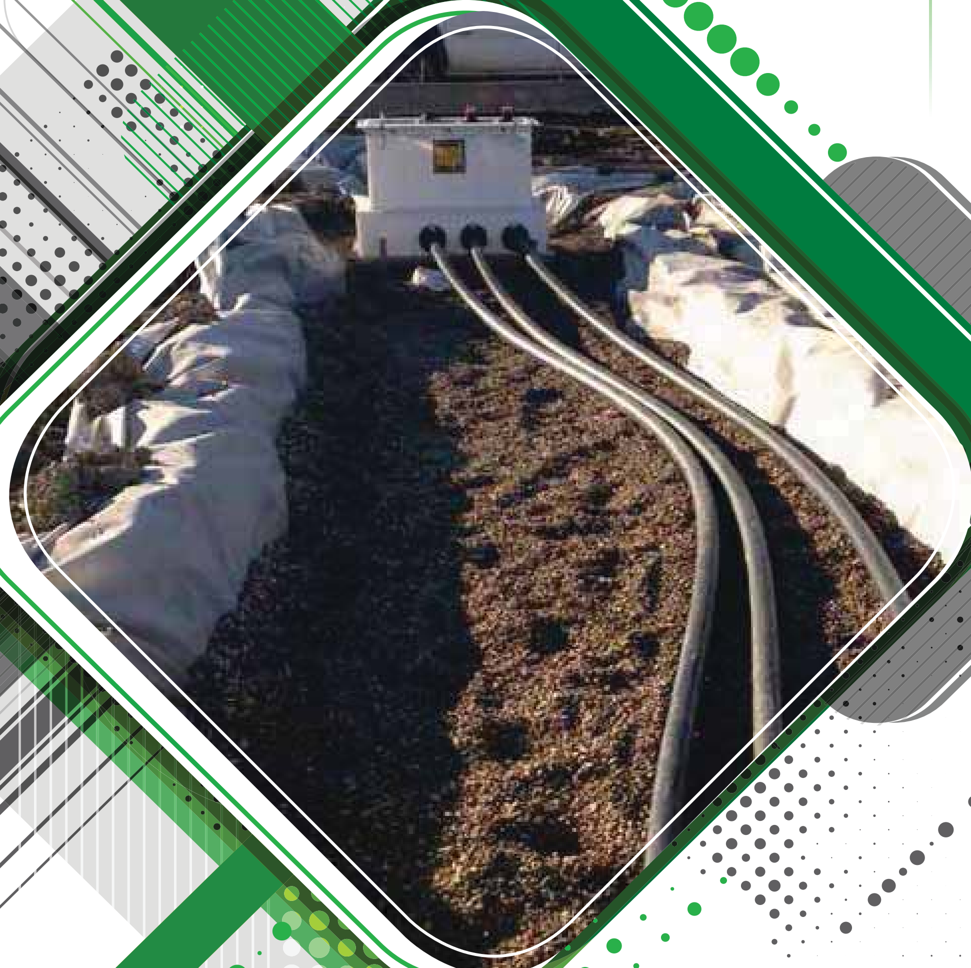
SMARTFLEX™

Catalog 2017

January 2017



Single and Double Wall Piping System

nupi
AMERICAS

SMARTFLEX Catalog 2017

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THE COMPANY

Nupi Americas Inc. was founded in 2001 and is based in Houston, TX where it established a warehouse and production facility. Another warehouse is located in **New England.**

Nupi Americas **has its roots** in NUPI Industrie Italiane S.p.A., born in 2015 to replace NUPIGECO S.p.A. that was founded in 2008 by the merger of NUPI S.p.A. and GECO System S.p.A. – two companies with more than 40 years of experience in the field.

NUPI Industrie Italiane S.p.A. and Nupi Americas together **develop and manufacture piping systems for use in industrial, sanitary (plumbing), HVAC, waterworks, gas and irrigation markets.** Relying on experience and constant growth, our companies have proven to be cutting edge manufacturers, ready to meet the needs of the market while also protecting the environment. In 1995, following the completion of an extensive Research and Development program, we introduced a new range of **revolutionary piping systems specifically designed for petroleum, chemical and petrochemical applications.** Since then, two special piping systems made of **High Density Polyethylene (HDPE)** have been marketed worldwide: **SMARTFLEX for the downstream and OILTECH for the upstream.**

ELOFIT is the High Density Polyethylene system of electrofusion fittings and special components for the conveyance of water and gas under pressure. It is suitable for the conveyance and distribution of drinking water and alimentary fluids, fuel and inert gases and for water treatment plants, centralised irrigation and sewage systems, fire protection systems and pipe relining.

NIRON is a complete Polypropylene pipe and fitting system for the distribution of hot and cold water in plumbing and air conditioning systems, for the conveyance of drinking water and alimentary fluids, industrial plants and for the transport of compressed air and chemical substances. The pipes and fittings that compose the NIRON range are manufactured using **Random Copolymer Polypropylene (PPRCT), a plastic material with a special molecular structure ensuring high mechanical resistance and duration, even at high temperatures and pressures.**

Registered Office & Headquarters - NUPI Industrie Italiane S.p.A. - Busto Arsizio (VA) Italy

Production, Operations & Administration Center - NUPI Industrie Italiane S.p.A. - Castel Guelfo di Bologna (BO) Italy

Production Facility - NUPI Industrie Italiane S.p.A. - Imola (BO) Italy

More product ranges marketed by Nupi Americas are **ELOPRESS** - a **complete range of PP fittings** for the **distribution of drinking water and alimentary fluids, ELAMID -** a **complete piping system made of Polyamide 12** that satisfies **high performance requirements in gas supply applications** and **SMARTCONDUIT** - designed to **contain electrical and communication cables in high groundwater or hydrocarbon-rich environments.**

Our trademarked systems are real **system solutions**, covering a wide range of applications, reducing costs, avoiding waste and increasing productivity. Thanks to their quality, these products have passed many different tests and have **obtained the most prestigious certificates** and listings, in line with the regulations of the five continents for the construction of water and gas networks and systems for the transport of fuels.

Producing better quality and being cost effective is the goal, which is made easier everyday by new technology. Our companies are **continuously investing in research and development programs,** while strengthening our production systems, operated by a sophisticated technology that guarantees the highest quality of products.

Our facilities use modern, state-of-the-art computer controlled production equipment and methods that **guarantee products of the highest quality together with continuous quality control systems.**

On these solid foundations NUPI Industrie Italiane and Nupi Americas demonstrate leadership throughout the thermoplastic piping industry. Our customers can rely on the best quality materials and precise manufacture, obtained through completely automated production systems and continuous on-time deliveries, resulting in timely deliveries which allow planning to be done in real time.

Customer satisfaction is pursued through high quality products and the constant attention to our customers' needs and requirements and by means of an effective team of people in post-sales service, effective and precise technical assistance and intensive training of installers.

Production, Operations & Administration Center - NUPI Industrie Italiane S.p.A. - Castel Guelfo di Bologna (BO) Italy

Production, Operations & Administration Center - NUPI AMERICAS INC. - Houston (TX)

SMARTFLEX™

SYSTEMS

1

TECHNICAL DATA

1.1 WHAT IS THE SMARTFLEX SYSTEM

The SMARTFLEX system comprises a Composite multilayer piping system, Electrofusion fittings and Tools suitable for the conveyance of petroleum products, alcohols, alcohol-gasoline mixtures and biofuels.

The SMARTFLEX range is available both in SINGLE WALL and DOUBLE WALL systems.

SMARTFLEX is manufactured using the latest technopolymers that are biocompatible and 100% recyclable.

The quality of the materials used and the strict quality controls in its manufacture allow NUPI AMERICAS to provide a product warranty of 30 years.

1.2 MAIN CHARACTERISTICS OF THE SMARTFLEX SYSTEM

FULL DOUBLE WALL RANGE
Range:

Primary ø 1" ½ - Secondary ø 2"
Primary ø 2" - Secondary ø 2" ½
Primary ø 3" - Secondary ø 5"
Primary ø 4" - Secondary ø 5"

Thanks to an investment of more than US $ 3,5 million all our fittings are molded. This means more compact parts (less bulky installations) and ease of implementation by reducing the time of labor.

FULL SINGLE WALL RANGE
Full range from ø 1" ½ to ø 4".
More than 12,000 service stations in the five continents in perfect working order.

NO CORROSION
HDPE pipes are resistant to all degrees of water hardness as well as chemicals (with pH values between 1 and 14). They have a high resistance to acids and alkalis in a wide range of concentrations and temperatures.

RESISTANCE TO STRAY CURRENTS
Polyethylene is a very poor electrical conductor, thereby avoiding the risk of perforation of the pipe or fittings caused by stray currents.

LOW PRESSURE DROP
Smartflex™ pipes have reduced pressure losses because their surface is very smooth (roughness = 0.000005 ft and Hazen-Williams friction factor = 150).

ABRASION RESISTANCE
The high resistance to abrasion of the Smartflex™ system provides high velocity of gasoline circulation without erosion problems.

LIFE
More than 30 years, depending on the temperature and working pressure.

1.3 FIELDS OF USE

The most common applications for SMARTFLEX pipes and fittings, both in suction and pressure installations, are as follows:

- ROAD AND MOTORWAY SERVICE STATIONS
- HARBOR AND MARINE SERVICE STATIONS (MARINAS)
- FUEL DISTRIBUTION IN AIRPORTS
- FUEL STORAGE TANKS
- GENERATOR CONNECTIONS TO FUEL TANKS

The Smartflex™ system has been optimised for use in underground applications and for the conveyance of the following fuels*:

- Gasoline
- Unleaded petrol 98
- Unleaded petrol 95
- Unleaded petrol 95 with 8-10% ethanol (E10-SE95)
- Methanol
- Toluene
- Kerosene
- Diesel without sulphur
- Diester Diesel
- Fuel (FOD)
- CLAMC (fuel for heating)
- Jet Fuel A
- Biodiesel
- E85
- Diesel Exhaust Fuel (DEF)

* The list is not complete

Note: For special applications such as AdBlue/DEF/Urea, the metal connection shall be made of AISI 304 stainless steel and the O-ring/gaskets shall be made of Viton.

It is suitable for all installations:

- Product
- Filling
- Vent
- Vapor recovery VR1 and VR2

It is also used for the conveyance of fuel at airports, in the industrial field and for the transport of aggressive fluids in general (contact us for further information).

1.4 SINGLE WALL PIPES

SMARTFLEX single wall pipes for the transport of petroleum products, alcohols, alcohol-gasoline mixtures and biofuels.

A primary pipe is the pipe that carries fuel and is provided of a protective liner.

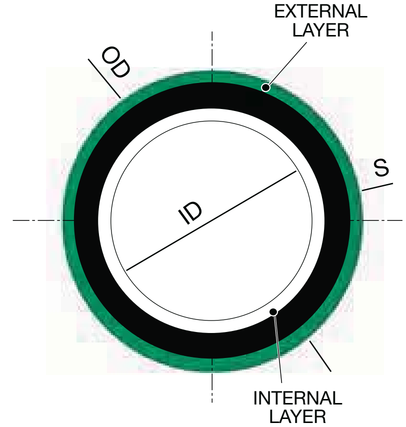
When primary pipe is used without a secondary pipe it is called a SINGLE WALL pipe.

Primary pipe is a multilayer pipe manufactured through a production process called “co-extrusion” (contemporary extrusion of various layers of pipe comprised of different materials).

It combines the excellent mechanical properties of HDPE (High Density Polyethylene) and the low permeability and high chemical resistance of an inner and/or outer layer made of a polymeric material specifically suited to the application.

This inner layer (liner) guarantees the following:

- A barrier impermeable to fuels
- Excellent resistance to wearing
- High resistance to long-term pressure
- Limited head loss



UL SINGLE WALL PIPES	OUTSIDE DIAMETER OD (in.)	MINIMUM PIPE WALL THICKNESS S min	MINIMUM PIPE INTERNAL DIAMETER ID
		(in.)	(in.)
TSMAXP	1” ½	0.18	1.56
	2”	0.22	1.98
	3”	0.30	2.89
	4”	0.35	3.56
TSMAUXP	1” ½	0.16	1.61
	2”	0.20	2.03
	3”	0.28	2.94
	4”	0.33	3.61

1.5 DOUBLE WALL PIPES

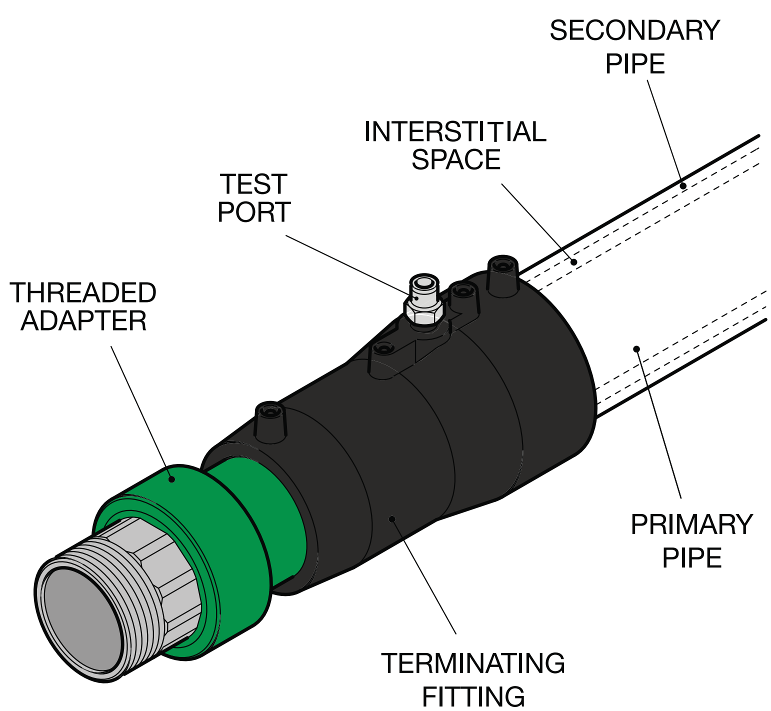
SMARTFLEX double wall pipes for the transport of fuels, alcohols, alcohol-gasoline mixtures and biofuels.

A DOUBLE WALL pipe is a primary pipe encapsulated by a secondary pipe.

In SMARTFLEX double wall pipes, the secondary pipe is not just a containment barrier but it is a real high-density polyethylene pipe capable of sustaining the pressure or pressure drop of an automated monitoring system. This external pipe is also available with an inner barrier layer as requested by standards (e.g. UL) and by customers' specific requests.

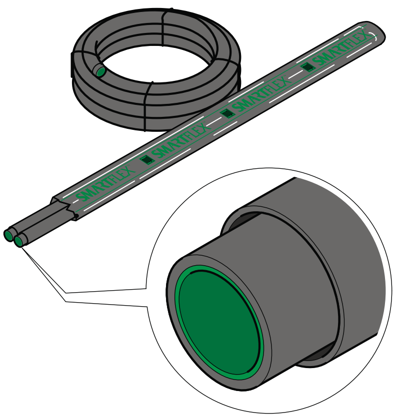
The advantages are as follows:

- Excellent chemical resistance to alcohols, solvents, saline, acid and alkaline solutions
- High resistance to long-term pressure



SINGLE WALL SYSTEM	DN	
TSMAXP	1” ½ - 2” - 3” - 4”	
TSMAUXP	1” ½ - 2” - 3” - 4”	
DOUBLE WALL SYSTEM	**DN primary**	**DN secondary**
TSMAXPD	1” ½ - 2” - 3” - 4”	2” - 2” ½ - 5”
TSMAUXPD	1” ½ - 2” - 3” - 4”	2” - 2” ½ - 5”
AdBlue/DEF/Urea SYSTEM	**DN primary**	**DN secondary**
TSMAUREA	1” ½	
TSMADUREA	1” ½	2”
SECONDARY SYSTEM	**DN**	
TSMAXS	2” - 2” ½ - 5”	
TSMAUXS	2” - 2” ½ - 5”	

1.6 PIPE PACKAGING



Each package includes a set number of straight lengths (see table below) to allow flexibility in the amount of lengths included in purchase orders.

Each plastic bag contains the following number of straight lengths:

Outside diameter OD (in.)	Quantity
1” ½	5
2”	4
2” ½	3
3”	2
4”	2

The plastic bag is made of black polyethylene.

Product	Model	Color Code	Application
SUPERSMARTFLEX	TSMAXP, TSMAXS,	Green	NV, VR, FL, PC, PS
SUPERSMARTFLEX	TSMAUXP, TSMAUXS,	Yellow	NV, VR
SMARTFLEX	TSMAUREA, TSMASUREA, TSMADUREA	Silver	NV, VR, FL, PC, PS

PS → Double Wall Pipe
PC → Primary Pipe
NV → Vent Pipe
VR → Vapor Recovery Pipe
FL → Fill Pipe

1.7 FITTINGS

The SMARTFLEX fitting range is the most comprehensive on the market today including the following:

- Single wall electrofusion fittings
- Adapters and risers
- Double wall coaxial electrofusion fittings
- Termination electrofusion fittings
- Electrofusion and mechanical penetration fittings
- Mechanical fittings
- Spigot fittings

1.7.1 SINGLE WALL ELECTROFUSION FITTINGS

The single wall electrofusion fitting range includes:

- Couplings (model SME, SMEN)
- 90° elbows (model SGE)
- 45° elbows (model SCE)
- Tees (model STE, STELV)
- End caps (model STPCLEL)
- Reducers (model SRDEL)

All provide a considerable insertion length and thickness, thus ensuring water tight connection as well as quick and secure installation.

1.7.2 SINGLE WALL SPIGOT FITTINGS

The single wall fitting range includes the following:

- Threaded adapters with nickel plated brass (model SAMNP, SAFNP), EZ FIT adapters with nickel plated brass (model SAEFNP) and galvanised (model SRCPG)
- Long risers male (model SALM) and EZ FIT long adapter (model SALE)
- Loose flanges (model SFLAKA) suitable for flanged connections. This model is available also with Viton gaskets and AISI 304 stainless steel flanges for special applications (e.g. AdBlue/DEF/Urea)
- Threaded adapters made of AISI 304 stainless steel for special applications (e.g. AdBlue/DEF/Urea)
- 90° elbows (model SG)
- Tees (model ST)
- Concentric reducers (model SR)
- End caps (model STPCL).

1.7.3 DOUBLE WALL COAXIAL ELECTROFUSION FITTINGS

Double wall electrofusion fittings are manufactured using NUPI AMERICAS proprietary procedures and technologies and are the most innovative products of their kind available on the market. SMARTFLEX double wall electrofusion fittings are entirely coaxial, therefore allowing them to have a continuous interstitial space that can be monitored. The interstitial space can be accessed through termination fittings (model SETFV and SETFCV) equipped with special quick connection valves compatible with pneumatic components that are available on the market. It can also be accessed through specific SMARTFLEX double wall fittings equipped with a special test port (model SCEDWTP, SGEDWTP, SMEDWTP, STEDWTP and SRDWETP).

The use of these fittings eliminates the need for bypass test tubing.
The double wall electrofusion fitting range includes the following:

- Straight connectors (model SMEDW, SMEDWR)
- Tees (model STEDW, STEDWR)
- Elbows 45° and 90° (model SCEDW and SGEDW)
- Termination fittings (model SETFC and SETF)

1.7.4 DOUBLE WALL SPIGOT FITTINGS

The double wall fittings range included the following:

- Threaded adapters (model SAWFDNP) and EZ FIT adapters (model SAEWFNP) with nickel plated brass
- Long riser (model SADWM and SADWMLTP) and EZ FIT long riser (model SADWE and SADWEL)

1.8 PENETRATION FITTINGS

Entry boots ensure the correct entry of pipes into the sumps placed over tanks or under dispensers. They provide a perfect water tight seal.

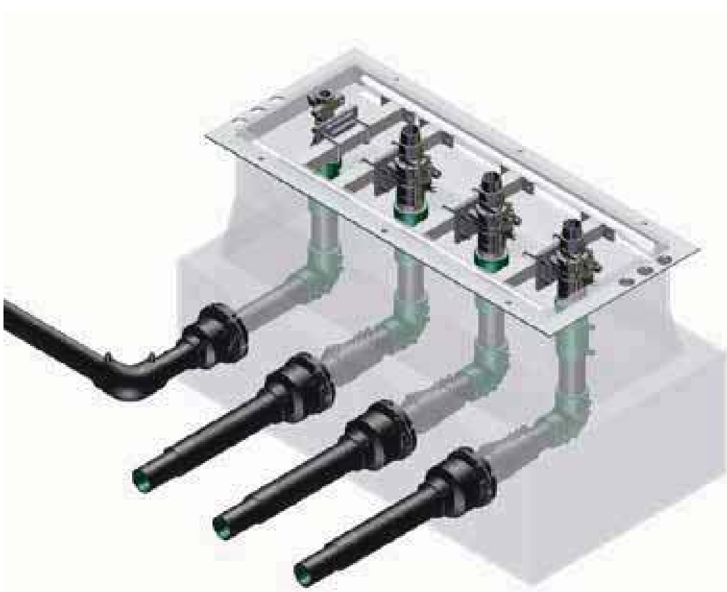
The range includes:

- Electrofusion entry boots (model SEBEP) provide a reliable and fast connection typical of the electrofusion welding process. They can also be installed on the outside of the sump allowing better use of internal space. The available sizes are from 2” to 5”.
- Entry boots with aluminium flange for fiberglass SW (model SEBEFM_A) and DW (model SEBEF_A) sumps. Model SEBEF_A is suitable for the monitoring of the interstitial space of a double wall sump with glycol. Do not use brine for monitoring. We recommend adding a suitable corrosion inhibitor to the monitoring fluid.

1.9 SUMPS AND ACCESSORIES

Electrofusion HDPE dispenser sumps (model DDS_HD) and tank sumps (model STS_HD and STTS_HD) are designed to:

- Ease and accelerate the installation process. They comprise two separate HDPE parts that are joined by electrofusion.
- Obtain a perfectly sealed installation thanks to the electrofusion welding process that allows joining the two parts.
- Optimise transport cost and volume and guarantee sump integrity during transport and storage.
- Offer maximum structural integrity over time.
- They are available in a range of sizes capable of satisfying most installation requests.




SMARTFLEX
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1.10 TOOLS AND ACCESSORIES

Follow all relevant instructions and use the specific tools and accessories for a correct installation of the SMARTFLEX system.

1.10.1 MULTIFUNCTION WELDING UNIT

The SMARTFLEX multifunction welding unit (model SSEL8404/SSEL8404L, SSE8404LP) features proprietary software that is designed to make the installer's task as easy and reliable as possible. A user-friendly menu guides the installer through the two operating modes:

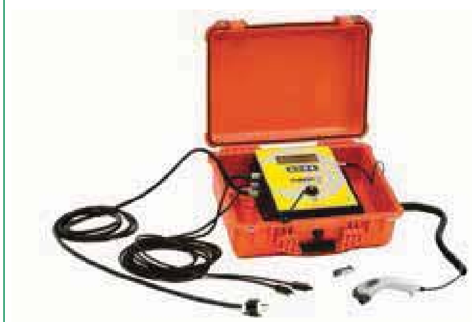
Welding mode
The multifunction welding unit can be used to weld SMARTFLEX pipes and fittings by electrofusion welding process reading the barcode welding parameters with either an optical pen or a barcode scanner.

Pressure test mode
The built-in recorder enables the welding unit to carry out pressure or vacuum tests and/or transfer of testing data (model SVTU, SENS010). Welding and testing data are stored in the internal memory of the multifunction welding unit and can be downloaded to a computer by Bluetooth connection.

