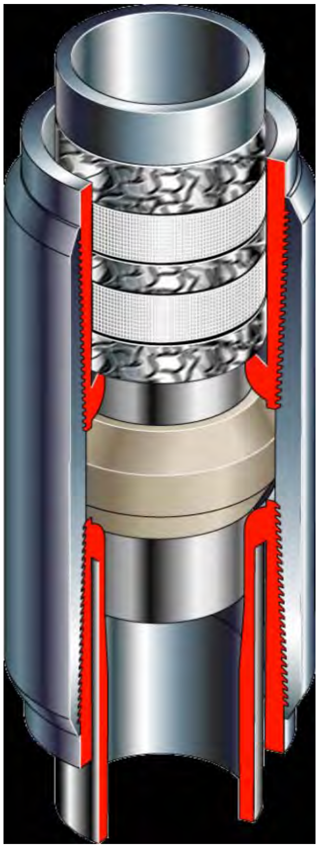

Vacuum Insulated Tubing

Oil Tech Services has acquired and is committed to extending and enhancing the technology originally developed by General Electric in 1969 to insulate permafrost production zones in wells at Alaska North Slope. The original concepts and insulations systems have advanced and High Vacuum, High Performance insulated tubulars are manufactured for steam injection wells.

Our mission is to be a reliable source of Vacuum Insulated Tubing, progressively improving the technology, performance and reliability. Our manufacturing is in Houston Texas. We provide the high quality Vacuum Insulated Tubulars enabling injection of high quality steam into deep heavy oil bearing zones. Strings can be customized for size, thermal performance and thread connection system.

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Houston, TX 77042
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mlombard@itmreps.com www.itmreps.com
Michael Lombard (CPMR)

Thermal Tube 3-H (High Vacuum, Getter™ maintained)

For Maximum Insulating Capacity at High Temperatures up to 670°F, and depths to 5000 feet.

- Thermal Protection of Well Casing
- Limits Well Bore Heat Loss to a Few Percent
- Delivers high Quality Steam to oil producing zone
- Available with Premium Threaded & Coupled Connection
- Available with Integral Premium Connection on Inner Pipe
- Insulated insert for Connection is provided
- 20 to 30 Plus Run/Pull Cycles
- Rugged Oil Field Tubulars
- Extended Life: 10 Years Plus of Continuous Service
- Available in Chrome Steels

Thermal Tube 2-H (Argon Gas Backfilled)

For Intermediate Insulating Capacity at High Temperatures up to 670°F.

Thermal Tube 2-H is an Argon gas backfilled tubular product. Mechanically it is the same as the higher performance 3-H (High Vacuum, Getter tubing)

Vacuum, Gettered, Pre-Stressed Insulated Tubulars with Maximum Insulating Capacity for High Temperature Applications up to 670° F

General Information	Size Range	
o Range II Standard Length	3-1/2" x 2-3/8"	Others Upon Request
o API, 5CT Tubulars and Couplings	4-1/2" x 2-7/8"	
o Modified Buttress Couplings (standard)	4-1/2" x 3-1/2"	
o Premium Connections Available	5-1/2" x 4-1/2"	

Typical Specifications

Physical Data	3.50 x 2.375	4.50 x 2.875	4.50 x 3.50	5.50 x 4.50
Total Weight (#/ft)	14.5	18.5	21.5	
Outer Casing				
-O.D. (in.)	3.50	4.50	4.50	5.50
--Wall Thickness (in.)	0.254	0.250	0.250	0.275
--I.D. (in.)	2.992	4.000	4.000	4.950
--Weight (#/ft.)	9.50	11.60	11.60	15.50
Inner Tubular				
--O.D. (in.)	2.375	2.875	3.500	4.500
--Wall Thickness (in.)	0.190	0.217	0.254	0.271
--I.D. (in.)	1.995	2.441	2.992	3.958
--Weight (#/ft.)	4.50	6.50	9.50	12.75

Operational Data – Vacuum System with Getter

Nominal Conductivity BTU/HR-FT-°F at 670° F		Typical Application	
Body	0.0018 – 0.0023	Operating Temperature	650° F
Coupling with Insulator	0.040 – 0.061	Operating Pressure (Wellhead)	2600 psi
Full Joint (Range II)	0.003 - 0.0043	Operating Pressure (Downhole)	2600 psi
		Start-Up Pressure	3000 psi

Operation Data – Argon Gas Backfilled

Nominal Conductivity BTU/HR-FT-°F at 670° F		Typical Application	
Body	0.015 – 0.020	Operating Temperature	650° F
Coupling with Insulator	0.040 – 0.061	Operating Pressure (Wellhead)	2600 psi
Full Joint (Range II)	0.030 - 0.040	Operating Pressure (Downhole)	2600 psi
		Start-Up Pressure	3000 psi

Sizes Available: Because of the lower efficiency of the Argon Gas insulation system a large diameter insulated annulus space is required. The 4-1/2” outer tube will have a 2-7/8” (maximum) inner tube and the 5-1/2” outer tube will have a 3-1/2” (maximum) inner tube.

