDE DRILLS** are used for cleaning tubes choked solidly with hard deposits.



CLEANING ACCESSORIES

**U-TUBE TOOLS** These tools are used to clean tubes that have sharp bends in them. They consist of a brush or cobalt tip mounted on a piece of flexible shaft so the tool can negotiate the bend.



**CUP BRUSH TOOLS - Brass or Stainless Steel**

Tube I.D.		Cup Brush Tools
mm	inch	
12.7-19.1	1/2-3/4	CBT-500B
12.7-19.1	1/2-3/4	CBT-500SS



CUP BRUSH TOOL

**WHEEL BRUSH TOOLS - Brass or Stainless Steel**

Tube I.D.		Wheel Brush Tools
mm	inch	
20.6-25.4	13/16-1	WBT-813B
20.6-25.4	13/16-1	WBT-813SS



WHEEL BRUSH TOOL

**COBALT TIP TOOLS**

Tube I.D.		Cobalt Tip Tools
mm	inch	
12.7	1/2	CTT-500
15.9	5/8	CTT-625



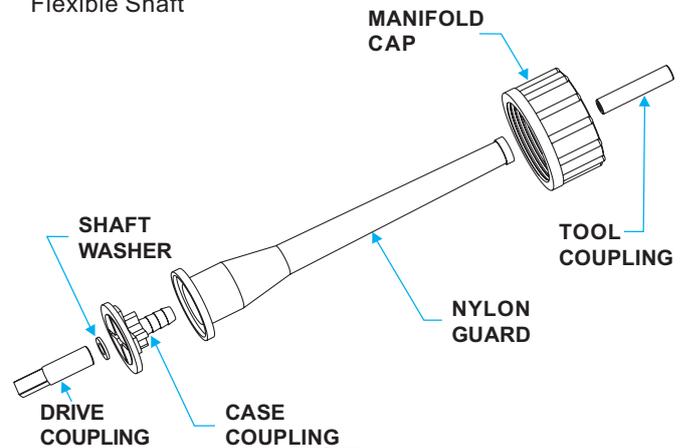
COBALT TIP TOOL

For sizes not listed above please contact us.

**SHAFT REPLACEMENT COUPLINGS**

Flexible Shaft Model	PFS-250	PFS-375	PFS-500	PFS-560	PFS-750
Tool Coupling	TC-250	TC-375	TC-500	TC-560	TC-750
Case Coupling	CC-250	CC-375	CC-500	CC-560	CC-750
Manifold Cap	MC-1	MC-1	MC-1	MC-1	MC-1
Shaft Washer	3/16x3/4	5/16x3/4	7/16x3/4	9/16x7/8	11/16x1
Drive Coupling	DC-250	DC-375	DC-500	DC-560	DC-750
Nylon Guard	NG-250	NG-250	NG-500	NG-500	NG-750

**FLEXIBLE SHAFT REPAIR AND MAINTENANCE**  
For PFS-250, PFS-375, PFS-500, PFS-560 and PFS-750 Flexible Shaft



**SHAFT REPAIR TOOL** allows users to quickly and safely attach couplings onto the shaft ensuring maximum useful life for the shaft.

- SHT-1 Shaft Repair Tool with Hammer.
- SHP-1 Replacement Hammer.



SHAFT REPAIR TOOL

**FLEXIBLE SHAFT LUBRICATOR** is used to lubricate flexible shafts for maximum useful life. They are also used to lubricate shafts prior to storage. The lubricator is filled with a water soluble lubricant that enters and lubricates the shaft when air supply is provided to the lubricator. The residue lubricant washes out with water when the shaft is used again.

- PFSL-1 Flexible Shaft Lubricator.
- PLUBE Lubricant for flexible shaft lubricator, 8 ounces (0.25 litres).



LUBRICANT



FLEXIBLE SHAFT LUBRICATOR



FLEXIBLE SHAFT

## For PTC-75, PTC-150

To order flexible shaft(s), determine tube I.D.(s) and length of longest tubes. Order flexible shaft(s) to correspond with tube I.D.(s) and lengths. (Consult factory for longer shafts if required.)

### FLEXIBLE SHAFTS (Wet application - Nylon casing) for tubes 1" (25.4mm) I.D. and UP

Tube I.D. Range		Flexible Shaft Model No.	Flexible Shaft Length		Shaft Core O.D.		Shaft Casing O.D.		Tool End Thread
mm	inch		feet	mtrs	mm	inch	mm	inch	
25.4	1	PFS-750-49	16	4.9	12.7	1/2	19.1	3/4	1/2 - 12F
		PFS-750-79	26	7.9					
		PFS-750-110	36	11.0					
		PFS-750-155	51	15.5					



FLEXIBLE SHAFT

### FLEXIBLE SHAFTS (Dry application - Steel casing) for tubes 1" (25.4mm) I.D. and UP

Tube I.D. Range		Flexible Shaft Model No.	Flexible Shaft Length		Shaft Core O.D.		Shaft Casing O.D.		Tool End Thread
mm	inch		feet	mtrs	mm	inch	mm	inch	
25.4	1	PFS-875-49	16	4.9	12.7	1/2	22.2	7/8	1/2 - 12F
		PFS-875-79	26	7.9					
		PFS-875-110	36	11.0					
		PFS-875-155	51	15.5					

### FLEXIBLE SHAFTS (Dry application - Stainless steel casing) for tubes 1" (25.4mm) I.D. and UP

Tube I.D. Range		Flexible Shaft Model No.	Flexible Shaft Length		Shaft Core O.D.		Shaft Casing O.D.		Tool End Thread
mm	inch		feet	mtrs	mm	inch	mm	inch	
25.4	1	PFS-875-49-SS	16	4.9	12.7	1/2	22.2	7/8	1/2 - 12F
		PFS-875-79-SS	26	7.9					
		PFS-875-110-SS	36	11.0					
		PFS-875-155-SS	51	15.5					

## BRUSHES

**NYLON BRUSHES** Recommended for removing soft scales in straight, non-ferrous tubes. (copper, brass, plastic, etc.) and ferrous (stainless steel, carbon steel) and for final 'finishing' of tubes. Order brush so that brush O.D. is marginally smaller than tube I.D.

**BRASS BRUSHES** Recommended for removing soft and light scale deposits in straight, non-ferrous tubes. Order brush so that brush O.D. is marginally smaller than tube I.D.

**STAINLESS STEEL BRUSHES** Recommended for removing soft and light scale deposits in straight, ferrous tubes. (carbon steel, stainless steel, etc.). Order brush so that brush O.D. is marginally smaller than tube I.D.

Brush O.D.		Nylon Brush	Brass Brush	Stainless Steel
mm	inch			
31.7	1.1/4	N - 1250	B - 1250	SS - 1250
38.1	1.1/2	N - 1500	B - 1500	SS - 1500
44.5	1.3/4	N - 1750	B - 1750	SS - 1750
51.0	2	N - 2000	B - 2000	SS - 2000
57.1	2.1/4	N - 2250	B - 2250	SS - 2250
63.5	2.1/2	N - 2500	B - 2500	SS - 2500
70.0	2.3/4	N - 2750	B - 2750	SS - 2750
76.2	3	N - 3000	B - 3000	SS - 3000
82.6	3.1/4	N - 3250	B - 3250	SS - 3250
89.0	3.1/2	N - 3500	B - 3500	SS - 3500
95.2	3.3/4	N - 3750	B - 3750	SS - 3750
101.6	4	N - 4000	B - 4000	SS - 4000



NYLON BRUSH



BRASS BRUSH



STAINLESS STEEL BRUSH

1" & UP  
I.D.

**BRUSHES & ACCESSORIES**

**CARBON STEEL BRUSHES** Recommended for removing soft and light scale deposits in straight, ferrous tubes. Order brush so that brush O.D. is marginally smaller than tube I.D.

**PLASTIC BRUSHES** Recommended for removing soft deposits in straight, ferrous and non-ferrous tubes and for final 'finishing' up of cleaning in hoses, tubes and pipes. Order brush so that brush O.D. is marginally smaller than tube I.D.

