SMARTFLEX™

Technical Catalogue
May 2011 Edition

MEMBER PEI — MEMBER IP THE INSTITUTE OF PETROLEUM — ERA TECHNOLOGY — kiwa — apea

Nupigeco Production Facility -
Imola - Italy

Nupigeco Headquarters - Busto Arsizio - Italy

Nupigeco Headquarters -
Busto Arsizio - Italy

Nupigeco Production Operations and
Administration Centre -
Castel Guelfo di Bologna - Italy

INDEX

1 • PRODUCT DESCRIPTION

SMARTFLEX was developed by NUPIGECO Industrial Group for the conveyance of petroleum products, alcohols, alcohol-gasoline mixtures and bio fuels.

NUPIGECO has over 50 years experience in the design and manufacture of the most modern polymeric materials culminating in the development of 12 complete product lines for Water, Gas, Industry Applications, Plumbing and Heating fields marketed all over the world.

Every year more than 25.000 km of pipes and 20 million fittings are installed worldwide.

NUPIGECO has always dedicated considerable investments to research & development activities, technological trainings and quality control.

This technological commitment allowed NUPIGECO to place itself among the first companies in its market segment in Europe.

1.1 WHAT IS THE SMARTFLEX SYSTEM

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

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 allows NUPIGECO to provide a product warranty of 30 years.

1.2 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
- HARBOUR 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
- 98 unleaded gasoline
- 95 unleaded gasoline
- 95 unleaded gasoline with 8 to 10% ethanol (SE95-E10)
- Methanol
- Toluene
- Kerosene
- Alcohol fuels
- Diesel fuels
- Aviation fuels
- Diesel oil
- Non-sulphur diesel oil
- Naphtha
- Jet Fuel A

The SMARTFLEX system has succesfully undergone many tests that proved its compatibility with the following new bio fuels:

- Bio diesel
- E85 ethanol

The list is not complete.

1.3 ELECTRO-FUSION

SMARTFLEX installation technology is based on “electro-fusion”, one of the most utilised connection methods in the installation of polyethylene pipes. Electro-fusion 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 electro-fusion 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.

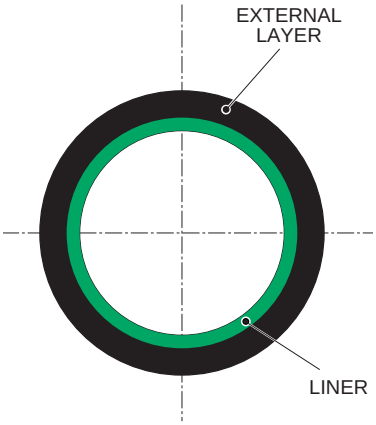
1.4 SINGLE WALL PIPES

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

A primary pipe is the pipe that carries fuel.

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 guarantees the following:

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

PIPES EN, IP & KIWA LISTED	OUTSIDE DIAMETER OD (mm)	OUTSIDE DIAMETER OD (in)	INTERNAL DIAMETER ID (mm)	INTERNAL DIAMETER ID (in)	NOMINAL PE THICKNESS (mm)	NOMINAL PE THICKNESS (in)
TSMA/TSMAU/TSMAH	32	1”	25.2	0.99”	3.4	0.13”
	50	1” ½	40.6	1.60”	4.7	0.18”
	63	2”	51.6	2.03”	5.7	0.22”
	90	3”	74.6	2.94”	7.7	0.30”
	110	4”	91.8	3.61”	9.1	0.36”
TSMA/TSMAH	160	6”	134.4	5.29”	12.8	0.50”
TSMAS/TSMAHS	63	2”	58.0	2.28”	2.5	0.10”
	75	2” ½	69.2	2.72”	2.9	0.11”
	125	5”	115.4	4.54”	4.8	0.19”
	225	9”	207.8	8.18”	8.6	0.34”

PIPES UL LISTED	OUTSIDE DIAMETER OD (mm)	INTERNAL DIAMETER ID (mm)	TOTAL NOMINAL THICKNESS (mm)
TSMAXP	50	41.6	4.7
	63	52.6	5.7
	90	75.6	7.7
	110	92.8	9.1
TSMAXS	63	57.0	3.0
	75	68.2	3.4
	125	114.4	5.3

1.5 DOUBLE WALL PIPES

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

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

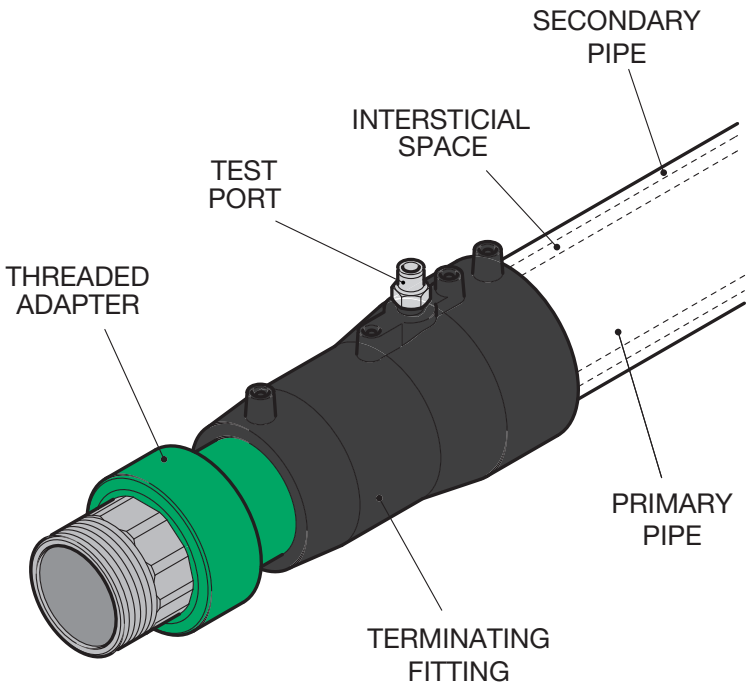
In SMARTFLEX double wall pipes, the secondary pipe is not just a containment barrier but it is a real high-density polyethylene pipe capable of sustaining the pressure or pressure drop of an automated monitoring system. This external pipe is also available with an inner barrier layer as requested by 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

ATTENTION:

See SMARTFLEX Product Catalogue for more details about the different types of pipes.