Recommend General Specification for Vacuum Insulated Tubing

Vacuum Insulated Tubing for thermal enhanced oil recovery, commonly called VIT, is a Multilayered High Vacuum Insulation System. This technology was developed through a joint effort involving Babcock & Wilcox, SAES Getters, and Shell Oil Company in 1983-84 and is described in United States Patent 4,574,615. The multilayered high vacuum insulation system is engineered and the manufacturing according to rigid quality control practices and procedures and requires a reasonable lever of vacuum manufacturing expertise. Oil Tech Services highly recommends all Buyers require potential suppliers to meet a number of minimum specifications listed below:

1. Tubing Materials shall be according to API Specification 5CT, latest edition. Depending on the well bore environment the outer tube shall be J55 or L80 welded or seamless. The inner tube shall be L80 seamless.
2. Connection shall be identified. The VIT standard is API Buttress or USS Improved Buttress (depending on the size) threaded and coupled on the outer tube and having the seal ring modification inside the collar. Optional connections are Hydril CS, or RTS-8 (or equal). For larger OD insulated tubing other connections systems are appropriate and the manufacturer should be asked for recommended connections.
3. Mechanical design shall be rated for 668°F (354°C) stem temperature and designed to carry axial loads for a 5,000 foot (1,524 meter) deep injection well.
   - 3.1. The inner tube shall be centralized within the outer tube and the centralizers shall be constructed in a manner to minimize conduction heat transfer to the outer tube.
4. Insulation system shall be a multilayered high vacuum Gettered insulation system.
   - 4.1. The inner tube shall be covered by a minimum of 7-layers of reflective material (radiation barriers) with each layer separated by binder free barrier insulating paper or fiberglass cloth. The radiation barriers shall be constructed and installed to minimize heat flux from the inner tube.
   - 4.2. All insulating materials installed into the annulus and surrounding the inner tube shall be designed and rated for "vacuum service". Technical data sheets shall be presented if requested.
   - 4.3. Getter shall be ST707 manufactured by SAES Getters, S.p.A., Milano, Italy.
   - 4.4. Getter shall be placed within the joint annulus being in close proximity to the inner tube and include a method to inhibit the Getter from migrating to one end of the joint.
   - 4.5. The Getter quantity shall be identified in the proposal and based on outer tube OD circumference. The minimum quantities are:

3-1/2" OD	300 grams	5-1/2" OD	550 grams
4-1/2" OD	400 grams	7" OD	630 grams
5" OD	500 grams		

5. Manufacturing processes shall include:
   - 5.1. Each joint shall be numbered.
   - 5.2. The OD of the inner tube and the ID of the outer tube shall be cleaned by grit blasting or chemical cleaning to remove mill oils and debris.
   - 5.3. Assembly of the VIT joint insulation system shall be in a clean, temperature controlled environment.
   - 5.4. Welding procedures and Welder Qualifications shall be maintained and reviewed by Buyer upon request.
   - 5.5. Each joint shall undergo a Temperature Programmed Desorption procedure (Bakeout) for removal of gasses trapped in the steel and insulating materials. This Bakeout procedure shall include a programmed process to slowly increase inner and outer tube temperatures to drive off trapped gasses and be conducted after assembly of the insulation system and the sealing the VIT joint whereby inner and outer tube are connected by welding at both ends.
   - 5.6. The Bakeout procedure shall include connecting the vacuum annulus to a mechanical vacuum pump and mechanical pumping to a vacuum level to maximize the residual sorbing capacity of the Getter prior to Getter activation.
   - 5.7. Care shall be taken during the Bakeout procedure not to prematurely activate the Getter materials.
   - 5.8. Getter materials shall be activated at high temperature at the final stage of the Bakeout procedure according to practices and procedures recommend by SAES Getters.
   - 5.9. The port used to connect the VIT joint to the mechanical vacuum pump shall be sealed with a metal having the same metallurgy as the corresponding tube and seal welded.
   - 5.10. Each VIT joint shall have a K-Value test to determine the joints conductivity value and this value shall be recorded along with the joint reference number and presented to the Buyer.
   - 5.11. Each VIT joint shall be individually tallied for its overall length.

Oil Tech Services, Inc.
Customer List

AERA Energy
AGR Petroleum
American Shale Oil
British Petroleum
ChevronTexaco
Citation Oil & Gas
ConocoPhillips
Cosmos Shogi
Exxon-Mobil
Husky Oil Operations, Ltd.
Laricina Energy, Ltd
LukOil
Nexen Energy
Occidental Petroleum
PDVSA
Pemex
Petrobras
Petroleum Development Oman (PDO)
Saaya, Japan
Salamanca Energy
Suncor
Tatweer Petroleum
Tidelands Oil Production Company
Total
Turkish Petroleum AO
Wintershall AG

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SPECIFICATION

Insulated Steam Injection Tubing

Revision 6, dated 24 July 2011

This specification is for vacuum insulated steam injection tubing manufactured by **Oil Tech Services, Inc.**, 800 Wilcrest Dr., Ste. 101, Houston, TX 77042.

The following U.S. Patents apply:

U.S. Patent 4,322,669 - Non-Evaporable Ternary Gettering Alloy and Method of Use for the Sorption of Water, Water Vapor and other Gases; Issued Jan. 26, 1982; Assigned to SAES Getters S.p.A., Milan, Italy

U.S. Patent 3,608,640 - Insulated Tubing - Prestressing; Assigned to CONOCO (this patent has expired)

Specification

I.) Tube Materials:

Outer tube: J-55, API Specification 5CT, ERW, Range II
Inner tube: L-80, API Specification 5CT, Seamless, Range II

(Other tube materials are available, based on Buyers requirements.)