Brush O.D.		Carbon Steel	Plastic Brush
mm	inch		
127.0	5	CS - 5000	P - 5000
152.4	6	CS - 6000	P - 6000
178.0	7	CS - 7000	P - 7000
203.2	8	CS - 8000	P - 8000
228.6	9	CS - 9000	P - 9000
254.0	10	CS - 10000	P - 10000
279.4	11	CS - 11000	P - 11000
305.0	12	CS - 12000	P - 12000
330.2	13	CS - 13000	P - 13000
355.6	14	CS - 14000	P - 14000

**Note :** Brushes over 1" O.D. require # TCB-C coupling to connect to PFS-750, PFS-875 and PFS-875-SS



**CARBON STEEL BRUSH**



**PLASTIC BRUSH**

**DRILL TIP DOUBLE DIAMETER BRUSHES**

These brushes are used to clean internally grooved tubes. The drill tip of brushes cleans through hard scale before the brush cleaning action takes over. The large diameter of this brush, cleans into the grooves of the tubes and the small diameter into the lands of the tube's rifling.

Tube I.D.		Drill Tip Nylon Brush	Drill Tip Brass Brush
mm	inch		
25.4	1	DTBN-1000	DTBB-1000
31.7	1.1/4	DTBN-1250	DTBB-1250



**DRILL TIP NYLON BRUSH**



**DRILL TIP BRASS BRUSH**

**CIRCULAR BRUSH TOOLS FOR STRAIGHT TUBES**

These tools consist of 4 stainless steel circular brushes that are mounted on a shaft and connected to a Universal Joint. These tools are used to clean soft to medium scales. Replacement circular brushes can be ordered when wear starts.



**CIRCULAR BRUSH  
(FOR STRAIGHT TUBES)**

Straight Tube I.D.		Circular Brush Tool Model	Brush O.D.		Spare Brush Model (4 needed)	Spare Universal Joint Model
mm	inch		mm	inch		
28.6-33.3	1.1/8-1.5/16	CBTS-1125	25.4	1	CBSB-1125	UCT-1063
35.0-39.7	1.3/8-1.9/16	CBTS-1375	31.7	1.1/4	CBSB-1375	UCT-1063
41.3-47.1	1.5/8-1.13/16	CBTS-1625	38.1	1.1/2	CBSB-1625	UCT-1063
47.6-52.6	1.7/8-2.1/16	CBTS-1875	44.5	1.3/4	CBSB-1875	UCT-1250
54.0-58.7	2.1/8-2.5/16	CBTS-2125	51.0	2	CBSB-2125	UCT-1250
60.3-65.1	2.3/8-2.9/16	CBTS-2375	57.1	2.1/4	CBSB-2375	UCT-1250
66.7-71.6	2.5/8-2.13/16	CBTS-2625	63.5	2.1/2	CBSB-2625	UCT-1250
73.0-77.8	2.7/8-3.1/16	CBTS-2875	70.0	2.3/4	CBSB-2875	UCT-1250
79.4-84.2	3.1/8-3.5/16	CBTS-3125	76.2	3	CBSB-3125	UCT-1250

**Note :** For larger sizes, please enquire.

## CIRCULAR BRUSH TOOLS FOR CURVED TUBES

These tools consist of 2 stainless steel circular brushes that are mounted onto a Double Universal Joint for maximum flexibility. These tools are used to clean soft to medium scales. Replacement circular brushes can be ordered when wear starts.



CIRCULAR BRUSH (FOR CURVED TUBES)

Curved Tube I.D.		Circular Brush Tool Model	Brush O.D.		Spare Brush Model (2 needed)	Spare Universal Joint Model
mm	inch		mm	inch		
31.7-35.6	1.1/4-1.7/16	CBTC-1125	25.4	1	CBSB-1125	UCT-1500
38.1-42.9	1.1/2-1.11/16	CBTC-1500	31.7	1.1/4	CBSB-1375	UCT-1500
44.5-49.2	1.3/4-1.15/16	CBTC-1750	38.1	1.1/2	CBSB-1625	UCT-1500
51.0-55.6	2-2.3/16	CBTC-2000	44.5	1.3/4	CBSB-1875	UCT-1250
57.1-61.9	2.1/4-2.7/16	CBTC-2250	51.0	2	CBSB-2125	UCT-1250
63.5-68.3	2.1/2-2.11/16	CBTC-2500	57.1	2.1/4	CBSB-2375	UCT-1250
70.0-74.6	2.3/4-2.15/16	CBTC-2750	63.5	2.1/2	CBSB-2625	UCT-1250
76.2-81.0	3-3.3/16	CBTC-3000	70.0	2.3/4	CBSB-2875	UCT-1250
82.6-90.6	3.1/4-3.9/16	CBTC-3250	76.2	3	CBSB-3125	UCT-1250

**Note :** For larger sizes, please enquire.



BUFFING TOOL



BUFFING TOOL WITH DRILL TIP



REPLACEMENT BLADES

## BUFFING TOOLS for Tubes/Pipes 1"-3" (25.4-76.2mm) I.D.

Buffing tool are used for final polishing or removal of light and soft deposits from ferrous and non-ferrous tubes that have been previously cleaned.

Used in straight or very large radius tubes in a clockwise direction only.

**PBT-7** Buffing Tools for tubes 1"-3" (25.4-76.2mm) I.D.

**PBT-7-T** Buffing Tools for tubes 1"-3" (25.4-76.2mm) with drill tip.

**PBB-5** Replacement Blades for PBT-7.

## CARBIDE DRILLS for Heavily choked tubes.

Carbide Drills are used for cleaning tubes choked solidly with hard deposits.

Tube I.D.		Carbide Drill
mm	inch	
19.1	3/4	CB-750
22.2	7/8	CB-875
25.4	1	CB-1000



CARBIDE DRILL



CLEANING ACCESSORIES

**CONE CUTTER TOOLS** These tools use patented ergocentric cutters to clean hard scale from typically larger tubes that are found in boilers. The ergocentric cutters ensure that the same tooth does not touch the same spot when cleaning and prevents grooves being formed in the tube scale. All cone cutter tools are fitted with universal joints to negotiate bends in curved tubes.

**ONE CONE TOOL** These consist of 1 Cone fitted onto a Universal Joint and are used when scale build up is not severe.

**TWO CONE TOOL** These consist of 2 Cones fitted onto a Universal Joint and are used when scale build up is severe.



SPARE CONE

Straight Tube I.D.		Curved Tube I.D.		One Cone Tool Model	Two Cone Tool Model	Cone Diameter		Spare Cone Model	Spare Universal Joint Model
m m	inch	m m	inch			m m	inch		
27.0-33.3	1.1/16-1.5/16	30.2-36.5	1.3/16-1.7/16	OCT-1063	TCT-1063	23.8	15/16	SCT-937	UCT-1063
31.7-36.5	1.1/4-1.7/16	36.5-42.9	1.7/16-1.11/16	OCT-1250	TCT-1250	27.0	1.1/16	SCT-1062	UCT-1250
35.0-39.7	1.3/8-1.9/16	42.9-49.2	1.11/16-1.15/16	OCT-1375	TCT-1375	30.2	1.3/16	SCT-1187	UCT-1250
38.1-46.0	1.1/2-1.13/16	49.2-55.5	1.15/16-2.3/16	OCT-1500	TCT-1500	36.5	1.7/16	SCT-1437	UCT-1250
44.5-58.7	1.3/4-2.1/16	55.5-61.9	2.3/16-2.7/16	OCT-1750	TCT-1750	42.9	1.11/16	SCT-1687	UCT-1250
50.8-60.3	2-2.3/8			OCT-2000	TCT-2000	49.2	1.15/16	SCT-1937	UCT-1250



ONE CONE TOOL



TWO CONE TOOL



THREE CONE TOOL

**THREE CONE TOOL**

These consist of 3 Cones fitted onto a base which is fitted with a Universal Joint and are used for cleaning larger (2.5/16" I.D. and up) tubes where scale build up is severe.

