

HydroSwage® System and Tooling



Haskel International, Inc. has over 50 years of hydraulic and pneumatic engineering experience in the design and manufacturing of a wide range of products and 27 years experience with hydraulic tube expansion or HydroSwage® systems.

Located in Burbank, California, USA, with an additional manufacturing plant in Sunderland, U.K., the company also has strategically placed subsidiaries, regional offices and dedicated distributors throughout the world.

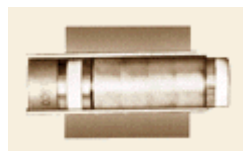
In 1970 Haskel introduced its first system for the high pressure hydraulic expansion of tubes. Using pressures in excess of

100,000 psi, this system is used for expanding aircraft tubing into sleeves. In 1975 the first system was developed for the hydraulic swaging of tubes for nuclear steam generators. In 1980 began with a series of major technical breakthroughs which gave rise to the first successful commercial method for hydraulically expanding tubes - the HydroSwage® System.

A continuous investment in the most modern machinery and technology ensures that Haskel remains a leader in hydraulic-tube expansion.

PRINCIPLES OF OPERATION

The HydroSwage® System is innovative and designed to hydraulically expand heat exchanger tubes into tube sheets through the direct application of high internal hydraulic pressure within an established expansion zone.

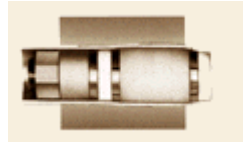


Tube-Loc™ Drawbar in Tube

A Tube-Loc™ Drawbar quickly positions and sets the tube into the tube sheet prior to HydroSwage® expansion. It is also used to set tubes prior to welding and to flare boiler tubes.

Water pressure from an air driven pumping system is intensified to the desired high pressure. It is transmitted through a small bore, flexible high pressure tube to a lightweight hand-held mandrel holder. A mandrel, which latches into the mandrel holder, directs the pressure to the inside diameter of the tube and is held within an

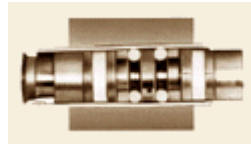
accurately prescribed pressure zone. Pressure is contained within the expanding tube by a soft elastic seal which is supported by a **patented elastic backup and an expanding segmented steel ring**. Pressure is applied over the full length of the joint in one step. The pressure zone is accurately adjusted which reduces the damaging crevices at the edges of the tube sheet. Stress, crevice corrosion, and metallurgical changes are thus minimized.



*Drawbar Puls, Positions and Sets
Tube in Place*

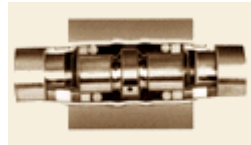
Direct hydraulic expansion with pure water produce clean joints. Lubricant is not forced into the tube surface, and there is no surface flaking or spalling inside the tube.

A smooth transition from expanded to unexpanded areas, along with no change in tube material properties, greatly reduces strain hardening, tube fatigue and stress induced corrosion cracking. Tube wall thickness and tube length change is minimal. Before contact is made with the tube sheet, a small reduction in tube wall thickness and length occurs because a constant volume of tube material is expanded to a larger diameter. However, no change occurs during the high pressure swaging, eliminating the shear strain and loss of seal between tube and sheet that is a characteristic of roller expanding.



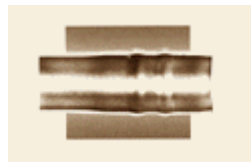
HydroSwage® Mandrel in Tube

The HydroSwage® tube expansion cycle is automatic and initiated by the operator button located on the mandrel holder. The tube is filled with distilled water at a low pressure, intensified to the higher setting and held for the time required to accomplish a stable plastic condition of the tube. This dwell time is essential to stabilize exotic tube materials. After the pressure is released, water is drained back into the reservoir. All of this occurs in a time period of a few seconds.