	O.D. Inches	Wall Thickness Inches	Weight #/ft
3.5” x 2.375”			
Outer Tube	3.5	0.254	9.5
Inner Tube	2.375	0.190	4.5
4.5” x 2.875”			
Outer Tube	4.5	.25	11.6
Inner Tube	2.875	0.217	6.5
4.5” x 3.5”			
Outer Tube	4.5	.25	11.6
Inner Tube	3.5	0.254	9.5
5.0” x 3.5”			
Outer Tube	5.0	0.362	18.00
Inner Tube	3.5	0.254	9.5

II.) Connection:

Connection options are:

a) API Buttress with AB Modified Seal ring threaded and coupled connection on the outer tube (4-1/2” outer tube and above.)
b) USS Buttress with seal ring modification threaded and coupled connection on outer tube (3-1/2” and below)
c) Heavy Duty 2-Step integral connection on the inner tube (interchangeable with Hydril CS). No coupling.

II.) Tube Coupling:

Coupling material shall be J-55 or better. Coupling will have Buttress thread (or USS Steel Improved Buttress) and be modified for API Teflon seal ring. Coupling will be supplied with seal ring installed. Coupling will have anti galling preparation of Manganese Phosphate. Sealing ring shall be Teflon/glass composition for high temperature.

III.) Thread Protectors: Thread protectors are installed on threads (both box and pin) after manufacture. Thread protector will be a composite protector providing maximum thread protection.

IV.) General: Each joint shall have a unique serial number for traceability.

V.) Coupling Insulator: The coupling insulator for the Buttress threaded and coupled connection is a short metal sleeve with a high temperature Teflon/Glass (PTFE) insulating donut around the middle. The I.D. of the coupling insulator is the same or slightly greater than the I.D. of the inner tube. The length is designed to provide minimal clearance when both its collar and tube threads are engaged at their maximum thread depths. The insert is supplied in one-piece and is installed into each collar during installation into the well.

The connection insulator for the Heavy Duty 2-step integral connection is a metal sleeve the same OD as the outer tube with an insulated ID. This external sleeve is placed over the box end of the integral joint during make-up on the rig.

The purpose of the Coupling Insulator is to insulate the collar from heat loss. Thermal resistance in the coupling area is from (a) steel sleeve, (b) Teflon/glass (PTFE) insulation, or the optional ceramic insulation for the external sleeve used with the integral type connection system.

VI.) Mechanical Design: The mechanical design is as follows:

A.) Maximum well depth 5000 feet (1524 meters)
B.) Maximum temperature 670°F (354.4°C)

VII.) Insulation System: Multi-layered High Vacuum GETTER maintained insulation system, according to the following:

(A) Getter: The quantity of GETTER is determined by recommended practices provided by SAES Getters, Milano, Italy, and shall be a minimum of 350 to 550 grams per Range II joint. The GETTER shall be SAES Getter St-707 manufactured by SAES Getters, Milan, Italy. (Quantity of Getter installed is dependent on the surface area of the outer and inner tubes.)

If a manufacturer proposes to use a getter other than SAES St-707, the manufacturer shall provide independent documentation the getter proposed is equal or better than the St-707 product at the mechanical design temperature shown above.

(B) Multi-layered Insulation: The insulation system will have a minimum of seven (7) layers of aluminum foil each layer separated by binder free barrier material being either ceramic paper, fiberglass, or equal. All materials will be specified as “vacuum grade”. All barrier materials separating the layers of foil shall be binder free to eliminate conduction heat transfer and reduce the quantity of gases that must be outgassed during the bake-out process (Temperature programmed desorption process).

(C) Vacuum Port: The outer tube shall have a vacuum port located at one end of the outer tube. This port is used for connection to a high efficiency vacuum pump. See Temperature Programmed Desorption (bakeout) below).

(D) Tube Processing: The ID of the outer tube and the OD of the inner tube shall be grit blasted “white” or chemically cleaned to remove mil scale, oils, contamination and surfaces gasses from the tube manufacturing process.

(D) Temperature Programmed Desorption Process (Bakeout): After the inner and outer tube have been welded at both ends creating a sealed annulus space (excepting a vacuum port for connection to a mechanical vacuum pump), each joint shall undergo a Temperature Programmed Desorption Process whereby over an extended period of time the joint is heated to drive off and desorb surface gasses and contaminants from raw materials. During this process the joint shall be connected to a high efficiency mechanical vacuum pump to withdraw the desorbed gasses and contaminants from the annulus space between inner and outer tubes. The bakeout temperature shall be progressively elevated while mechanically pumping the annulus. When the mechanical vacuum pump has reached its lowest design input pressure the bakeout temperature shall be elevated to the “Getters” design activation temperature and held at this temperature to assure a 90%-100% “Getter Activation”. Every possible effort shall be taken during the Temperature Programmed Desorption Process to maximize the removal of surface gasses and contaminants from all materials. Manufacturer shall maintain documentation and test reports on the vacuum manufacturing process...

(E) Getter Position: Getter shall be positioned within the annulus of each joint to maximize its effectiveness, prevent premature activation during the bakeout process, and maximize its residual capacity after the joint is sealed (vacuum port close-out)

(F) Vacuum Port Closeout: The manufacturer shall provide a tool or device the surround the vacuum port and connect the vacuum port to the high efficiency vacuum pump. After Getter activation the vacuum port shall be mechanically sealed with a steel plug creating a metal-to-metal seal with the vacuum port. When the manufacturer is assured there is zero leakage from this plug the connection tool shall be removed and the steel plug shall be seal welded.

(G) Optional: A high temperature Aluminum base paint applied to the outer tube (3 to 5 mils thick).

VIII.) Prestress: Each joint of insulated steam injection tubing shall be prestressed for the design steam temperature.