SINGLE WALL SYSTEM	AVAILABLE NDs (mm)	AVAILABLE NDs (in)
TSMA	32 - 40 - 50 - 63 90 - 110 - 160	1" - 1" ¼ - 1" ½ 2" - 3" - 4" - 6"
TSMAH	50 - 63 - 90 - 110 - 160	1" ½ - 2" - 3" - 4" - 6"
TSMAXP	50-63-90-110	1" ½ - 2" - 3" - 4"
TSMAU	32 - 40 - 50 63 - 90 - 110	1" - 1" ¼ - 1" ½ 2" - 3" - 4"
DOUBLE WALL SYSTEM	AVAILABLE NDs (mm)	AVAILABLE NDs (in)
TSMAD	50 - 63 - 90 - 110 - 160	1" ½ - 2" - 3" - 4" - 6"
TSMAHD	50 - 63 - 90 - 110 - 160	1" ½ - 2" - 3" - 4" - 6"
TSMAXPD	50 - 63 - 90	1" ½ - 2" - 3"
AdBlue/DEF/Urea SYSTEM	AVAILABLE NDs (mm)	AVAILABLE NDs (in)
TSMAUREA	50 - 63 - 90	1" ½ - 2" - 3"
TSMADUREA	50 - 63 - 90	1" ½ - 2" - 3"
SECONDARY SYSTEM	AVAILABLE NDs (mm)	AVAILABLE NDs (in)
TSMAS	63 - 75 - 125 - 225	2" - 2" ½ - 5" - 9"
TSMAXS	63 - 75 - 125 - 225	2" - 2" ½ - 5" - 9"

1.6 FITTINGS

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

- Single wall electro-fusion fittings
- Transition fittings
- Double wall coaxial electro-fusion fittings
- Termination electro-fusion fittings
- Electro-fusion and mechanical penetration fittings
- Mechanical fittings

1.6.1 SINGLE WALL ELECTRO-FUSION FITTINGS

The single wall electro-fusion fitting range includes:

- Couplings (model SME)
- 90° elbows (model SGE)
- 45° elbows (model SCE)
- Tees (model STE)

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

1.6.2 SINGLE WALL FITTINGS

The single wall fitting range includes the following:

- Threaded adapters (model SAM/SAF) with brass, nickel plated or AISI 316 stainless steel parts for special applications (e.g. AdBlue/DEF/Urea)
- Long risers (model SALM)
- Swivel adapters (model SAFSW) with gasket resistant to fuels
- Loose flanges (model SFLAK) suitable for flanged connections. This model is available also with Viton gaskets and AISI 316 stainless steel flanges for special applications (e.g. AdBlue/DEF/Urea).
- Square flange kits (model SAFFQ) for compact connections
- Reducers
- End caps

1.6.3 DOUBLE WALL COAXIAL ELECTRO-FUSION FITTINGS

Double wall electro-fusion fittings are manufactured using NUPIGECO proprietary procedures and technologies and are the most innovative products of their kind available on the market. SMARTFLEX double wall electro-fusion 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) 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 SGEDWTP, SMEDWTP and STEDWTP).

ATTENTION:

Vacuum, pressure, liquid or gas Leak Monitoring Systems can be used with the SMARTFLEX double wall system.

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

- Straight connectors (model SMEDW)
- Tees (model STEDW)
- Elbows and bends (model SGEDW and SCEDW)
- Termination fittings (model SETFV)

1.6.4 DOUBLE WALL SPIGOT FITTINGS

The long spigot double wall adapter (model SAWFD) enables a more compact transition and can be used with flex connectors. It is also available with a stainless steel (AISI 316) threaded insert for special applications (e.g. AdBlue/DEF/Urea).

1.7 ENTRY BOOTS (PENETRATION FITTINGS)

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

The range includes:

- Electro-fusion entry boots (model SEBE) provide a reliable and fast connection typical of the electro-fusion welding process. They can also be installed on the outside of the sump allowing better use of internal space. The available sizes are from 1" (32mm) to 5" (125mm).
- Metal/rubber composite entry boots for piping (model SEB). They also provide a reliable entry into the sumps preventing any metal component being exposed to the external environment. The available sizes are from 3/4" (25mm) to 5" (125mm).
- Termination fittings (model SEBTF or SEBTFV) for 3" (90mm) double wall systems.
- Entry boots for fibreglass SW (model SEBEFM) and DW (model SEBEF) sumps. Model SEBEF 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.

1.8 MECHANICAL FITTINGS

A full range of mechanical fittings (model SBF, SBGF or SBTEF) completes the SMARTFLEX system. Initially designed as connections to pumps and dispensers, they include two fuel resistant joints that fit the pipe wall (internally and externally) whilst ensuring maximum joint integrity. They often represent an alternative solution for temporary installations or whenever the presence of explosive vapours does not allow electro-fusion operations or in case of repair.

WARNING:

Mechanical fittings are not certified according to current standards.

1.9 SUMPS AND ACCESSORIES

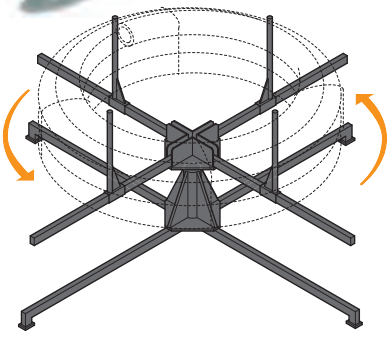
Electro-fusion HDPE dispenser sumps (model S21DS) and tank sumps (model S22TS) are designed to:

- Ease and accelerate the installation process. They comprise two separate HDPE parts that are joined by electro-fusion.
- Obtain a perfectly sealed installation thanks to the electro-fusion 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.

The tightness of both tank and dispenser sumps can be tested on site during every installation step by carrying out a vacuum test. Test kits for dispenser sumps (model SDSVTL), quick connection valves (model SVT), ejector pumps (model SVE) vacuum test units (model SVTU) are available for this type of test.

One-piece versions of the tank and dispenser sumps are also available as well as tank sumps with increased wall thickness for specific installations (high groundwater, alluvial soil, low quality backfill material, etc.).