Installation Tools
The SMARTFLEX system includes a wide range of tools and accessories such as*:

- SCUT – Pipe cutter
- RAT1A, RATUL, RATOR, CAM – Universal scraper
- RAM1, RAM2 - Manual scraper
- SCUTDW – Double wall pipe cutter
- STP – Metal protection templates
- ALL225/4 – Pipe aligner
- CHIAVE - Wrench
- SPLIDW – Double wall pliers
- BCSCAN – Barcode scanner
- BPEN - Optical pen

* The list is not complete





1.11 MAXIMUM OPERATING PRESSURE AND MINIMUM BENDING RADIUS

The SMARTFLEX system has been designed for buried installations. The following table shows its main characteristics.

Pipe nominal diameter	Maximum operating pressure of primary pipe at 68°F	Maximum operating pressure of secondary pipe at 68°F	Minimum bending radius
1"½	116 (psi)	58 (psi)	35"
2"	116 (psi)	58 (psi)	45"

The pressures indicated in the table above have been calculated based upon laboratory regression curves using hydrocarbons as a testing fluid. Pipes have a nominal pressure (PN) of 180 psi (primary pipe) and 90 psi (secondary pipe) when tested with water or air considering only their HDPE thickness.

1.12 PRODUCT WARRANTY

All SMARTFLEX components have a 30-year warranty both for raw material used and production process. The only exception is rubber components having a 2-year warranty. To validate this product warranty the SMARTFLEX system shall be installed by SMARTFLEX certified installers only according to the latest installation and assembly instructions.

The Smartflex™ system is covered by a liability insurance in accordance with EC directives no. 85/374 and D.P.R. no. 244 dated 24th May 1988 (see conditions).

The warranty is valid only if NUPI AMERICAS is provided with the following documents:

- Warranty Certification Form completed
- Welding Reports
- Pressure Test Report

The abovementioned documents can be sent by e-mail to the following address:
info@nupiamericas.com

Or through the Interactive Tracking System (ITS) at:
http://its.nupiamericas.com

ITS is an Internet based Interactive Tracking System provided by NUPI AMERICAS. It allows you access to data regarding the installation of the SMARTFLEX system in a specific site (completed welding reports, pressure test results, installed products, installation site etc.).

1.13 APPROVALS

The Smartflex™ system is certified by 85 prestigious international quality control institutions such as:

• UL United States of America - UL971

The complete list can be downloaded from our website www.nupiamericas.com

Certificate of Compliance

Certificate Number 20110328-MH25887
Report Reference MH25887, 2006 May 8
Issue Date 2011 March 28

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Underwriters Laboratories

Issued to: NUPIGECO SPA

Via Stefano Ferrario Z I Sud Ovest
Busto Arsizio, VA 21052
Italy

This is to certify that representative samples of

PIPING, FLAMMABLE LIQUID, UNDERGROUND
Smartflex Piping TSMAXP and TSMAXPD
Smartflex Piping TSMAUXP and TSMAUXPD

Have been investigated by Underwriters Laboratories in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: UL 971 - STANDARD FOR NONMETALLIC UNDERGROUND PIPING FOR FLAMMABLE LIQUIDS - Edition

Additional Information: See UL On-line Certification Directory at WWW.UL.COM for additional information.

Only those products bearing the UL Listing Mark for the US and Canada should be considered as being covered by UL's Listing and Follow-Up Service meeting the appropriate requirements for US and Canada.

The UL Listing Mark for the US and Canada generally includes: the UL in a circle symbol with "C" and "US" identifiers: the word "LISTED"; a control number (may be alphanumeric) assigned by UL; and the product category name (product identifier) as indicated in the appropriate UL Directory.

Look for the UL Listing Mark on the product

William R. Carney
Director, North American Certification Programs
Underwriters Laboratories Inc.
Any information and documentation involving UL Mark services are provided on behalf of Underwriters Laboratories Inc. (UL) or any authorized licensee of UL.

For questions, please contact a local UL Customer Service Representative at http://www.ul.com/global/eng/pages/corporate/contactus/

1.14 REFERENCES

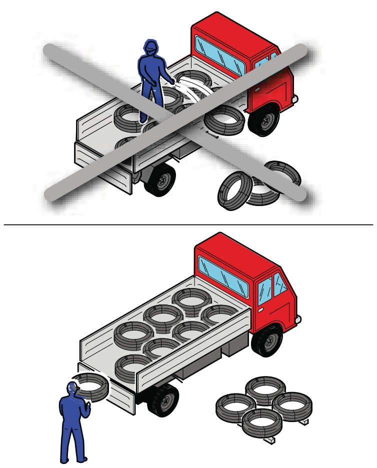
Below the main references of the Smartflex™ system*:

- TOTAL
- BP
- ENI
- TAMOIL
- CHEVRON
- PALTEX
- ENGEN
- MAPCO
- PDVSA
- UNO PETROL
- PETROCHINA
- PETRONAS

* The list is not complete

2 • STORAGE & HANDLING

2.1 PIPE LOADING AND UNLOADING



Loading, transport, unloading, stacking, storing and any other maneuver concerning plastic pipes and plastic fittings must be carried out with extreme care using suitable means according to the type and diameter of the item. All necessary safety measures shall be taken to avoid breakage, cracking or any other damage to pipes.

Any impact, bending and excessive overhang must therefore be avoided, as well as any contact with pointed or blunt objects.

If transport vehicles are used for loading and/or unloading operations and/or these operations are carried out using a crane or similar machine, pipes must always be lifted at their center point using a lifting beam with adequate width.

Slings must be made of suitable material fit for this purpose and in compliance with local regulations. They shall not jeopardize the pipe surface.

If loading or unloading operations are performed manually, avoid grazing the pipes along any edge, on the platform of the transport vehicle, or on any sharp objects.

2.2 PIPE TRANSPORT

When transporting pipes, use either flat-bed or purpose made vehicles. The bed shall be free from nails and other protuberances.

Secure the pipes effectively before transporting them. Any side support post shall be flat and free from sharp edges.

When loading socket-ended pipes, stack the pipes so that the sockets are not in contact with adjacent pipes.

The largest diameter pipes should be placed on the bed of the vehicle.

2.3 PIPE HANDLING

When handling the pipes, take care to prevent damage. Plastics pipes can be damaged when in contact with sharp objects or if dropped, thrown or dragged along the ground.

When loading or unloading pipes with fork lift equipment, then only fork lift trucks with smooth forks should be used. Care should be taken to ensure that forks do not strike the pipe when lifting.

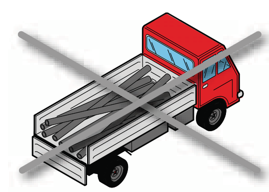
The impact resistance of plastics pipes is reduced at very low temperatures and under these conditions, take more care during handling.

2.4 PIPE STORAGE

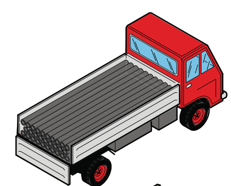
- Although plastics pipes are light, durable and resilient, take reasonable precautions during storage.
- Stack the pipes or coils on surfaces free from sharp objects, stones or projections.
- Where the pipes are supplied in coils, store them either vertically or stacked flat one on top of the other, taking care to protect the pipes from extremes of temperature.
- When straight pipes are stored on racks, these shall provide sufficient support to prevent permanent deformation.
- Do not place pipes in close proximity to fuels, solvents, oils, greases, paints or heat sources.
- If pipes are supplied in a bundle or other packaging, the restraints and/or packaging should be removed as late as possible prior to installation.

2.5 PIPE STACKING

On site a clean dry area protected from weather conditions shall be provided to stack pipes and store fittings and other accessories.

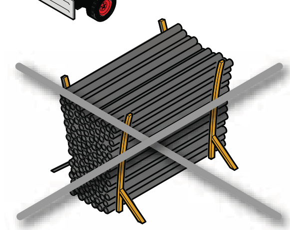


Supporting surfaces must be level without any roughness. We suggest using wooden surfaces whenever possible.



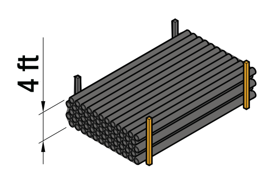
The stacking height for pipes in straight lengths must not exceed 5 ft whatever their diameter or in accordance with local regulations.

The stacking height for coiled pipes stacked on a flat surface must not exceed 7 ft or in accordance with local regulations.



If it is necessary to build side supports or frames to hold the pipes, they should be installed with a maximum distance of 5 ft between them or in accordance with any local regulation.

End caps protecting pipe ends or black plastic bags should not be removed under any circumstances to avoid deposits of leaves, animals, dust, etc. in the pipes until product is being installed.



It is not recommended to install pipes that have been stored in yards with no protection for over two years.

To provide extra protection to straight lengths, NUPI AMERICAS supplies them encased in suitable plastic bags and wooden frames depending upon quantities and transport means.


SIDE A
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3 • TECHNICAL DATA

Some countries require that all piping installations for flammable fluid transport must be placed underground. In the case of derogation to the rule it is necessary that the safety measures approved by the local authorities be adopted.

In other countries, on the contrary, these above ground piping installations are permitted.

3.1 MECHANICAL IMPACT AND LOADING

Any piping material that is installed aboveground is subject to the rigors of the surrounding environment and to weather conditions. The movement of vehicles or other equipment can damage it and such damage generally results in gouging, deflecting or flattening of the pipe surfaces.

When designing a SMARTFLEX aboveground installation, the following guidelines shall be followed:

- Avoid point loading.
- Meet minimum distance between supports.
- Protect the system against abrasion.
- Support ancillary equipment independently of the pipe.
- Comply with the recommended minimum bending radius.

In general, in an installation where any section of the pipe has been damaged in excess of 10% of the minimum wall thickness, this portion shall be removed and replaced with a new pipe. When the pipe has been excessively or repeatedly deflected or flattened, it may exhibit stress whitening, cracking, breaking or other visible damage.

3.2 INSTALLATIONS WHERE THERMAL EXPANSION IS ALLOWED

Any material is subject to dimensional expansions caused by temperature changes. The coefficient defining this property is called the linear thermal expansion coefficient (α). It relates the dimensional expansions of a body to temperature changes according to the following equation:

(Eqn. 3.2.1) $$\Delta L = \alpha \cdot L \cdot \Delta T$$

Where:

ΔL thermal expansions (in.)
L initial length (in.)
ΔT temperature change [1] (°F)
α linear thermal expansion coefficient (°F^{-1})

Equation (3.2.1) is valid only when the body movement is not subject to external constraints that limit or modify its freedom of movement.

[1] ΔT represents the temperature change between the pipe operating temperature and the installation temperature.

The following table shows the values of α and of the elasticity modulus E for different materials used in the manufacturing of pipelines.

Material	α [$°F^{-1}$]	E [psi]
SMARTFLEX	7.2×10^{-5}	145,000
Carbon steel	0.7×10^{-5}	29.0×10^{6}
Stainless steel	0.9×10^{-5}	29.0×10^{6}
Fiberglass	0.9×10^{-5}	1.26×10^{6}

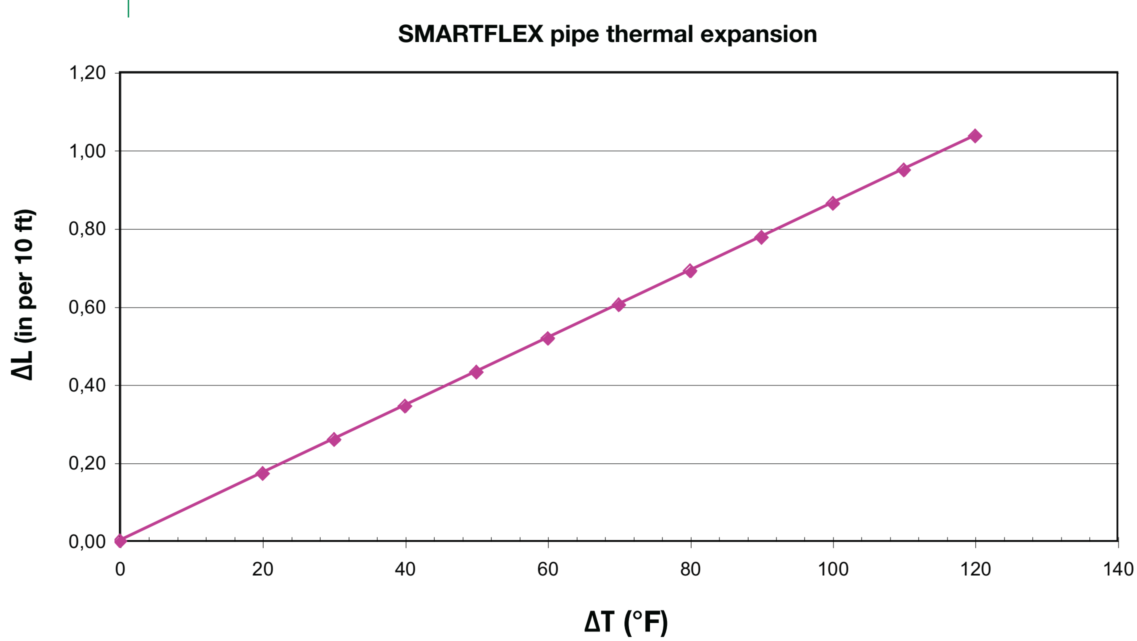
As can be seen, the coefficient α for plastics assumes a value 5 to 15 times greater than that of the most commonly used metallic materials. On the other hand, the elasticity modulus assumes values 100 to 200 times smaller (i.e. plastics show greater elasticity).

The following table shows the length and temperature changes for single wall pipes.

Table: thermal expansion for single wall pipes

ΔT (°F)	ΔL (in. per 10 ft)
70	0.60
80	0.69
100	0.86

The following figure shows thermal expansion of SMARTFLEX single wall pipe.

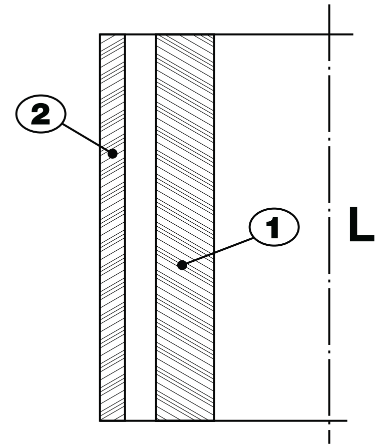


If a double wall pipe is free to expand (for example before being buried and when the end limits yield) the following parameters can be calculated:

ΔL	total structure expansion (that can be found in a new balanced position) (in.)
F_1 and F_2	forces that contrast single pipe movement (lb)
Ftot	total force at the structure end (lb)

Where:

L	initial length (in.)
A_1 and A_2	primary and secondary cross-sections respectively (in.²)
T_1 and T_2	operating temperatures of the primary and the secondary installation respectively (°F)
T_0	installation temperature (°F)
α	inear thermal expansion coefficient (°F $^{-1}$)
E	elasticity modulus (psi)



1: Primary pipe
2: Secondary pipe

The results from the balance and congruence equations, as well as for the mechanical behavior analogy for two parallel springs model, are:

$$\Delta L_1 = L \cdot \alpha \cdot (T_1 - T_0) - \frac{F_1 \cdot L}{A_1 \cdot E}$$

$$\Delta L_2 = L \cdot \alpha \cdot (T_2 - T_0) - \frac{F_2 \cdot L}{A_2 \cdot E}$$

$$\Delta L_1 = \Delta L_2 = \Delta L$$

$$F_{tot} = \frac{\Delta L \cdot E}{L} \cdot \left(\frac{A_1 + A_2}{A_1 \cdot A_2}\right)$$

As an example, the following table shows the thermal analysis of a TSMAXP50, presuming that the installation temperature is fixed at 68°F, that the temperature of the primary pipe conveying relatively cold fluid is at 50°F and that the temperature of the secondary pipe is variable (e.g. it could be exposed to sunlight) in case of approximately 3 ft.

Table: thermal stress analysis

	Temperature change (T1-T2) °F			
	40	**50**	**70**	**90**
Ftot (lb)	-1.7	2.5	6.6	10.7
F1 (lb)	15.8	25.8	35.8	45.7
F2 (lb)	-17.5	-23.3	-29.2	-35.0
ΔL1=ΔL2 (in.)	-0.006	0.009	0.024	0.039
σ1 (psi)	-211	-344	-477	-611
σ2 (psi)	166	221	277	332

σ_1 and σ_2 = thermal stress due to temperature changes

Thermal expansion compensation

If thermal expansion is allowed, then the dimensional variations must be estimated. There are two different installation techniques that allow the compensation of thermal expansion:

- Changes in direction/offsets
- Expansion loops (see figure on the following page).

Assuming that the pipe is a cantilevered beam and limiting the strain to a safe 1%, the length of the expansion loop (ℓ) is given by:

(Eqn. 3.2.2) $$\ell = \sqrt{\frac{3}{2} \cdot \alpha \cdot \Delta T \cdot L \cdot \frac{OD}{0.01}} \cong 12 \cdot \sqrt{OD \cdot \Delta L}$$

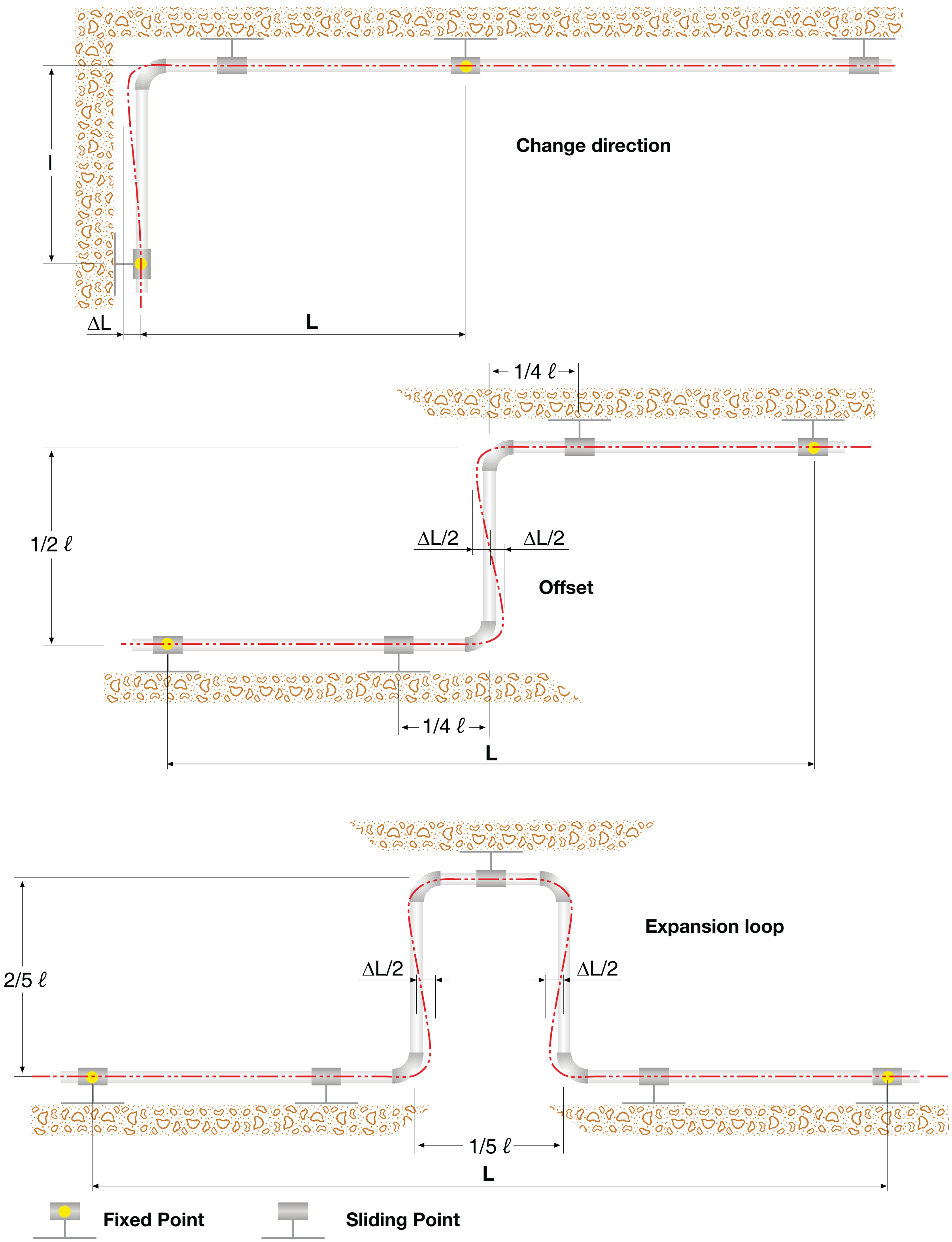
Where:

L	length of the pipe run (in.)
ΔL	thermal expansion (in.)
ΔT	temperature change (°F)
α	linear thermal expansion coefficient (°F $^{-1}$)
OD	pipe outside diameter (in.)

The following table shows the minimum length of the expansion loop according to the outside pipe diameter for various temperature changes. For temperatures other than those indicated, the linear interpolation will approximate the length of the loop within 5%.

Table: minimum loop length (ℓ) according to various temperature changes

Temperature change	Length of pipe run (L)	OD				
		1" ½	2"	2" ½	3"	4"
		Minimum loop length [in.] (ℓ)				
ΔT = 50 °F	30 ft	22	24	27	29	32
	150 ft	49	55	60	65	72
	300 ft	69	77	84	92	102
		Minimum loop length [in.] (ℓ)				
ΔT = 70 °F	30 ft	26	29	32	35	38
	150 ft	58	65	70	77	85
	300 ft	81	91	100	109	121
		Minimum loop length [in.] (ℓ)				
ΔT = 90 °F	30 ft	29	33	36	39	43
	150 ft	65	73	80	88	97
	300 ft	92	104	113	124	137


Change direction
l
ΔL
L
1/4 ℓ
1/2 ℓ
ΔL/2
ΔL/2
Offset
1/4 ℓ
L
Expansion loop
2/5 ℓ
ΔL/2
ΔL/2
1/5 ℓ
L
Fixed Point
Sliding Point

3.3 INSTALLATIONS WHERE THERMAL EXPANSION IS NOT ALLOWED

For these types of installations, the structure must be calculated and an evaluation of the mechanical characteristics of the material in the working conditions must be made.

Thermal Load

If the dimensional variations caused by temperature changes are totally restrained, then stress (traction or compression) will develop in the piping itself. The axial stress is given by:

(Eqn. 3.3.1) $$\sigma = -E \cdot \frac{\Delta L}{L} = -E \cdot \alpha \cdot \Delta T$$

Where:

ΔL	thermal expansion (in.)
L	pipe length (in.)
E	elasticity modulus (psi)
α	linear thermal expansion coefficient (°F $^{-1}$)
ΔT	temperature change (°F)

The minus sign indicates that, for positive ΔT (heating) the tension will be compressive (conventionally assumed as negative), whereas for negative ΔT the tension will be tensile (conventionally assumed as positive).

The axial forces generated inside the pipe are discharged at the pipe ends near the fixed points (ex. valves, pumps, etc.). They generate forces that can be calculated by multiplying the axial stress σ by the pipe section A:

(Eqn. 3.3.2) $$F = \sigma \cdot A = -E \cdot \alpha \cdot \Delta T \cdot A$$

Where:

F	resulting force (lb)
σ	thermal stress (psi)
A	cross section (in.^{2})
E	elasticity modulus (psi)

It is interesting to note that the stress status arising in a situation of inhibited deformation does not depend on the structure geometry (e.g. pipe length or cross section) but exclusively on temperature change, expansion coefficient and elasticity modulus.

The following table shows the thermal end-load according to the temperature change:

Table: thermal end-load (lb) – SMARTFLEX Single Wall Pipe

Temperature Change	OD [in.]			
	1” ½	2”	3”	4”
	Thermal end-load (lb)			
50 °F	586	899	1746	2531
70 °F	783	1199	2328	3375
90 °F	979	1501	2910	4217

If these loads on the constraints are excessive, a compensation system must be used, as described in the previous paragraph.