IX.) Outer Tube Finish: After manufacture, the outer tube shall be coated with a protective high temperature aluminum based coating to avoid corrosion. (Optional process)

X.) Inspection: Welding: A number of elements shall be in place to assure proper performance of the welds connection inner to outer tubes including appropriate materials, people, appropriate equipment and programmed equipment, procedures, and assurance procedures are followed.

Elements	Documents
Materials	Certificate of Conformance and manufacturers' literature, standards, and practices.
Personnel	Welder Qualification Tests
Automatic Equipment	Welder Qualification Tests
Procedures	Welding Procedure Specifications and Procedure Qualification Test Records

Vacuum: After Getter Activation and vacuum port close-out each joint shall be tested for its individual conductivity value (K-Value). This value shall be recorded in a log maintained by the manufacturer. The Buyer shall receive a detailed K-Value report showing the individual K-Value for each joint purchased and listed by the joints serial number. The average K-Value for each string of tubing shall not exceed 0.003Btu/Hr.-Ft.-°F. Mill Test Certificates for all materials shall be maintained by the manufacturer and available for inspection by the purchaser and or purchaser's agent, or provided to the Buyer upon request.

The Buyer shall receive a Tube Tally showing the serial number and the measured length of each joint shipped.

XI.) Outer Markings: The outer tube shall be marked as follows:

Size: (Outer Tube O.D.) x (Inner Tube O.D.)
Thread: "Buttress" or "USS Steel Improved Buttress"
Example: ***4-1/2 x 3-1/2 - Buttress***

Additional markings shall include:

a) Serial Number:
b) Country of manufacturer

(Other markings required by the Buyer shall be noted in the Purchase Order or by specific instructions to the manufacturer.)

Recommended quality control steps for the Petroleum Engineer having responsibility for specifying and Purchasing Insulated Tubing:

1. Traceability of raw materials. Company shall have an internal system for traceability of Material Test Reports and Conformance reports on all raw materials used.

2. Inspection of welding procedures and welder qualifications.

3. Calibration records for all equipment used in the manufacturing operation:

    a. Welding equipment.
    b. Post weld heat treatment equipment.
    c. Control of ambient temperature and humidity in the manufacturing space.
    d. Leak detection equipment at the Bakeout oven.
    e. Oven temperature controls.
    f. K-Value checking equipment (thermocouples).
    g. Thread gauging equipment.

4. Raw material storage. Adequate temperature and humidity control.

5. Confirm the insulating raw materials are manufactured for vacuum service and insulating materials are without binders or other contamination that will outgas into the evacuated annulus.

6. Joints shall have a unique serial number for traceability.

7. Confirm the OD of the inner tube and the ID of the outer tube are cleaned by suitable method to remove mill scale, oils, and other contamination prior to assembly.

8. General cleanliness of the tubing assembly area and procedures used to assure joints are assembled in a clean manner.

9. Observe welding and prestress operations.

10. Examine records for the Programmed Temperature Desorption Cycle and Getter Activation (Bakeout cycle). Confirm Getter activation is within manufacturers specifications and activation is within the specified time & temperature limit to become 90-100% effective.

11. Observe K-Value testing.

12. Observe threading operation.

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Sample – Multiple Layers of Insulation

The inner tube is wrapped with multiple layers of alternating aluminum foil, ceramic glass insulating paper, and fiberglass cloth providing radiation and conduction heat transfer barriers. The aluminum foil is chemical cleaned for high vacuum service. The ceramic paper between each layer of foil is "without" binders because these binders will outgas and contaminate the vacuum space. The fiberglass cloth is specially manufactured and chemically cleaned for high vacuum service.

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The St707 Alloy

The St707 wide operating temperature range down to room temperature and its availability in different formats make this alloy the best solution for several applications, from particle accelerators to plasma fusion machines, from laboratory vacuum systems to batteries.

The St707 getter material is a ternary alloy with the following nominal composition:

Zirconium 70%
Vanadium 24.6%
Iron 54%

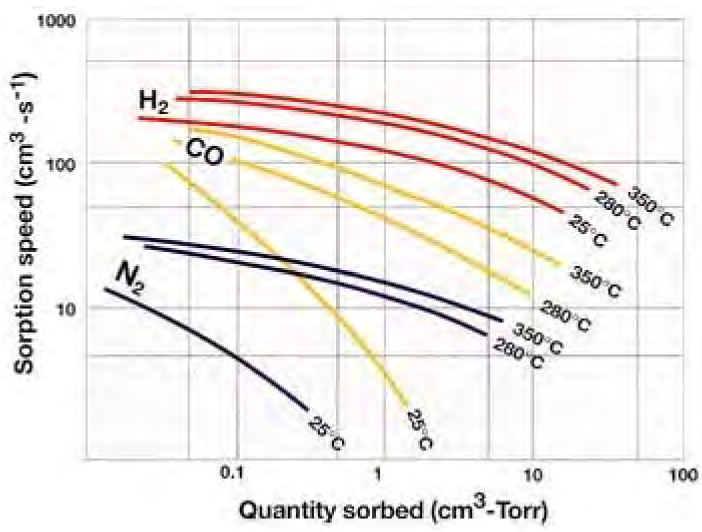
St707 Getter Activation

The St707 getters have a protective passivation layer that must be eliminated to start the gettering action. This process, called activation, is carried out by heating the getter under vacuum or in an inert gas atmosphere.

The optimum activation conditions are at 450-500°C for 10 minutes.

St707 Getter Operation

Once the alloy is activated, reactive molecules such as O2, H2O, N2, CO, CO2 and H2 are adsorbed via a three steps adsorption mechanism: surface dissociation, surface sorption and bulk diffusion. Hydrocarbons are adsorbed at lower pumping speed at temperatures above 200°C.