Straight Tube I.D.		Curved Tube I.D.		Three Cone Tool Model	Spare Cone Model	Spare Base Model	Spare Universal Joint Model
m m	inch	m m	inch				
58.7-73.0	2.5/16-2.7/8	61.9-79.4	2.7/16-3.1/8	PCT-2313	SCT-937	CTB-2313	UCT-1250
71.4-85.7	2.13/16-3.3/8	77.8-93.7	3.1/16-3.11/16	PCT-2813	SCT-937	CTB-2813	UCT-1250
84.1-96.8	3.5/16-3.13/16	92.1-103.2	3.5/8-4.1/16	PCT-3313	SCT-1062	CTB-2813	UCT-1250

**SCRAPER TOOLS**

Scraper Tools use scrapper blades that 'fly out' when the tool is rotated, coming into contact with scale and scraping it out. These tools can be coupled with brushes for simultaneous 'finishing' of the cleaning operation as with carbide drills to initially drill through tubes that have very hard deposits.

Straight Tube I.D.		Curved Tube I.D.		Scraper Tool Model
m m	inch	m m	inch	
20.6-39.7	13/16-1.9/16	23.8-46.0	15/16-1.13/16	SCR-813
36.5-58.7	1.7/16-2.1/16	42.9-65.1	1.11/16-2.9/16	SCR-1438
42.9-77.8	1.11/16-3.1/16	61.9-77.8	2.7/16-3.1/16	SCR-1687



FLEX HUB ASSEMBLY



REPLACEMENT BLADES



CARBIDE DRILL



UNIVERSAL JOINT

**SPARES FOR SCRAPER TOOLS**

- Model **SCR-813-SB** Spare Set of 3 Scraping Blades for SCR-813.
- Model **SCR-1438-SB** Spare Set of 3 Scraping Blades for SCR-1438.
- Model **SCR-1687-SB** Spare Set of 3 Scraping Blades for SCR-1687.
- Model **CB-750** Carbide Drill for use with SCR-1438 Scraper tool to drill through tubes with very hard deposits.
- Model **CB-875** Carbide Drill for use with SCR-1687 Scraper tool to drill through tubes with very hard deposits.
- Model **UCT-1250** Universal Joint for use with scraper tool for use with curved tubes.

## COMBINATION CONE-CARBIDE DRILL TOOL

These combination tools use the extreme hardness of a carbide drill coupled with the ergocentric cleaning properties of cone cleaning cutters to drill through and simultaneously clean tubes that are choked with very hard deposits.

Tube I.D.		Combination Cone-Carbide Drill Tool Model
mm	inch	
23.8-27.0	15/16-1.1/16	CCD-938
27.0-30.2	1.1/16-1.3/16	CCD-1063
30.2-36.5	1.3/16-1.7/16	CCD-1188
36.5-42.9	1.7/16-1.11/16	CCD-1438
42.9-49.2	1.11/16-1.15/16	CCD-1687



COMBINATION CONE-CARBIDE DRILL TOOL

## CYLINDER CUTTER TOOL

These tools are used typically in boilers and other larger tubes that have a light to medium deposit. These tools use patented ergonomic cutting wheels that ensure the same tooth of the cutter wheel does not touch the same spot when cleaning. This prevents grooves being formed in the tube scale. The cutters 'fly out' when the tool is rotated and perform cleaning action.

Tube I.D.		Cylinder Cutter Tool Model	Spare Cylinder Cutter Model
mm	inch		
36.5-47.6	1.7/16-1.7/8	CCT-1438	CYC-1438
46.0-73.0	1.13/16-2.7/8	CCT-1813	CYC-1438
55.5-81.0	2.3/16-3.3/16	CCT-2188	CYC-2188
79.4-98.4	3.1/8-3.7/8	CCT-3125	CYC-2188



CYLINDER CUTTER TOOL

## WING TOOLS-STIFF ARM CUTTER

These tools use long stiff arms with patented cone cutters on their ends, that spread out when rotated. These tools are used to clean light to medium deposits in large diameter tubes and pipes.

Tube I.D.		Wing Tool-Stiff Arm Cutter Model	Spare Cone Cutter Model
mm	inch		
42.9-101.6	1.11/16-4	WTS-1688	SCT-937
100.0-165.1	3.15/16-6.1/2	WTS-3938	SCT-937



WING TOOLS-STIFF ARM CUTTER

## WING TOOLS-FLEXIBLE ARM CUTTER

These tools are similar in operation to the Stiff Arm Winged Tools, but patented Cone Cutters are attached onto flexible arms. These tools are used in typically very large vertical pipes and are used in cleaning pipes from top to bottom.

Tube I.D.		Wing Tool - Flexible Arm Cutter Model	Spare Cone Cutter Model
mm	inch		
100.0-309.0	3.15/16-12	WTF-3938	SCT-937

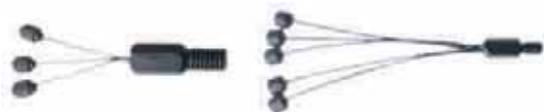


WING TOOLS-FLEXIBLE ARM CUTTER

## WING TOOLS-FLEXIBLE ARM-CARBIDE BALL TIP

These tools are similar in operation to the Flexible Arm Cutter Wing Tools except these use carbide balls for removing light scale in large diameter tubes and pipes.

Tube I.D.		Wing Tool - Flexible Arm Carbide Ball Tip Model	Number of Balls Used
mm	inch		
23.8-52.4	15/16-2.1/16	WTC-938	4
49.2-103.2	1.15/16-4.1/16	WTC-1938	6
100.0-204.8	3.15/16-8.1/16	WTC-3938	6



WING TOOLS-FLEXIBLE ARM-CARBIDE BALL TIP

## WING TOOLS-FLEXIBLE NYLON ROD

These tools are fitted with abrasive nylon rods that spread out when rotated. These tools are used to clean light deposits in thin tubes and pipes of exotic materials where damage to tubes is to be avoided.

Tube I.D.		Wing Tool - Flexible Nylon Rod Model
mm	inch	
49.2-431.8	1.15/16-17	WTN-1938



WING TOOLS-FLEXIBLE NYLON ROD



# SHAFT REPAIR

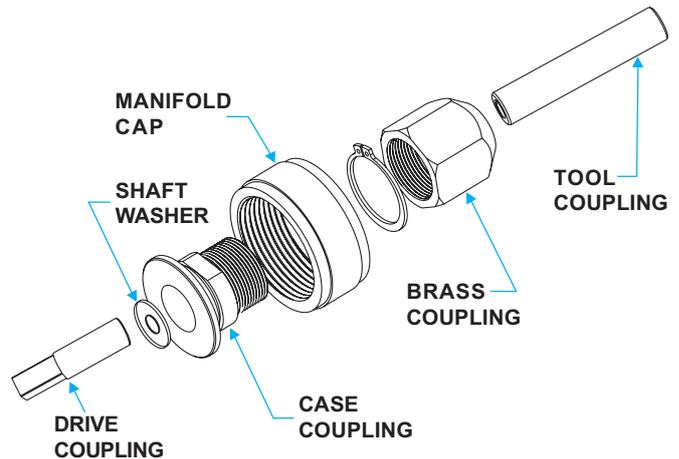
## FLEXIBLE SHAFTS REPAIR / MAINTENANCE

For PFS-750, PFS-875 and PFS-875-SS Flexible Shafts

### SHAFT REPAIR COUPLINGS

The life of flexible shafts can be extended by proper use and maintenance. If a flexible shaft should break at either end it can be easily repaired by cutting off the end portion and using a shaft repair tool to attach a coupling onto the cut shaft.

Flexible Shaft Model	PFS-875/ PFS-875-SS
Tool Coupling	TC-750
Case Coupling	CC-875
Manifold Cap	MC-2
Shaft Washer	9/16x7/8
Drive Coupling	DC-750
Brass Coupling	BC-875



### SHAFT REPAIR TOOL FOR FLEXIBLE SHAFT REPAIR

Allows users to quickly and safely attach couplings onto the shaft ensuring maximum useful life for the shaft.

- SHT-1** Shaft Repair Tool with Hammer.
- SHP-1** Replacement Hammer.



### FLEXIBLE SHAFT LUBRICATOR

Is used to lubricate flexible shafts for maximum useful life. They are also used to lubricate shafts prior to storage. The lubricator is filled with a water soluble lubricant that enters and lubricates the shaft when air supply is provided to the lubricator. The residue lubricant washes out with water when the shaft is used again.