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 MULTI-FUNCTION WELDING UNIT

The SMARTFLEX multi-function welding unit (model SSEL8404) 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 multi-function welding unit can be used to weld SMARTFLEX pipes and fittings by electro-fusion 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. Welding and testing data are stored in the internal memory of the multi-function welding unit and can be downloaded to a computer by means of a Bluetooth connection. Data can be downloaded via the new download unit (model DLU) avoiding the use of a computer on site. Data can also be printed on site using a Bluetooth printer (model BTPRINT) available upon request.

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

- SCUT – Pipe cutter
- RAT0, RAT1A, RATUL – Universal scraper
- RAM1, RAM2 - Manual scraper
- SCUTDW – Double wall pipe cutter
- STP – Metal protection templates
- ALL225/4 – Pipe aligner
- MARK – White marker
- RAT0SB, SLRCUT, SLRDW, RATKITRIC – Spare blades
- SPLIDW – Double wall pliers
- BCSCAN, BCSCAN8403 – Barcode scanner
- GPS – GPS device
- DLU – Download unit
- BTPRINT – Bluetooth printer

The welding unit model SSEL8404 operates in the following languages: English, Italian, Spanish, French, German, Portuguese, Dutch. There is also a special version for the Russian language.

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 20°C	Maximum operating pressure of secondary pipe at 20°C	Minimum bending radius
1” (32mm)	116 (psi) 8 (bar)	58 (psi) 4 (bar)	23” (580mm)
1 1/2” (50mm)	116 (psi) 8 (bar)	58 (psi) 4 (bar)	35” (900mm)
2” (63mm)	116 (psi) 8 (bar)	58 (psi) 4 (bar)	45” (1100mm)

The pressures indicated in the following table have been calculated based upon laboratory regression curves using hydrocarbons as a testing fluid. Pipes have a nominal pressure (PN) of 12.5 bars (primary pipe) and 6.3 bars (secondary pipe) when tested with water or air considering only their HDPE thickness.

ATTENTION:

For fuels and/or operating conditions other than those listed above, please contact NUPIGECO Customer Service.

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 warranty is valid only if NUPIGECO 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:
infoid@nupigeco.com

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

1 • PRODUCT DESCRIPTION

SMARTFLEX™

ITS is an Internet based Interactive Tracking System provided by NUPIGECO. 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.).

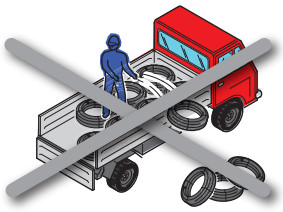
The aim of this technical manual is to provide specific instructions aimed at completing reliable installations using the SMARTFLEX system.

The SMARTFLEX system shall be installed by qualified installers only. Installers shall follow the manufacturer's installation and assembly instructions and all the regulations and local laws in force.

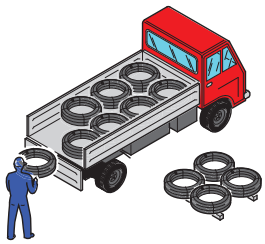
2 • TRANSPORT AND INSTALLATION OF SMARTFLEX PIPES AND FITTINGS

2.1 PIPE LOADING AND UNLOADING

Loading, transport, unloading, stacking, storing and any other manoeuvre 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.

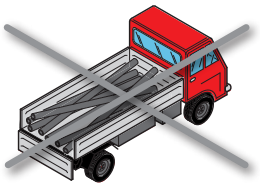


If transport vehicles are used for loading and/or unloading operations and/or these operations are carried out using a crane or similar machine, pipes must always be lifted at their centre point using a lifting beam with adequate width.

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

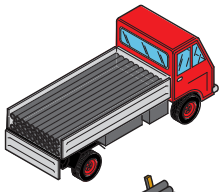
If loading or unloading operations are performed manually, avoid grazing the pipes along any edge, on the platform of the transport vehicle, or on any sharp objects.

2.2 PIPE STACKING



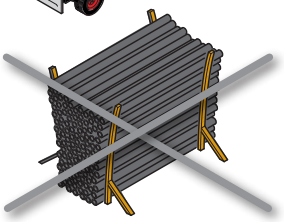
On site a clean dry area protected from weather conditions shall be provided to stack pipes and store fittings and other accessories.

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



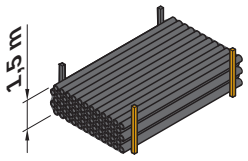
The stacking height for pipes in straight lengths must not exceed 5 ft. (1.5 m) whatever their diameter or in accordance with local regulations.

The stacking height for coiled pipes in coils stacked on a flat surface must not exceed 7 ft. (2 m) or in accordance with local regulations.



If it was necessary to build side supports or frames to hold the pipes, they should be installed with a maximum distance of 5 ft (1.5 m) 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.

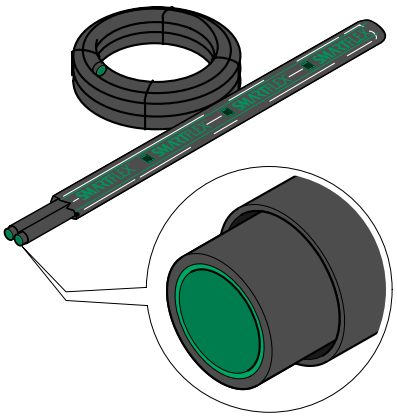


It is not recommended to install pipes that have been stored in yards with no protection for over two years.

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

2.3 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 (mm)	Quantity
50	5
63	4
75	3
90	2
110	2
125	1
160	1

Plastic bag made of black polyethylene

Product	Model	Color Code	Application
SUPERSMARTFLEX	TSMAXP,TSMAXS, TSMAXPD	Green	NV, VR, FL, PC, PS
SMARTFLEX H	TSMAH,TSMAHD, TSMAHS	Red	NV, VR, FL, PC, PS
SMARTFLEX	TSMA,TSMAD, TSMAS	Green	NV, VR, FL, PC, PS, SC
SMARTFLEX	TSMAU	Yellow	NV, VR, FL
SMARTFLEX	TSMAUREA	Silver	NV, VR, FL, PC, PS

PS → Double Wall Pipe
PC → Primary Pipe
SC → Secondary Pipe
NV → Balancing/Vent Pipe
VR → Vapour Recovery Pipe
FL → Load Pipe

2.4 LAYOUT AND INSTALLATION

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

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.