Once adsorbed, oxygen, nitrogen and carbon atoms cannot be released by the St707 due to the formation of strong chemical bonds with the alloy atoms.

Hydrogen reacts differently: it diffuses into the St707 getter bulk even more quickly than the other species and it distributes almost uniformly within the bulk even at low temperatures. However, since the bonds hydrogen-alloy are weak, some of the hydrogen sorbed at low temperatures can be released at higher temperature.

Manufactured by:
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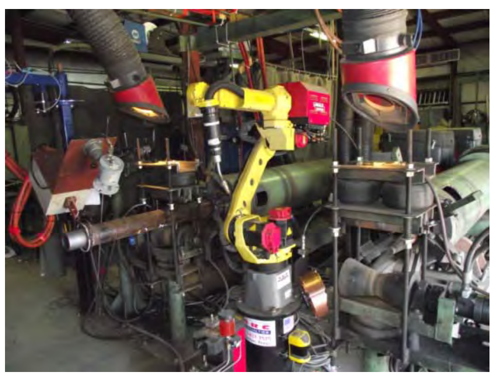
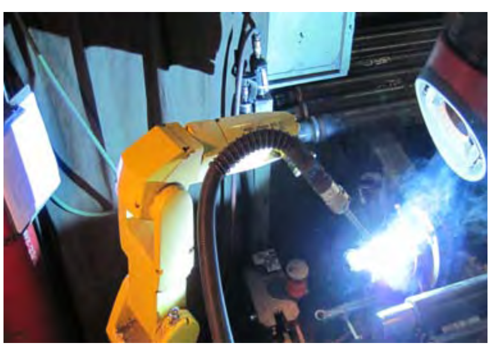
WELDING

Weld Procedure Specifications (WPS): Welding is one part of the VIT manufacturing process that requires a number of elements to be in place to insure the highest quality finished product. These elements are: appropriate materials must to be used, people performing the work must be capable, procedures must be appropriate for the work, and such procedures must be followed. Finally, appropriate inspection must take place to ensure that all of these steps have been properly executed. American Welding Society (AWS) codes contain provisions describing minimum requirements for each of these elements, and documentation is required to assure each of these elements is in place.

Procedure Qualification Record (PQR): Further, these weld procedure specifications (WPS's) are qualified on a periodic basis by test. These qualification tests are conducted by welding a test sample using the parameters to be tested and by subjecting the weld to bend tests, tensile tests and, Charpy V-notch tests. Test results and variables qualified are shown in a Procedure Qualification Record (PQR).

Robotic Welding on All Connection Welds:





Computer Controlled
Robotic Welding

Post Weld Heat Treating

28 February 2012

Oil Tech Services, Inc.

By: Michael Lombard

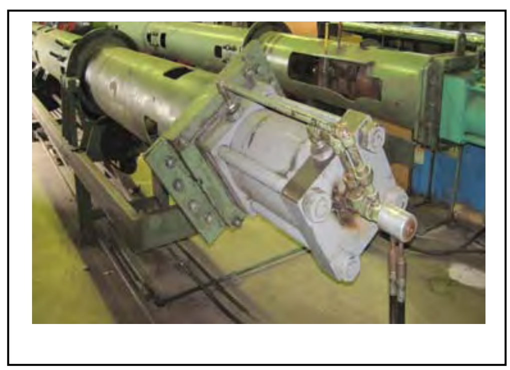
PRESTRESSING: An important design feature of insulated tubing is the method to overcome thermal expansion differences between the inner and outer tubes. The theoretical concepts and mathematical formulas used by OTSI are well known in the industry but we like to keep our methods proprietary therefore they are not disclosed herein.

Details:

Equipment: The amount of prestress in the product is important for in service performance and for assurance for the product reaching its expected in-service life. Therefore each step in the prestress operation is equally important.

The prestress machine consists of a large fixture that holds an entire ThermalTube joint. In the prestress operation hydraulic clamping devices on the OD of the outer tube, the ID of the inner tube, and the inner tube to outer tube weld at one-end of the joint provide the holding and restraining mediums respectively.

Immediately after loading an insulated inner tube inside an outer tube one end of the joint is welded and heat treated. After the completing of this welding process the joint is loaded into the prestress machine. A set of ID clamping slips is run into the inner tube and the slips are positioned near the un-welded end of the joint. Hydraulic pressure and movement are used to engage the slips grabbing onto the ID of the inner tube. Hydraulic clamping devices are engaged around the outer tube and hold the outer tube in position.



A hydraulic cylinder connected to the ID slips locked onto one end of the inner tube provides the force to physically prestress the joint. Hydraulic pressure is applied to the cylinder causing its piston to extend, the inner tube being welded at one end is thereby stretched to a predetermined length. The amount of prestress is measured with machinist ruler and compared to the calculated prestress values in the accompanying the work order. When the specified stretch of the inner tube is reached the operator will engage zero leakage lock valves mechanically holding the prestressed inner tube in position relative to the outer tube. An automatic welding machine is positioned and commences the welding procedure followed by heat treating. After welding and heat treating hydraulic pressure is used to unlock the zero leakage load holding valves releasing the completed joint which is then removed from the prestress fixture and ready for the next manufacturing operation, bakeout.

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5 January 2012, Rev. 1

Temperature-programmed Desorption (TPD)
Bake-Out Process

The vacuum bake-out process is a combination of several operations performed to achieve a high vacuum sealed within the annular space between the inner and outer tubes of a VIT assembly. This high vacuum including the multiple thermal radiation barriers wrapped around the inner tube becomes the thermal insulation of the VIT joint.