Pipe Buckling

Considering the pipe size, constrained at its two ends and subject to thermal expansion like a point-loaded rod, the value of the critical force of pipe buckling is obtained by using equation 3.3.3:

(Eqn. 3.3.3) $$F_{cr} = \frac{\pi^2 E I}{L^2} \quad \text{or} \quad \sigma_{cr} = \frac{\pi^2 E I}{\ell^2 A}$$

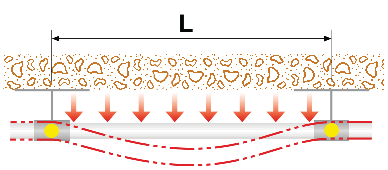
Where:

E elasticity modulus (psi)

I moment of inertia (in.^{4})

L maximum span length between two anchor points (in.)

A pipe cross-section (in.^{2})



Pipe buckling will be avoided if:

(Eqn. 3.3.4) $$\sigma < \frac{\sigma_{cr}}{\eta}$$

Where:

η safety coefficient (1,5)

σ thermal stress due to temperature changes (psi)

The result of combining equations 3.3.1, 3.3.3 and 3.3.4 is the maximum span length allowed between two anchored points:

(Eqn. 3.3.5) $$L < \sqrt{\frac{\pi^2 I}{\eta A \alpha \Delta T}}$$

Where:

α linear thermal expansion coefficient

ΔT temperature variation

In the following table, the maximum span length between two anchored points is indicated for different diameters and temperature changes ΔT ($\eta = 1.5$).

Table: maximum span length between two anchor points (in.)

Temperature Change [°F]	OD				
	1" ½	2"	2" ½	3"	4"
	Maximum span length [in.] (L)				
ΔT = 85 °F	24	31	37	44	54
ΔT = 105 °F	21	26	31	38	46

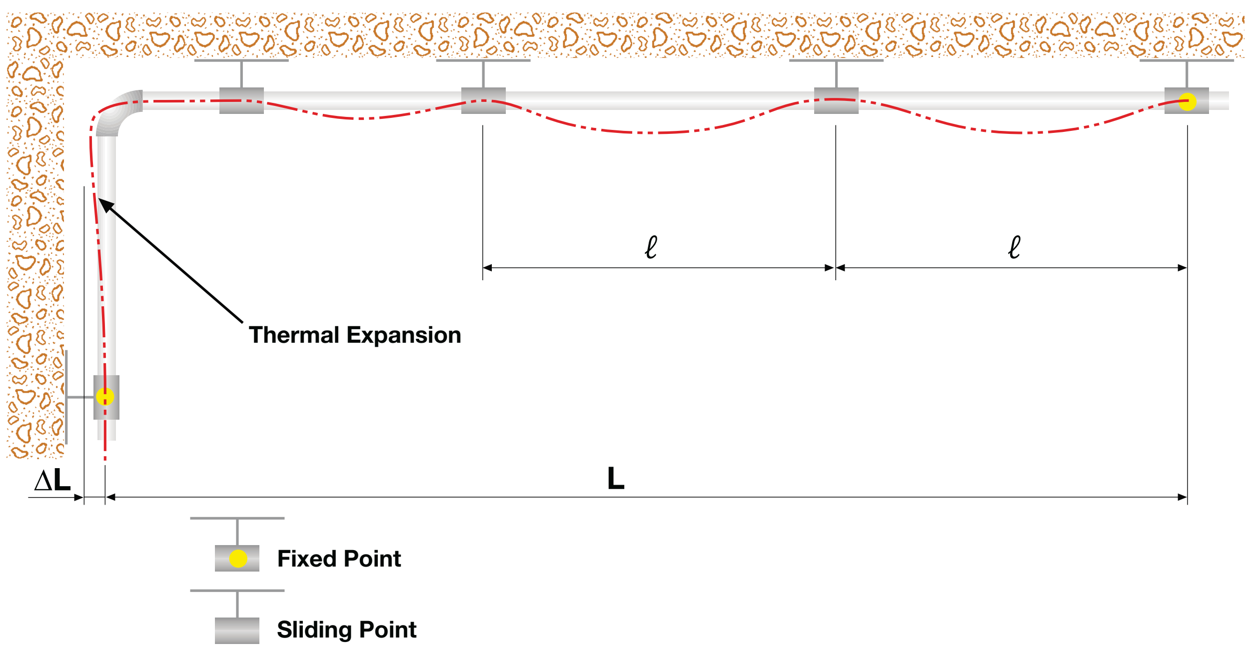
3.4 SUSPENDED PIPE INSTALLATIONS

When installations are suspended, they must be designed taking into account temperature changes and pipeline weight (beam deflection).

In general, supported applications can be divided into two classes:

A – INSTALLATIONS WHERE THERMAL EXPANSION IS ALLOWED
If thermal expansion is allowed, anchoring points must be positioned to compensate the thermal expansion. Once this has been done, the installation designer shall evaluate the deflection due to pipeline weight (including the weight of the fluid) and will check that the obtained value is lower than the maximum allowed values.

Deflection due to pipe weight
When pipe is installed allowing thermal expansion, the calculation of deflection caused by the pipeline weight can be carried out considering the pipe as a uniformly loaded beam with fixed ends at each span. The load is due to the weight of the pipeline itself plus the weight of the conveyed fluid.



The deflection that is generated between spans (Δy) is given by:

(Eqn. 3.4.1) $$\Delta y = \frac{5 \cdot g \cdot \ell^4}{384 \cdot E \cdot I}$$

Where:

q	total weight per unit length	$=W+\pi\cdot\rho\cdot g\cdot\frac{ID^2}{4}(lb/in.)$
W	weight of the pipe per unit length (lb/in.)	
ρ	density of internal fluid (lb/in.^{3})	
ℓ	span length (in.)	
q	load per unit length (lb/in.)	
g	standard acceleration of gravity (in./s^2)	
E	creep modulus of the pipe at average temperature at 10 years (lb/in.^{2})	
ID	internal diameter (in.)	
OD	outside diameter (in.)	
I	moment of inertia = $(\pi/64)\cdot(OD^4 - ID^4)$ (in.^{4})	

By limiting the deflection to a safe 0.5% of the span length for safety reasons, it is possible to obtain the maximum span length between two adjacent supports from equation, 3.4.1.

Maximum Span Length

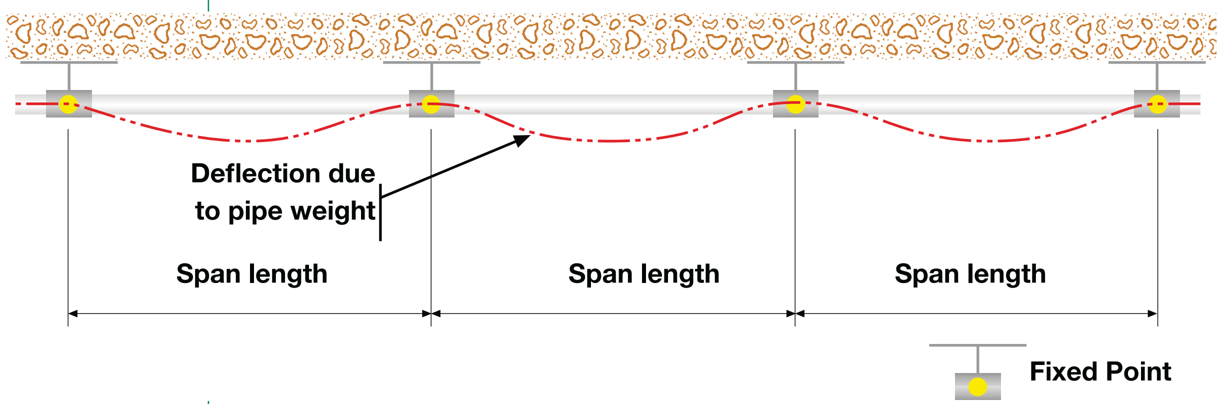
OD	Maximum span length ℓ (in.)
in.	in.
1” ½	35
2”	41
2”½	46
3”	52
4”	60
6”	77

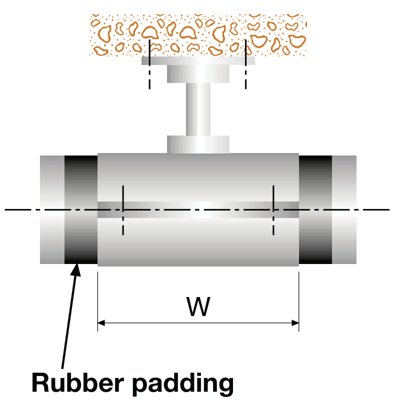
Generally speaking, most suspended pipelines include more than one single span. They usually consist of a series of uniformly spaced spans. Therefore, the actual system will be stiffer than the presumed one, as each segment limits the deflection of its adjacent span. The result of the above mentioned analysis will then be conservative.

CAUTION:

In the previous calculation, each span between two supports was considered as a single uniformly loaded beam with fixed ends at each span and the benefits of having adjoining segments have not been taken into consideration.

B – INSTALLATIONS WHERE THERMAL EXPANSION IS NOT ALLOWED
In this case, the installation designer shall verify that the thermal load will not cause pipe buckling, as described in the previous paragraph.





Anchoring Points, Brackets and Supports
Anchoring points shall be positioned to give the pipe a proper direction and to limit the length variation due to temperature. Therefore, they must have adequate strength to restrain pipe deformation due to the applied forces (temperature load, pipe weight, fluid weight, environmental loads, etc.).

Anchoring points are necessary at any direction change or at any pipe size change and where thermoplastic pipes are connected to other materials or to auxiliary items (e.g. valves).

Anchoring points and supports are available in different shapes. In any case, they must be free from sharp edges and meet the following minimum dimensions:
- w = 4” for up to 4” diameter pipes
- w = pipe OD for pipes with a diameter larger than 4”

3.5 SECURING OF THREADED FITTINGS

The use of a proper thread sealant is recommended for the securing of threaded fittings. It is always necessary to check the compatibility between the thread sealant and the fluid to be conveyed before using it. Special care has to be used when applying torque while tightening up the fitting. The following table shows the maximum Nominal Torque values recommended.

Thread (in.)	Nominal Torque (lb · ft)
1” ½	60
2”	75
3”	95
4”	110

WARNING

Excessive torque can cause the polyethylene to detach from the metal insert. This can result in micro leakage.

3.6 WATER HAMMER EFFECT

Piping is subject to sudden pressure increase above its nominal working pressure under special conditions. This pressure increase is known as water hammer effect. It occurs in case of sudden flow change when a pump is suddenly started/shut or when valves are suddenly opened/closed.

It is a very dangerous effect that can cause serious problems and failure if it is not under control.

The use of SMARTFLEX pipes significantly reduces this effect. As a matter of fact, the low elasticity modulus of the pipe significantly reduces pressure peaks while protecting the entire system.

The sudden change of fluid flow Δv causes a pressure increase ΔP given by:

(Eqn. 3.6.1) $$\Delta P = \rho \cdot c \cdot \Delta v$$

Where:

ΔP	pressure peak (psi)
ρ	fluid density (lb/in.^{3})
Δv	fluid flow change (ft/s)
c	velocity of the shock wave in the pipe (ft/s); c depends on the elasticity of both the fluid and the pipe wall

In case of a freely supported pipe, the following equation applies:

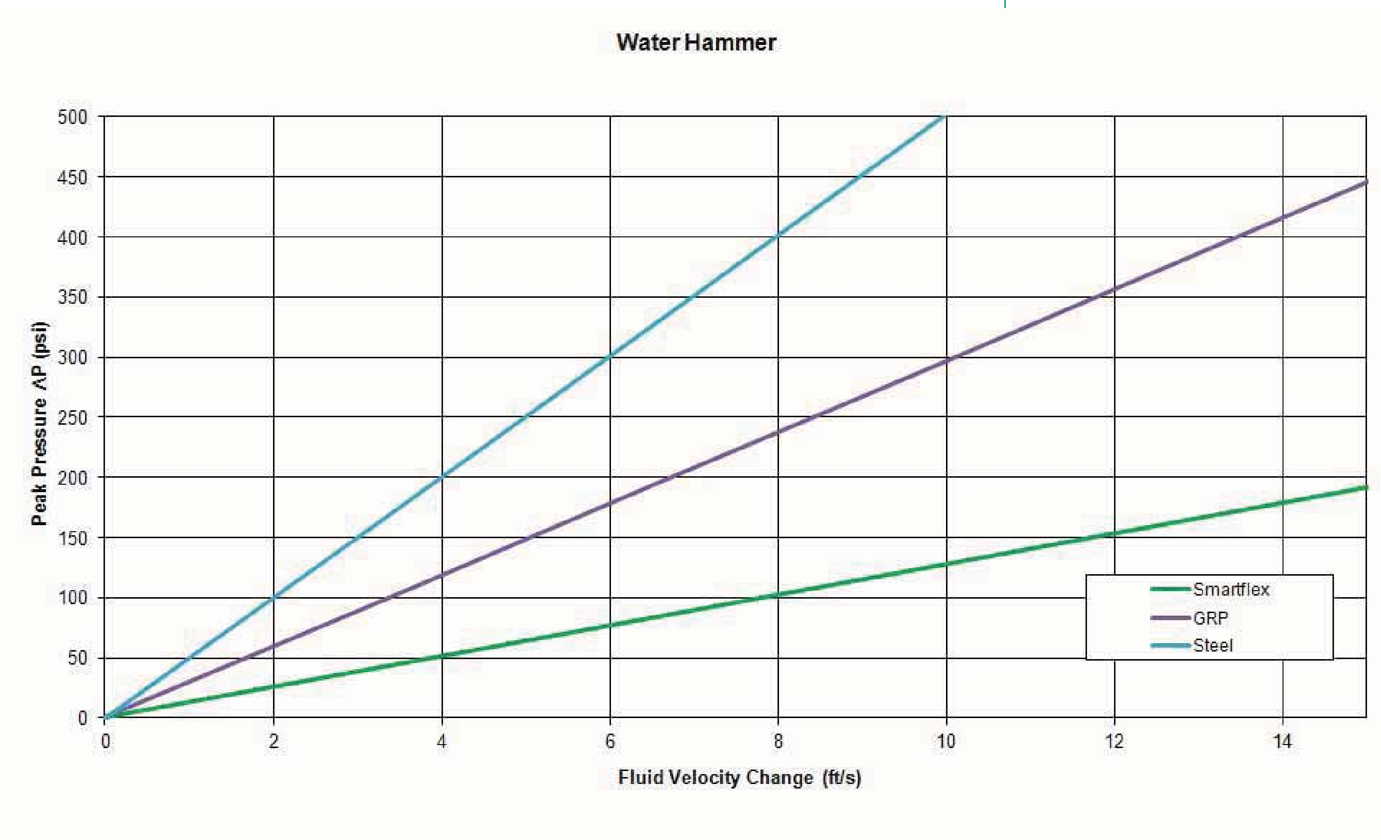
(Eqn. 3.6.2) $$c = \sqrt{\frac{\frac{E_p}{\rho}}{\frac{E_p}{E_w} + \frac{D_m}{t}}}$$

Where:

Ew	water elasticity modulus (psi)
Ep	elasticity modulus of the pipe material (psi)
Dm	average pipe diameter (in.)
t	pipe thickness (in.)

The following diagram shows the peak pressure generated after sudden events, as sudden pump shutdown or a rapid valve closure in case water is conveyed and for different types of piping. The diagram shows that SMARTFLEX piping provides the lowest pressure peak thanks to its elasticity.

Table: water hammer effect for various types of piping



3.7 HEAD LOSSES

3.7.1 PIPE HEAD LOSSES

Gasoline - Head losses and fluid speed

Q=flow rate (gpm)
V=fluid speed (ft/s)
ΔP= head losses (ft/100ft)

Q	TSMAXP 1" ½		TSMAXP 2"		TSMAXP 3"		TSMAXP 4"	
(gpm)	ΔP	V	ΔP	V	ΔP	V	ΔP	V
1.0								
2.0								
4.0	**0.2**	0.65						
6.0	**0.3**	0.97	**0.1**	0.60				
8.0	**0.5**	1.29	**0.2**	0.80				
10.0	**0.7**	1.61	**0.2**	1.00				
12.0	**1.0**	1.94	**0.3**	1.20	**0.1**	0.57		
14.0	**1.4**	2.26	**0.4**	1.40	**0.1**	0.67		
16.0	**1.7**	2.58	**0.5**	1.60	**0.1**	0.76		
18.0	**2.1**	2.91	**0.7**	1.80	**0.1**	0.86		
20.0	**2.6**	3.23	**0.8**	2.00	**0.1**	0.95	**0.1**	0.63
30.0	**5.3**	4.84	**1.7**	2.99	**0.3**	1.43	**0.1**	0.94
40.0	**8.8**	6.46	**2.8**	3.99	**0.5**	1.90	**0.2**	1.26
50.0			**4.1**	4.99	**0.7**	2.38	**0.3**	1.57
60.0			**5.8**	5.99	**1.0**	2.86	**0.4**	1.88
70.0			**7.6**	6.98	**1.3**	3.33	**0.5**	2.20
80.0					**1.6**	3.81	**0.6**	2.51
90.0					**2.0**	4.29	**0.7**	2.83
100.0					**2.4**	4.76	**0.9**	3.14
110.0					**2.9**	5.24	**1.1**	3.46
120.0					**3.4**	5.71	**1.2**	3.77
130.0					**3.9**	6.19	**1.4**	4.08
140.0					**4.5**	6.67	**1.6**	4.40
150.0							**1.9**	4.71
160.0							**2.1**	5.03
170.0							**2.3**	5.34
180.0							**2.6**	5.65
190.0							**2.9**	5.97
200.0							**3.1**	6.28

Diesel - Head losses and fluid speed

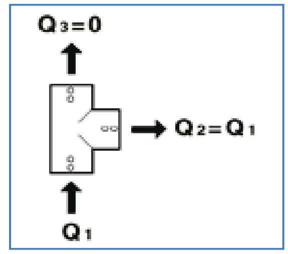
Q=flow rate (gpm)
V=fluid speed (ft/s)
ΔP= head losses (ft/100 ft)

Q	TSMAXP 1" ½		TSMAXP 2"		TSMAXP 3"		TSMAXP 4"	
(gpm)	ΔP	V	ΔP	V	ΔP	V	ΔP	V
1.0								
2.0	**0.1**	0.32						
4.0	**0.2**	0.65	**0.1**	0.40				
6.0	**0.4**	0.97	**0.1**	0.60				
8.0	**0.7**	1.29	**0.2**	0.80				
10.0	**1.1**	1.61	**0.3**	1.00	**0.1**	0.48		
12.0	**1.5**	1.94	**0.5**	1.20	**0.1**	0.57		
14.0	**1.9**	2.26	**0.6**	1.40	**0.1**	0.67		
16.0	**2.4**	2.58	**0.8**	1.60	**0.1**	0.76	**0.1**	0.50
18.0	**2.9**	2.91	**0.9**	1.80	**0.2**	0.86	**0.1**	0.57
20.0	**3.5**	3.23	**1.1**	2.00	**0.2**	0.95	**0.1**	0.63
30.0	**7.1**	4.84	**2.3**	2.99	**0.4**	1.43	**0.1**	0.94
40.0	**11.8**	6.46	**3.7**	3.99	**0.6**	1.90	**0.2**	1.26
50.0			**5.5**	4.99	**1.0**	2.38	**0.4**	1.57
60.0			**7.6**	5.99	**1.3**	2.86	**0.5**	1.88
70.0			**10.0**	6.98	**1.7**	3.33	**0.6**	2.20
80.0					**2.2**	3.81	**0.8**	2.51
90.0					**2.7**	4.29	**1.0**	2.83
100.0					**3.2**	4.76	**1.2**	3.14
110.0					**3.8**	5.24	**1.4**	3.46
120.0					**4.5**	5.71	**1.7**	3.77
130.0					**5.1**	6.19	**1.9**	4.08
140.0					**5.9**	6.67	**2.2**	4.40
150.0							**2.5**	4.71
160.0							**2.8**	5.03
170.0							**3.1**	5.34
180.0							**3.4**	5.65
190.0							**3.7**	5.97
200.0							**4.1**	6.28

3.7.2 FITTING HEAD LOSSES

Tee - Any fuel - Concentrated head losses

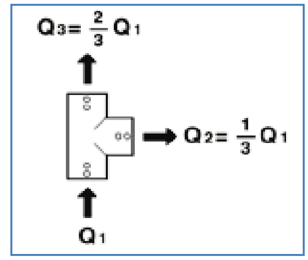
Q = flow rate (gpm)
Q1 = Q2 ; Q3 = 0
ΔP 1-2 = Head loss in lateral branch (ft)
ΔP 1-3 = Head loss in straight branch (ft)



	STE 1" ½		STE 2"		STE 3"		STE 4"	
Q	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3
(gpm)	**(ft)**		**(ft)**		**(ft)**		**(ft)**	
1.0	0.9		0.4		0.1			
2.0	12.4		4.7		1.1		0.5	
4.0	36.8		14.0		3.2		1.4	
6.0	74.2		28.3		6.5		2.8	
8.0	124.6		47.6		10.8		4.7	
10.0	188.1		71.8		16.4		7.1	
12.0	264.5		101.0		23.0		10.0	
14.0	354.0		135.1		30.8		13.4	
16.0	456.4		174.2		39.7		17.3	
18.0	571.9		218.3		49.7		21.6	
20.0	700.3		267.3		60.9		26.5	
30.0	841.8		321.3		73.2		31.9	
40.0	996.2		380.2		86.6		37.7	
50.0			444.1		101.2		44.0	
60.0			513.0		116.9		50.9	
70.0			586.9		133.7		58.2	
80.0					151.6		66.0	
90.0					170.7		74.3	
100.0					190.9		83.1	
110.0					212.3		92.4	
120.0					336.0		146.2	
130.0					487.9		212.3	
140.0					668.1		290.8	
150.0							381.5	
160.0							484.5	
170.0							599.9	
180.0							867.4	
190.0							1184.2	
200.0							1550.2	

Tee - Any fuel - Concentrated head losses

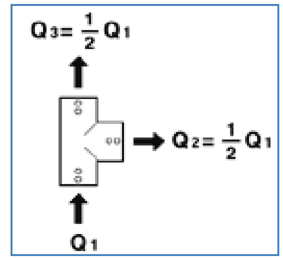
Q = flow rate (gpm)
Q2 = 1/3xQ1 ; Q3 = 2/3xQ1
ΔP 1-2 = Head loss in lateral branch (ft)
ΔP 1-3 = Head loss in straight branch (ft)



	STE 1" ½		STE 2"		STE 3"		STE 4"	
Q	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3
(gpm)	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**
1.0	0.2	0.2	0.1	0.1				
2.0	3.0	2.6	1.1	1.0	0.3	0.2	0.1	0.1
4.0	8.8	7.8	3.4	3.0	0.8	0.7	0.3	0.3
6.0	17.7	15.8	6.8	6.0	1.5	1.4	0.7	0.6
8.0	29.8	26.6	11.4	10.1	2.6	2.3	1.1	1.0
10.0	45.0	40.1	17.2	15.3	3.9	3.5	1.7	1.5
12.0	63.3	56.4	24.1	21.5	5.5	4.9	2.4	2.1
14.0	84.6	75.4	32.3	28.8	7.4	6.6	3.2	2.9
16.0	109.1	97.2	41.7	37.1	9.5	8.5	4.1	3.7
18.0	136.8	121.8	52.2	46.5	11.9	10.6	5.2	4.6
20.0	167.5	149.2	63.9	56.9	14.6	13.0	6.3	5.6
30.0	201.3	179.3	76.8	68.4	17.5	15.6	7.6	6.8
40.0	238.2	212.2	90.9	81.0	20.7	18.5	9.0	8.0
50.0			106.2	94.6	24.2	21.6	10.5	9.4
60.0			122.7	109.3	27.9	24.9	12.2	10.8
70.0			140.3	125.0	32.0	28.5	13.9	12.4
80.0					36.3	32.3	15.8	14.1
90.0					40.8	36.4	17.8	15.8
100.0					45.7	40.7	19.9	17.7
110.0					50.8	45.2	22.1	19.7
120.0					80.3	71.6	35.0	31.1
130.0					116.7	103.9	50.8	45.2
140.0					159.8	142.3	69.5	61.9
150.0							91.2	81.3
160.0							115.9	103.2
170.0							143.4	127.8
180.0							207.4	184.8
190.0							283.2	252.3
200.0							370.7	330.3