- PFSL-1** Flexible Shaft Lubricator.
- PLUBE** Lubricant for flexible shaft lubricator, 8 ounces (0.25 litres).



### FLEXIBLE SHAFT REPAIR KITS

Flexible shaft repair kits include 4 drive end repair couplings, 4 tool end repair couplings, 1 shaft repair tool with punch, 1 flexible shaft lubricator, 2 bottles [8 ounce (0.25 liter) each] of lubricant for flexible shaft lubricator.

- REP-750-KIT** Repair kit for PFS-750, PFS-875 and PFS-875-SS Flexible shafts.



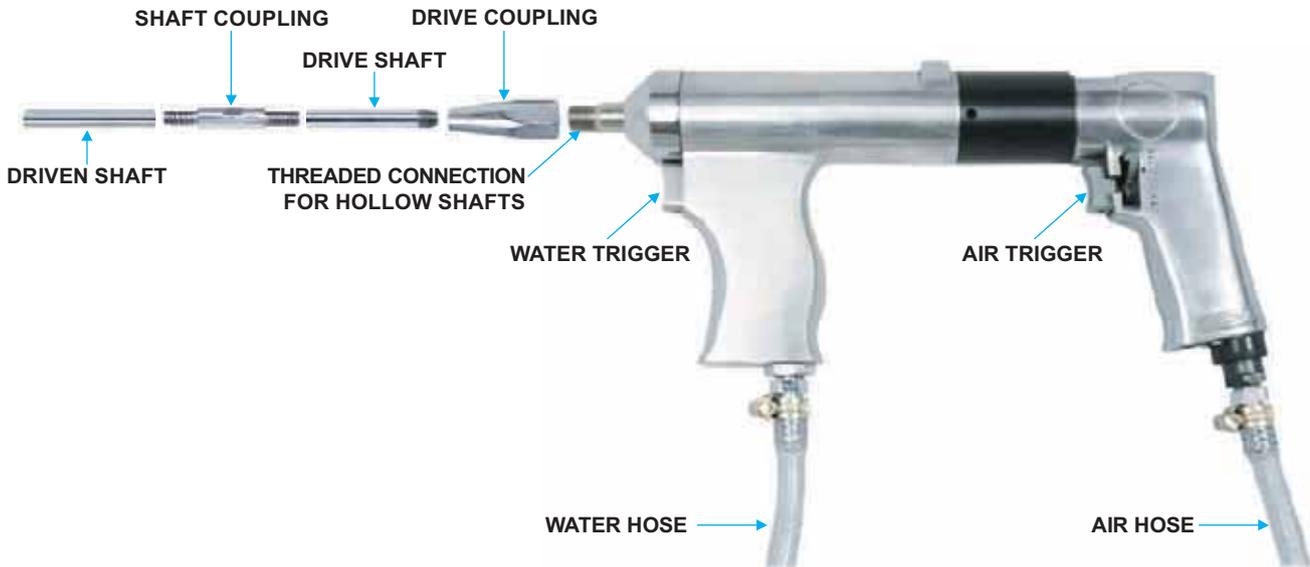
COMING SOON IN OUR TUBE CLEANER LINE

- 1) *Boiler Cleaning Systems (Twin Drive).*
- 2) *Shoot Thru Tube Cleaning Guns.*

And more.....

# PORTABLE PNEUMATIC TUBE CLEANERS

3/16"-2"  
I.D.



**Operation :** The portable pneumatic tube cleaners use hollow shafting of different diameters as per tube I.D. to be cleaned which can be coupled together to form lengths as per the length of the tube to be cleaned.

Water flows through the hollow tube and washes out deposits that are dislodged by the cleaning tools attached to the driven shafts. Typical cleaning tools used are carbide drills for severely clogged tubes, brushes for light deposits and buffing tools for final polishing of tubes. The water flow is independently controlled allowing the user to determine how much water is needed in the application.

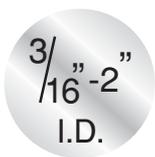
Model **C-10** is typically used on oil coolers, small heat exchangers and condensers.

Model **CP-315** is typically used on larger diameter tubes of process vessels, heat exchangers and condensers.

Tube I.D.'s suited for		Model No.	Max Motor Power		Free Speed RPM	Air Supply		Water Supply		Weight	
mm	inch		HP	kW		Min	Max	Min	Max	lbs.	kg.
4.8-25.4	3/16-1	C-10	0.6	0.45	700	60psi@16cfm	90psi@16cfm	30psi	100psi	5.72	2.6
22.2-51.0	7/8-2	CP-315	1	0.746	1000	90psi@20cfm	90psi@40cfm	30psi	100psi	6.60	3.0

**Note :** The tube cleaners above are supplied with a heavy duty plastic carrying case with separate provision to house upto 8, 4ft. (1.2m) long hollow shafts, 15ft. (4.6m) air hose, 15ft. (4.6m) water hose.





## PORTABLE PNEUMATIC TUBE CLEANER ACCESSORIES

• **Hollow Drive Shaft** - 4ft. (1.2m) long aircraft quality steel shafts to connect to drive.  
 Model **DS-300 to DS-500**  
 Model **DS-562 to DS-750**



• **Hollow Driven Shaft** - 4ft. (1.2m) long aircraft quality steel shafts to connect to driven shafts. Order quantities based on length of tube to be cleaned.  
 Model **DN-300 to DN-500**  
 Model **DN-562 to DN-750**



• **Drive Coupling** - To Couple hollow drive shaft to drive.  
 Model **DC-300 to DC-500**  
 Model **DC-562 to DC-750**



• **Shaft Coupling** - To Couple 2 hollow shafts together.  
 Model **SC-300 to SC-500**  
 Model **SC-562 to SC-750**



• **Starter Drill** - To make pilot holes in deposits of completely clogged tubes.  
 Model **SD-312 to SD-500**  
 Model **SD-562 to SD-750**



Tube I.D.'s suited for mm	Tube I.D.'s suited for inch	Drive Model No.	Hollow Drive Shaft Model No.	Hollow Driven Shaft Model No.	Drive Coupling Model No.	Shaft Coupling Model No.	Starter Drill Model No.
4.8-6.4	3/16-1/4	C-10	DS-300	DN-300	DC-300	SC-300	-
9.5	3/8		DS-312	DN-312	DC-312	SC-312	SD-312
11.1	7/16		DS-375	DN-375	DC-375	SC-375	SD-375
12.7-14.3	1/2-9/16		DS-437	DN-437	DC-437	SC-437	SD-437
15.9-17.5	5/8-11/16		DS-500	DN-500	DC-500	SC-500	SD-500
19.1-20.6	3/4-13/16		DS-562	DN-562	DC-562	SC-562	SD-562
22.2-25.4	7/8-1	CP-315	DS-625	DN-625	DC-625	SC-625	SD-625
27.0-51.0	1.1/16-2		DS-750	DN-750	DC-750	SC-750	SD-750

## CLEANING TOOLS FOR USE WITH PORTABLE PNEUMATIC TUBE CLEANERS

- **Nylon Brushes** - ..... Refer to pages 100, 103
- **Brass Brushes** - ..... Refer to pages 100, 103
- **Stainless Brushes** - ..... Refer to pages 100, 103
- **Buffing Tools** - ..... Refer to pages 101, 105
- **Carbide Drills** - ..... Refer to pages 101, 105



## PORTABLE PNEUMATIC TUBE CLEANING KITS

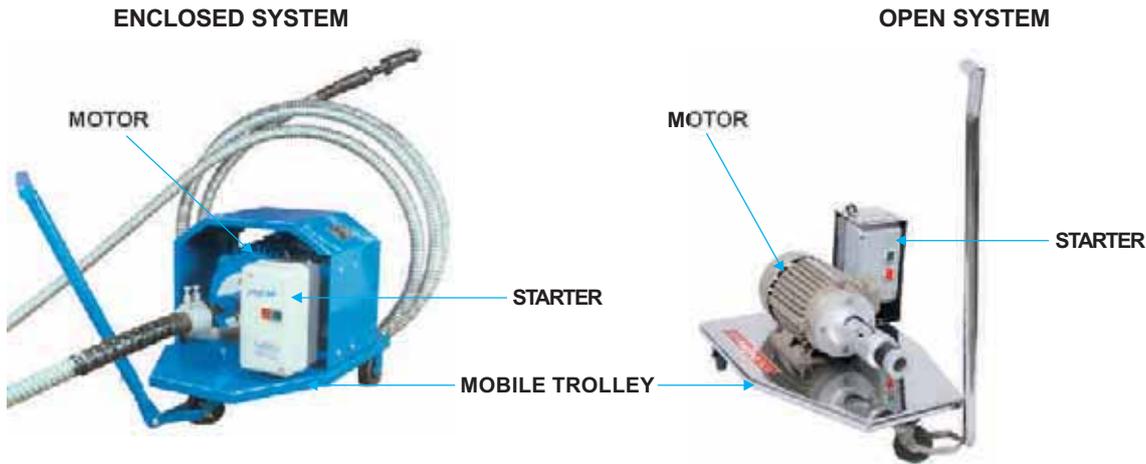


Build your own kit by adding price of Drive (C-10 or CP-315), Hollow Drive Shafts, Hollow Driven Shafts, Shaft Couplings, Drive Coupling based on length of tube to be cleaned and cleaning tools (Brushes, Carbide Drills, Buffing Tools).