High Pressure Expansion of Tube

Actual pressure at the tube is read on a digital pressure indicator. An adjustable "under" or "over" pressure condition and operating sequence is shown at the control panel and the operator mandrel holder. Analog connections are provided for chart recorders, computers or printers (optional equipment) for permanent quality control records.



*Smooth Transition from
Expanded to Unexpanded Areas
Groove Penetration is Accurate*

HYDROSWAGE® OPERATION

MARK IV HYDROSWAGE® SYSTEM

The Mark IV HydroSwage® System features an electronically controlled, air driven hydraulic system which includes a high pressure intensifier producing pressures to 50,000 psi (3445 bar).

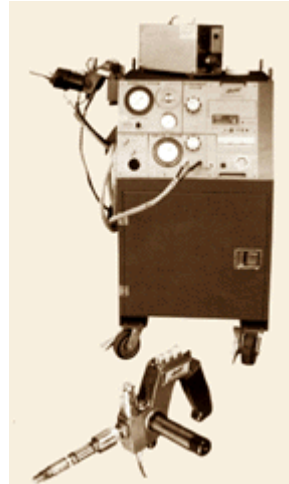
*Mark IV Power Supply with Intensifier and Tools
Attached 42769*

The control panel contains all tooling connections, a precision digital display, and is configured to allow Tube-Loc™ and swage functions to be performed simultaneously using two operators.

The Mark IV is housed in a sturdy metal cabinet with heavy duty industrial casters for portability. In addition, Analog connections are provided to accommodate chart recorders, computers or printers (optional equipment) for permanent quality control records.

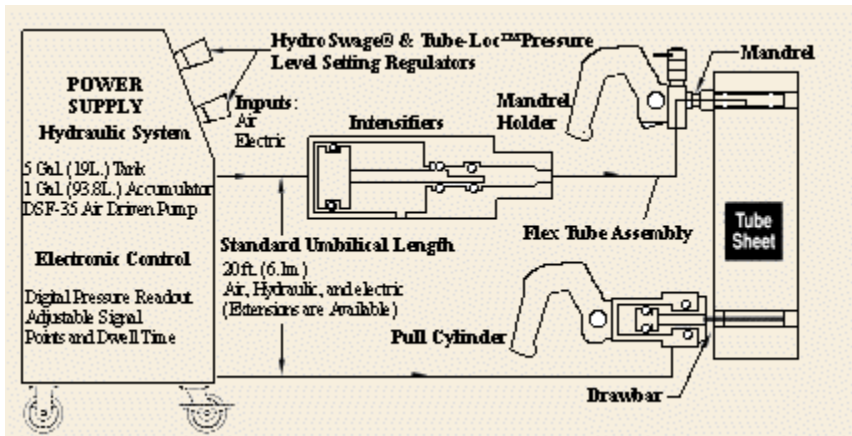
Connection to the intensifier by an 8ft. (2.4m) long

high pressure flexible tube (longer lengths available), the Mark IV mandrel holder gives the operator complete control of the swaging cycle. The operating button initiates the sequence of pre-fill, high pressure swage and dwell. The electronic transducer senses the pressure within the tube and displays it at the control panel. The signal lights (yellow for run, green for complete cycle, and red for incomplete cycle) advise the operator of swaging status.



Mandrel Holder with Expansion Mandrels 42203

Mark IV Diagram

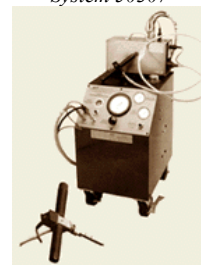


ES-675 BASIC 'HYDROSWAGE® SYSTEM

The ES-675 HydroSwage® System is the most cost effective system of the HydroSwage® line offering outstanding performance similar to the Mark IV at a very economical price.

ES-675 HydroSwage® System 50307

Like the Mark IV, the ES-675 uses features an air driven hydraulic system which includes a high pressure intensifier producing pressures to 50,000 psi (3445 bar).