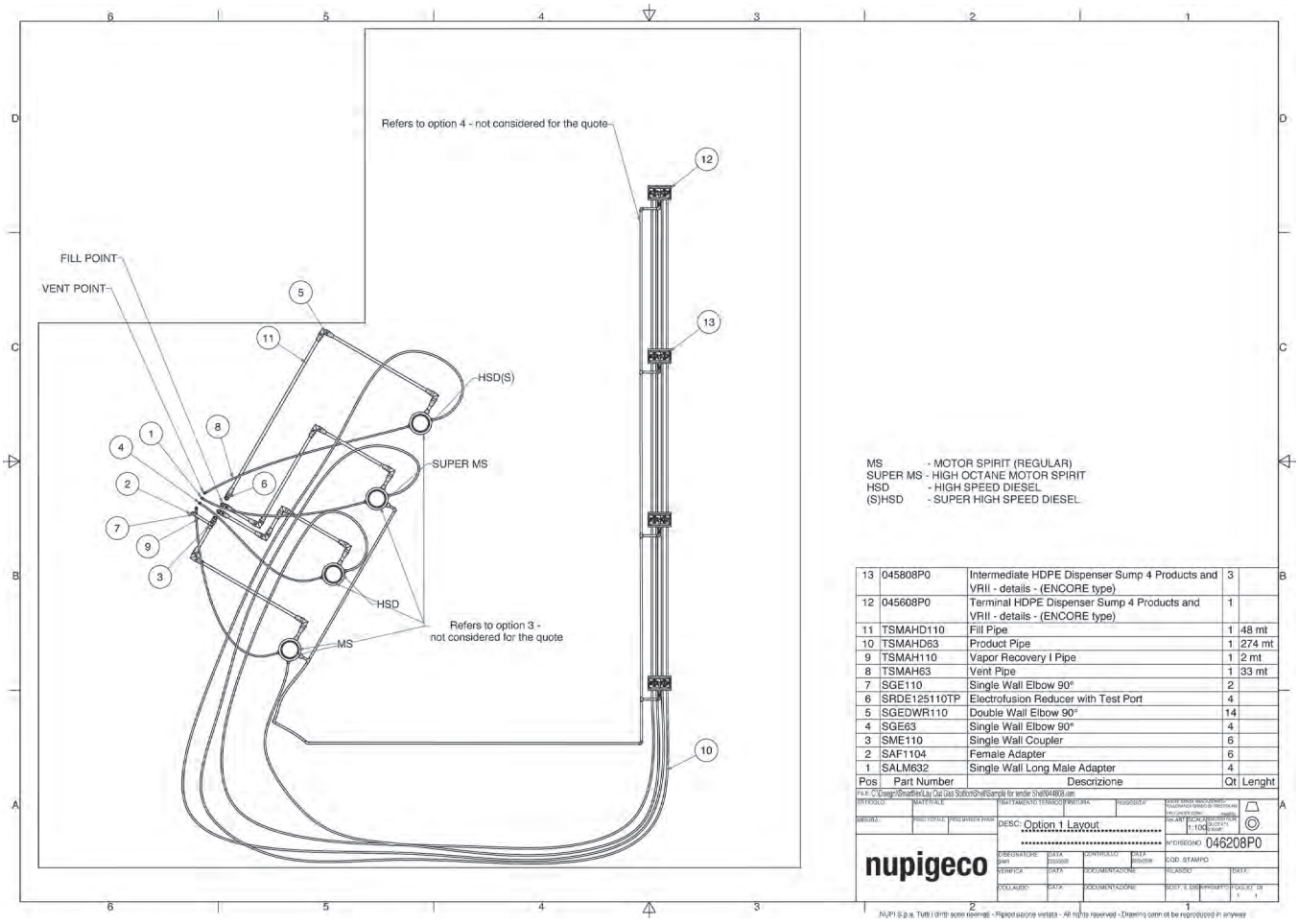
2.5 INSTALLATION LAYOUT

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 vapour recovery and vent.

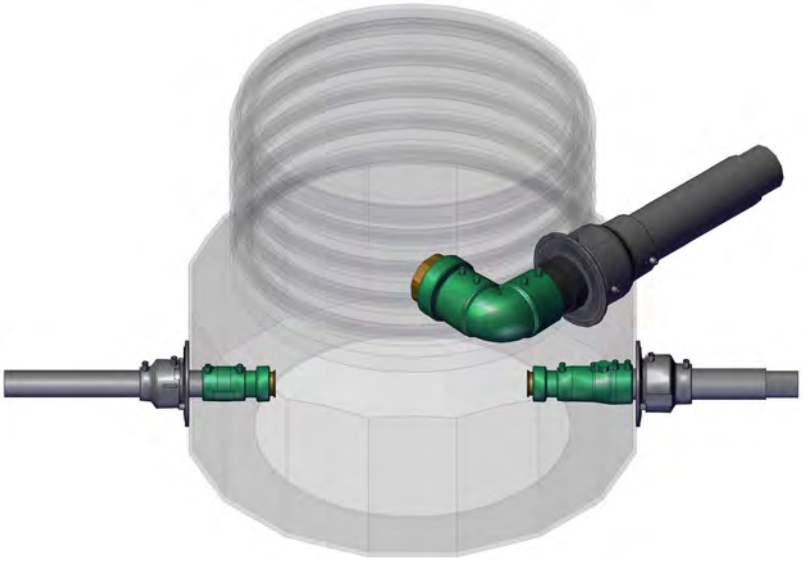
All piping shall slope by at least 1:100 (1/8” per foot or 1cm per meter) towards the tank. It is necessary to take precautions to prevent the formation of siphon traps or wells.