We will supply all the above in a handy box at no extra charge ! The box will accomodate a maximum of 1 Drive + 4 Hollow Shafts + 5 Couplings + 18 Cleaning Tools (Brushes, Carbide Drills, Buffing Tools).

# SUGAR MILL TUBE CLEANERS

1" & UP  
I.D.



## FLEXIBLE SHAFT MACHINE (ELECTRICALLY DRIVEN)

**FLEXIBLE SHAFT MACHINE** is a self-contained portable unit, mounted on a 3-wheel trolley, fitted with a carrying handle. It incorporates a directly coupled, totally enclosed squirrel cage, 2800 rpm. continuously rated electric motor. Selecting the H.P. of the motor depends upon length and size of flexible shaft and nature of scaling. It is controlled by a push button starter which is provided with three thermal adjustable overload relays. Each machine is fully wired, carefully tested and is fitted with a 10-foot length of PVC Cable to main supply. Longer cable can be supplied upon request. Please consult us if your electric supply is different from listed below. Motors for alternate supplies are also available.

Model No.	Motor H.P.	Speed (RPM)	Electric Supply
TC-30	3.0	2800	440V 3 PHASE 50 Hz
TC-50	5.0		
TC-75	7.5		



## FLEXIBLE SHAFTS (DRIVES)

The Flexible Shaft transmits constant torque / power from the motor unit to the tool head or brush within the tube. **INNER CORE** - is double wound in opposing layers made out of high tensile-spring steel wires and passed through stress relieving process, made to absolute-vibration free performance and continuous duty.

**OUTER CASING** - is flexible, made out of galvanized steel strip and provided with special steel anti-friction lining for the entire length.

**CONNECTIONS** - Suitable motor connection at one end and detachable ball bearing hand piece (tool holder) with threaded spindle for tool head or brush at other end.

The size of the flexible shaft is based on internal diameter (I.D.) of the tube. The length of flexible shaft required is the addition of the length of the longest tube plus the distance between the mouth of the tube and the position of the power unit. The power unit should be located so that the flexible shaft be kept as straight as possible.

Inner Core mm (inch)		12 - 13 (1/2")	15 - 16 (5/8")	19 - 20 (3/4")
Outer Casing mm (inch)		25 - 26 (1")	31 - 32 (1.1/4")	34 - 35 (1.3/8")
<b>Length</b>				
<b>mtr.</b>	<b>feet</b>	<b>Model No.</b>	<b>Model No.</b>	<b>Model No.</b>
7.5	25.0	IFS-105-25	IFS-106-25	IFS-107-25
9.0	30.0	IFS-105-30	IFS-106-30	IFS-107-30
10.0	33.0	IFS-105-33	IFS-106-33	IFS-107-33
12.0	40.0	IFS-105-40	IFS-106-40	IFS-107-40
15.0	50.0	IFS-105-50	IFS-106-50	IFS-107-50
18.0	60.0	IFS-105-60	IFS-106-60	IFS-107-60
20.0	65.0	IFS-105-65	IFS-106-65	IFS-107-65
<b>Spare Inner Core Per mtr.</b>		IC-105	IC-106	IC-107
<b>Spare Outer Casing Per mtr.</b>		OC-105	OC-106	OC-107
<b>Spare Hand Piece</b>		HP-105	HP-106	HP-107

1 1/4" - 4"  
I.D.

**SUGAR MILL WIRE BRUSHES  
FOR SUGAR MILL JUICE HEATERS, EVAPORATORS, BOILERS**



**"TH" FOR SOOT REMOVAL FROM SMOKE TUBES, GENERAL CLEANING.**



**"DS" FOR REMOVING LIGHT SCALE AND BURNISHING ALL TYPES OF TUBES.**



**"WBA" HEAVY DUTY BRUSHES.**



**"EXP" EXPANDING BRUSH FOR THIN SCALE, SOOT OR SOFT DEPOSITS.**



**"MB" FOR GENERAL PURPOSE POLISHING AND DEBURRING.**



**"CB" SPARE BRUSH WHEELS FOR "MB" BRUSHES.**



**"RS" HEAVY DUTY BRUSHES FOR HEAVY SCALE REMOVAL.**



**"EXS" EXPANDING SCRAPERS FOR THIN SCALE, SOOT OR SOFT DEPOSITS.**

Size		'TH' Turk Head Brush Model No.	'DS' Double Spiral Brush Model No.	'WBA' Brush Model No.	'EXP' Expanding Brush Model No.	'MB' Multi Purpose Brush Model No.	'CB' Circular Wheel Brush Model No.	'RS' Cup Shape Brush Model No.	'EXS' Expanding Scrapers Model No.
mm	inch								
31.7	1.1/4	TH-10	DS-10	WBA-10	EXP-10	MB-10	CB-10	-	EXS-10
35.0	1.3/8	TH-11	DS-11	WBA-11	EXP-11	MB-11	CB-11	-	EXS-11
38.1	1.1/2	TH-12	DS-12	WBA-12	EXP-12	MB-12	CB-12	-	EXS-12
41.3	1.5/8	TH-13	DS-13	WBA-13	EXP-13	MB-13	CB-13	-	EXS-13
44.5	1.3/4	TH-14	DS-14	WBA-14	EXP-14	MB-14	CB-14	-	EXS-14
47.6	1.7/8	TH-15	DS-15	WBA-15	EXP-15	MB-15	CB-15	-	EXS-15
50.8	2	TH-16	DS-16	WBA-16	EXP-16	MB-16	CB-16	RS-16	EXS-16
54.0	2.1/8	TH-17	DS-17	WBA-17	EXP-17	MB-17	CB-17	RS-17	EXS-17
57.1	2.1/4	TH-18	DS-18	WBA-18	EXP-18	MB-18	CB-18	RS-18	EXS-18
60.3	2.3/8	TH-19	DS-19	WBA-19	EXP-19	MB-19	CB-19	RS-19	EXS-19
63.5	2.1/2	TH-20	DS-20	WBA-20	EXP-20	MB-20	CB-20	RS-20	EXS-20
66.7	2.5/8	TH-21	DS-21	WBA-21	EXP-21	MB-21	CB-21	RS-21	EXS-21
70.0	2.3/4	TH-22	DS-22	WBA-22	EXP-22	MB-22	CB-22	RS-22	EXS-22
73.0	2.7/8	TH-23	DS-23	WBA-23	EXP-23	MB-23	CB-23	RS-23	EXS-23
76.2	3	TH-24	DS-24	WBA-24	EXP-24	MB-24	CB-24	RS-24	EXS-24
79.4	3.1/8	TH-25	DS-25	WBA-25	EXP-25	MB-25	CB-25	RS-25	EXS-25
82.5	3.1/4	TH-26	DS-26	WBA-26	EXP-26	MB-26	CB-26	RS-26	EXS-26
85.7	3.3/8	TH-27	DS-27	WBA-27	EXP-27	MB-27	CB-27	RS-27	EXS-27
88.9	3.1/2	TH-28	DS-28	WBA-28	EXP-28	MB-28	CB-28	RS-28	EXS-28
92.1	3.5/8	TH-29	DS-29	WBA-29	EXP-29	MB-29	CB-29	RS-29	EXS-29
95.2	3.3/4	TH-30	DS-30	WBA-30	EXP-30	MB-30	CB-30	RS-30	EXS-30
98.4	3.7/8	TH-31	DS-31	WBA-31	EXP-31	MB-31	CB-31	RS-31	EXS-31
101.6	4	TH-32	DS-32	WBA-32	EXP-32	MB-32	CB-32	RS-32	EXS-32

# SUGAR MILL CUTTER HEADS

1 1/4" - 4"  
I.D.