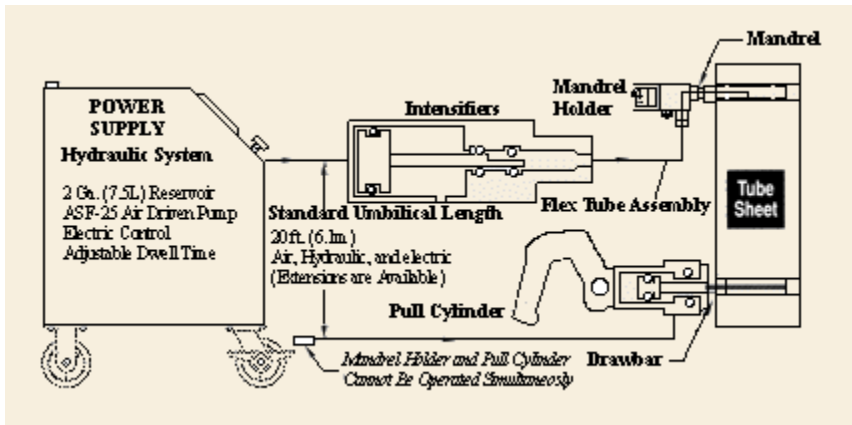
ES-675 Mandrel Holder 44183

The ES-675 uses the same tooling as the Mark IV, and offers Tube-Loc™ capability (non-simultaneous use). Unlike the Mark IV, the ES-675 features all analog gauges, and is housed in a much smaller cabinet with heavy duty industrial casters for portability.

The ES-675 Mandrel Holder (44183) incorporates many of the same features as the Mark IV Mandrel Holder, but does not feature an electronic pressure transducer.

Connected to the intensifier by an 8ft. (2.4m) long high pressure flexible tube (longer lengths available), the ES-675 Mandrel Holder gives the operator complete control of the swaging cycle. The operating button initiates the sequence of pre-fill, high pressure swage and dwell. A dual colored signal light (green for completed cycle and red for incomplete cycle) advise the operator of swaging status.

ES-675 Diagram



HydroSwage® Expanding Mandrels

Designed to provide one step high pressure swage regardless of the tube sheet thickness, HydroSwage® expanding mandrels feature a **patented segmented seal support system** which enables the HydroSwage® System to develop and hold high pressures with minimal seal extrusion.

Mandrels are available in .5mm increments (diameter) and in adjustable lengths which permit exact expansion zone settings. The expansion zone of any mandrel can be tightly controlled assuring full depth tube sheet expansion thus minimizing crevice exposure.



Expansion Mandrels for 1/4" O.D. thru 2" O.D. Tube Size

Hydrotest Tools 42330(1"), 44183 (1-1/2"), 43494(2")

Hydrotest Tools with elastic hoses, gauges, and shut-off valves quickly connect and disconnect from 43244 air-driven and hand operated Pump Power Supply. They provide a quick and efficient means of hydrotesting boiler tubes from inside the boiler. The hydrotest tool with an O-ring sealing at the tube I.D. is locked into the tube I.D. and a collar-mounted seal is advanced to the drum inner wall. The isolated chamber between drum face and tube O.D. is pressurized with the hand operated/air driven pump. The pressurized volume is locked in the elastic hose and joint leakage evaluated by gauge bleed down characteristics.

Hydrotest Power Supply 43244



Hydrotest tool (1 inch) 42330

Tube-Loc™ Drawbar Assembly

The Tube-Loc™ Drawbar Assembly quickly positions and sets the tube sheet creating uniform tube end protrusion, and preventing the tube from moving during welding and swage operations.

The Tube-Loc™ Drawbar operates from the Mark IV and ES-675 Power Consoles or from its own dedicated Tube-Loc™ Power Supply (42380).