The processes necessary in the vacuum bake-out are:

- Cleaning (Grit Blasting)
- Assembly (Getter Installation)
- Vacuum Bake-Out (Temperature Programmed Desorption)
- Sealing

Cleaning: In order to reduce off gassing during the vacuum bake-out process mill scale, oils, greases, and other volatile hydrocarbons and contamination are removed by grit blasting of the inside diameter of the outer tube and the outside diameter of the inner tube.

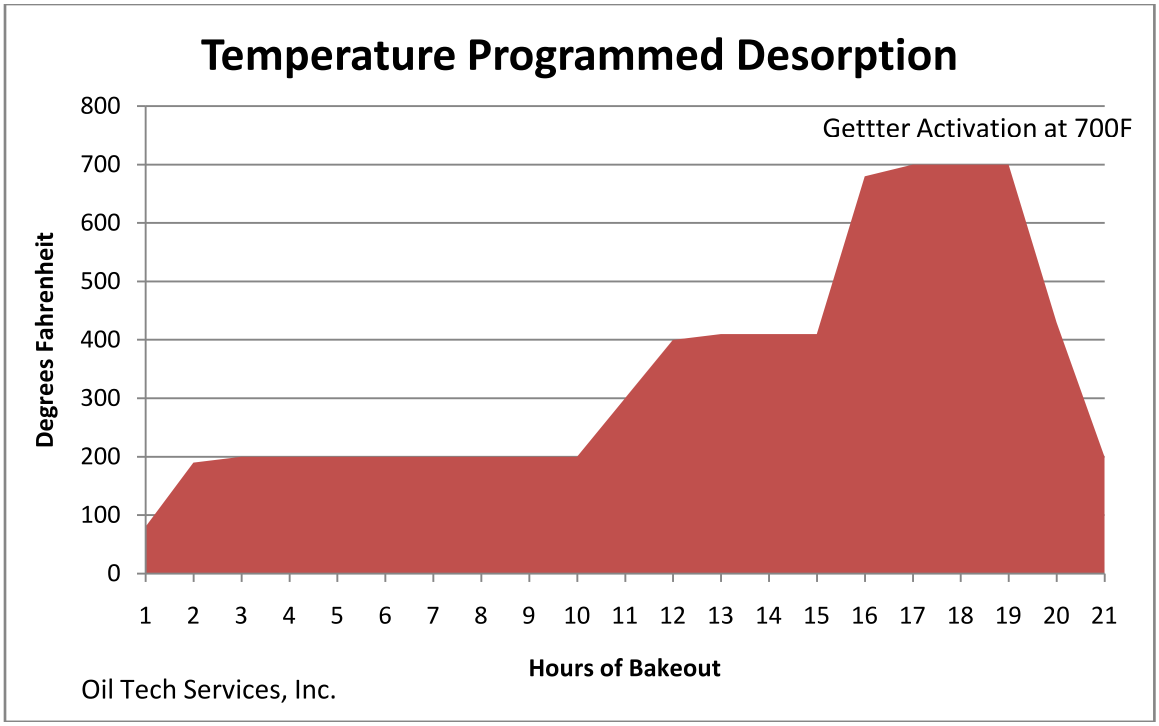
Getter Installation: During assembly (wrapping of multiple layers of aluminum foil separated by ceramic paper and fiberglass cloth) the Getter is installed within the closest aluminum foil wrap to the OD of the inner tube.

Vacuum Bake-Out (Temperature Programmed Desorption): After the assembled VIT joint is welded at both ends sealing the vacuum and connecting the inner tube to the outer tube, the full length of the VIT joint, including the vacuum fixture, is positioned inside a bake-out oven. The VIT joint has a vacuum port drilled into the outer tube approximately 18-inches from the tube end. A special fixture is installed over vacuum port and attached to the manifold / vacuum pump system. The mechanical vacuum pump is started, the oven is turned on and a programmed time-temperature cycle takes over control of the oven and process.

This programmed temperature desorption cycle causes the mechanical (through the vacuum pump) removal of gasses sorbed and occluded into the steel surface and held within the inner and outer tube internal matrix structure. Oven temperature is slowly increased to maximize removal of these sorbed gasses from the carbon steel inner and outer tubes: This time period is approximately 12-15 hours.

Vacuum levels are continuously measured through the fixture covering the vacuum port. Once the mechanical pump has lowered the annulus pressure to a medium vacuum level, the oven temperature is quickly increased causing the passivation layer protecting the Getter from premature activation to be released allowing any remaining gas molecules within the annulus to react with the Getter alloy thereby chemically pumping the vacuum to approximately15 milli-Torr.

Once the desire vacuum level is obtained, sealing of the vacuum port is completed. A seal plug pre-installed within the vacuum port fixture is pressed into the vacuum port (hole) and a metal-to-metal seal is confirmed using a Helium leak detection process. Once the metal-to-metal seal is confirmed, the fixture is removed and the plug is seal welded around the plug circumference.



Additional comments: One or more insulated tubing manufacturers do not use a bakeout process in their manufacturing. The following information is presented to help the engineer understand the importance to this step in the manufacture of a high vacuum system.

Getters are actually quite forgiving in terms of the activation process and how they are activated. If an insulated tube was to rely on the first steam cycle to activate the getter, steam temperature will need to be 200°C (400°F) or hotter. According to SAES Getters general activation recommendations the suggested a temperature of activation is 450°C (845°F) for a period of 10-15 minutes and longer periods at lower temperatures.