**SINGLE LAYER  
'H' TOOL**

**TWO LAYER  
'H' TOOL**

**THREE LAYER  
'H' TOOL**

**CLOSE 'HZ' TOOL  
(HZ-10 TO HZ-11)**

**OPEN 'HZ' TOOL  
(HZ-11A TO HZ-16)**

## 'H' TYPE CUTTER HEADS

for Tubes/Pipes 1.1/4"-4" (31.7mm-101.6mm) I.D.

These Cutter Heads are designed for cleaning straight and curved tubes as found in Boilers, Air Heaters, Economizers, etc. Cutter Heads are provided with 3 cutter wheels, one each of straight teeth, teeth cut right hand, teeth cut left hand, for quicker cleaning and prevention of scale grooving.

Model NO.	Tube I.D.		Cutter Wheels Set (3)	Spare Spindle
	mm	inch	Model No.	Model No.
H-10	31.7	1.1/4	HSRL-1	HA-1
H-11	35.0	1.3/8	HSRL-1	HA-1
H-12	38.1	1.1/2	HSRL-1	HA-1
H-13	41.3	1.5/8	HSRL-2	HA-2
H-14	44.5	1.3/4	HSRL-2	HA-2
H-15	47.6	1.7/8	HSRL-2	HA-2
H-16	51.0	2	HSRL-2	HA-2
H-17	54.0	2.1/8	HSRL-2	HA-2
H-18	57.1	2.1/4	HSRL-3	HA-3
H-20	63.5	2.1/2	HSRL-3	HA-3
H-22	70.0	2.3/4	HSRL-4	HA-3
H-24	76.2	3	HSRL-4	HA-3
H-26	82.5	3.1/4	HSRL-5	HA-3
H-28	88.9	3.1/2	HSRL-5	HA-3
H-30	95.2	3.3/4	HSRL-6	HA-4
H-32	101.6	4	HSRL-6	HA-4

## 'HZ' TYPE CUTTER HEADS

for Tubes/Pipes 1.1/4"-2" (31.7mm-51.0mm) I.D.

These spring loaded, self expanding Cutter Heads are designed for rapid removal of hard and obstinate scale formation in straight tubes as found in Evaporators, Juice Heaters, etc. It consists of 3 bevel, 4 straight cutter wheels, 4 left cutter wheels and 4 right cutter wheels, fitted on 3 bridge type arms.

Model NO.	Tube I.D.		Cutter Wheels Set (15)	Spare Arms
	mm	inch	Model No.	Model No.
HZ-10	31.7	1.1/4	HZSRL-1	HZA-1
HZ-10A	33.3	1.5/16	HZSRL-1	HZA-1
HZ-11	35.0	1.3/8	HZSRL-1	HZA-1
HZ-11A	36.5	1.7/16	HZSRL-1	HZA-2
HZ-12	38.1	1.1/2	HZSRL-1	HZA-2
HZ-12A	39.7	1.9/16	HZSRL-1	HZA-2
HZ-13	41.3	1.5/8	HZSRL-1	HZA-2
HZ-13A	42.9	1.11/16	HZSRL-1	HZA-2
HZ-14	44.5	1.3/4	HZSRL-2	HZA-3
HZ-14A	46.0	1.13/16	HZSRL-2	HZA-3
HZ-15	47.6	1.7/8	HZSRL-2	HZA-3
HZ-15A	49.2	1.15/16	HZSRL-2	HZA-3
HZ-16	51.0	2	HZSRL-2	HZA-3



## 'WA' TYPE CUTTER HEADS

for Tubes/Pipes 1.1/2"-4" (38.1mm-101.6mm) I.D.

These Cutter Heads produce excellent results in curved or straight tubes. Pivoted arms of Cutter Heads swing out by centrifugal force so that the cutters contact every part of the tube wall.

Model NO.	Tube I.D.		ConeCutter Set (3)	Spare Arms	Universal Joint
	mm	inch	Model No.	Model No.	Model No.
WA-12	38.1	1.1/2	WAL-1	WAA-1	WAUJ-1
WA-14	44.5	1.3/4	WAL-1	WAA-1	WAUJ-1
WA-16	51.0	2	WAL-1	WAA-1	WAUJ-1
WA-18	57.1	2.1/4	WAL-2	WAA-1	WAUJ-2
WA-20	63.5	2.1/2	WAL-2	WAA-1	WAUJ-2
WA-22	70.0	2.3/4	WAL-2	WAA-1	WAUJ-2
WA-24	76.2	3	WAL-3	WAA-2	WAUJ-2
WA-28	88.9	3.1/2	WAL-3	WAA-2	WAUJ-2
WA-32	101.6	4	WAL-4	WAA-2	WAUJ-2



## 'SA' TYPE CUTTER HEADS

for Tubes/Pipes 2"-4" (51.0mm-101.6mm) I.D.

These Cutter Heads have 3 to 5 freely pivoted arms, activated centrifugally, which swing out to give access to any part of tube wall.

Model NO.	Tube I.D.		Cone & Flat Cutter Set (9)	Arms	Universal Joint
	mm	inch	Model No.	Model No.	Model No.
SA-16	51.0	2	SAFC-1	SAA-1	SAUJ-1
SA-18	57.1	2.1/4	SAFC-2	SAA-2	SAUJ-2
SA-20	63.5	2.1/2	SAFC-2	SAA-2	SAUJ-2
SA-22	70.0	2.3/4	SAFC-3	SAA-2	SAUJ-2
SA-24	76.2	3	SAFC-3	SAA-2	SAUJ-2
SA-28	88.9	3.1/2	SAFC-4	SAA-2	SAUJ-2
SA-32	101.6	4	SAFC-5	SAA-3	SAUJ-2

1 1/2" - 7"  
I.D.

## CUTTER HEADS FOR STRAIGHT TUBES IN REFINERIES AND STILL TUBES



'P' & 'TC' TYPE

The model "P" & "TC" cutter head is used for cleaning straight tubes from 1-1/2" I.D. through 7" I.D. It is usually direct coupled to drive motor but flexible couplings, universal joints or flexible holders, are used to negotiate curved or bend tubes.

The model "P" & "TC" is for heavy and hard tube deposits as found in refinery and still tubes. It is tough in its parts and assembly as necessary to stand up in this service and it makes economical provision, as described below, for inevitable wear due to large forces which must transmit through the assembly. The model "P" & "TC" is conformed to do its work quickly and thoroughly even when deposits are of varying thickness and hardness.

Cone cutters, with tapered cutting edges at the front of the cutter head, expand against tube deposits by centrifugal force and break up uneven shoulders of scale. This is followed by long rows of expanding "no-track" cutter wheels which finish up with thorough, repeated cuts. Centrifugal force assures good working contact between tube deposits and cutting edges and "no track" means that cutters cannot fall into a pattern which skips over and leaves strips of scale behind.

The expansion range (range of cutter head diameters) of these cutter heads is considerable (See chart below.) and is due to (1) slotted cutter pin bearing bores and (2) intentional "play" in pin bearing inserts, features which include an economical bonus. Large cutter forces transmit through and wear the cutter pin bearing bore. By designing this bore into a replaceable insert, cutter body life is greatly increased, obviously providing increased economy of operation and service life.