Tee - Any fuel - Concentrated head losses

Q = flow rate (gpm)
Q2 = 0.5xQ1 ; Q3 = 0.5xQ1
ΔP 1-2 = Head loss in lateral branch (ft)
ΔP 1-3 = Head loss in straight branch (ft)



	STE 1" ½		STE 2"		STE 3"		STE 4"	
Q	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3	ΔP1-2	ΔP1-3
(gpm)	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**
1.0	0.6	0.5	0.2	0.2				
2.0	7.5	6.1	2.9	2.3	0.7	0.5	0.3	0.2
4.0	22.4	18.1	8.5	6.9	1.9	1.6	0.8	0.7
6.0	45.2	36.5	17.2	13.9	3.9	3.2	1.7	1.4
8.0	75.9	61.2	29.0	23.4	6.6	5.3	2.9	2.3
10.0	114.5	92.4	43.7	35.3	10.0	8.0	4.3	3.5
12.0	161.0	130.0	61.5	49.6	14.0	11.3	6.1	4.9
14.0	215.5	173.9	82.2	66.4	18.7	15.1	8.2	6.6
16.0	277.8	224.2	106.0	85.6	24.2	19.5	10.5	8.5
18.0	348.1	281.0	132.9	107.2	30.3	24.4	13.2	10.6
20.0	426.3	344.1	162.7	131.3	37.1	29.9	16.1	13.0
30.0	512.4	413.6	195.6	157.8	44.5	36.0	19.4	15.6
40.0	606.4	489.5	231.4	186.8	52.7	42.6	22.9	18.5
50.0			270.3	218.2	61.6	49.7	26.8	21.6
60.0			312.3	252.0	71.1	57.4	31.0	25.0
70.0			357.2	288.3	81.4	65.7	35.4	28.6
80.0					92.3	74.5	40.2	32.4
90.0					103.9	83.9	45.2	36.5
100.0					116.2	93.8	50.6	40.8
110.0					129.2	104.3	56.2	45.4
120.0					204.5	165.1	89.0	71.8
130.0					297.0	239.7	129.3	104.3
140.0					406.7	328.2	177.0	142.9
150.0							232.2	187.4
160.0							294.9	238.0
170.0							365.1	294.7
180.0							528.0	426.2
190.0							720.8	581.8
200.0							943.6	761.6

90° Elbow - Any fuel - Concentrated head losses

Q = flow rate (gpm)
ΔP= head losses (ft)

Q	SGE 1" ½	SGE 2"	SGE 3"	SGE 4"
(gpm)	ΔP (ft)			
1.0	0.5	0.2		
2.0	1.9	0.7	0.2	0.1
4.0	7.8	3.0	0.7	0.3
6.0	17.5	6.7	1.5	0.7
8.0	31.1	11.9	2.7	1.2
10.0	48.6	18.6	4.2	1.8
12.0	70.0	26.7	6.1	2.6
14.0	95.3	36.4	8.3	3.6
16.0	124.4	47.5	10.8	4.7
18.0	157.5	60.1	13.7	6.0
20.0	194.4	74.2	16.9	7.4
30.0	437.5	167.0	38.0	16.6
40.0	777.8	296.8	67.6	29.4
50.0		463.8	105.7	46.0
60.0		667.9	152.1	66.2
70.0		909.1	207.1	90.1
80.0			270.5	117.7
90.0			342.3	149.0
100.0			422.6	183.9
110.0			511.4	222.6
120.0			608.6	264.9
130.0			714.2	310.9
140.0			828.4	360.5
150.0				413.9
160.0				470.9
170.0				531.6
180.0				596.0
190.0				664.0
200.0				735.7

45° Elbow - Any fuel - Concentrated head losses

Q=flow rate (gpm)
ΔP= head losses (ft)

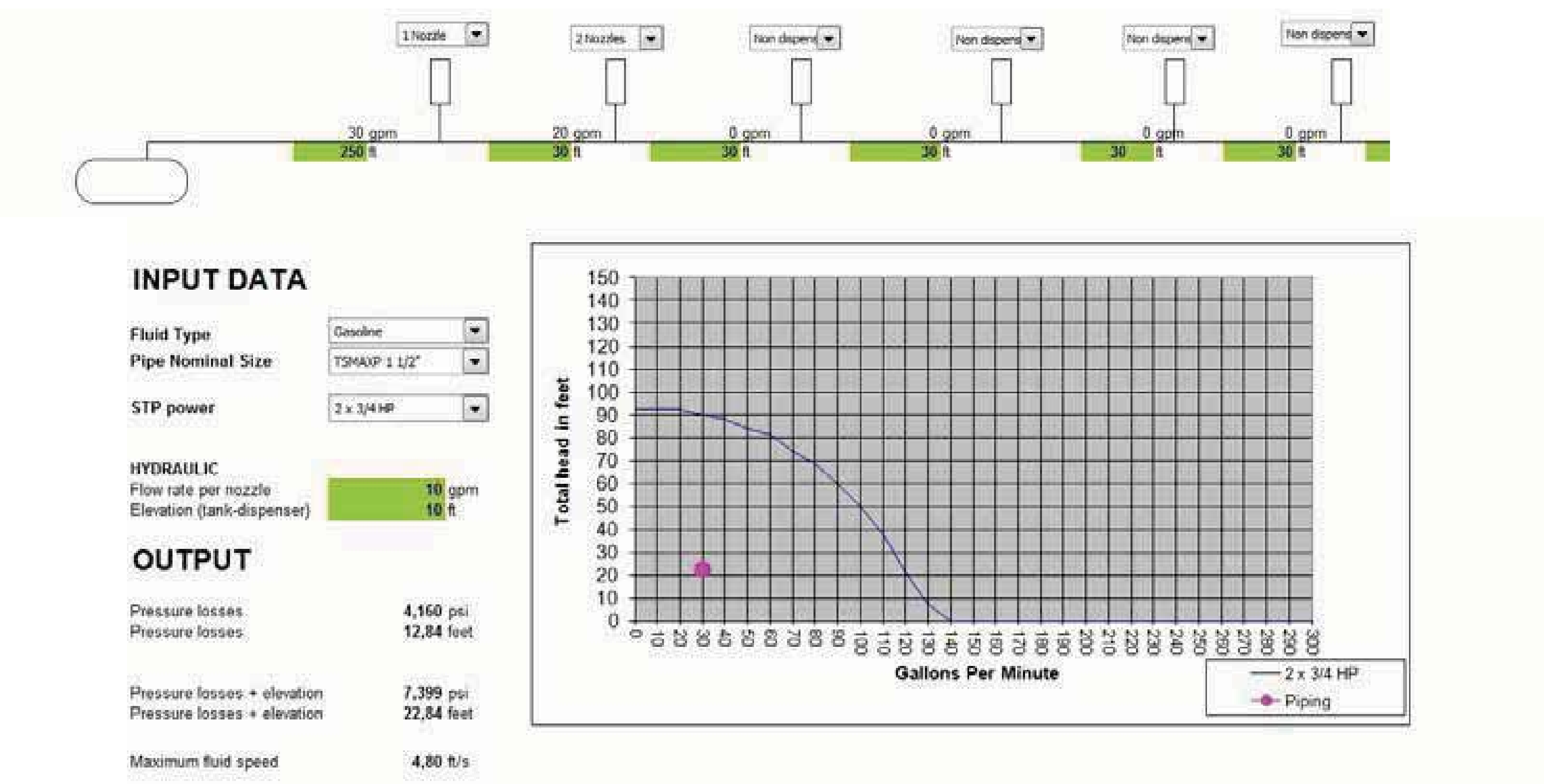
Q	SCE 1" ½	SCE 2"	SCE 3"	SCE 4"
(gpm)	ΔP (ft)			
1.0	0.1			
2.0	0.5	0.2		
4.0	1.9	0.7	0.2	0.1
6.0	4.4	1.7	0.4	0.2
8.0	7.8	3.0	0.7	0.3
10.0	12.2	4.6	1.1	0.5
12.0	17.5	6.7	1.5	0.7
14.0	23.8	9.1	2.1	0.9
16.0	31.1	11.9	2.7	1.2
18.0	39,4	15.0	3.4	1.5
20.0	48.6	18.6	4.2	1.8
30.0	109.4	41.7	9.5	4.1
40.0	194.4	74.2	16.9	7.4
50.0		116.0	26.4	11.5
60.0		167.0	38.0	16.6
70.0		227.3	51.8	22.5
80.0			67.6	29.4
90.0			85.6	37.2
100.0			105.7	46.0
110,0			127.8	55.6
120.0			152.1	66.2
130.0			178.6	77.7
140.0			207.1	90.1
150.0				103.5
160.0				117.7
170.0				132.9
180.0				149.0
190.0				166.0
200.0				183.9

3.8 PIPING SIZES CALCULATION

NUPI AMERICAS recommends to use its SMARTFLEX PIPING SIZES SPREADSHEET to choose the proper piping size. The file can be downloaded without logging in from our website; the file name is **154US01_SuperSmartflex Pressure Losses Spreadsheet R1.0**

The Smartflex Pressure Drop Calculator allows to check that the product pipe size is adequate to the site conditions. It is a Microsoft Excel spreadsheet that evaluates the fluid flow through the pipe and, consequently, the pressure drop along the pipe runs.

Below is a sample image showing correct dimensioning.



4 • INSTALLATION INSTRUCTIONS OF PIPE AND FITTINGS

4.1 INTRODUCTION

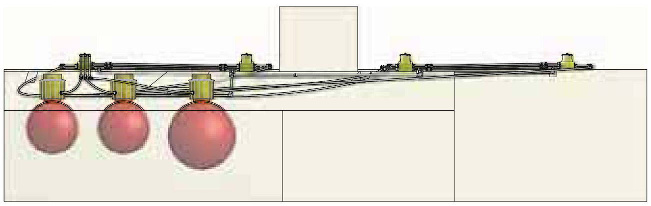
Before commencing any installation, all installers shall be familiar with the installation procedures described in this catalog.

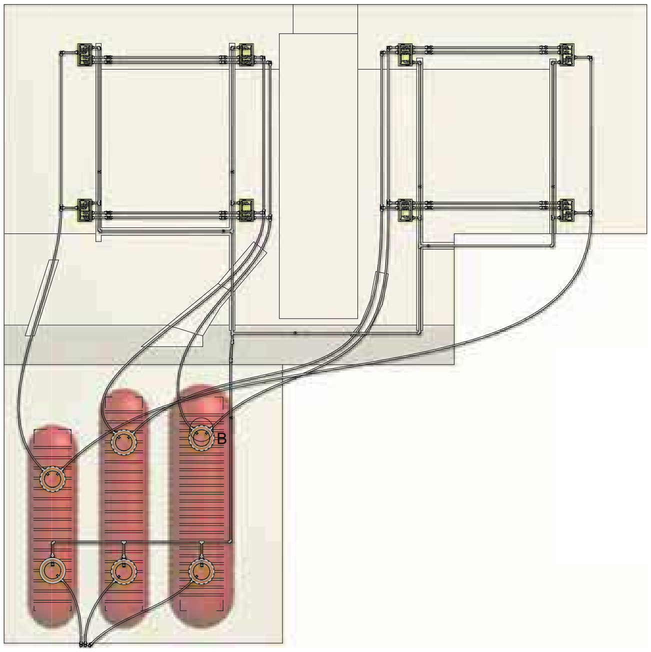
Every installation is different depending on station size, piping size and weather conditions. Therefore, it is important to follow the general guidelines that apply to most piping installations i.e.:

- A two-worker crew is the minimum recommended for most average-size service stations, however, the number of people in the crew must be increased by one person if larger pipe diameters are to be installed or when installing double wall pipes.
- Ensure all necessary tools and equipment are at the construction site prior to commencing the installation of pipes and fittings.
- Establish a working schedule so that all phases of installation are carried out in a timely manner.

4.2 INSTALLATION LAYOUT

Advanced planning for the piping layout is essential to aid the installation process and possibly reduce the number of fittings required.





We recommend using pipes in coils to connect the tank to the first product dispenser and straight lengths between other product dispensers.

If compliance to California Air Resources Board (CARB) recommendations is required, use only straight lengths for vapor recovery and vent.

All piping shall slope by at least 1:100 (1/8” per foot) towards the tank. It is necessary to take precautions to prevent the formation of siphon traps or wells.

4.3 TRENCHING AND BACKFILLING

Proper construction of trenches is important to assure that the SMARTFLEX system is installed under the best conditions possible. Trenches should be wide enough and deep enough to accommodate the piping and backfill material.

When using tamping equipment, prevent vibration from driving small stones into the pipe walls. The amount of compaction and the type of soil determine the soil modulus.

Two pipes crossing over one another must be separated by a minimum of 2” of compacted backfill material to prevent point loading conditions or 1” of protective Styrofoam.

What is generally considered as flexible piping is piping that changes shape when it encounters loads such as those transmitted by the soil to underground installations.

The designer and installer shall use the backfill material to limit the deformation of the pipes within an acceptable range.

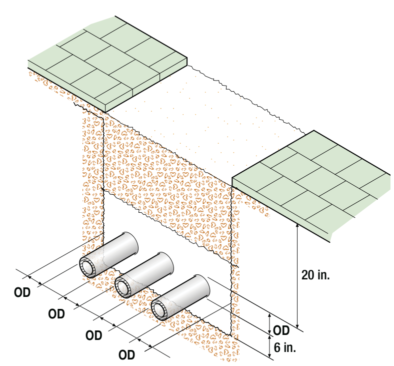
The level of interaction between the pipe and the backfill material soil surrounding it essentially depends on: burial depth, soil characteristics and backfill material, superficial loads and pipe resistance to deflection.

Generally, pipes and fittings should be installed at a minimum depth of 20”. Installations requiring shallower or deeper depths may be used when designed in accordance with the specific project requirements (for example: when high frost load conditions are present).

For shallow installations, the minimum burial depths shown in the table below are recommended:

Surface type	Minimum burial depth
Unpaved	20”
4” asphalt	12”
4” concrete	10”

All piping shall be separated by a distance of at least its diameter from any other pipe as well as the trench wall (see figure). The material removed while excavating the trench can be re-used as backfill material only if it fulfils the required criteria. The trench must be properly filled and compacted.



The support allowed by the backfill material is proportional to its rigidity. For this reason, the backfill material in contact with the piping must be well compacted.

The rigidity of the backfill above the pipe also has an important role in transmitting superficial loads to the pipe. Loads on the pipe are significantly reduced when the forces on the soil above and around the pipe are redistributed.

The more rigid the backfill above the pipe is, the less force is transmitted to the pipe.

Along with the characteristics of the backfill material of the trench, the material around the pipe must also be taken into consideration. Special attention must be given to soft clay and humid soils or sandy soils that can flake and make the walls of the trench unstable during excavation.

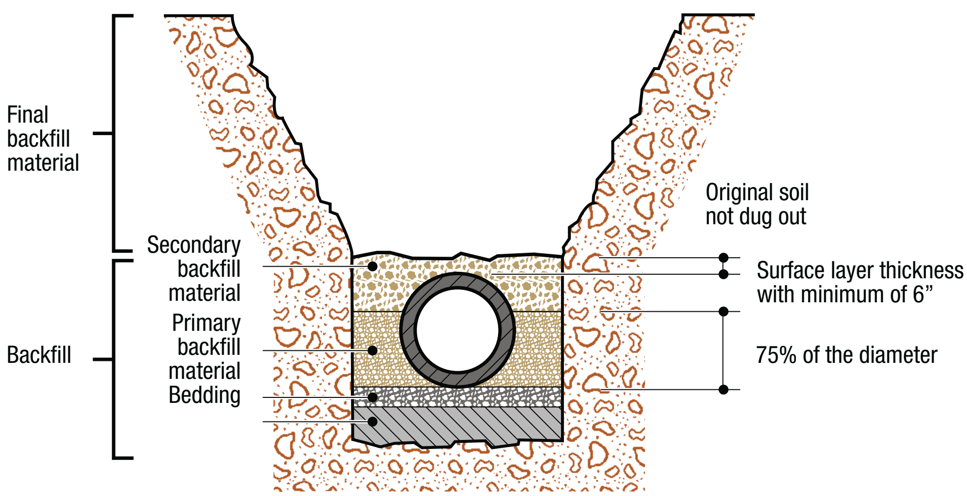
Flexible piping can be installed in similar circumstances without particular deformations if these conditions are respected. The main goal for installations with flexible piping is to avoid them being deflected. Pipe deflection can occur due to two principal reasons: the first is installation (that reflects the care and techniques used when the pipes are installed) and the second is the workload.

4.4 BACKFILL

The backfill material surrounding the pipes can be that which is present or imported, such as gravel or granules or material excavated directly from the trench (filling material).

This material must guarantee resistance, rigidity, contact uniformity and stability to minimise pipe deflection due to the soil pressure.

We recommend wetting the layer of sand in contact with the pipe repeatedly to obtain the best compacting results possible.



Groundwork: required only when the bottom of the trench does not provide a suitable base for the pipe bedding.

Bedding: it evens out the bottom of the trench to guarantee a uniform support base for the entire length of the pipe. When necessary, it also assures that slopes required for the pipe will be respected.

Primary backfill material: this material provides primary support against lateral pipe deflection. This area should cover at least 75% of the pipe diameter along the trench bedding.

Secondary backfill material: the material in this area basically distributes superficial loads and isolates the pipes from any possible effect derived from the final backfill material.

Final backfill material: the nature and quality of this material is less important than the other two regarding the effects on flexible pipes. In any case, a rigid fill helps reduce the stress created by superficial loads. To avoid possible impacts or loads concentrated on the pipes during and after filling the trench, the backfill material should not contain large stones, organic material or rubble.

In any case the reduction of the superficial loads is favored by a rigid backfill.

The backfill material shall not include big stones, organic material or rubble to avoid any shock or concentrated load on the piping both during and after the trench filling.

4.5 BACKFILL CLASSIFICATION

When selecting backfill, pay close attention to the size of the granules, as well as to the form and distribution of the grains. Generally, material with large grains provides maximum rigidity and offers the best resistance.

Round grains tend to roll around easier compared to irregular grains that tend to lock into one another therefore providing better resistance to damage.

For example, gravel has a typical modulus of 1.000 psi without being compacted, while sand requires light compaction (Proctor density of 85%) to achieve the same modulus.

Refer to standards ASTM D3839 or AWWA C950, ASTM D2487 and ASTM D2774.

Recommended types of backfill material are:
- Clean washed rough sand
- Pea gravel, 1/8” to 3/4”

Mixed material tends to offer better characteristics than material with consistent characteristics. All backfill material must be dry and free from ice, snow or debris.

Along with the grain characteristics, density also provides an important effect on the rigidity of the underground installation. For example, the grains lock into each other in a dense soil. Movement in the soil is restrained and much energy is required, whereas in a mobile soil, movement causes rolling and sliding of the grains, which requires much less energy. Mobile soils cause more deflection for certain superficial loads respecting dense soil.

When a pipe is deflected, two effects can occur:

- The pipe pushes against the material surrounding it and forces the soil to move. When this occurs, the soil resists it and prevents further deflection.
- Vertical deflection causes the load transmitted to the pipe to be reduced and produces an "arch" effect in the soil.

Compaction is therefore a fundamental parameter. Compaction should be of a W level type (Well compacted material) or at least M level type (Moderately compacted material) ASTM D2487.

Backfill material has been grouped into five main classes. Backfill with low numbers corresponds to larger grains, which are more suitable for pipe burial.

Coarse grain soils (e.g. class 1 and 2) are granular and provide maximum support as shown by the high elasticity coefficient of the soil. The high permeability of these soils eases trench drainage while making them suitable in conditions where problems may occur due to water.

When a pipe is set under water level in the soil, granular backfill should be used (class 1 and 2). It is important that the grains are irregular to reduce eventual movement to a minimum.

Table: relationship between compaction class, backfill material type and Proctor density

Compaction class	Backfill material class			
	1	2	3+4	5
	Proctor density			
Low (N)	100	90	87	84
Moderate (M)	100	93	90	87
Good (W)	100	97	95	92

4.6 CONCRETE BACKFILL

Concrete backfill turns the piping installation into a rigid system. Short piping sections can be embedded in concrete without any problem but precautions have to be taken in case of long sections.

Failure to do so will result in concrete and plastic to have no connection between them and the pipe may be free to shrink and expand according to temperature changes.

We suggest to embed the whole piping section into concrete including fittings and to constrain the piping every 15 ft by means of well fastened metal pipe clamps that will function as fixed points. In case of double wall piping, the pipe clamps shall be oval shaped in order to lock the primary pipe on the secondary pipe.

4.7 MULTIFUNCTION WELDING UNIT

All the instructions and guidelines regarding safety precautions are outlined in the multifunction welding unit (model SSEL8404) user's manual. However, pay close attention to the following:

- The multifunction welding unit can be used only for electrofusion welding of NUPI AMERICAS SMARTFLEX pipes and fittings. It is not intended for use with any other electrofusion piping system.
- The unit can perform testing functions when used with the SMARTFLEX Pressure Test Unit (model SENS010) or the Vacuum Test Unit (model SVTU).
- Certified installers/operators are responsible for assurance of recommended energy/power sources. Power sources should be checked (confirmed) for compliance to the following specifications: -110 VAC, 50 Hz (min.) with a 10% tolerance (min.).
- Inspect the multifunction welding unit, power cords and barcode reading device and replace any damaged components prior to use. Care must be taken not to damage the barcode reading device.
- Download the welding and pressure test reports and erase the data from the memory at the completion of each job.

The multifunction welding unit incorporates a system that automatically controls all steps of the welding procedure and informs the operator about errors and/or faults by means of signals or alarms. The alarm/error code is always shown on the LCD display and recorded on the welding report. Types of Alarm/Error Codes are:

- Error 0 successful weld
- Error 2 ambient temperature value outside limits for electrofusion
- Error 4 short circuit, overload, load current exceeded
- Error 5 open circuit
- Error 6 parameter control error
- Error 11 memory full
- Error 12 internal temperature exceeded
- Error 13 power supply interruption
- Error 14 no data in machine memory
- Error 22 manual or forced interruption of welding
- Error 23 power supply voltage outside parameters
- Error 30 not a NUPI AMERICAS fitting
- Error 31 fitting resistance out of tolerance range
- Error 101 RAM memory data and date/time not valid
- Error 200 pressure test stopped manually by the user
- Error 201 pressure loss in the system being tested

NEW AUTOMATIC WELDING UNIT WITH BARCODE SCANNER - LIGHT VERSION

New welding unit for SMARTFLEX system welding up to diameter 5” - USB technology that allows the transfer of data easily to your PC.

Weight 29 lbs, completely automated thanks to barcode system that reduces human errors, full welding report and pressure test report.

ITS

ITS is an Internet based Interactive Tracking System provided by NUPI AMERICAS. It allows you access to data regarding the installation of the SMARTFLEX system in a specific site (completed welding reports, pressure test results, installed products, installation site etc.).

For further information you can download the User manual from the LITERATURE section of NUPI AMERICAS website www.nupiamericas.com

MULTIFUNCTION - SMART - WELDING UNIT INCORPORATED IN SUITCASE WITH BARCODE SCANNER

A new evolved welding unit as the Smartweld associated with the app "Nupi Welding Cloud" allows a 360° management of all information related to the costruction site, the weld itself, the traceability of the products installed, the mapping using GPS tracking as well all testing activities later.