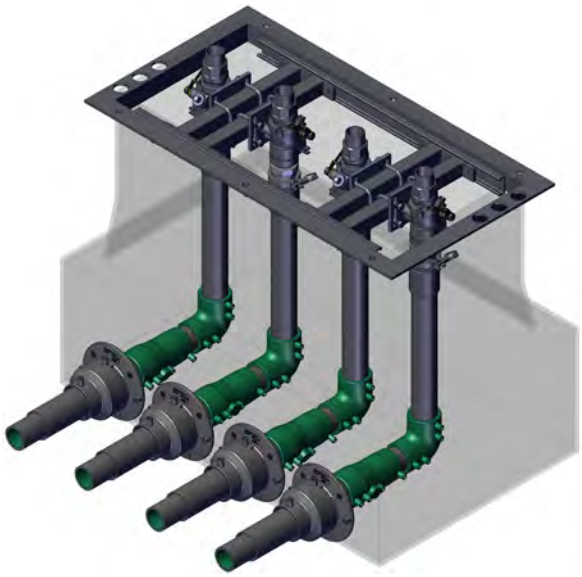


MS - MOTOR SPIRIT (REGULAR)
SUPER MS - HIGH OCTANE MOTOR SPIRIT
HSD - HIGH SPEED DIESEL
(S)HSD - SUPER HIGH SPEED DIESEL

Pos	Part Number	Descrizione	Qt	Lenght
13	045808P0	Intermediate HDPE Dispenser Sump 4 Products and VRII - details - (ENCORE type)	3	
12	045608P0	Terminal HDPE Dispenser Sump 4 Products and VRII - details - (ENCORE type)	1	
11	TSMAHD110	Fill Pipe	1	48 mt
10	TSMAHD63	Product Pipe	1	274 mt
9	TSMAH110	Vapor Recovery I Pipe	1	2 mt
8	TSMAH63	Vent Pipe	1	33 mt
7	SGE110	Single Wall Elbow 90°	2	
6	SRDE125110TP	Electrofusion Reducer with Test Port	4	
5	SGEDWR110	Double Wall Elbow 90°	14	
4	SGE63	Single Wall Elbow 90°	4	
3	SME110	Single Wall Coupler	6	
2	SAF1104	Female Adapter	6	
1	SALM632	Single Wall Long Male Adapter	4	

DESC: Option 1 Layout
N°DISEGNO 046208P0
nupigeco





3 • UNDERGROUND INSTALLATIONS

3.1 TRENCHING AND BACKFILLING

Proper construction of tren ches 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" (5 cm) of compacted backfill material to prevent point loading conditions or 1" (2.5 cm) of protective Styrofoam.

What is generally considered 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.

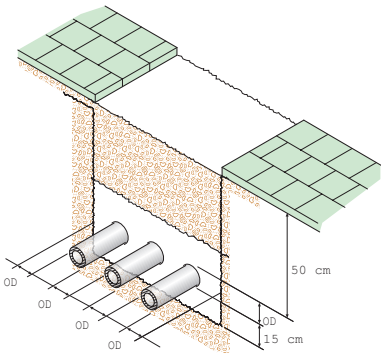
The level of interaction between the pipe and the backfill material soil surrounding it essentially depends on: burial depth, soil characteristics and backfill material, superficial loads and pipe resistance to deflection.

Generally, pipes and fittings should be installed at a minimum depth of 20" (50 cm). 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:

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 (as outlined in chapter 3.2). The trench must be properly filled and compacted.

Surface type	Minimum burial depth
Unpaved	20" (50cm)
4" (10cm) asphalt	12" (30cm)
4" (10cm) concrete	10" (25cm)



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.

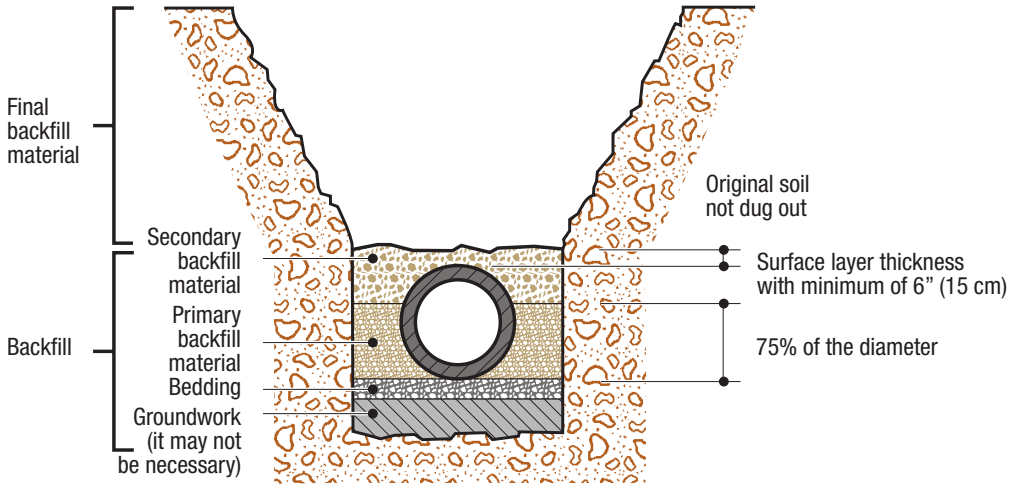
Flexible piping can be installed in similar circumstances without particular deformations if these conditions are respected. The main goal for installations with flexible piping is to avoid them being deflected. Pipe deflection can occur due to two principal reasons: the first is installation (that reflects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

3.2 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 minimize 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 favoured 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.

3.3 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 (7 MPa) 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 and CEN/TR 1295-3 for further details.

Recommended types of backfill material are:
- Clean washed rough sand
- Pea gravel, 1/8” to 3/4” (3mm to 19mm)

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) according to the classification as per European standard CEN/TR 1295-3 or equivalent.

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

Class 1 and 2 soils (GS1 and GS2 according to the European standard CEN/TR 1295-3) are granular and provide maximum support as shown by the high elasticity coefficient of the soil (E). The high permeability of materials belonging to class I and II eases trench drainage while making this material 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
Low (N)	100	90	87	84
Moderate (M)	100	93	90	87
Good (W)	100	97	95	92

3.4 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.

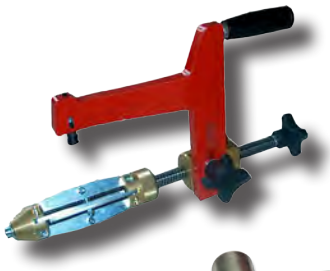
We suggest to embed the whole piping section into concrete including fittings and to constrain the piping every 5 metres by means of well fastened metal pipe clamps that will function as fixed points. In case of double wall piping the pipe clamps shall be oval shaped in order to lock the primary pipe on the secondary pipe.