Model No.	Tube I.D. inch	Minimum Dia. Over Cutter inch.	Minimum Dia. Over Cutter inch.	Cone Cutter Set Model No.	Cylinder Cutter Set Model No.	Cutter Pin Set Model No.
TC-14	1.1/2	1.3/8	1.23/32	1787-1	1788-2	1584-1
TC-11	1.3/4	1.5/8	2	1587-1	1588-2	1584-1
TC-17	1.7/8	1.11/16	2	2287-3	2288-6	1584-3
TC-16	2	1.13/16	2.3/16	1787-3	1788-6	1584-PY
TC-13	2.1/8	1.15/16	2.5/16	1787-3	1788-6	1584-PY
P-15	2.1/4	2.1/16	2.7/16	2487-3	3338-6	2484-PY
P-9-S	2.3/8	2.3/16	2.11/16	C52-3	C76-6	2484-3
P-9	2.1/2	2.1/4	2.13/16	1587-3	1588-6	1584-PY
P-8	2.5/8	2.9/16	2.7/8	1087-3	1088-6	184-3
P-7	2.3/4	2.9/16	2.15/166	1087-3	1088-6	184-3
P-6-A	3	2.11/16	3.1/8	1087-3	1088-6	184-3
P-6	3.1/8	2.13/16	3.1/4	1087-3	1088-6	184-3
P-5	3.1/4	3.1/16	3.9/16	987-3	988-6	184-3
P-4	3.1/2	3.3/16	3.13/16	787-3	788-6	884-3
P-3	3.3/4	3.9/16	4.3/16	887-B3	888-B6	884-3
P-2	4	3.3/4	4.1/2	887-3	888-6	884-3
P-1	4.1/4	3.13/16	4.3/4	887-3	888-9	884-P3
P-0	4.1/2	4.1/8	4.15/16	887-3	888-9	884-P3
P-10	4.3/4	4.3/8	5.3/16	887-3	888-9	884-P3
TC-19-H-S	5	4.1/2	5.9/16	1287-3	1288-9	884-P3
TC-19-S	5.1/4-5.1/2	4.7/8	5.15/16	1287-4	1288-12	884-P4
TC-20-S	6	5.1/2	6.1/2	1287-4	1288-12	884-P4
TC-21-S	6.1/4	5.3/4	6.3/4	11887-4	11888-12	884-P4
TC-22-S	6.1/2	6	7.1/16	11887-4	11888-12	884-P4
TC-23-S	6.3/4	6.1/4	7.5/16	8287-4	8288-12	2484-S4
TC-24-S	7	6.1/2	7.9/16	8287-4	8288-12	2484-S4



# TUBE CLEANER SELECTION GUIDE

## TUBE CLEANER QUICK SELECTION

Vessel	Type of Tube	Deposit	Machine	Recommended Cleaning Tools
Heat Exchanger Condenser	Non-Ferrous Straight 1/4"-1" (6.4-25.4mm)	Soft Deposits	PTC-40, PTC-60, PORTO	Nylon Brush
Heat Exchanger Condenser	Non-Ferrous Straight 1/4"-1" (6.4-25.4mm)	Medium to Hard Scale	PTC-40, PTC-60, PORTO	Carbide Drill
Heat Exchanger Condenser	Non-Ferrous U-Tube 1/2"-1" (12.7-25.4mm)	Soft Deposit	PTC-40, PTC-60, PORTO	Cup Brush, Wheel Brush
Heat Exchanger Condenser	Non-Ferrous U-Tube 1/2"-1" (12.7-25.4mm)	Hard Scale or Blockage	PTC-40, PTC-60, PORTO	Cobalt Tip Tool
Heat Exchanger Condenser	Ferrous Straight 1/4"-1" (6.4-25.4mm)	Soft Deposit Light Scale	PTC-40, PTC-60, PORTO	Stainless Steel Brush
Heat Exchanger Condenser	Ferrous Straight 1/4"-1" (6.4-25.4mm)	Medium to Hard Scale	PTC-40, PTC-60, PORTO	Carbide Drill, Wheel Brush Tool
Heat Exchanger Condenser	Ferrous U-Tube 1/2"-1" (12.7-25.4mm)	Soft Deposit Light Scale	PTC-40, PTC-60, PORTO	Cup Brush, Wheel Brush Tool
Heat Exchanger Condenser	Ferrous U-Tube 1/2"-1" (12.7-25.4mm)	Hard Scale or Blockage	PTC-40, PTC-60, PORTO	Cobalt Tip Tool
Heat Exchanger Condenser	Non-Ferrous Straight 1/4"-1" (6.4-25.4mm)	Soft Deposit	C-10 with Hollow Tube	Nylon Brush, Brass Brush
Heat Exchanger Condenser	Ferrous Straight 1/4"-1" (6.4-25.4mm)	Soft Deposit	C-10 with Hollow Tube	Stainless Steel Brush
Heat Exchanger Condenser	Non-Ferrous Straight 5/16"-1" (7.9-25.4mm)	Medium to Hard Scale	C-10 with Hollow Tube	Buffing Tool with Drill Tip, Carbide Drill
Heat Exchanger Condenser	Non-Ferrous or Ferrous Straight 3/16"-3/8" I.D. (4.8-9.5mm)	Hard Scale Blockage	C-10	Hollow Drills (other diameters and lengths available on request-consult factory for prices and delivery)
Heat Exchanger Condenser	Non-Ferrous or Ferrous Straight 7/8"-2" I.D. (22.2-51.0mm)	Hard Scale Blockage	C-315	HCD Series Carbide Drills
Heat Exchanger Condenser	Non-Ferrous or Ferrous Straight 3/16"-1" I.D. (4.8-25.4mm)	Hard Scale Blockage	C-10 with Hollow Tube	Carbide Drills
Heat Exchanger Condenser	Non-Ferrous Straight 1"-14" I.D. (25.4-355.6mm)	Soft Deposit	PTC-75	Buffing Tool, Wing Tool-Flexible Arm-Carbide Ball Tip, Carbon Steel Brush
Heat Exchanger Condenser	Non-Ferrous Straight 1"-14" I.D. (25.4-355.6mm)	Medium to Hard Scale	PTC-75	Buffing Tool, TCB Brush, Wing Tool-Stiff Arm Cutter
Heat Exchanger Condenser	Ferrous Straight 1"-14" I.D. (25.4-355.6mm)	Soft Deposit	PTC-75	Buffing Tool, Wing Tool-Flexible Arm-Carbide Ball Tip, CBTS Brush, Carbon Steel Brush
Hoses	Plastic 1.1/4"-14" I.D. (31.7-355.6mm)	Soft Deposit	PTC-75	Nylon Brush and Plastic Brushes
Firetube Boiler	Straight Steel 1.3/8"-4" O.D. (35.0-101.6mm)	Soot and Light Scale	PTC-75	Buffing Tool, CBTS Series Brush
Firetube Boiler	Straight Steel 1.3/8"-4" O.D. (35.0-101.6mm)	Hard Heavy Scale	PTC-150	Scraper Tool, Cone Cutter Tool, Wing Tool-Stiff Arm Cutter
Vaccum Pan, Juice Heater	Ferrous Straight 1.18"-1.49" I.D. (30.0-38.0mm)	Medium to Hard Scale	TC-30	HZ Cutter, H Cutter, TH Brush, WBA Brush, DS Brush
Vaccum Pan, Juice Heater	Ferrous Straight 1.53"-2.55" I.D. (38.4-65.0mm)	Medium to Hard Scale	TC-50	H Cutter, WA Cutter, SA Cutter, TH Brush, DS Brush, WBA Brush
Vaccum Pan, Juice Heater	Ferrous Straight 2.59"-3.93" I.D. (66.0-100.0mm)	Medium to Hard Scale	TC-75	H Cutter, WA Cutter, SA Cutter, TH Brush, DS Brush, WBA Brush
Watertube Boiler	Straight Steel 1"-3.1/4" I.D. (25.4-82.6mm)	Soft Deposit Light Scale	PTC-75	Buffing Tool, CBTS Brush, Wing Tool-Flexible Arm-Carbide Ball Tip
Watertube Boiler	Straight Steel 1"-3.1/4" I.D. (25.4-82.6mm)	Medium to Hard Scale	PTC-75	Buffing Tool, Cylinder Cutter Tool



*Powermaster exports Tube Expanding, Tube Cleaning and related equipment to over 120 countries worldwide.*