Tube-Loc™ Drawbar Attached to pull cylinder 41732 *Tube-Loc™ Drawbar Attached to Pull Cylinder 42140*

Tube-Loc™ Power Supply 42380

Designed to fit through a 12"x16" (30x40 cm) elliptical marine boiler manway, this system offers the greatest flexibility when using Tube-Loc™ tools. All electrical controls on the power supply are transformed from 115vac to 12 vac for optimum operator safety. To assure reliable performance, the Tube-Loc™ Power Supply uses the same hydraulic pump found in HydroSwage® Power Consoles, and is specifically designed to operate all Tube-Loc™ Pull Cylinders.



Tube-Loc™ Power Supply 42380

Strain Control Sleeving System

Most heat exchangers are designed with a certain amount of extra tube capacity to allow a percentage of tubes to be plugged during the life of the exchanger.

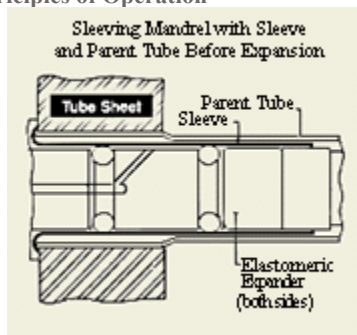
Two primary causes of tube failure, which often result in tubes being plugged or replaced, are erosion and corrosion. In fact heat exchangers are often completely re-tubed to repair tube failures which occur only at the tube ends.

The HydroSwage® Strain Control Sleeving System 43101 offers an economical method of prolonging the life of aging or failing heat exchanger tubes by installing sleeves (ferules) to restore lost tube material or as sacrificial barriers to the damaging elements which cause the tube loss.

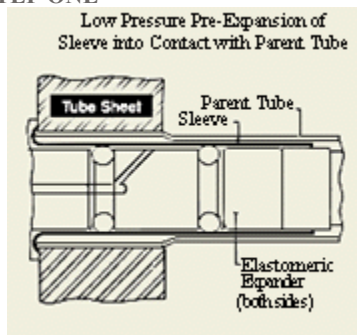
Strain control is a two stage process which pre-expands a prepared metal sleeve into the damaged or failing section of the tube. The first stage expands the sleeve at a pre-calculated hydraulic pressure beyond the sleeve yield strength, but less than combined yield strength of the sleeve and parent tube.

The second stage expansion is controlled by injecting (at a higher pressure) a pre-determined volume of water to control the radial expansion of the sleeve and parent tube to produce a constant interference fit between the sleeve and parent tube.

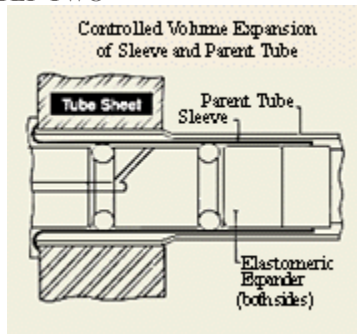
Principles of Operation



STEP ONE



STEP TWO



Strain Control Sleeving System 43101

Flare-Loc™ Tool

The Flare-Loc™ Tool is used to flare and swage tubes into boiler plates and drums in a one-step operation. The swaging operation requires approximately 5 seconds per tube and is adjustable to cover plate or drum thickness from 3/8" to 1". The tooling is available to cover standard boiler tube diameters from 1-1/2" to 2-1/2".

The Flare-Loc™ Tube Expansion System (44024) consists of an Air Driven Power Supply Unit (80161), a Pull Cylinder Unit (43990), and a Mandrel Assembly (43980-XX) for the tube size being expanded.

The power supply is housed in a portable, lightweight, steel casing with handle.

The pull cylinder consists of a cylindrical high pressure body and associated high pressure hose. The mandrel assembly consists of a series of cam actuated segments and elastomeric expander rings. These act together under load to expand the i.d. of the tube into interference fit with tube sheet. The tool offers: (1) the option of flaring (or beelling) the tube-end protruding from primary face of tube sheet, (2) variable width expansion zone within the tube sheet, and (3) the ability to bulge or seal the tube at the secondary face. The operation can be done simultaneously or independently of each other at the users discretion.