4 • ELECTRO-FUSION WELDING PROCESS

4.1 ELECTRO-FUSION TOOLS

Appropriate tools are essential to ensure that the electro-fusion welding process is carried out correctly. The tools required are:

- Pipe cutter (model **SCUT**) – It cuts pipes cleanly at 90° to the pipe axis without leaving any burrs.
- Double wall pipe cutter (model **SCUTDW**) and protection metallic sleeves (model **STP**) – They must be used to cut double wall pipe to the correct insertion lengths.
- Universal scraper (model **RAT0**) or revolving scrapers (model **RAT1A** and **RATUL**) – Used to remove the oxidized surface layer of the pipe from the welding zone.
- Manual scraper (model **RAM1** and **RAM2**) - Used to remove the oxidized surface layer of the pipe from the welding zone.
- Aligner (model **ALL225/4**) – Used to position and lock the parts to be welded to eliminate stress and/or tension from the welded connection during the welding and cooling process.
- Double wall pliers (model **SPLIDW**) – Used when installing double wall pipe and fittings to prevent the primary pipe from sliding in the secondary during insertion of pipes into double wall coaxial fittings.
- Primer (model **LID1**) – Used to cleanse the pipe from any trace of grease.



4.2 MULTI-FUNCTION WELDING UNIT

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

- The multi-function welding unit can be used only for electro-fusion welding of NUPIGECO SMARTFLEX pipes and fittings. It is not intended for use with any other electro-fusion piping system.
- The unit can perform testing functions when used with the SMART-FLEX Pressure Test Unit (model SENS010) or the Vacuum Test Unit (model SVTU).
- Certified installer(s)/operators are responsible for assurance of rec-ommended energy/power sources. Power sources should be checked (confirmed) for compliance to the following specifications: -110 VAC, 50 Hz (min.) with a 10% tolerance -220 VAC and 50 Hz (min.) with a 10% tolerance.
- Inspect the multi-function 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 multi-function 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 electro-fusion
- 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 NUPIGECO 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

DLU

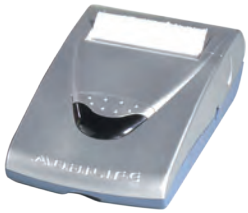
The SMARTFLEX Download Unit (DLU) provides a download capability of up to 300 welding data records and up to 8 different pressure test reports. The DLU exchanges data with the multi-function welding unit via Bluetooth connection. The downloaded data can then be transmitted to a PC by means of the cable and software included.

GPS

The SMARTFLEX GPS device allows you to log the coordinates of the fitting to be welded (altitude, latitude, longitude) by positioning it over the fitting. It is very useful as it allows you to plot fitting positions on as built drawings. It is good practice to assign a number to every fitting so you can locate at a later time if excavation is necessary.

BTPRINT

The BTPRINT is a portable Bluetooth printer that allows you to obtain a printout of all welds. The printed record produced provides all the data in reference to the weld performed, including multi-function welding units serial no., fitting details and welding parameters. If used in conjunction with the GPS device its data will also be included.



ITS

ITS is an Internet based Interactive Tracking System provided by NUPIGECO. 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 DOWNLOAD section of NUPIGECO website www.nupigeco.com

4.3 CHECKS PRIOR TO ELECTRO-FUSION WELDING

Before commencing the electro-fusion welding process, check that the site generator, if required, is working correctly and efficiently. Check the condition of the extension leads and fuel supply (to provide the necessary electrical power for the duration of the entire welding process). Finally, check the multi-function 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 multi-function welding unit ensure that it is of the asynchronous type. Correct welding requires careful use of the extension leads. The lead cross-section/length ratio is of vital importance. NUPIGECO recommends the following lengths and sizes:

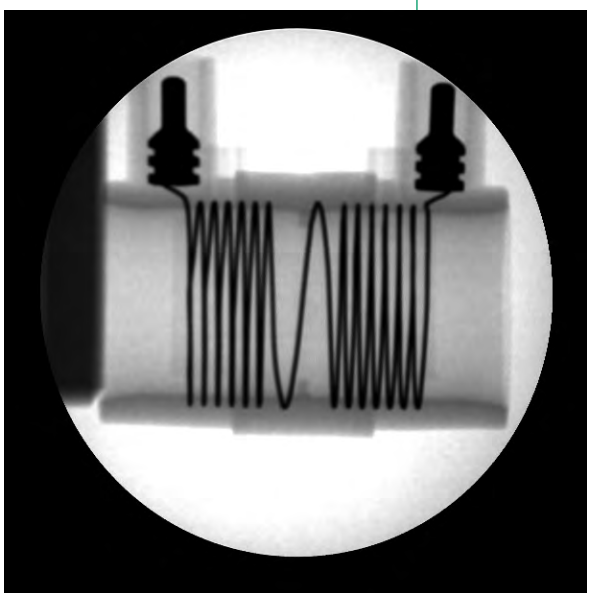
WARNING:

The misuse of the multi-function 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.

Wire size	Recommended cable length
0.10 (in^2) 2.5 (mm^2)	19-22 (ft) 6-7 (m)
0.16 (in^2) 4.0 (mm^2)	30-36 (ft) 9-11 (m)
0.24 (in^2) 6.0 (mm^2)	49-55 (ft) 15-17 (m)

4.4 ELECTRO-FUSION WELDING

Single and double wall coaxial fittings contain resistors that provide the required heat for welding the pipe and fittings together (X-ray of a sleeve shown as example) when connected to the multi-function 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.



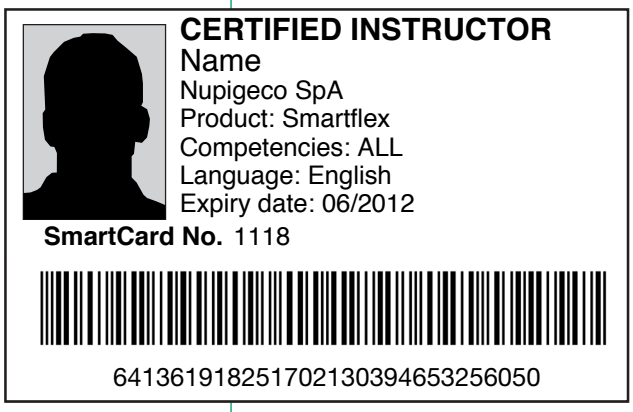
Only SMARTFLEX Certified Installers can access the welding unit using their specific SMART-CARD that contains an identifiable barcode and the following information:

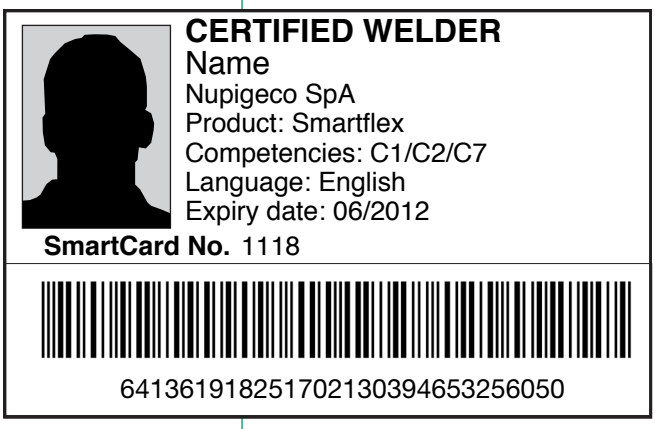
- Classification of the SMARTFLEX Certified Holder
- Operator's name, photograph and number
- Company name and location (city, state/province and country)
- Training level indicated by the codes listed in the table below
- Language
- Expiration date
- Contact information

NUPIGECO regularly trains and reviews certified installers worldwide.

Table: Training levels

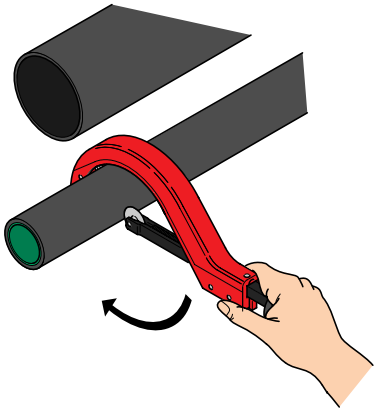
C1	Single wall pipe
C2	Double wall pipe
C3	Double wall fill pipe
C4	UL listed pipe
C5	Containment sumps
C6	SMARTCONDUIT
C7	Installation equipment
C8	Electro-fusion entry boots
C9	Entry boots for fibreglass
C10	Leak monitoring
C11	Pressure testing





4.5 GUIDELINES FOR PERFORMING ELECTRO-FUSION WELDING

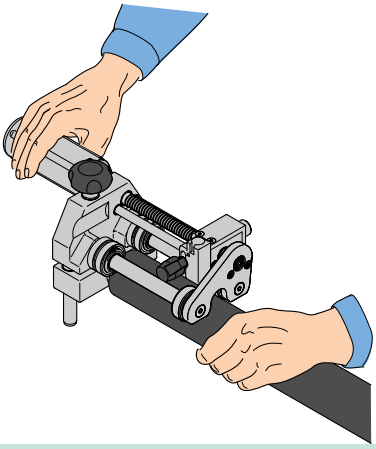
For detailed welding procedures for any SMARTFLEX component, please refer to the individual installation instructions that can be downloaded from the DOWNLOAD section of NUPIGECO website www.nupigeco.com.



Cutting
Cut the pipes at a 90° angle with the specific pipe cutter (model SCUT or SCUTDW).

WARNING:

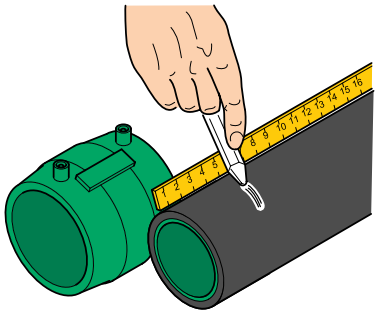
A non-perpendicular cut can prevent complete insertion. Consequently, molten material may enter the pipe interior during welding or two resistor coils may touch each other creating a short circuit.



Scraping
Scrape the outer surface of the pipes to be welded with the specific scrapers (model RATO, RAT1A and RATUL) to completely remove the superficial oxidized layer.

CAUTION:

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



Indication of insertion length
Use the SMARTFLEX marker (model MARK) to clearly indicate the insertion length on the pipe.

Cleaning
Clean the pipe and fitting ends with the recommended SMARTFLEX solvent (model LID1) a special liquid detergent and clean cloth. Also avoid contact with the parts that have just been cleaned.

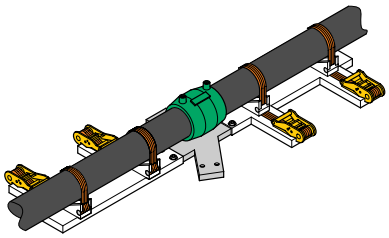
The following solvents may be used to clean the pipes:
- Acetone
- Isopropyl alcohol
- Trichlorethane

CAUTION:

Do not use gasoline, denatured alcohol (methylated spirits) or tricloroethylene.

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

Always use the aligner (model ALL250/4) whenever possible to support the pipes and keep them in line during welding and cooling process.

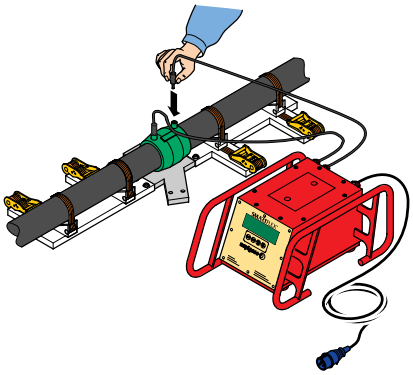


Electro-fusion welding
Connect the two welding lead connectors to the fitting, turn on the machine and follow the instructions shown on the display.

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

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.

N.B.: 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.



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.

The following basic recommendations apply:

- electro-fusion welding shall be carried out in dry areas. In the event of rain, fog or excessive exposure to the sun's rays, work should be carried out under appropriate cover;
- it is recommended that electro-fusion welding is carried out within the ambient temperature range from +14°F to +113°F (from -10°C to +45°C);
- scrape the entire area of the pipe involved in the welding process. The external oxidized layer must be removed in a uniform manner from the entire circumference and for a depth of:
  - 0.004" (0.10mm) for outside diameters up to 2" (63mm)
  - 0.006" (0.15mm) for outside diameters up to 4" (110mm) 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 ALL250/4) 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 electro-fusion 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.

N. B. For detailed welding procedures for any SMARTFLEX component, please refer to the individual installation instructions that can be downloaded from the DOWNLOAD section of NUPIGECO website www.nupigeco.com. You can also request them to our Technical Department at infoid@nupigeco.com.