This bake-out process is a common practice for all high vacuum systems and a critical process to cause the passive film protecting the Getter from premature activation to diffuse into the bulk of the Getter making the Getter surface active for sorption and insuring maximum residual Getter capacity. It is essential to heat the Getter under a medium vacuum of $1x10^{-3}$ Torr or better to prevent the accumulation of gasses from building up another passivation layer and stopping the gettering action.

The getter's task is to maintain the vacuum in the annulus of the insulated tube: The better the bake out the lower the amount of residual gas. The challenge for the manufacturer is to have sufficient getter material to exceed the amount of gas evolving from the inner and outer tubes during the life of the product. A clean inner tube OD and outer tube ID (such as a grit blasted surface) makes this easier. An insulated tube manufactured without a bakeout cycle needs substantially more Getter and assurance there is sufficient temperature and time during the initial steam cycle to properly activate the Getter avoiding contamination of the Getter surface with a new passivation coating stopping the gettering action.

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K-Factor Testing

An integral part of the manufacturing process and quality control program is the necessity to detect the presence or non-presence of vacuum at the end of the manufacturing cycle. OTSI uses a thermal process to accomplish the test providing a thermal insulation K-Factor for each joint manufactures which is further recorder for each joint according to serial number.

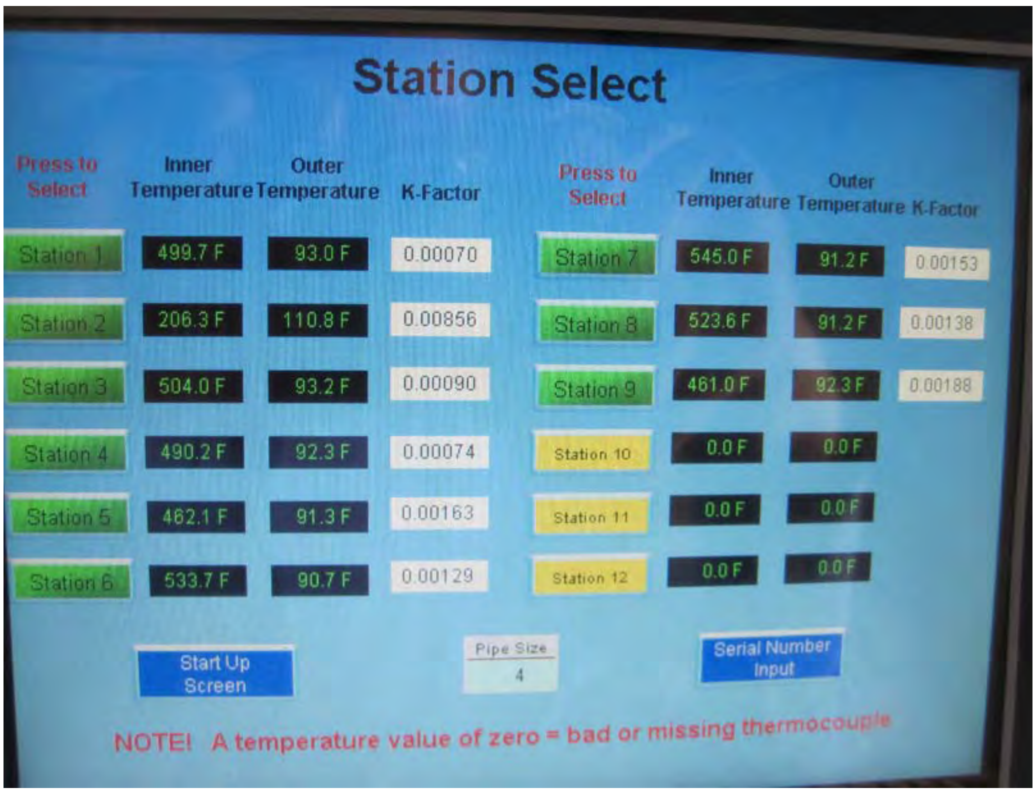
Once the insulated joints are removed from the oven after the bake-out process (temperature programmed desorption process), they are subjected to ambient temperatures and the outer tube will cool quickly while the inner tube remains at oven temperature because of the vacuum insulating system. Insulated plugs are installed into each end of the joint to maintain the high inner tube temperature. The outer tube is subjected to ambient temperatures and differential temperature between the inner and outer tubes rapidly reaches approximately 500-550°F (260°C - 337.5° C)[1]. *(Outer tube cools to ambient temperature of approximately 100°F and the inner tube temperature cools slowly from the final oven removal temperature of approximately 650ºF[2]-[3].)*

[1] The bake-out process is a controlled ramp-up and hold to the desired temperature before removal from the bakeout oven. After removal from the bake-out oven the outer tube will cool to ambient temperature very quickly, while the inner tube will remain at an elevated temperature for a considerable period of time due to the insulating performance of the high vacuum insulation system.

[2] The maximum differential temperature of 550°F is an estimate. OTSI believes this estimate is conservative and defensible based on our manufacturing plant being located in Houston, Texas where based on experience even on a cold day, the outer tube normally does not cool below 100°F prior and during the K-Value test cycle.

[3] SPE Paper No. 112981, New Advances and a Historical Review of Insulated Steam Injection Tubing, page 5, GETTER activation temperatures. Maximum GETTER activation temperature is 850ºF (450ºC) for SAES ST707 and lower for other GETTER compounds. The temperature value used above is conservative and based on manufacturing experience.