STEP THREE

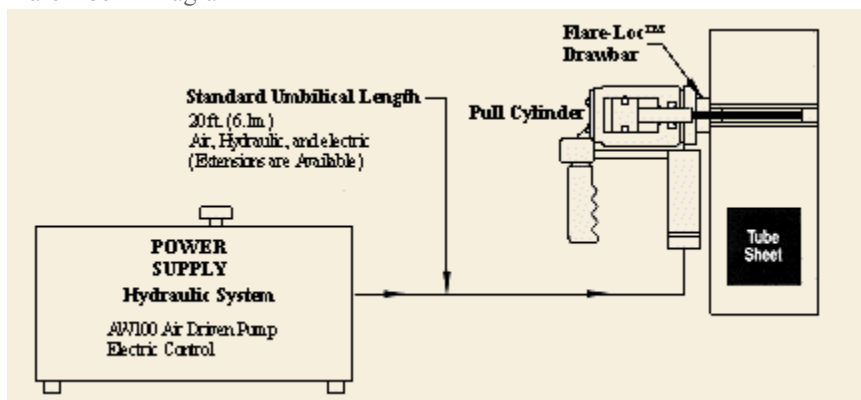
Mandrel Assembly 43980-XX



*Flare-Loc™ Pull Cylinder 43990
Air Driven Power System Unit*



Flare-Loc™ Diagram



Part Numbers and Specifications

--	--	--	--	--

Part Number	Description	Approximate Overall Inches (cm)			Approximate Weight Lbd (Kg)	
		Height	Length	Width	Operator	Shipping
Mark IV and ES-675 HydroSwage® Systems						
42769**	Power Supply	42(107)	26(66)	27(68)	N/A	305(138)
50306**	Power Supply (ES-675)	31(79)	23(58)	18(46)	N/A	143(65)
42202	Intensifier (IV)	9(23)	17¾(45)	10½(27)	N/A	60(27)
50309	Intensifier (ES-675)	9(23)	17¾(45)	10½(27)	N/A	60(27)
42203	Mandrel Holder (IV)	6½(17)	7¾(20)	1¾(4)	4(2)*	8(4)
50311	Mandrel Holder (ES-675)	3½(9)	10½(27)	1¾(4½)	3(8)*	4(10)
Mini HydroSwage® System						
42758	Power Unit	20½(52)	14½(37)	11¼(22)	N/A	74(34)
43760	Control Box	18½(47)	10(25)	8½(22)	N/A	26(12)

Drawbar Thread	Effective Area IN² (CM²)	Tube-Loc™ System					
		Power	Supply	11¼ (20)	25(26)	14¼ (36)	N/A
41915**	¼" - 28	1.35 (8.71)	2½ (6)	6(15)	2½ (6)	3½ (2)*	5½ (3)
41732**	9/16" - 18	2.70 (17.42)	7(18)	12(30)	3½(9)	8(4)*	11(5)
42140**	7/8" -24	11.46 (73.94)	7¾ (20)	11(28)	5½ (14)	14 (6)	17¼ (8)
Flare-Loc™ System							
80161	Power System		11(28)	20(51)	11(28)	N/A	56(25½)
43990**	Pull Cylinder		9½ (24)	9 (23)	4½ (11½)	17(8)	22 (10)
Hydrotest System							
43244	Power Supply	Haskel 36 Ratio Water Service Pump. Air or Hand Operated Pump in 3 Liter (183cu.in.) Tank. Weight 18½lbs.(8.4).					
42330**	Hydrotest Tool	1 x .085 & .095 Flared Tube Joints. Weight 7½lbs. (3).					
44326**	Hydrotest Tool	2 x 134 & .165 Flared Tube Joint. Weight 8½lbs. (4).					
43494	Hydrotest Tools supplied with 20ft. elastic hose with plumbing and gage that connects to 43244 Power Supply						

Note ** Supplied with 20 ft. (6.1m) umbilical - hydraulic, air electric. * Actual weight imposes on operator for hand-help equipment.



Major Benefits

Accuracy The degree of expansion is directly proportional to the pre-set hydraulic pressure.