The welding unit is incorporate in the most innovative waterproof case. The case is watertight, waterproof, sand proof, dust proof and able to withstand harsh environments and shocks.

4.8 CHECKS PRIOR TO ELECTROFUSION WELDING

Before commencing the electrofusion welding process, check that the site generator, if required, is working correctly and efficiently. Check the condition of the extension leads and the presence of emergency fuel supply to ensure that electrical power will be supplied for the entire duration of the welding process. Finally, check the multifunction welding unit cables and ensure that all components are working properly.

The quality of the electricity you intend to use must also be checked: if a generator powers the multifunction welding unit, ensure that it is of the asynchronous type. Correct welding requires careful use of the extension leads. The cross-section/length ratio is of vital importance. NUPI AMERICAS recommends the following lengths and sizes:

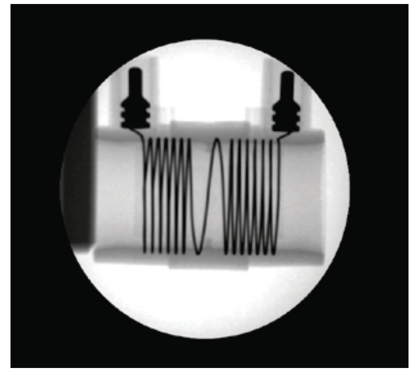
WARNING:

The misuse of the multifunction welding unit can result in hazardous situations for both the operator and the integrity of system components. Prior to commencing any welding operation, ensure you read the user's manual carefully.

Recommended cable cross-section	Recommended cable length
0.10 ($in.^2$)	19-22 (ft)
0.16 ($in.^2$)	30-36 (ft)
0.24 ($in.^2$)	49-55 (ft)

4.9 ELECTROFUSION WELDING

SMARTFLEX installation technology is based on “electrofusion”, one of the most utilised connection methods in the installation of polyethylene pipes. Electrofusion is the thermal junction process between pipe and fitting obtained by heating a resistance wire included in the fitting.



Due to the Joule effect, the thermal energy created by this resistance heating softens the components in contact causing them to melt and amalgamate with each other after the cooling down period.

To be welded, all SMARTFLEX electrofusion fittings require maximum voltage of 42 V as requested in international safety standards.

All SMARTFLEX fittings are provided with a barcode label that allows the acquisition of the welding parameters by means of an optical pen or barcode scanner.

Regarding the use of generators to weld the fittings, the following rule is valid:

a 3kV generator is sufficient for 1” or 2” fittings
a 5kV generator is sufficient for 3” or 4” fittings

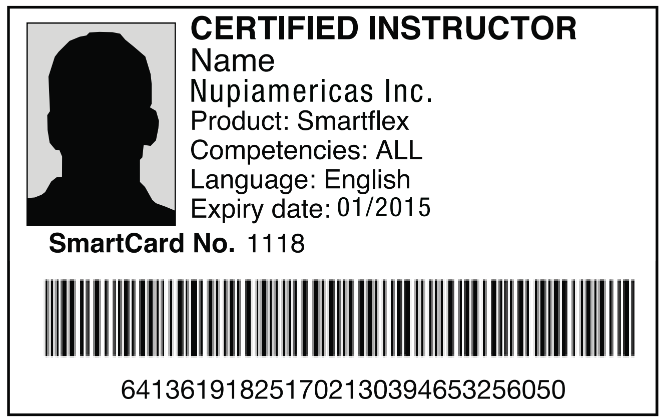
Note: The power of the generator is to be used only for the welding unit. If you want to connect more than one unit, you need greater generator power.

Single and double wall coaxial fittings contain electrical wires that provide the required heat for welding the pipe and fittings together (X-ray of a sleeve shown as example) when connected to the multifunction welding unit. Each fitting connection is identified by a barcode, which contains the specific welding parameters (required voltage and welding time) and a description of the specific fitting to be welded, the characteristics of the fitting (type and size) and other information regarding the facility, batch number and raw material type. This system also allows complete traceability of each fitting.

Only SMARTFLEX Certified Installers can access the welding unit using their specific SMARTCARD that contains an identifiable barcode and the following information:

- Operator's name, photograph and serial number
- Company name (city)
- Product
- Training level indicated by the competencies codes listed in the table below
- Language
- Expiration date
- Contact information

NUPI AMERICAS regularly trains and reviews certified installers worldwide.



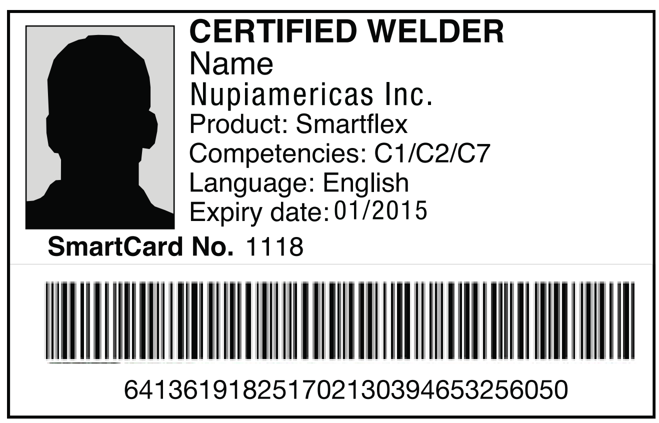


Table: Competencies codes

C1	Single wall pipe
C2	Double wall pipe
C3	Double wall fill pipe
C4	UL listed pipe
C5	Containment sumps
C6	SMARTCONDUIT
C7	Installation equipment
C8	Electrofusion entry boots
C9	Entry boots for fiberglass
C10	Leak monitoring
C11	Pressure testing

4.10 ELECTRO-WELDING GUIDELINES

Cutting

Cut the pipe perpendicularly at the correct length using the appropriate pipe cutter (Model **SCUT**).

Note: a cut which is not perpendicular to the pipe axis can influence its correct and complete insertion. As a consequence, some melt material could enter into the pipe during welding or two resistance wires might touch leading to a short circuit.

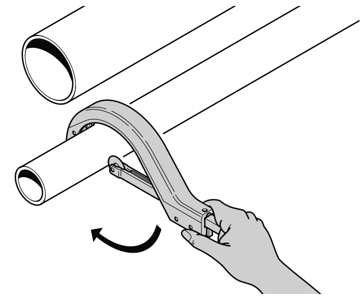


Fig.1

Scraping

Scrape the entire piping area involved in the welding process using the revolving scraper to completely remove the outer layer.

WARNING: Never use under any circumstances sand paper, emery cloth, files, knives or sharp objects.

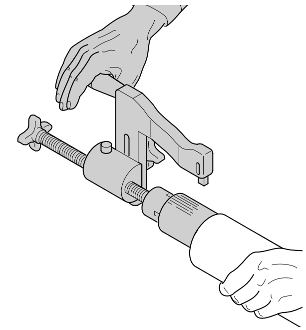


Fig.2

Insertion length

Clearly mark the insertion length on the pipe using the proper white marker (Model **MARK**).

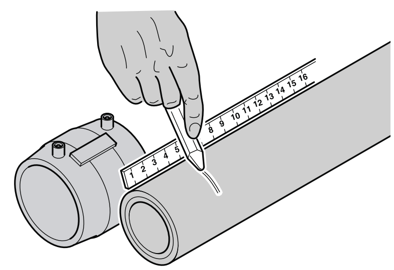


Fig.3

Cleaning

Clean the ends of the pipe, the fitting spigot and the socket with a clean cloth soaked with a recommended cleaning solvent (Model **LID1**). Do not touch the parts that have just been cleaned.

Note: The following solvents may be used, **Acetone, Isopropyl Alcohol, Trichloroethane and Dichloromethane.** The use of other primers or solvents is not allowed.

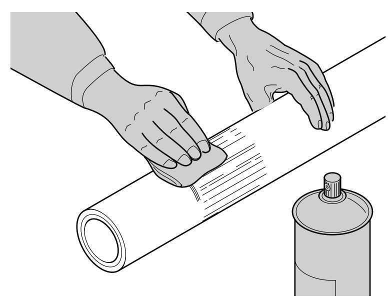


Fig.4

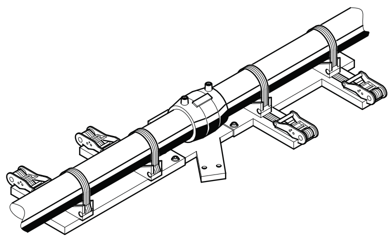


Fig.5

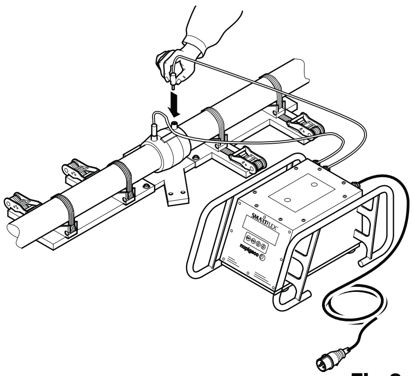


Fig.6

CAUTION:

After cleaning the pipe and fittings, ensure that any residual solvent has evaporated prior to inserting pipe ends into the fitting.

WARNING:

Some degreasers and solvents are extremely flammable. Be sure to read any warning labels on containers. Never use gasoline, turpentine, denatured alcohol (methylated spirits), tricloroethylene or diesel fuel to clean contaminated surfaces, as these products are generally greasy and may leave an oily film on the welding surface that would block molecular fusion of the two parts that are to be welded together.

Assembly

Insert the pipes into the fittings ensuring that the insertion depth previously indicated on the pipe is reached.

Always use the aligner (model ALL225/4) whenever possible to support the pipes and keep them in line during welding and cooling process.

Electrofusion welding

Connect the two welding lead connectors to the fitting, turn on the machine and follow the instructions shown on the display.

Read the barcode on the fitting with the barcode scanner connected to the welding unit to carefully respect the appropriate welding time.

Refer to the welding unit manual for the correct welding procedure.

Note: Ensure to scrape and completely remove the green outer layer of the **SUPERSMARTFLEX** pipe from the primary pipe until the black polyethylene layer is clearly visible on the outside of the pipe before commencing the welding process. Remove the outer layer completely, including the tie layer, until you reach the black HDPE layer. For a correct installation, please refer to the procedures and assembly instructions for each SMARTFLEX product.

When the welding process is completed, let the assembly cool without moving it for the time indicated on the barcode found on the fitting itself.
The following basic recommendations apply:

- electrofusion welding shall be carried out in dry areas. In the event of rain, fog or excessive exposure to the sun rays, work should be carried out under appropriate cover;
- it is recommended that electrofusion welding is carried out within the ambient temperature range from +14°F to +113°F);
- scrape the entire area of the pipe involved in the welding process. The external oxidised layer must be removed in a uniform manner from the entire circumference and for a depth of:
  - 0.004” for outside diameters up to 2”
  - 0.006” for outside diameters up to 4” or larger;
- use the SMARTFLEX marker (model MARK) to clearly mark the insertion length on the pipe;
- it is important to properly align pipes and fittings during the welding and cooling process to within a maximum angle of 15°;
- where possible use the aligner (model ALL225/4) to avoid deflection and eliminate stress on the welded connection;
- the pipe aligner must only be removed after the welded pipe and fitting have cooled completely but not before the cooling down period shown in the fitting barcode;
- the joining surfaces must be clean and dry before the electrofusion welding operation commences;
- in the event of a power outage, welding can be restarted only after the fitting and pipe have cooled down completely. This can only be undertaken once otherwise replace the fitting;
- before disconnecting the welding leads from the fitting, it is good practice to mark the welded socket with the weld number displayed on the welding unit screen or any other mark so that before the pressure test any non-welded fittings can be easily identified.

Note: For detailed welding procedures for any SMARTFLEX component, please refer to the individual installation instructions that can be downloaded from the LITERATURE section of NUPI AMERICAS website www.nupiamericas.com. You can also request them to our Technical Department at info@nupiamericas.com.

4.11 CHECKS AFTER ELECTROFUSION WELDING

Non destructive checks on electrofusion welded assemblies consist mainly of a visual inspection checking the following:

- that any misalignment between the two pipes does not exceed 10°-15°;
- that correct in fitting insertion lengths have been observed;
- that there is no escape of molten material;
- that an area of the pipe that has been scraped is protruding outside the fitting (at least 3/8”);
- that no parts of the wire of the inserted fitting will protrude.

4.12 ASSEMBLY INSTRUCTIONS OF COAXIAL DOUBLE WALL FITTINGS FOR Ø 1" ½ – 2" - 4" PRIMARY PIPE AND FOR Ø 2" - 2" ½ - 5" SECONDARY PIPE

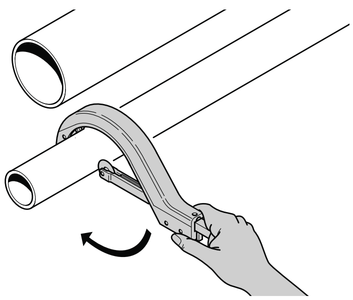


Fig.1

Cut the primary and secondary pipes to the same length using the appropriate pipe cutter (Model SCUT) when using straight length pipes/sticks.

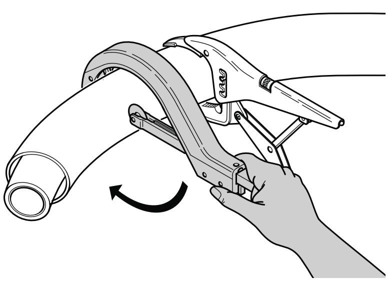


Fig.2

Cut the primary and secondary pipes to the same length using the appropriate pipe cutter (Model SCUT) when using pipes in coils.

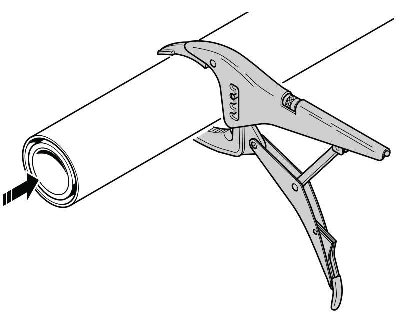


Fig.3

Ensure the primary pipe is constrained by using the pliers for double wall pipes (Model SPLIDW).

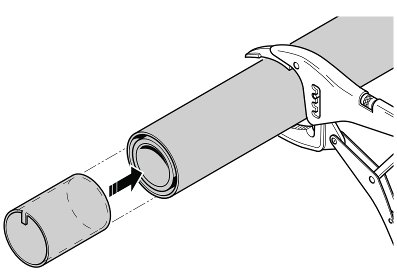


Fig.4

Insert the metallic protective sleeves (Model STP) between the secondary and primary pipes.

Use the appropriate marker (Model MARK) to clearly indicate on the secondary pipe the measurement **Px**.

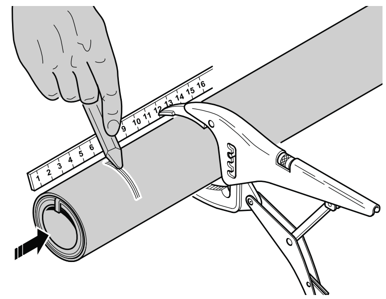


Fig.5

Cut the pipe at the correct length using the appropriate pipe cutter (Model SCUT).

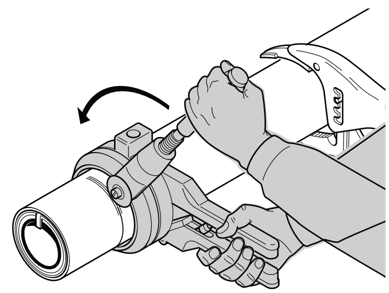


Fig.6

Scrape the primary pipe to a length equivalent to **P** (as listed in the table on page 66), using the revolving scraper (Model RAT1A or RATUL).

Note: For a correct installation of the **SUPERSMARTFLEX** pipe, ensure to **SCRAPE AND COMPLETELY REMOVE THE GREEN OUTER LAYER** from the primary pipe until the black polyethylene layer is clearly visible on the outside of the pipe. Remove the outer layer completely, including the tie layer, until you reach the black HDPE layer. The omission of this step can cause a weld to fail.

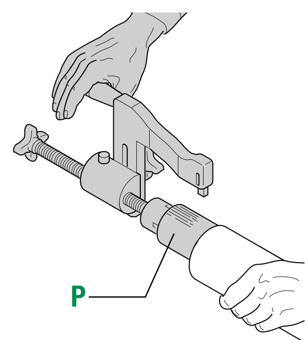


Fig.7

Scrape the secondary pipe to a length equivalent to **S** (as listed in the table on page 66) using the manual scraper (Model RAM1 or RAM2) or the revolving scraper (Model RAT1A or RATOR).

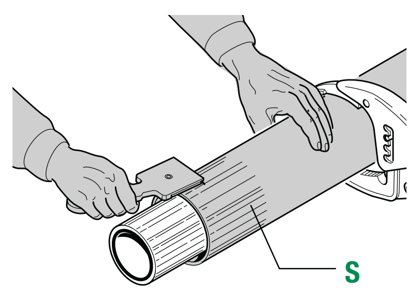


Fig.8

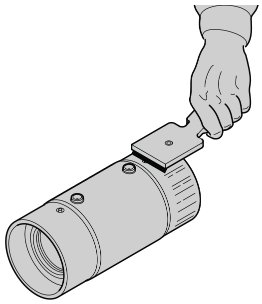


Fig.9

Scrape the fitting spigot with the manual scraper (Model RAM1 or RAM2). If the fitting is taken from its protective wrapping and used immediately it is not necessary to scrape it.

Note: Never use under any circumstances sand paper, emery cloth, files, knives or sharp objects.

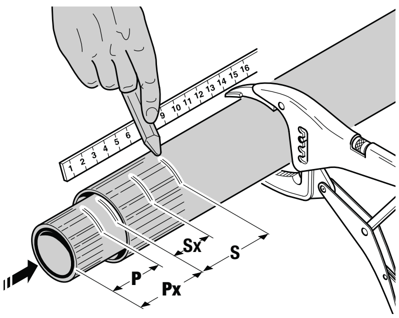


Fig.10

Use the appropriate marker (Model MARK) to clearly indicate the insertion length **Px** on the primary pipe and **Sx** (as listed in the table below) on the secondary pipe.

Note: When possible, always use the pipe aligner (Model ALL225/4) to eliminate stress and/ or tension during the welding process.

ITEM	Ø	Sx	S	P	Px
SMEDW50	1” ½	1.85”	3.94”	2.20”	2.36”
SMEDW63	2”	2.36”	4,72”	2.44”	2.76”
SCEDW50	1” ½	1.85”	3.94”	2.20”	2.36”
SCEDW63	2”	2.36”	4.72”	2.44”	2.76”
SGEDW50	1” ½	1.85”	3.94”	2.20”	2.36”
SGEDW63	2”	2.36”	4.72”	2.44”	2.76”
STEDW50	1” ½	1.85”	3.94”	2.20”	2.36”
STEDW63	2”	2.44”	4.72”	2.44”	2.76”
SGEDW110	4”	4.13”	7.87”	3.54”	4.53”
SCEDW110	4”	4.13”	7.87”	3.54”	4.53”

ITEM	Ø	Sx	S	P (scrape 0,4 in. more)
SETFC50-SETFCV50	1” ½	1.65”	2.05”	1.69”
SETFC63-SETFCV63	2”	1.65”	2.05”	1.69”
SETFC110-SETFCV110	4”	2.52”	2.91”	2.64”

Clean the ends of the primary and secondary pipes, the fitting spigot and the socket with a clean cloth soaked with a recommended cleaning solvent (Model LID1).

Note: The following solvents may be used, **Acetone, Isopropyl Alcohol, Trichloroethane and Dichloromethane.** The use of other primers or solvents is not allowed.

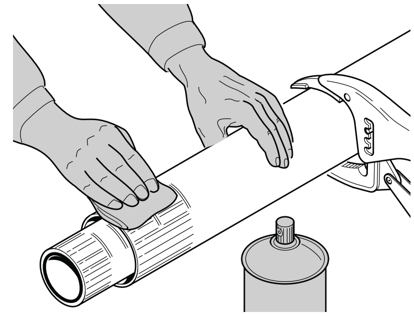


Fig.11

Fit the reducer and slide it along the secondary pipe.

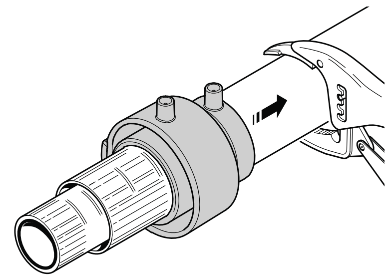


Fig.12

WELDING OF THE PRIMARY PIPE

Check that the pipes are correctly clamped with the pliers (Model SPLIDW), then insert the primary pipe ensuring that the insertion length **Px** (as listed in the table on page 66) is reached. Electrofusion welding of pipe and fitting may now commence following the instructions shown on the welding unit's display.

NOW WE RECOMMEND YOU PERFORM THE PRESSURE TEST ON THE PRIMARY LINE

The test can be performed only after the cooling down process has been completed.

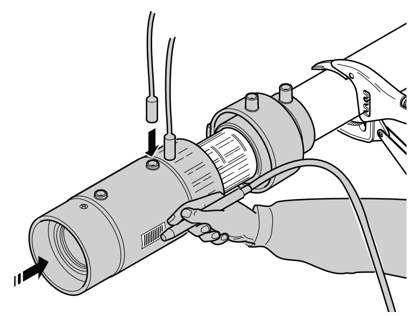


Fig.13

WELDING OF THE SECONDARY PIPE

Slide the reducer until it fits correctly on the fitting and check the insertion length **Sx** previously marked on the pipe is visible.

Note: Do not force the pipe to a complete stop inside the fitting as this may shut off the interstitial space.

Electrofusion welding of secondary pipe may now commence following the instructions shown on the welding unit's display.

NOW WE RECOMMEND YOU PERFORM THE PRESSURE TEST ON THE SECONDARY LINE

The test can be performed only after the cooling down process has been completed.

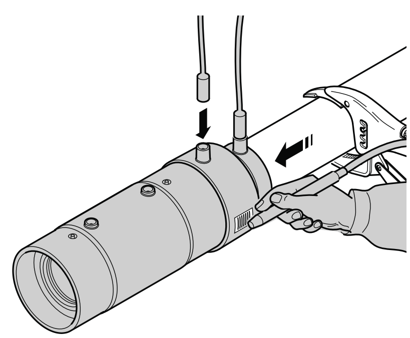


Fig.14

4.13 ASSEMBLY INSTRUCTIONS OF COAXIAL DOUBLE WALL FITTINGS FOR Ø 3" PRIMARY PIPE AND FOR Ø 5" SECONDARY PIPE

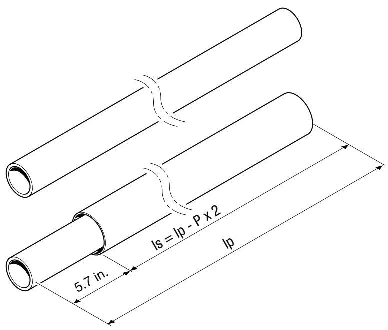


Fig.1

Cut the two pipes perpendicularly using the appropriate pipe cutter (Model SCUT or Model SCUTDW) to the correct length for the installation, then remove a further length equal to **P** x 2 (as listed in the table below) from the secondary pipe using the appropriate pipe cutter (Model SCUT or Model SCUTDW).

ITEM	Ø	Sx	S	P (scrape 0,4 in.)
SMEDW90	3"	3.43"	3.82"	2.83"
SCEDW90	3"	3.43"	3.82"	2.83"
SGEDW90	3"	3.43"	3.82"	2.83"
STEDW90	3"	3.43"	3.82"	2.83"

ITEM	Ø	Sx	S	P (scrape 0,4 in.)	Px
SETF90 - SETFV90	3"	3.35"	3.74"	2.22"	3.08"

Separate the primary pipe from the secondary pipe.