Thermal couples are installed on both the inner and outer tubes and the temperature differential is measured and recorded over a prescribed period of time. These temperature readings are then used to calculate an average thermal conductivity value (K-Factor) for each joint.



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CONNECTION OPTION FOR VACUUM INSULATED TUBING

AND

MAGNESIUM PHOSPHATE COATING

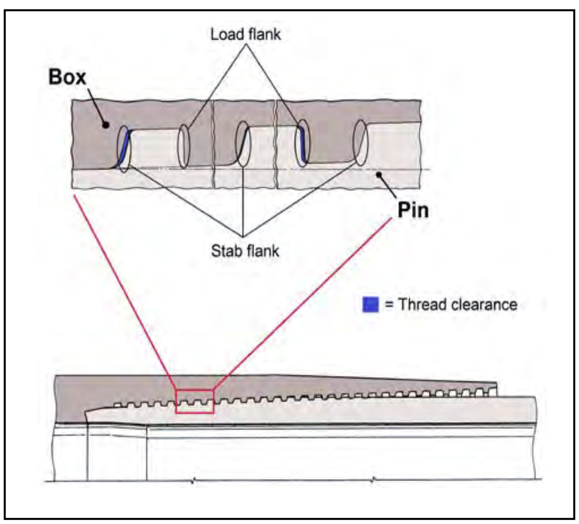
When completing high temperature and high pressure wells the both the tubing string and casing, insulated or not, must be able to withstand extreme conditions. The threaded connections are the most critical component of the entire chain. The Oil Tech Services insulated tubing offers two connection configurations:

1. API Buttress with AB Modification Sealing Ring threaded & coupled connection on the outer tube, and
2. Heavy Duty 2-Step connection, integral flush joint, on the inner tube (interchangeable with Hydril CS).

Buttress Connection

Historically, the API Buttress or its equal the USS Improved Buttress used on 3-1/2" sizes and below has been the standard thread configuration for Insulated Tubing. This threaded & coupled connection has a favorable history because of the ability to demount and reuse the tubing string multiple times. In recent years some operators have asked for semi-premium and premium threaded connections to fulfill certain wellbore requirements and in these cases the Heavy Duty 2-Step connection has been the thread of choice.

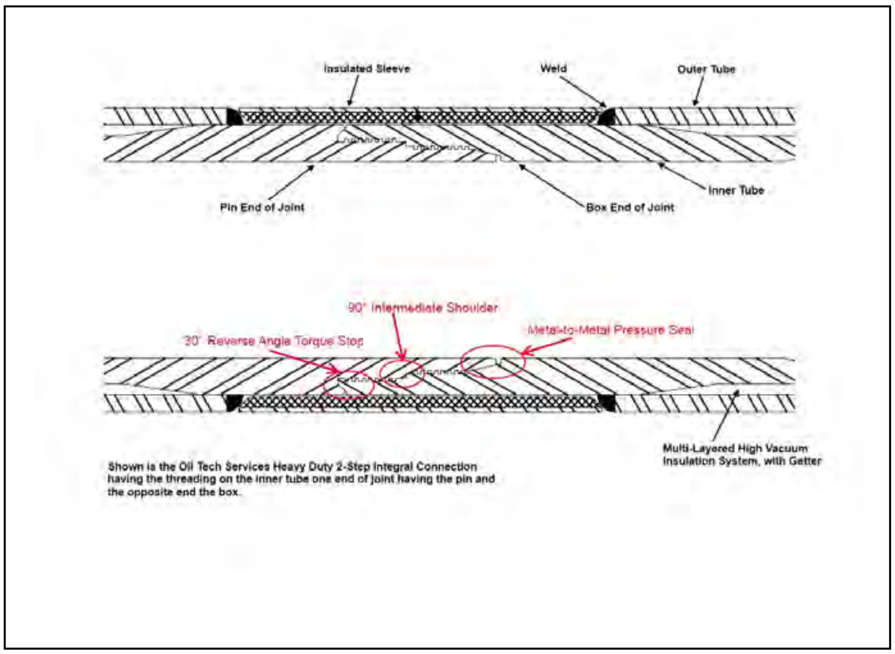
The API Buttress connection, patented by Samuel Webb (US2772102 - Sealed Threaded Pipe Joint, Nov. 27, 1956) provides excellent joint strength and the mismatch leads closing the thread clearance on the stab flanks when combined with the AB Modification Seal Ring provide the required leak resistance.



The Buttress T&C connection is less sensitive to stress concentrations and in most cases will have higher tension ratings than integral connections. These Buttress tapered threads inherently establish a certain make-up torque and have high resistance to cross threading.

Heavy-Duty 2-Step Connection

The second type of thread is the integral flush joint connection OTSI has named Heavy Duty 2-Step (interchangeable with Hydril CS) which offers metal-to-metal pressure seal. The primary metal-to-metal seal is located near the torque shoulder and a center step torque shoulder.



The connection offers a 30° degree reverse angle torque stop, an 90° intermediate shoulder, and a metal-to-metal pin nose seal providing a gas tight seal under high pressure and temperature.

Manganese Phosphate Coating

Manganese phosphate coatings is applied to all threads to increase wear resistance and anti-galling properties. The manganese phosphate improves the ability of threads to retain pipe dope further improving the anti-friction properties and corrosion resistance of the connection.

Manganese phosphate is applied by immersion method that includes:

- Pickling (acid cleaning). Oxide films and rust stains are dissolved in acid.
- Water rinsing.
- Phosphating is by immersion at high temperature.ing method.
- Water rinsing.
- Drying.