## TUBE CLEANER SPECIFICATIONS QUICK REFERENCE GUIDE

Model	Pages	Tube Size	Motor Power	Power Source	Shaft/Drill Speed
PTC-40	94	1/4"-1" I.D. (6.4-25.4mm)	1/2 HP (0.40 kW)	Electric 110 or 220V, 50 or 60 Hz	890 rpm
PTC-60	94	1/4"-1" I.D. (6.4-25.4mm)	3/4 HP (0.60 kW)	Electric 110 or 220V, 50 or 60 Hz	890 rpm
PTC-75	94	1" & UP I.D. (25.4mm & UP)	1 HP (0.75 kW)	Electric 110 or 220V, 50 or 60 Hz	1780 rpm
PTC-150	94	1" & UP I.D. (25.4mm & UP)	2 HP (1.50 kW)	Electric 110 or 220V, 50 or 60 Hz	1780 rpm
PORTO	98	1/4"-1" I.D. (6.4-25.4mm)	1/2 HP (0.40 kW)	Electric 110 or 220V, 50 or 60 Hz	1760 rpm
C-10	109	3/16"-1" I.D. (4.8-25.4mm)	0.6 HP (0.45 kW)	Air:Min.60psi@16cfm	700 rpm
C-315	109	7/8"-2" I.D. (22.2-51.0mm)	1 HP (0.75 kW)	Air:Min.90psi@20cfm	1000 rpm

# SPECIAL TABLES

**Recommended Expansion of Tubes for Optimum Joint Strength in Heat Exchanger and Condensers**  
 Use expansion listed in the tube expansion column plus clearance between tube O.D. and sheet hole I.D.  
 Recommended expansion may be plus or minus .001 in. (0.25mm).

Tube O.D.		Gauge	Tube Expansion		Tube O.D.		Gauge	Tube Expansion		Tube O.D.		Gauge	Tube Expansion	
mm	inch		mm	inch	mm	inch		mm	inch	mm	inch		mm	inch
12.7	1/2	14	.15	.006	15.8	5/8	20	.10	.004	25.4	1	10	.22	.009
12.7	1/2	15	.15	.006	15.8	5/8	21	.10	.004	25.4	1	11	.22	.009
12.7	1/2	16	.15	.006	19.0	3/4	10	.20	.008	25.4	1	12	.22	.009
12.7	1/2	17	.12	.005	19.0	3/4	11	.20	.008	25.4	1	13	.20	.008
12.7	1/2	18	.12	.005	19.0	3/4	12	.20	.008	25.4	1	14	.20	.008
12.7	1/2	19	.10	.004	19.0	3/4	13	.20	.008	25.4	1	15	.17	.007
12.7	1/2	20	.10	.004	19.0	3/4	14	.20	.008	25.4	1	16	.15	.006
12.7	1/2	21	.10	.004	19.0	3/4	15	.17	.007	25.4	1	17	.12	.005
15.8	5/8	12	.15	.006	19.0	3/4	16	.15	.006	25.4	1	18	.12	.005
15.8	5/8	13	.15	.006	19.0	3/4	17	.12	.005	31.7	1.1/4	8	.25	.010
15.8	5/8	14	.15	.006	19.0	3/4	18	.12	.005	31.7	1.1/4	10	.25	.010
15.8	5/8	15	.15	.006	19.0	3/4	19	.12	.005	31.7	1.1/4	12	.22	.009
15.8	5/8	16	.15	.006	19.0	3/4	20	.12	.005	31.7	1.1/4	14	.20	.008
15.8	5/8	17	.12	.005	19.0	3/4	21	.10	.004	31.7	1.1/4	16	.17	.007
15.8	5/8	18	.12	.005	25.4	1	8	.22	.009	31.7	1.1/4	18	.15	.006
15.8	5/8	19	.10	.004	25.4	1	9	.22	.009					

**ADDITIONAL SIZES :**

- 1/4 in. (6.3 mm) O.D. tube - expand all gauges .003 in. (.07 mm) after contact with tube sheet hole.
- 3/8 in. (9.5 mm) O.D. tube - expand all gauges .004 in. (.10 mm) after contact with tube sheet hole.

The above recommendation is based on our experience. However, 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.

**EXAMPLE :**

- 3/4 in. (19.0 mm) O.D. x 14 gauge tubes
- Recommended expansion .008 in. (.20 mm)
- Tube sheet hole .760 in. (19.3 mm)
- Therefore, expand as follows :
- Tube I.D. before expanding .584 in. (14.8 mm)
- Recommended expansion .008 in. (.20 mm)
- Clearance between tube and tube sheet hole .010 in. (.25 mm)
- Finish I.D. .602 in. (15.2 mm)

## TUBE SIZES - BIRMINGHAM WIRE GAUGES

Tube O.D. inch	Birmingham Wire Gauge (Gauge - Inches)																										
	00-380	0-340	1-300	2-284	3-258	4-238	5-220	6-203	7-180	8-165	9-148	10-134	11-120	12-109	13-095	14-083	15-072	16-065	17-058	18-049	19-042	20-035	21-032	22-028	23-025	24-022	
1/4																				.152	.166	.180	.186	.194	.200	.206	
3/8																.209	.231	.245	.259	.277	.291	.305	.311	.319	.325	.331	
1/2															.310	.334	.356	.370	.384	.402	.416	.430	.436	.444	.450	.456	
5/8														.407	.435	.459	.481	.495	.509	.527	.541	.555	.561	.569	.575	.581	
3/4											.482	.510	.532	.560	.584	.606	.620	.634	.652	.666	.680	.686	.694	.700	.706		
7/8										.607	.635	.657	.685	.709	.731	.745	.759	.777	.791	.805	.811	.819	.825	.831			
1								.670	.704	.732	.760	.782	.810	.834	.856	.870	.884	.902	.916	.930	.936	.944	.950	.956			
1.1/4								.920	.954	.982	1.010	1.032	1.060	1.084	1.106	1.120	1.134	1.152	1.166	1.180	1.186	1.194	1.200	1.206			
1.1/2								1.170	1.204	1.232	1.260	1.282	1.310	1.334	1.356	1.370	1.384	1.402	1.416	1.430	1.436	1.444	1.450	1.456			
1.3/4							1.310	1.344	1.390	1.420	1.454	1.482	1.510	1.532	1.560	1.584	1.606	1.620	1.634	1.652	1.666	1.680	1.686	1.694	1.700	1.706	
2					1.524	1.560	1.594	1.640	1.670	1.704	1.732	1.760	1.782	1.810	1.834	1.856	1.870	1.884	1.902	1.916	1.930	1.936	1.944	1.950	1.956		
2.1/4	1.490	1.570	1.650	1.682	1.732	1.774	1.810	1.844	1.890	1.920	1.954	1.982	2.010	2.032	2.060	2.084	2.106	2.210	2.134	2.151							
2.1/2	1.740	1.820	1.900	1.932	1.982	2.024	2.050	2.094	2.140	2.170	2.204	2.232	2.260	2.282	2.310	2.334	2.356	2.370	2.384	2.402							
2.3/4	1.990	2.070	2.150	2.182	2.232	2.274	2.310	2.344	2.390	2.420	2.454	2.482	2.510	2.532	2.560	2.584	2.606	2.620	2.634	2.652							
3	2.240	2.320	2.400	2.432	2.482	2.524	2.560	2.594	2.640	2.670	2.704	2.732	2.760	2.782	2.810	2.834	2.856	2.870	2.884	2.902							
3.1/4	2.490	2.570	2.650	2.682	2.732	2.774	2.810	2.844	2.890	2.920	2.954	2.982	3.010	3.032	3.060	3.084	3.106	3.120	3.134	3.151							
3.1/2	2.740	2.820	2.900	2.932	2.982	3.024	3.060	3.094	3.140	3.170	3.204	3.232	3.260	3.282	3.310	3.334	3.356	3.370	3.384	3.402							
3.3/4	2.990	3.070	3.150	3.182	3.232	3.274	3.310	3.344	3.390	3.420	3.454	3.482	3.510	3.532	3.560	3.584	3.606	3.620	3.634	3.652							
4	3.240	3.320	3.400	3.432	3.482	3.524	3.560	3.594	3.640	3.670	3.704	3.732	3.760	3.782	3.810	3.834	3.856	3.870	3.884	3.902							