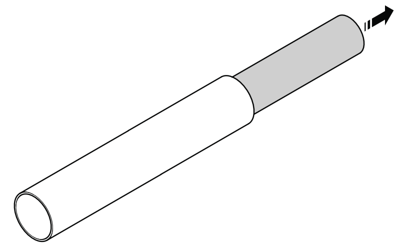


Fig.2

Scrape the primary pipe to a length equal to P using the revolving scraper (Model RAT1A or RATUL).

Note: Never use under any circumstances sand paper, emery cloth, files, knives or sharp objects.

Note: For a correct installation of the **SUPERSMARTFLEX** pipe, ensure to **SCRAPE AND COMPLETELY REMOVE THE GREEN OUTER LAYER** from the primary pipe until the black polyethylene layer is clearly visible on the outside of the pipe. Remove the outer layer completely, including the tie layer, until you reach the black HDPE layer. The omission of this step can cause a weld to fail.

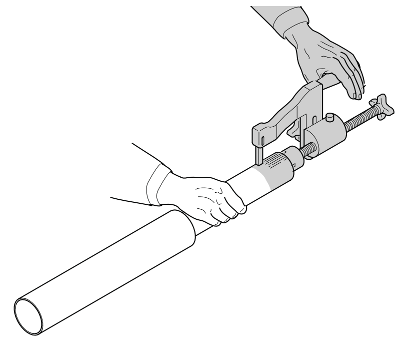


Fig.3

Separate the primary pipe from the secondary pipe.

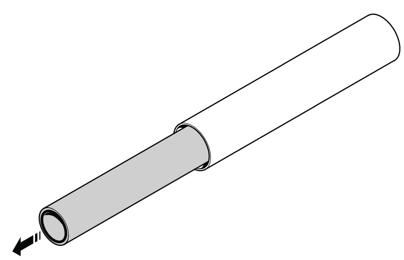


Fig.4

Scrape the secondary pipe to a length equal to S using the revolving scraper (Model RAT1A or RATUL).

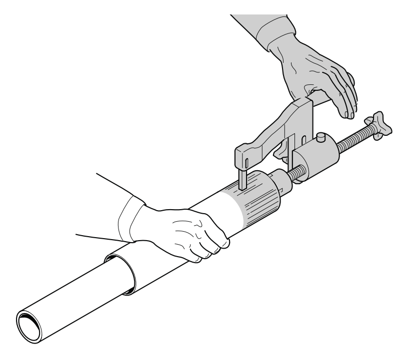


Fig.5

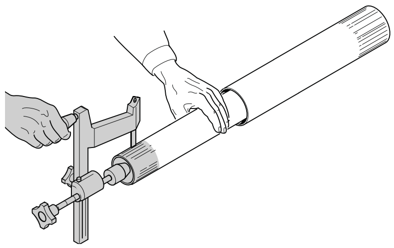


Fig.6

Scrape the other end of the primary pipe to a length equal to P using the revolving scraper (Model RAT1A or RATUL).

Note: For a correct installation of the **SUPERSMARTFLEX** pipe, ensure to **SCRAPE AND COMPLETELY REMOVE THE GREEN OUTER LAYER** from the primary pipe until the black polyethylene layer is clearly visible on the outside of the pipe. Remove the outer layer completely, including the tie layer, until you reach the black HDPE layer. The omission of this step can cause a weld to fail.

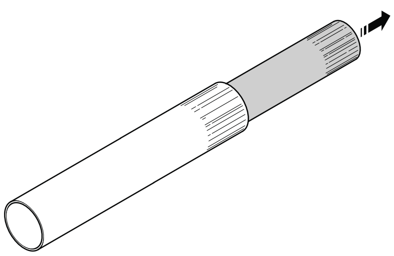


Fig.7

Separate the primary pipe from the secondary pipe.

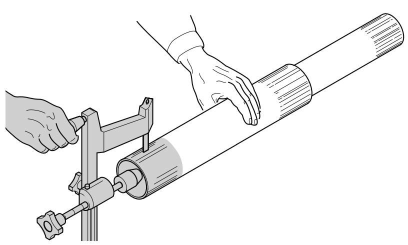


Fig.8

Scrape the secondary pipe to a length equal to S using the revolving scraper (Model RAT1A or RATOR).

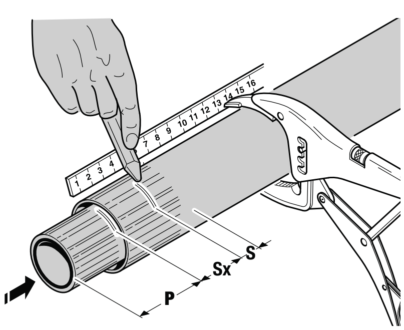


Fig.9

Use the appropriate marker (Model MARK) to clearly indicate the insertion lengths on the surface of the primary and secondary pipes.

Clean the ends of the primary and secondary pipes, the fitting spigot and the socket with a clean cloth soaked with a recommended cleaning solvent (Model LID1).

Note: The following solvents may be used, **Acetone, Isopropyl Alcohol, Trichloroethane and Dichloromethane.** The use of other primers or solvents is not allowed.

Note: When possible, always use the pipe aligner (Model ALL225/4) to eliminate stress and/or tension during the welding process.

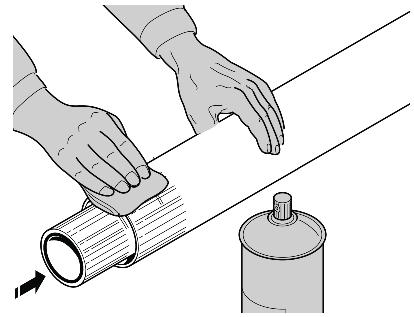


Fig.10

Insert the double wall pipe into the fitting, ensuring that the marked insertion depth is reached or until it comes to a stop against the internal stop inside the fitting.

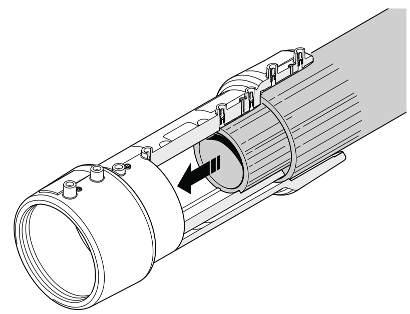


Fig.11

You can now commence the welding process of the primary pipe following the instructions shown on the welding unit's display.

NOW WE RECOMMEND YOU PERFORM THE PRESSURE TEST ON THE PRIMARY LINE
The test can be performed only after the cooling down process has been completed.

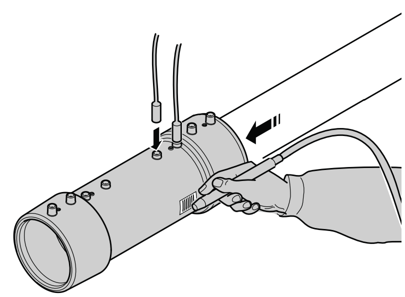


Fig.12

You can now commence the welding process of the secondary pipe following the instructions shown on the welding unit's display.

NOW WE RECOMMEND YOU PERFORM THE PRESSURE TEST ON THE SECONDARY LINE
The test can be performed only after the cooling down process has been completed.

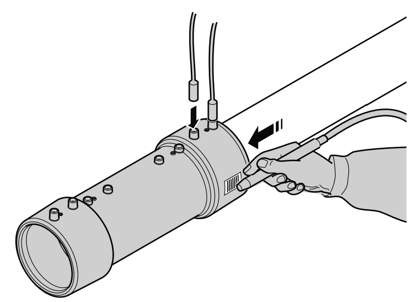


Fig.13

4.14 ASSEMBLY INSTRUCTIONS FOR MODEL SMEDWR110125 (Ø 3" PRIMARY PIPE FOR Ø 5" SECONDARY PIPE)

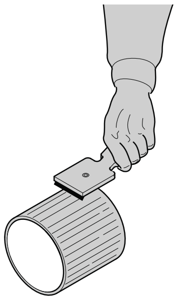


Fig.1

Scrape the secondary straight connector to its complete length.

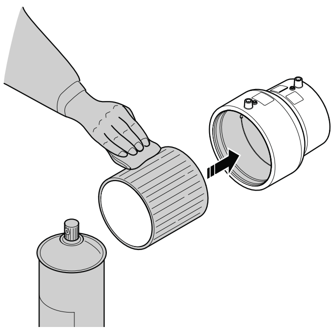


Fig.2

Clean one of the fitting spigots and the internal part of one of the reducers with a recommended cleaning solvent (Model LID1).

Insert the cleaned spigot of the secondary fitting inside the cleaned reducer to its complete stop. Before carrying out this step check and clearly mark the insertion length on the spigot of the secondary fitting.

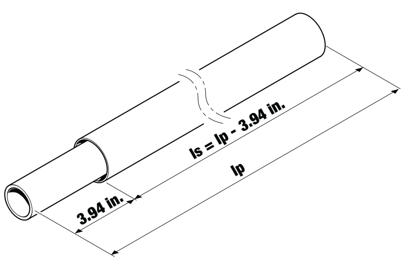


Fig.3

Cut the secondary pipe to a length equal to about 3.94 in.

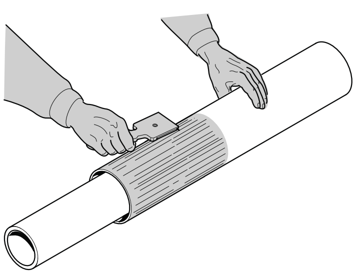


Fig.4

Scrape the secondary pipe to a length of 10.7 in. (1.5 times the length of the reducer).

Mark the insertion length of the secondary pipe equal to about 2.95 in.

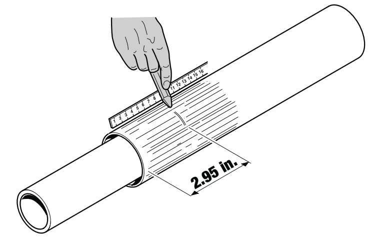


Fig.5

Slide the reducer that has just been assembled on the scraped secondary pipe.

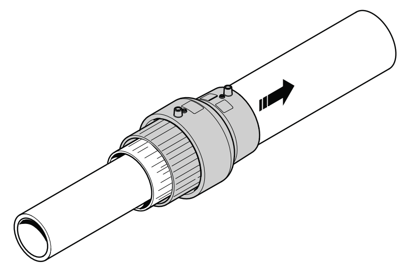


Fig.6

Let the primary pipe come out of the assembly as per figure 6, scrape it and clean it to a length equal to its insertion length inside the primary straight connector.

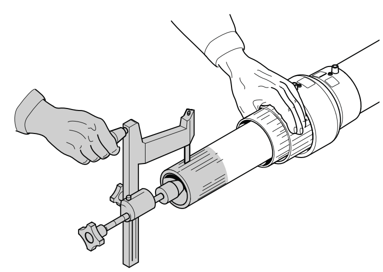


Fig.7

Mark the insertion length of the primary pipe inside the primary straight connector equal to about 3.03 in.

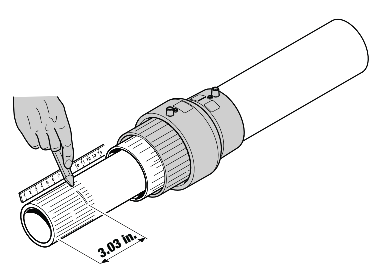


Fig.8

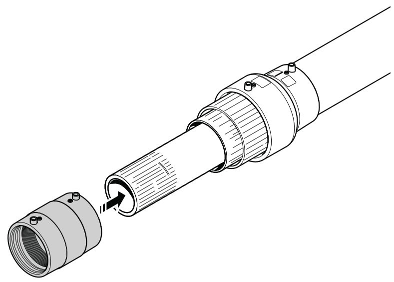


Fig.9

Insert the primary pipe inside the straight connector.

Cut the other secondary pipe to a length equal to about 3.94 in.

Scrape the secondary pipe that has just been cut to a length equal to 1 time the length of the reducer (about 7.10 in.).

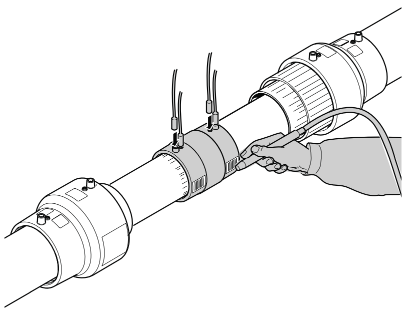


Fig.10

Mark the insertion length of the secondary pipe equal to about 2.95 in.

Repeat the steps as per figures 6, 7 and 8.

Weld the primary pipe by reading the barcode indicated on the straight connector.

When the weld is finished and after the fitting passed the hydraulic test, cut/tear off the brass parts of the welding pins so that the copper wire is not visible. Insulate the end of the welding pin by using insulating tape or paste. Place the covered wires so that they remain inside the secondary reducer.

Note: We recommend to insulate all cable lugs or metal ends that are visible inside the cavity or non-grounded.

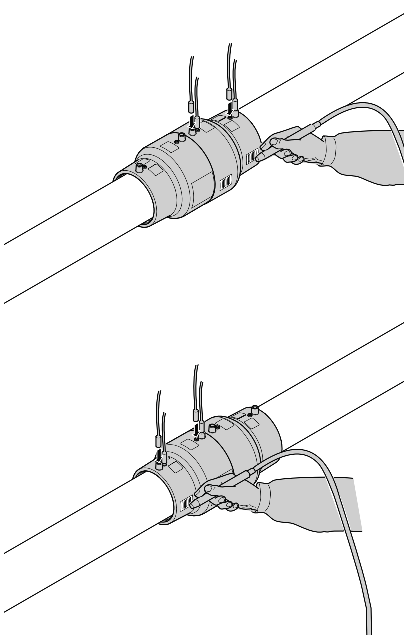


Fig.11-12

Slide the pre-assembled spigot of the secondary fitting on the primary straight connector that has just been welded.

Clean the free spigot of the secondary straight connector and the two ends of the secondary pipe previously scraped with a recommended cleaning solvent (Model LID1).

Insert the second reducer on the free spigot of the secondary fitting.

Make sure that the two secondary pipes have been inserted to the insertion lengths previously marked.

Weld the secondary pipe.

Note: We strongly recommend to proceed with the welding of the whole primary line and carry out the pressure test to check the tightness of the joints before proceeding with the welding of the secondary line.

4.15 ASSEMBLY INSTRUCTIONS FOR MODEL STEDWR110125 (Ø 4” PRIMARY PIPE FOR Ø 5” SECONDARY PIPE)

Measure the insertion length of the primary pipes. It is the distance between the complete stop inside the primary tee and the spigot rim of the secondary tee (about 11.40 in.).

Cut the secondary pipes to the insertion length of the primary pipes previously measured.

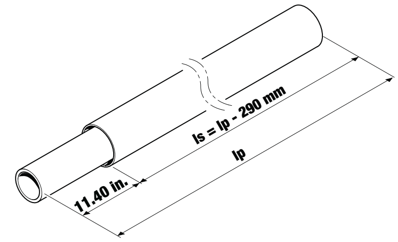


Fig.1

Scrape the secondary pipes to a length of 11.81 in. each.

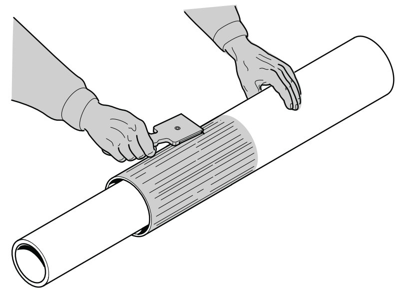


Fig.2

Mark the insertion length of the secondary pipes equal to 3.94 in. each.

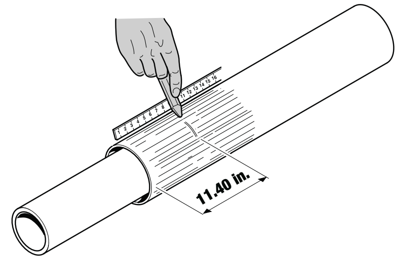


Fig.3

Scrape the primary pipes to a length of 3.94 in. each.

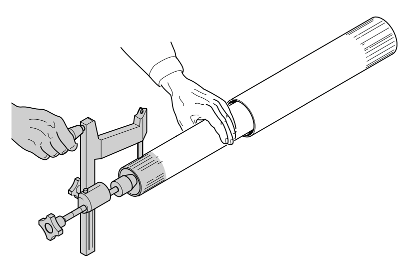


Fig.4

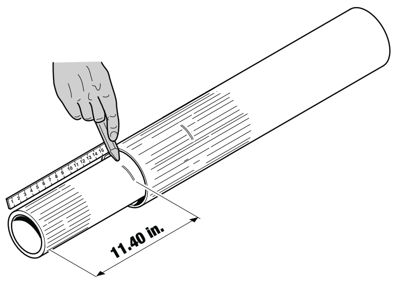


Fig.5

Mark the insertion length of the primary pipes (measured as per figure 1).

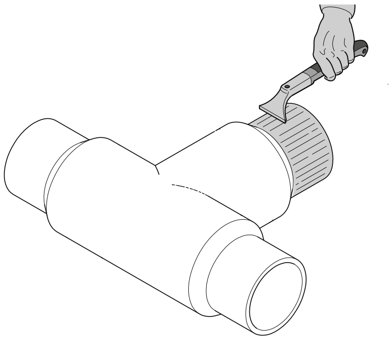


Fig.6

Scrape the secondary fitting spigot to a length of 3.54 in.

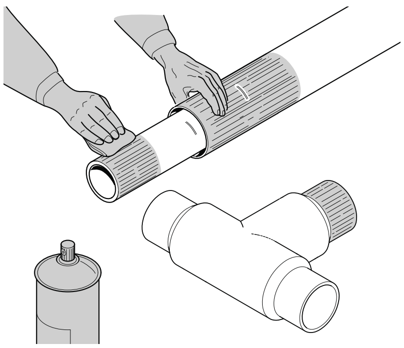


Fig.7

Clean the external surfaces of the pipes, the internal and external surfaces of the fitting and the internal surface of the reducer with the recommended cleaning solvent.

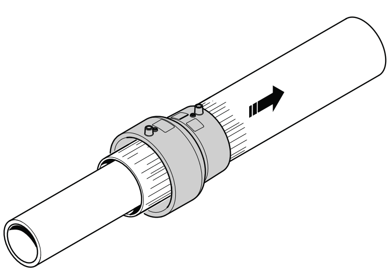


Fig.8

Slide the reducers on the secondary pipes to the whole length of the scraped part.

Insert the two primary pipes inside the fitting in both the ends of the long side to its complete stop inside the internal tee.

Make sure that the welding pins come out of the fitting.

Weld the two primary pipes of the long side at the same time (the internal fitting is single-wire) by reading the barcode indicated on the long side of the external tee.

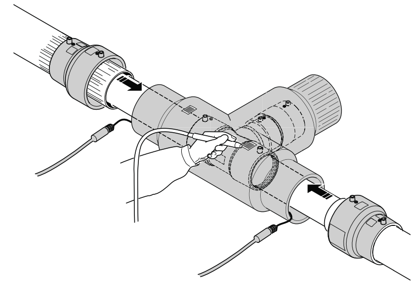


Fig.9

Insert the primary pipe to its complete stop inside the straight connector placed on the short side of the internal tee.

Insert the connectors (short side) inside the pins of the welding machine and weld by reading the barcode indicated on the short side of the external tee.

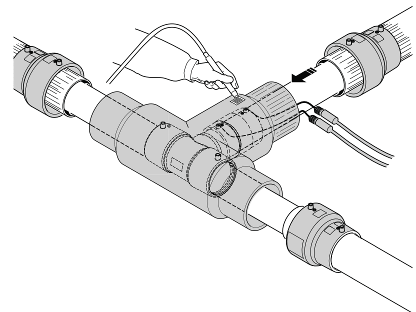


Fig.10

Slide the electric reducers on the secondary fitting spigot previously scraped and cleaned. Make sure that the insertion length indicated in figure 3 is reached.

Weld the reducers by reading the barcode indicated on the reducers.

When the weld is finished and after the fitting passed the hydraulic test, cut/tear off the brass parts of the welding pins so that the copper wire is not visible. Insulate the end of the welding pin by using insulating tape or paste. Place the covered wires so that they remain inside the secondary reducer.

Note: We recommend to insulate all cable lugs or metal ends that are visible inside the cavity or non-grounded.

Note: We strongly recommend to proceed with the welding of the whole primary line and carry out the pressure test to check the tightness of the joints before proceeding with the welding of the secondary line as the welding pins will remain trapped in the interstitial space of the secondary line. It will not be possible to repeat the welding operation.

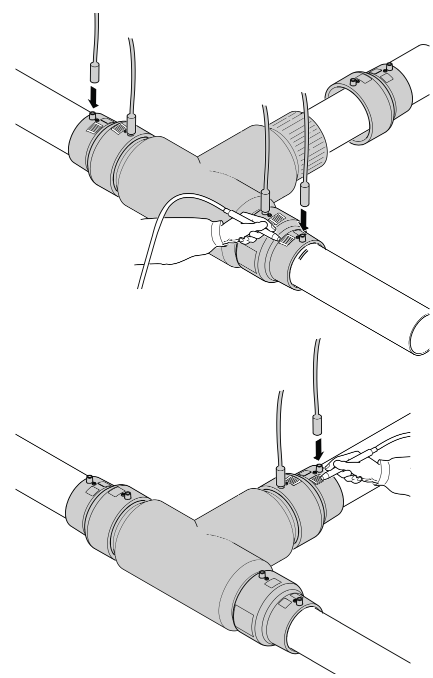


Fig.11-12

model SEBEP
US Patent nr: 9316336

5 • INSTALLATION INSTRUCTIONS OF ENTRY BOOTS

5.1 ASSEMBLY INSTRUCTIONS OF AN ELECTROFUSION ENTRY BOOT FOR SINGLE AND DOUBLE WALL SYSTEMS MODEL SEBEP

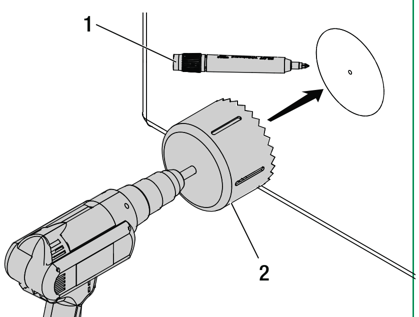


Fig.1

Assemble the mandrel (2) (Model SMAN) and the hole saw (Model STAZ) and insert them into the power drill. Mark (1) the position along the long side of the sump where the entry boot (Model SEBEP) is to be installed. Now drill the required hole through the wall of the sump. Repeat the procedure if more than one entry boot is to be installed.

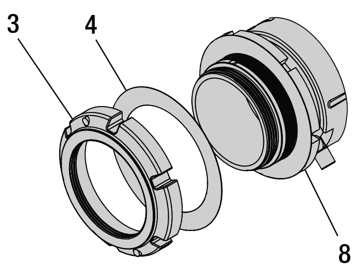


Fig.2

Remove the threaded ring (3) and one of the paper rings (4) from the body of SEBEP. Make sure the other paper ring (4) is in contact with the body surface of SEBEP.

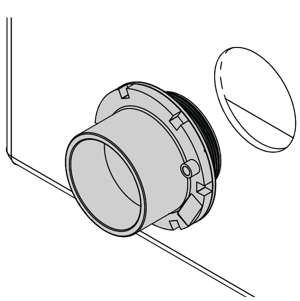


Fig.3

Place the entry boot into the hole previously made.

Place the paper ring (4) onto the SEBEP body and assemble the threaded ring (3) on the threaded part of SEBEP crossing the sump wall.