Repeatability Each tube is expanded by the same pressure which is held to within an approximate 2% tolerance of +1000 psi (69 bars).

Quality Control Strip chart recorder, computer or a printer (optional equipment) can be used to record the actual pressure used to swage each tube to a read out accuracy of better than .5% of full operating range.

Safety	No adverse torque reaction on the operator. Swaging pressure is confined within the tube and tube sheet. Automatic shut-off if tube mandrel seal is lost.
Ease of Operation	Go/no-go lights alert operator as to the swaged condition of each tube. Since success is determined by pressure, not feel, training time is minimized to a great degree compared to mechanical methods.
Fast	Even the thickest tube sheets are swaged in one step in just seconds. As the tool does all the work, no additional operator is needed to pin tube to prevent it's movement
Versatile	One basic system handles all sizes. Interchangeable mandrels accommodate any tube diameter (1/4"-2") and gauge, and any tube sheet thickness.
Ends Chasing Leaks	Even in partial re-tubing operations, the accuracy of the HydroSwage® process minimizes disturbing the seal of adjacent tubes.
No Tube Wall Reduction	Wall thickness or tube length does not change after contact is made with tube sheet. Therefore, the seating of the tube is not disturbed as swage pressure is increased nor are there metallurgical changes.
Stress Corrosion	Stress corrosion, work hardening and other metallurgical changes are minimized, prolonging tube service life.
Reduced Crevice	Reduces crevice corrosion due to accurate control of tube to tube sheet crevice.
Accommodates Distorted Holes	This is no problem with the HydroSwage® process (within allowable tolerances). Uniform hydraulic pressure swages the tube to each hole's configuration. In a shop, in the field, aboard a ship, complete or partial re-tubing, new fabrication, tube setting prior to welding or sleeving, there is a HydroSwage®
Full Product Line	System for every application

HYDROSWAGE® SYSTEM - AVAILABLE INFORMATION

- Tooling Handbook HP001
- Mark IV & E5675
- ASME 82-JPGC-PWR-1 "Hydroexpanding The Current State of the Art."
- Central Test Laboratories Test Report MET 341 B/81- "HydroSwage® - Roller Comparison as to Stress Corrosion Cracking."
- Truesdail Laboratories, Inc. Report 37991 ASTM G35 "Stress Corrosion Cracking of Tubes (HydroSwage® vs. Rollers)
- Haskel Application Reports
- ASME Code Acceptance for Hydraulic Expansion BC-80-529
- Chemical Engineering Reprint "Heat Exchanger Tube to Tube-Sheet Connections."
- User's List
- Haskel HydroSwage® System / Video Tape
- Marine Boiler Re-tubing / Video Tape

Haskel®, HydroSwage®, and SuperSwage® are registered trademarks of Haskel International, Inc. HydroSwage® devices and processes are protected by one or more of the following:

U.S. Patents- 4,359,889, 4,362,324, 4,382,379, 4,387,507, 4,405,292, 4,407,150, 4,414,739, 4,441,862, 4,567,631, 4,581,817, 4,602,500, 4,445,261, 4,450,612, 4,467,630, 4,470,280, 4,502,308, 4,505,142, 4,604,918, 4,607,426, 4,470,280, 4,761,981, 5,009,002, 5,062,199.

Canadian Patents - 1,153,322, 1,157,689, 1,158,682, 1,170,921, 1,176,040, 1,191,436, 1,192,029, 1,193,526, 1,213,761, 1,217,415, 1,245,082, 1,256,681.

French Patents - FR0084940, FROI 21160, 66,871.

German Patents - P3364558-2, P346421 1-0.

Italian Patents - IT0084940, ITOI 21160.

U.K. Patents - GB0084940, GBO1 21160.

Australian Patents - 549,750.

Other U.S., Canadian and EPC Pending.

Other Foreign Patents Issued or Pending.



Copyright, 2002, Haskel International, Inc. All rights reserved.