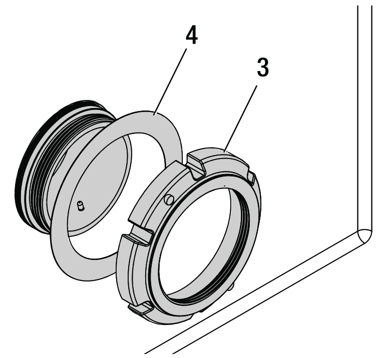


Fig.4

Check the correct tightening (you can use Model CHIAVE to carry out the correct tightening).

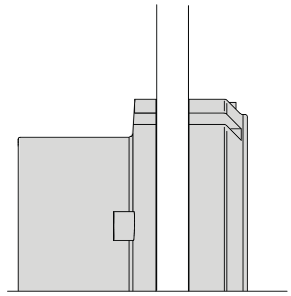


Fig.5

Use the connectors (5) to weld the entry boot by scanning the barcode sticker and following the instructions shown on the welding unit's display.

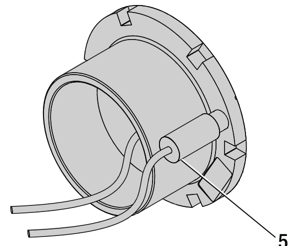


Fig.6

Use the manual scraper (6) (Model RAM1) to scrape the surface of the entry boot spigot.

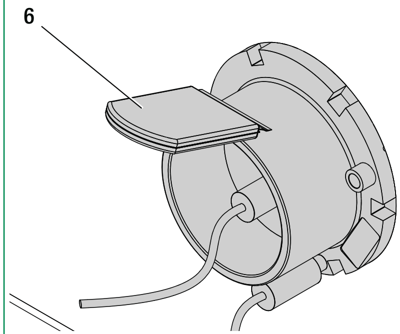


Fig.7

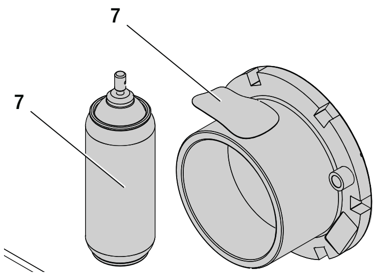


Fig.8

Clean the scraped surface and the inside of the reducer with a clean cloth soaked with a recommended cleaning solvent (Model LID1).

Note: The following solvents may be used, **Acetone, Isopropyl Alcohol, Trichloroethane and Dichloromethane.** The use of other primers or solvents is not allowed.

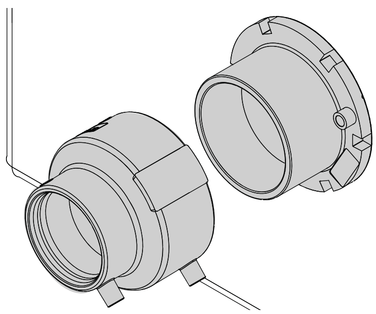


Fig.9

Place the reducer onto the entry boot spigot.

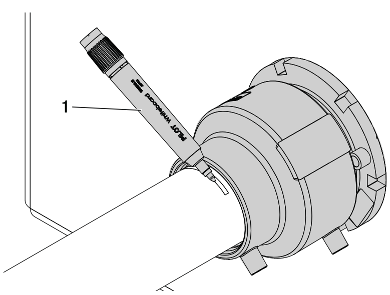


Fig.10

Insert the pipe through the entry boot and place it in the correct position. Use the appropriate marker (1) to indicate the position at the contact point between the pipe and the reducer on the outside surface of the primary and/or secondary pipes.

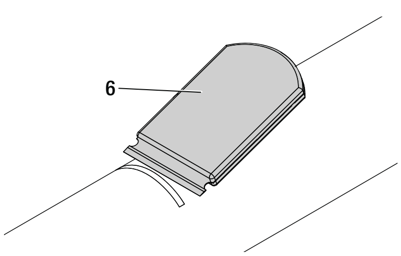


Fig.11

Remove the pipe the scrape its surface using the manual scraper (6) (Model RAM1) where the welding process is to be undertaken. Scrape a distance of 50mm or greater.

Note: For a correct installation of the **SUPERSMARTFLEX** pipe, ensure to **SCRAPE AND COMPLETELY REMOVE THE GREEN OUTER LAYER** from the primary pipe until the black polyethylene layer is clearly visible on the outside of the pipe. The omission of this step can cause a weld to fail.

Clean the scraped surface with a clean cloth soaked with a recommended cleaning solvent (7) (Model LID1).

Note: The following solvents may be used, **Acetone, Isopropyl Alcohol, Trichloroethane and Dichloromethane.** The use of other primers or solvents is not allowed.

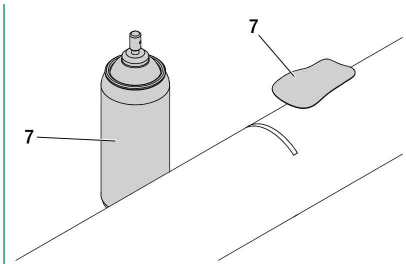


Fig.12

Insert and slide the pipe through the entry boot ensuring to place it in the correct position as marked. Weld the reducer by scanning the barcode sticker and following the instructions shown on the welding unit's display.

Note: Wait until the cooling down time shown on the barcode has elapsed before performing other operations.

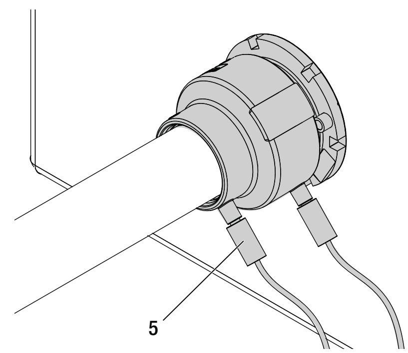


Fig.13

5.2 ASSEMBLY INSTRUCTIONS OF AN ELECTROFUSION ENTRY BOOT FOR FIBERGLASS TANKS MODEL SEBEF_A

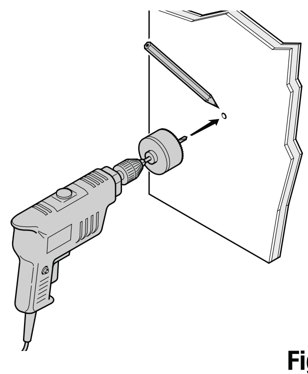


Fig.1

Assemble the mandrel (Model SMAN) and the hole saw (Model STAZ) and insert them into the power drill. Mark the position along the long side of the sump where the entry boot (Model SEBEF_A) is to be installed. Now drill the required hole through the wall of the sump. Repeat the procedure if more than one entry boot is to be installed.

STAZ89 3"½	To be used with SEBEFM_A and SEBEF_A diameters 1" ½, 2" and 2" ½
STAZ152 6"	To be used with SEBEFM_A and SEBEF_A diameters 3", 4" and 5"

Prepare the surface of the sump wall where the entry boot is to be installed with an angle grinder fitted with the appropriate sanding disc.

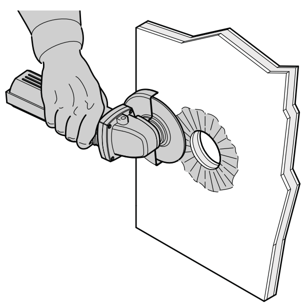


Fig.2

ATTENTION: The sanded area around the hole shall be larger than the outside diameter of the entry boot.

Clean all the components involved in the assembly with a clean cloth soaked with a recommended cleaning solvent (Model LID1).

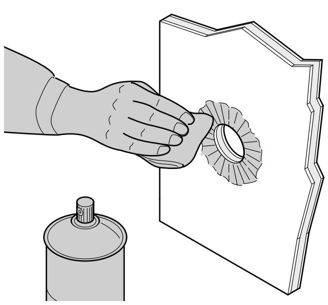


Fig.3

Note: The following solvents may be used, **Acetone, Isopropyl Alcohol, Trichloroethane and Dichloromethane.** The use of other primers or solvents is not allowed.

Use a proper emery cloth to clean thoroughly the SEBEF_A aluminium flat surfaces.

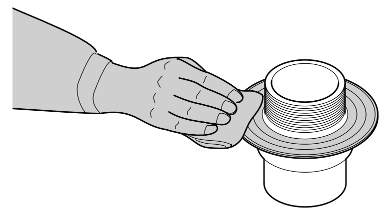


Fig.4

Pour and spread a consistent layer of epoxy sealant (Petrol Seal) over the contact side of the brass flanges. Avoid any spillage of product.

ATTENTION: During this process, avoid contaminating the SEBEF_A threaded parts and the internal surface of the sump.

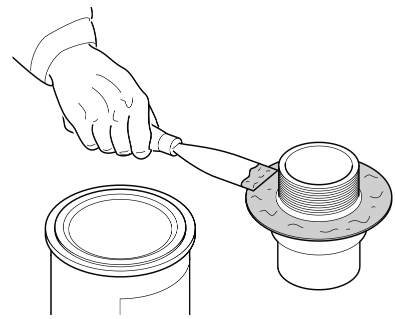


Fig.5

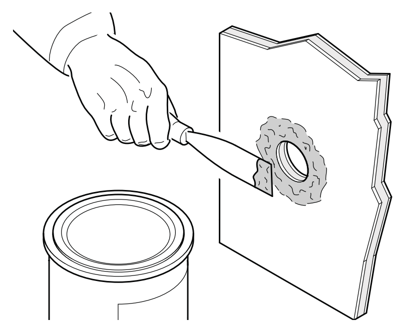


Fig.6

Assemble the two components of the entry boot together centring the flanges through the hole.

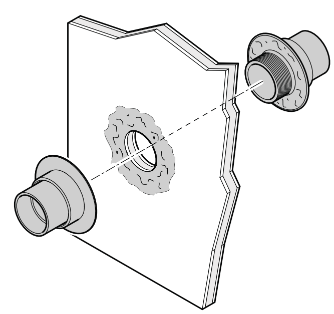


Fig.7

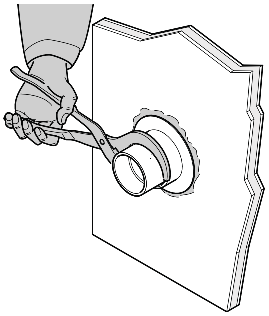


Fig.8

Tighten the SEBEF_A assembly (special filter pliers are available).

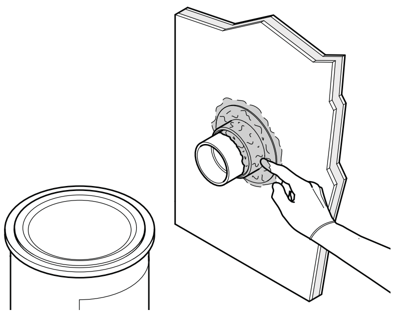


Fig.9

Pour and spread the Epoxy Sealant “Petrol Seal” on each side of the entry boot using the tip of the gloved finger and coat all the metal surfaces.

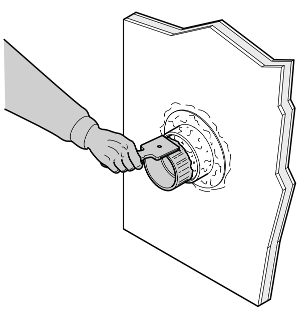


Fig.10

Let the assembly cure for the appropriate time (24 hours).

> **ATTENTION:** Protect the fitting from any direct contact with water (such as rain) during the curing time.

After the curing time, scrape the HDPE ends using the manual scraper (Model RAM1 or RAM2).

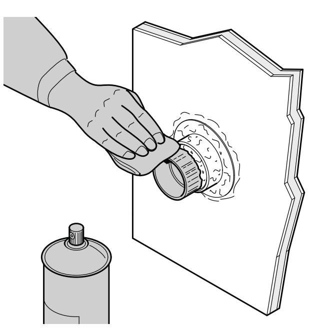


Fig.11

Clean the scraped surfaces with a clean cloth soaked with a recommended cleaning solvent (Model LID1).

> **Note:** The following solvents may be used, **Acetone, Isopropyl Alcohol, Trichloroethane and Dichloromethane.** The use of other primers or solvents is not allowed.

Place the reducers on the entry boot previously scraped and cleaned.

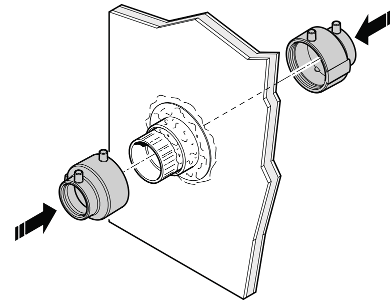


Fig.12

Insert the pipe into the entry boot until the correct position is reached. Use the appropriate marker to indicate the position at the contact point between the pipe and the reducer on the outside surface of the pipe.

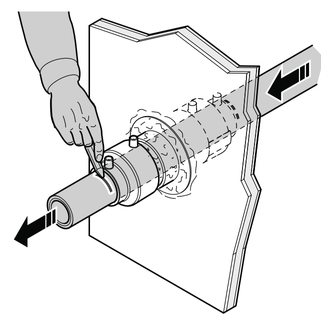


Fig.13

Remove the pipe and scrape along its length where it is to be welded using the manual scraper (Model RAM1 or RAM2).

From the point previously marked, scrape 1.97 in. from each side.

Note: For a correct installation of the **SUPERSMARTFLEX** pipe, ensure to **SCRAPE AND COMPLETELY REMOVE THE GREEN OUTER LAYER** from the primary pipe until the black polyethylene layer is clearly visible on the outside of the pipe. The omission of this step can cause a weld to fail.

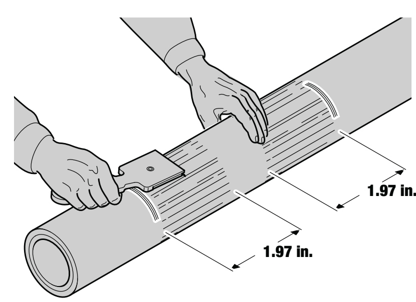


Fig.14

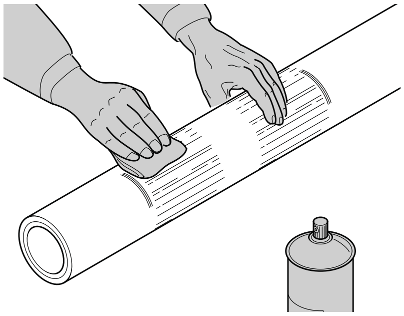


Fig.15

Clean the scraped surface with a clean cloth soaked with a recommended cleaning solvent (Model LID1).

Note: The following solvents may be used, **Acetone, Isopropyl Alcohol, Trichloroethane and Dichloromethane.** The use of other primers or solvents is not allowed.

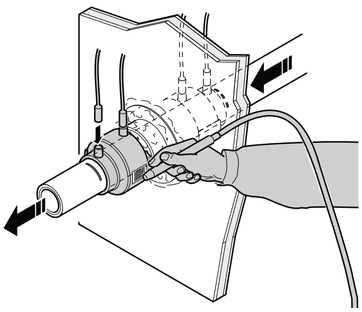


Fig.16

Re-insert the pipe through the fitting until it lines up with the previously marked position.

Weld each reducer by scanning the barcode sticker and following the instructions on the welding unit's display.

Note: Wait until the cooling down time shown on the barcode has elapsed before performing other operations.

ATTENTION: The preferred fluid to be used for monitoring purposes is PP glycol.

DO NOT USE BRINE!

The use of a proper corrosion inhibitor to be added to the monitoring fluid is also recommended.

Please contact our Technical Department for other types of fluid.

ATTENTION: We recommend to flow air into the sump annulus when the epoxy is not dry yet to make sure that the purge holes remain open and free of blockage.

HOLE SAW (STAZ) - ENTRY BOOT SIZE MATCHING CHART

Code	ø	Notes
STAZ89	89	for SEBEFM_A, SEBEF_A Ø 1"½, 2", 2"½
STAZ111	111	for SEBEP Ø 2", 2"½
STAZ152	152	for SEBEFM_A, SEBEF_A Ø 3", 4", 5", SEBEP Ø 3", 4", 5"


WARNING
WARNING

6 • MODIFICATION AND REPAIR OF SMARTFLEX SITES

The purpose of this document is to give a short guideline on how to operate when doing a modification or repair of a Smartflex piping system. This guideline is in any case not exhaustive and should never surpass the national/local regulation and practices, particularly in terms of health and safety regulations.

All the operations described below have to be performed, consideration must be given to all the necessary safety procedures in terms of health and safety of the on-site personnel and must take into consideration all the relative environmental aspects and rules.

For additional information, please make reference to:

- IP – Code of safe practice for contractors working on filling stations (March 2005).
- APEA/IP – Design, construction, modification, maintenance and decommissioning of filling stations.

PROCEDURE

1. Turn off and shut down the electrical supply to the submersible pump (if present) and the dispensers. This may require the assistance of authorised personnel.
2. Disconnect the pump and any dispenser devices.
3. Ready the UST closest dispenser hose to release pipeline pressure and to empty the product into a suitable sealed containment vessel.
4. Empty the line completely of any fuels.
5. Test the confined space in the sump to be repaired by the use of an (O_2) Oxygen sensor/meter.
6. Before any personnel enter the sump, check the presence of enough (O_2) Oxygen.
7. Close the ball valve of the submersible pump.
8. Open the test ports on the secondary containment fittings.
9. Detach the product line from the tank sump connection.
10. Assure to collect any residual fluid into the sealed containment vessel.
11. Open the shear valve access ports of the interested line to permit the fluid to flow down to the tank sump.
12. Close the shear valve when the line is completely drained and dried.
13. Ventilate the sump to achieve an Oxygen (O_2) level suitable for personnel to re-enter (20-25%).
14. Remove the filled containment vessel from the tank sump.
15. Proceed with the repairing process following the Smartflex installation instructions.
16. During the repairing process care shall be taken to keep the line and the sumps continuously purged with an inert gas like Nitrogen. It is important to monitor continuously the (O_2) Oxygen level.
17. Fill the line to be repaired and the sumps with Nitrogen until no Oxygen (O_2) is present (to be checked with the (O_2) Oxygen meter).
18. Place the welding unit as far as possible from the repairing site/area, aboveground, ensuring that the connecting cables are not tensioned.
19. Turn off the Nitrogen supply and immediately commence the welding process.
20. At the end of the welding process, turn off the welding unit power supply and again start to convey Nitrogen into the line and sump leaving the connecting cables connected to the fitting.
21. The flow of Nitrogen should continue for least 20-30 minutes during the cooling down period.
22. Permit air exchange and when the (O_2) level again reaches 20-25% the operator can enter the welding zone and disconnect the cables.
23. Once the repairing process has been completed, the line shall be pressure tested as per the Smartflex instructions.
24. After a positive result of the pressure test has been achieved, the line can be re-commissioned and start working again.

7 • SMARTFLEX PRESSURE TEST

CAUTION:

Before testing the primary pipe, ensure that the test ports on the double wall fittings are open and the interstice is properly vented.

CAUTION:

If gaseous fluids are employed for the pressure test, adequate safety precautions must be exercised.

All SMARTFLEX installations must be pressure tested prior to being placed into service.

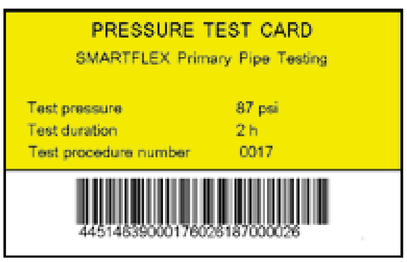
The primary pipe and secondary containment pipe (where applicable) shall be tested separately. The primary pipe shall be tested before completing all the welds in the secondary system.

A pressure gauge with test pressure at mid-scale is recommended. If the SMARTFLEX Pressure Test Device SENS010 is used as testing device please refer to its specific instruction guide.

If the installation has pressure constraints due to the installation of auxiliary devices, please contact our technical office before testing.

The following table provides testing parameters. Higher test pressures must be approved by the manufacturer.

	Gaseous Fluids		Liquid Fluids	
	Test Pressure	**Test Duration**	**Test Pressure**	**Test Duration**
Primary pipe	87 psi	2 hours	116 psi	2 hours
Secondary pipe	58 psi	2 hours	58 psi	2 hours
Rubber termination fittings	5 psi	2 hours	5 psi	2 hours


PRESSURE TEST CARD

SMARTFLEX Primary Pipe Testing

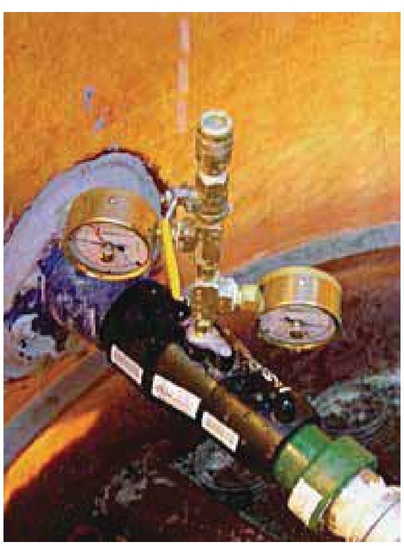
Test pressure	87 psi
Test duration	2 h
Test procedure number	0017

445148390001760281870000026

The conditions above are valid for the pipe at ambient temperature (68°F). For higher temperatures, wait for the conditions to be restored. The pipe shall NOT be tested when it is hot (pipe temperature > 95°F). It is recommended to carry out the pressure test in the early morning during the warm season of the year.

The pressure test shall be carried out on pipe runs with a maximum length of 300 ft in order to avoid that small pressure drops due to micro leaks will spread on the entire system under test and will not be detected.

The SMARTFLEX system includes a special testing device (Model SENS010) to be connected to the welding unit and the fluids generator. Barcode PRESSURE TEST CARDS are available for test performing.



Prior to commencing any pressure test it is good practice to inspect all welded fittings to ensure all fittings have been welded correctly.

The fluids recommended for the tests are: compressed air, nitrogen, helium or water.

Make sure that the filling phase of the sumps to be monitored is carried out gradually, avoiding overpressures.

Record the ambient temperature at the beginning and at the end of testing, as temperature changes will affect gas pressure inside the pipe.

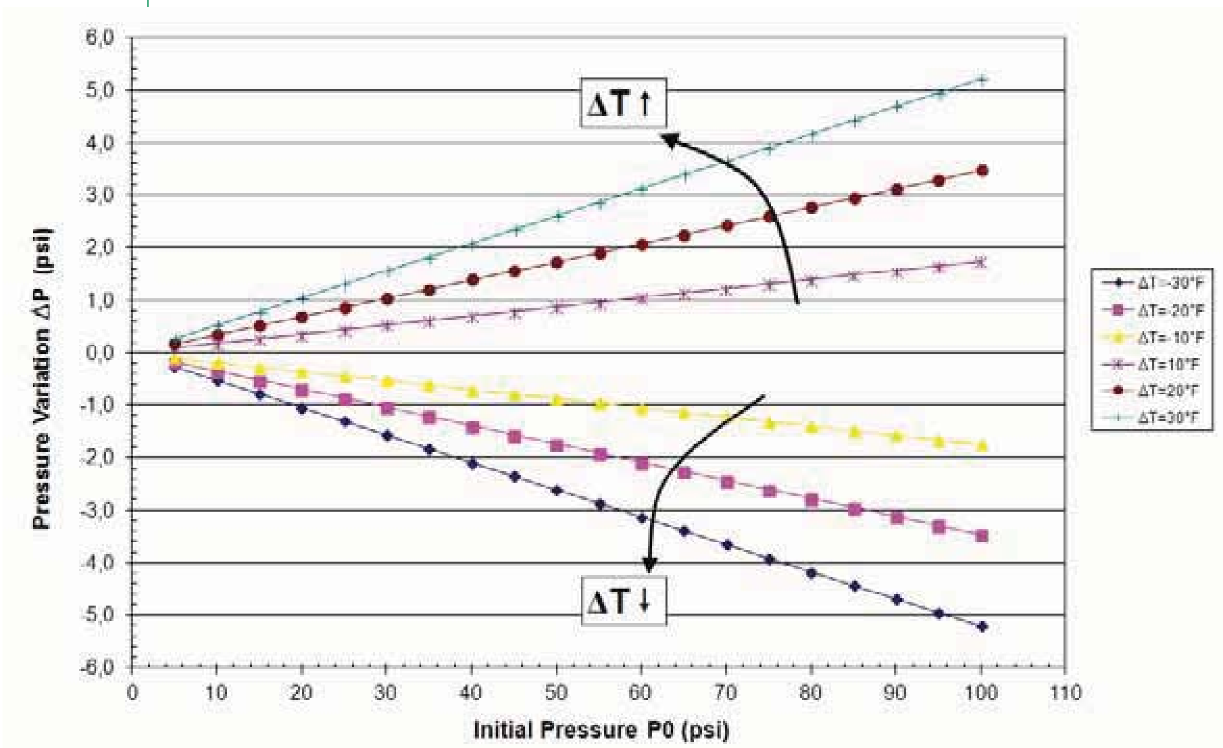
Pressure change due to temperature (only for gaseous fluids) is 0.19% for °F. [e.g. ± ΔT = -18°F will cause ΔP= -3.5%, hypothesizing that the temperature at the start of the test is around 60°F].

A net pressure change (after temperature compensation) of -2% is typically considered acceptable to take into account eventual micro leakage of testing devices.

The following table shows the final pressure P (psi) in function of initial pressure P0 (psi) and of temperature change ΔT (°F).

Initial pressure (psi)	**Temperature variation ΔT (°F)**						
	-27	-18	-9	0	9	18	27
	Final pressure (psi)						
5	4.7	4.8	4.9	5.0	5.1	5.2	5.3
10	9.5	9.7	9.8	10.0	10.2	10.3	10.5
15	14.2	14.5	14.7	15.0	15.3	15.5	15.8
20	19.0	19.3	19.7	20.0	20.3	20.7	21.0
25	23.7	24.1	24.6	25.0	25.4	25.9	26.3
30	28.4	29.0	29.5	30.0	30.5	31.0	31.6
35	33.2	33.8	34.4	35.0	35.6	36.2	36.8
40	37.9	38.6	39.3	40.0	40.7	41.4	42.1
45	42.7	43.4	44.2	45.0	45.8	46.6	47.3
50	47.4	48.3	49.1	50.0	50.9	51.7	52.6
55	52.1	53.1	54.0	55.0	56.0	56.9	57.9
60	56.9	57.9	59.0	60.	61.0	62.1	63.1
65	61.6	62.7	63.9	65.0	66.1	67.3	68.4
70	66.4	67.6	68.8	70.0	71.2	72.4	73.6
75	71.1	72.4	73.7	75.0	76.3	77.6	78.9
80	75.8	77.2	78.6	80.0	81.4	82.8	84.2
85	80.6	82.0	83.5	85.0	86.5	88.0	89.4
90	85.3	86.9	88.4	90.0	91.6	93.1	94.7
95	90.1	91.7	93.4	95.0	96.6	98.3	99.9
100	94.8	96.5	98.3	100.0	101.7	103.5	105.2

The following diagram shows the pressure change ΔP (psi) in the system, considering an initial pressure P0 and according to various temperature changes ΔT (°F).



Note: the procedure described above is a quick test procedure carried out under a so-called low pressure. This testing procedure could rarely not allow detection of anomalies caused by non-perfectly welds e.g. pasted welds, excessive offset or pipe that has not reached its correct position inside the fitting.

In case the pressure test had a negative result due to a leak at a fitting detected through soapy water or a suitable leak detection gas, the test shall be interrupted and the fitting shall be removed and replaced with a new one.

Problem solving in case of leak at any welded assembly

Considering that the electrofusion welding process is an optimal welding process (as it is based on molecular fusion between the materials that creates the assembly), possible leaks of the welded parts can occur only for the following reasons:

- The welding process was interrupted. Therefore, it was not completed correctly (the welding unit would have displayed an error on the screen).

Or:

- The pipes and fittings were not scraped and cleaned correctly. In this case, the material may not have fused together properly.

Since it is not possible to determine defective welding solely through a visual examination, we recommend:

- Re-welding the fitting one further time.
- Repeating the pressure test once welded and cooled.

Guidelines for system maintenance

The following guidelines shall be explained to the installer during their training:

- If a leak or anomaly is detected in any part of the system (by inspecting the sumps or through the leak monitoring system), the problem must be resolved by the maintenance person immediately.
- If the piping system is damaged or there is a leak, the manufacturer or distributor should be contacted for further advice.

The service station operator should be advised accordingly.

CAUTION:

Ignoring or disabling any monitoring system alarm may cause future damage.

8 • BIOFUELS

8.1 BIOFUELS: THE ANSWER IS THE SMARTFLEX SYSTEM

Biofuels are fuels extracted from the agro-energy. In other words, they can be obtained from the processing of agricultural raw materials, biomass and wood. Biofuels are therefore considered as a renewable energy source. Their natural origin is more easily absorbable by nature and allows to reduce the greenhouse gas emissions from private transport by 70% and reduce the import of oil from abroad. These two issues are taken very seriously by the European Union which requires all member countries to meet at least 2% of national energy demand by using biofuels, an intermediate target towards the final target of 5.75 % to be reached by December 2010 (20% by 2020).

There are two main biofuels: biodiesel and bioethanol.

It is important to emphasise that materials previously considered suitable for installations transporting traditional fuels are not just as suitable for the transport of new biofuels.

As for piping, thermoplastic piping are the most suitable ones (preferably made of HDPE with a suitable barrier layer) which are absolutely unaffected by biofuels that show instead a strong corrosive action on traditional metals. This is due to a more oxidising environment due both to the higher percentage of water contained and the increased bacterial growth of yeasts and mold and the relative change of PH caused by their metabolites.

Precaution should be taken then for the metal parts in contact with biofuels. Stainless steel, bronze and nickel-plated brass or aluminum are the most suitable ones.

The SMARTFLEX system offers a complete range of pipes and fittings to meet all the necessary requirements for the proper transport of biofuels.

The SMARTFLEX system has already been tested and certified by ERA TECHNOLOGY for the transport of E85 and biodiesel at 100% (EN14125) and KIWA Nederland B.V. (BRL5523).

9 • ELECTROSTATIC SAFETY FOR THE SMARTFLEX SYSTEM

The SMARTFLEX piping system has received the complete electrostatic safety certification by exceeding the many rigorous tests required by the Wolfson laboratory (UK).

Plastic piping that are made conductive and metal pipework that is conductive by its own nature cannot be defined as completely safe as regards the electrostatic risk and each installation must be carefully evaluated. For example, conductive metal pipework must be properly earthed and conductive plastic piping installations must be conductive in every part, both pipes and fittings, and must be properly earthed. Failure or poor achievement of this precaution could even increase the electrostatic risk.


Wolfson Electrostatics

Certificate of Electrostatic Safety

Presented to

NUPI S.p.A.

for

The SMARTFLEX Piping System

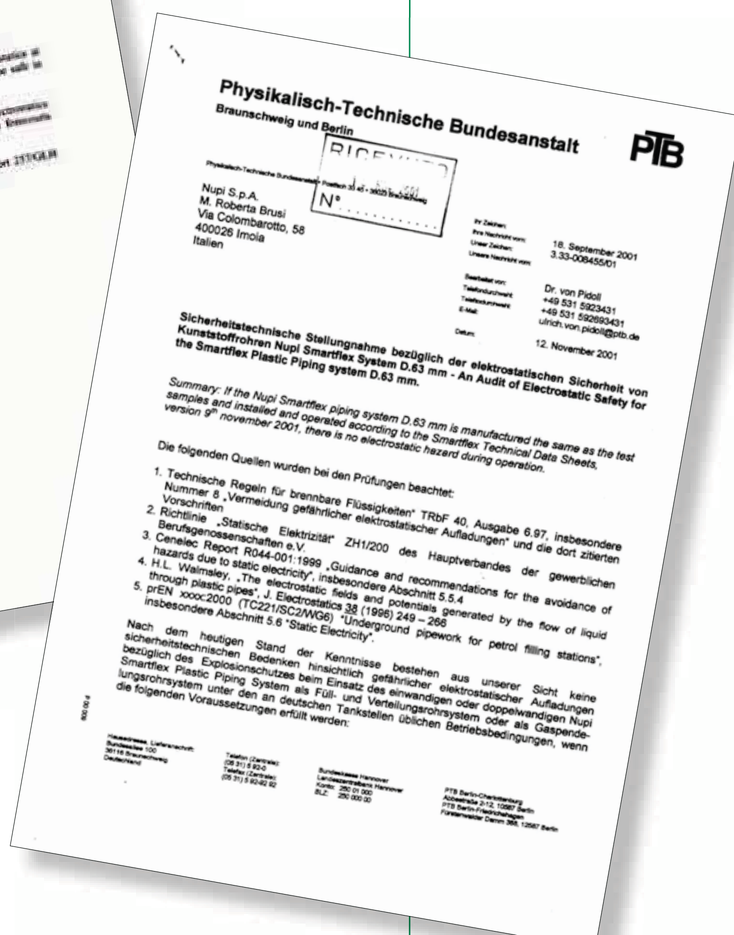
This is to certify that the SMARTFLEX piping system audited by Wolfson Electrostatics at the University of Southampton has been rigorously tested and has been found to be safe in respect of electrostatic ignition hazards.

The SMARTFLEX products encompassed in this audit and detailed in Wolfson Electrostatics Technical Report 237/GLH are suitable for use in fuel handling applications at forecourts involving gasoline (petrol) liquids and vapours and Diesel.

The conditions covered in section 4 of the Wolfson Electrostatics Technical Report 237/GLH will apply.

For and on behalf of Wolfson Electrostatics

28th November 2000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12. November 2001

Sicherheitstechnische Stellungnahme bezüglich der elektrostatischen Sicherheit von Kunststoffrohren Nupi Smartflex System D.63 mm - An Audit of Electrostatic Safety for the Smartflex Plastic Piping system D.63 mm.

Summary: If the Nupi Smartflex piping system D.63 mm is manufactured the same as the test samples and installed and operated according to the Smartflex Technical Data Sheets, version 9th november 2001, there is no electrostatic hazard during operation.

Die folgenden Quellen wurden bei den Prüfungen beachtet:

1. Technische Regeln für brennbare Flüssigkeiten" TRbF 40, Ausgabe 6.97, insbesondere Nummer 8 „Vermeidung gefährlicher elektrostatischer Aufladungen" und die dort zitierten Vorschriften
2. Richtlinie „Statische Elektrizität" ZH1/200 des Hauptverbandes der gewerblichen Berufsgenossenschaften e.V.
3. Cenelec Report R044-001:1999 „Guidance and recommendations for the avoidance of hazards due to static electricity", insbesondere Abschnitt 5.5.4
4. H.L. Walmsley, „The electrostatic fields and potentials generated by the flow of liquid through plastic pipes", J. Electrostatics 38 (1996) 249 – 266
5. prEN xxxx:2000 (TC221/SC2/WG6) "Underground pipework for petrol filling stations", insbesondere Abschnitt 5.6 "Static Electricity".

Nach dem heutigen Stand der Kenntnisse bestehen aus unserer Sicht keine sicherheitstechnischen Bedenken hinsichtlich gefährlicher elektrostatischer Aufladungen bezüglich des Explosionschutzes beim Einsatz des einwandigen oder doppelwandigen Nupi Smartflex Plastic Piping System als Füll- und Verteilungsrohrsystem oder als Gaspendelungsrohrsystem unter den an deutschen Tankstellen üblichen Betriebsbedingungen, wenn die folgenden Voraussetzungen erfüllt werden:

Electrostatic charges are generated through a process arising from the presence in parts per million (or billion) of ions in the fuel.

Positive or negative ions selectively attach themselves to any interfacial surface in contact with the fuel, such as the inner wall of the pipe, due to selective chemical absorption.

As a consequence, the inside surface of the pipe acquires a unipolar charge and ions of the opposite polarity in the fuel are attracted to it. A charged layer then extends from the wall into the fuel of a thickness that increases with decreasing fuel conductivity.

The net charge in the pipe is zero when the fuel is at rest.

When the fuel flows, the ions in the boundary layer tend to be carried along, while the opposite charge on the wall dissipates to earth at a rate depending primarily upon the pipe material's conductivity.

In any piping system, either metal or plastic, the primary source of charge generation is due to the flow of fuel through the pipe.

In addition to the electrostatic charging mechanisms, there is also the possibility of electrostatic charge being generated by friction with pipe wall and other plastic components, such as the walls of tanks or sumps, etc. In such cases, the frictional charge generation mechanism could be rubbing or brushing with clothing.

The construction of a non-conductive pipe with a conductive inner liner implies the need to use continuity bridges inside the assemblies and periodically check the continuity of the installation and its grounding. This increases the risks of the installation. If a bridge is not well positioned or forgotten, it interrupts the continuity of the system thus converting it into a capacitor with a consequent risk of ignition. In addition, periodic monitoring of the installation and its grounding is both difficult and expensive. The use of the SMARTFLEX system, which is wholly non-conductive, is therefore absolutely safe and is preferred to a non-conductive system with a conductive inner liner.

9.1 TESTS

In order to investigate electrostatic potential developed on the various components of a SMARTFLEX piping system, a test pipeline was created at the Wolfson Electrostatics Laboratories (UK).

The test set-up enabled electrostatic measurements to be undertaken at various points during the flow of low conductivity fuel, which was pumped through the SMARTFLEX pipeline at high velocity using a pneumatic diaphragm pump.

The SMARTFLEX system under test comprised two sections, a 2" diameter pipe and a 3" diameter pipe. It also included a number of electro-welded couplings and spigot fittings.

In order to perform these fuel flow trials, 150 US Gallons of refined iso-octane and toluene (50:50 mixture) were used. A pump able to deliver over 50 US Gallons per minute was chosen in order to obtain practical worst-case electrostatic charging situations (i.e. four or five nozzles delivering fuel simultaneously at a flow of 10 US Gallons per minute).

The maximum allowed flow is equal to 75 US Gallons per minute for each pipe.

A total of 22 test runs were undertaken with the main controlled variable being flow direction and fuel conductivity.

Measurements were taken on each run to determine the electrostatic potential on the pipe wall and the electrostatic potential developed on the fittings and electrofusion couplings.

9.2 CONCLUSIONS

With regard to the issue of electrostatic ignition hazards, the investigation described above has demonstrated that:

- The SMARTFLEX system does not show any significant increase in the electrostatic ignition hazard as compared to conventional metal pipe work for the same type of installations.
- Based on the typical fuel flow of gas station applications, there is no risk of hazardous brush discharges from the pipe due to fuel flow.
- As a rule of good practice, it is recommended to earth all metal components such as valves, entry boot rings, etc. It is also recommended to stop up/close off or insulate the welding pins of the electrofusion fittings if not earthed. When the welding process has ended, the metal welding pins shall be removed from any free welding wire and the wire ends shall be protected or insulated.
- The electrostatic potentials developed on the walls of the piping during fuel flow are at least two orders of magnitude lower than the electrical breakdown strength of polyethylene. Therefore, no danger of electrical breakdown through the pipe wall exists.

New biofuels comprising alcohols (EtOH - E85) are not dangerous according to electrostatic safety if conveyed using the SMARTFLEX system. E85 is more conductive than gasoline (up to 10 times more conductive than crude oil); therefore the charge disperses quickly by reducing the risk of electrostatic storage.

10 • FREQUENTLY ASKED QUESTIONS

General Questions

Is it true that all plastic piping systems swell or expand when in contact with hydrocarbon vapours?

Absolutely not! SMARTFLEX pipes will not expand in length when exposed continuously to hydrocarbon vapors in sumps. The reason is that the pipe and fittings employ high-density materials, which ensure a higher degree of hydrocarbon resistance.

Is the SMARTFLEX piping system rigid or flexible?

The SMARTFLEX piping system is classified semi-rigid. Therefore, it offers the rigidity required by CARB (California Air Resources Board) regulations and, at the same time, the flexibility required by installers during the installation process.

How do you become a SMARTFLEX certified installer?

The SMARTFLEX piping system can only be installed by SMARTFLEX certified installers. The operator must undergo a SMARTFLEX Certified Installer training course prior to obtaining their Certified Installer credentials. Certified Installer training is valid for a period of three years. Contact NUPI AMERICAS or in-country distributor for further information.

What is the warranty on SMARTFLEX products?

The SMARTFLEX piping system offers a 30-year warranty. In order to validate the warranty, the SMARTFLEX piping system must be installed by a certified installer in accordance with the latest published installation instructions.

It was reported recently that a thermoplastic flexible pipe system "swelled/expanded" (grew in length) due to continuous exposure to hydrocarbon vapors within a containment sump. The abnormal growth caused a failure of the containment sump entry fittings. Will the SMARTFLEX piping system behave in the same manner?

Absolutely not! SMARTFLEX pipes will not noticeably swell or expand in length when exposed continually to hydrocarbon vapors in sumps. The reason is that the pipe and fittings employ high-density materials, which ensure a higher degree of hydrocarbon resistance.

Are there any other piping manufacturers that offer pipe and fitting traceability?

Barcode technology is offered all over the world, but this does not imply traceability. The barcode alone is just a quicker way to enter the welding parameters into the welding machine.
SMARTFLEX is a true traceable system as it integrates:

- Double barcode fittings.
- A proprietary welding unit featuring a simple program that allows downloading of the welding parameters and system pressure tests.
- ITS: a web based application which provides the end user and NUPI AMERICAS to enter, store and retrieve all the specific site installation data.
- UNI EN ISO 9001:2008 and UNI EN ISO 14001:2004 certified production facilities and OHSAS 18001:2007.

What is the ITS system?

ITS is an Internet based Interactive Tracking System provided by NUPI AMERICAS. It allows you access to data regarding the installation of the SMARTFLEX system in a specific site (completed welding reports, pressure test results, installed products, installation site etc.).

What is the recommended backfill material?

Sand and pea gravel. Please refer to section 4.4.

What is the pressure rating of a piping system?

The pressure rating (or max. operating pressure) is the estimated gauge pressure that the medium in the pipe can exert continuously with the likelihood that failure of the pipe will not occur. All SMARTFLEX primary and secondary pipes are sized to have a pressure rating of 116 psi and 58 psi respectively with hydrocarbon as converted fluids. With water they are classified pressure of 180 psi and 87 psi respectively.

Can the interstitial space be monitored?

Yes, thanks to SMARTFLEX double wall coaxial fittings that allow the interstitial space to remain uninterrupted throughout the complete line.

What is the pipe bending radius?

Nominal pipe diameter (in.)	Minimum bending radius (ft)
1" 1/2	3
2”	4

What is the double barcode?

The double barcode contains added information that allows complete tracking of the fitting including manufacture site, raw material batch number and characteristics.

Is the SMARTFLEX piping system suitable for biofuels?

Yes, it is! The SMARTFLEX piping system is suitable for the conveyance of biofuels and their blends (e.g. E85, biodiesel etc.).

Is the SMARTFLEX piping system suitable for AdBlue/DEF/Urea?

Yes, it is! NUPI AMERICAS created a multilayer pipe (SMARTFLEX Urea) specifically designed to satisfy the requirements of AdBlue/DEF/Urea conveyance in compliance with the DIN70070 standard. In addition, we provide a wide range of fittings in stainless steel (AISI 304) for this application.

Is it possible to electro-weld while in presence of explosive vapors?

No, it isn’t! Prior to commencing the electrofusion welding procedure any residual hydrocarbons (liquid or vapor) must be eliminated from the line. This can be done by fluxing the line with an inert gas (e.g. nitrogen).

What is required to download welding or pressure test reports from the welding unit?

For model SSEL8404 and SSEL8404L the data can be directly transferred to a computer via Bluetooth.

What are the main advantages of the SMARTFLEX double wall pipe system versus other pipe systems currently available on the market?

The SMARTFLEX double wall piping system is, in fact, a true double wall pipe system as the secondary pipe is not a simple jacket but an actual structural pipe. For this reason, our double wall piping system can be continuously monitored (24/7) at a pressure of 55 psi except in cases where rubber components are present.

What connection methods do you use to install SMARTFLEX piping systems?

The primary connection method for the SMARTFLEX system is based on electrofusion welding technology.

Can the SMARTFLEX piping system be used for both pressure and suction systems?

Yes, it can! SMARTFLEX can be used for both pressure and suction systems.

Does NUPI AMERICAS provide a leak monitoring system?

Yes, it does! It is an over-pressure system that contains a leak monitoring unit (Model SMSIT), a manifold and tubing for connecting the system to the double wall fittings via a specific quick-connecting valve.

Is the SMARTFLEX piping system specifically designed for use with petroleum products, alcohol mixtures, biofuels and their blends?

The SMARTFLEX piping system is designed and manufactured specifically for the conveyance of automotive fuels. This includes all gasoline, diesel fuels, alcohol/gasoline mixtures and biofuels.

Can the primary and secondary lines be tested together?

No, they can't! Only all the primary lines can be connected and tested together or all the secondary lines (using the specific manifolds). As the test pressures vary for the two pipelines, please refer to the Technical Catalog, section 7, for further information.

In the event that the internal pipe liner has been excessively exposed to ultra-violet (UV) rays, what corrective action should the installer perform?

The installer shall remove not less than 5 cm or one pipe diameter, whichever the greater, off the end of each exposed pipe.

What is the ambient temperature range within which electrofusion welding can be carried out?

From +14°F to +113°F .

What is the minimum recommended burial depth for SMARTFLEX pipes and fittings?

It is 20”.

If pipes are crossed over one another, is there any particular procedure required?

Yes, there is. The pipes should be protected by a minimum of 2” of compacted backfill or 1” of protective Styrofoam to prevent point-loading damage of the pipes.

Is it important to align the pipes and fittings during the welding and cooling process?

Yes, the pipes and fittings must be aligned during the entire welding and cooling stage for welding to be performed correctly. A maximum misalignment of 10-15° is allowable.

In the event of a power shortage, can the electrofusion welding process be restarted?

The electrofusion welding process can only be restarted after the assembly has completely cooled down to ambient temperature. NOTE: this process can only be performed once.

Can SMARTFLEX welding units be used in potentially explosive environments?

SMARTFLEX welding units are NOT intrinsically safe devices and may only be used on pipe sections that do not contain hydrocarbons. Always refer to local regulations and codes for the use of electrical devices in service stations.

Since HPDE pipe has a higher coefficient of thermal expansion than reinforced fiberglass pipe, how does the installer(s) determines the correct length of pipe to cut between two points?

This is not a real issue when installing SMARTFLEX pipes. Just measure the pipe and cut it to the appropriate length and install it. Although SMARTFLEX has a higher expansion coefficient than either metal or fiber reinforced materials, its elastic modulus is much lower (from 10 to 200 lower). This means that the load applied to pipe constraints due to thermal expansion/contraction (in “restraining” installations) and pipe expansion (in “free-supporting” installations) is usually negligible and lower than the results obtained with the previously mentioned pipes.

If the barcode reading device fails to read a specific barcode, how should the installer proceed?

The installer must get an identical fitting and read its barcode in order to continue the welding process. If the problem persists, contact our Customer Service at +1 281-590-4471 or at info@nupiamericas.com.

How does the SMARTFLEX piping system react to hydrocarbon permeability?

SMARTFLEX piping system permeability to petroleum products and alcohol fuels is negligible and completely in compliance with various international certification requirements. In fact, SMARTFLEX pipes and fittings are created with special "barrier" materials that assure high resistance to petroleum products and biofuels.

CERTIFICATIONS

Is the SMARTFLEX piping system UL971/ULC certified?

Yes, it is!

WARNING: This document contains recommendations and information about products manufactured by NUPI INDUSTRIE ITALIANE and NUPI AMERICAS (NUPI group) and their installation. It is based on currently available data and is representative of the product under specified conditions. However, factors such as changes in environment, application, installation, operating procedure or extrapolation of data may cause different results.

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