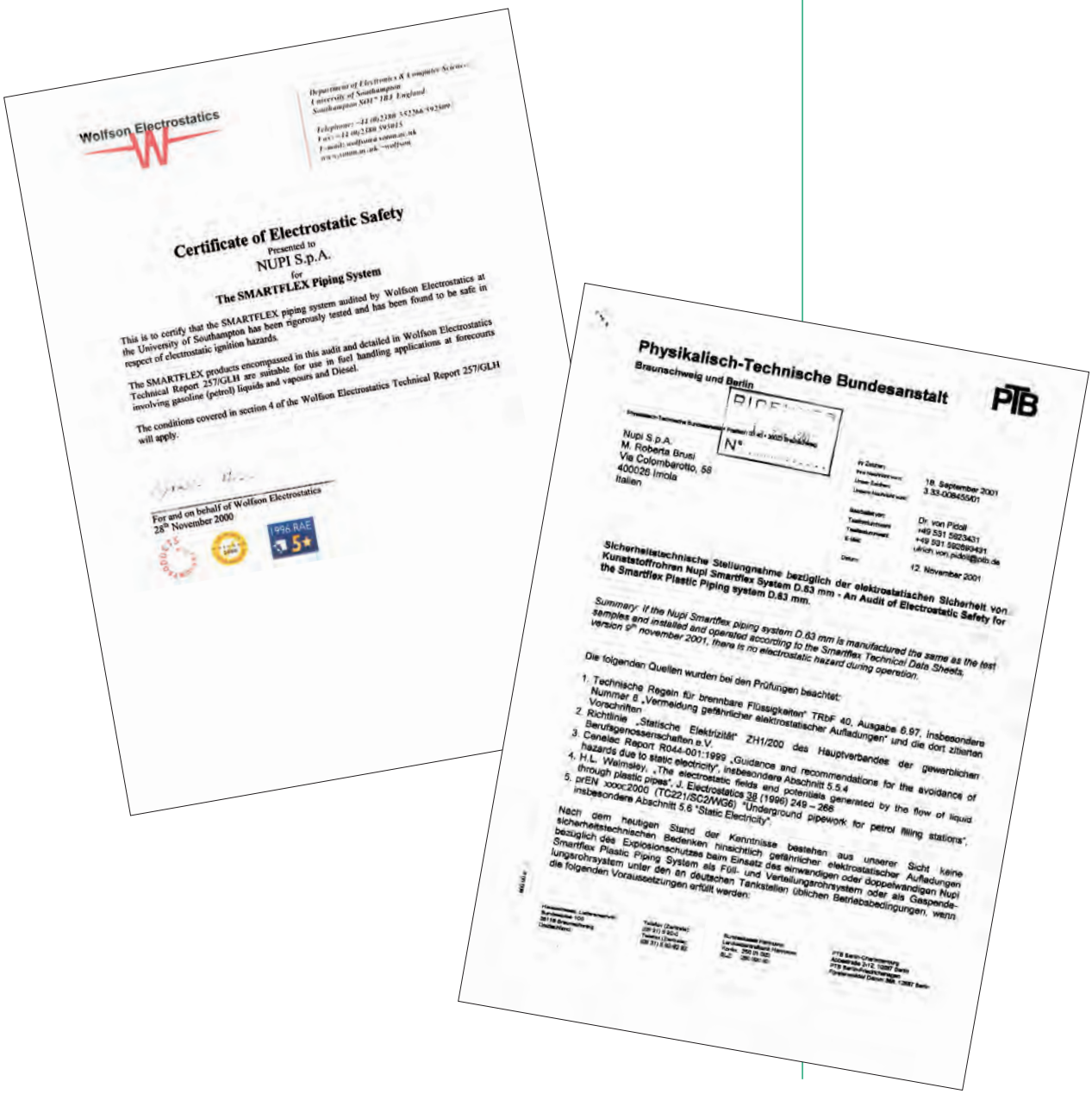
4.6 CHECKS AFTER ELECTRO-FUSION WELDING

Non-destructive checks on electro-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") (10mm)];
- that no parts of the wire of the inserted fitting will protrude.

5 • 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 257/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 257/GLH will apply.

For and on behalf of Wolfson Electrostatics
28th November 2000

Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

PTB

Nupi S.p.A.
M. Roberta Bruni
Via Colombarottio, 58
40026 Imola
Italien

18. September 2001
3.33-00845/01

Dr. von Pidoll
+49 531 5923431
+49 531 5923893431

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 8.97, 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. Canelas 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 Explosionsschutzes 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.

5.1 TESTS

In order to investigate electrostatic potential developed on the various elements 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" (63mm) diameter pipe and a 3" (90mm) 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 (600 litres) of refined iso-octane and toluene (50:50 mixture) were used. A pump able to deliver over 50 US Gallons (200 litres) 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) (40 litres per minute).

The maximum allowed flow is equal to 75 US Gallons (250 litres) 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 electro-fusion couplings.

5.2 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 electro-fusion 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 bio fuels 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.

6 • ABOVE GROUND INSTALLATIONS

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.

6.1 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 support dimensions.
- Protect the system against abrasion.
- Support auxiliary 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 gouged in excess of 10% of the minimum wall thickness, the gouged 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. Any such regions shall be removed and replaced with new pipe.

6.2 INSTALLATIONS WHERE THERMAL EXPANSION IS ALLOWED

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

(Eqn. 6.2.1) $$\Delta L = \alpha \cdot L \cdot \Delta T$$

Where:

ΔL	length variation
L	original length
ΔT	temperature change [1]
α	linear thermal expansion coefficient

Equation (6.2.1) 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 of the operating pipe and the temperature used for bedding.

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}]	α [°C^{-1}]	E [psi]	E [MPa]
SMARTFLEX	7.2 x 10^{-5}	13 x 10^{-5}	145,000	1,000
Carbon steel	0.7 x 10^{-5}	1.2 x 10^{-5}	29.0 x 10^{6}	200,000
Stainless steel	0.9 x 10^{-5}	1.6 x 10^{-5}	29.0 x 10^{6}	200,000
Fibreglass	0.9 x 10^{-5}	1.6 x 10^{-5}	1.26 x 10^{6}	8,700

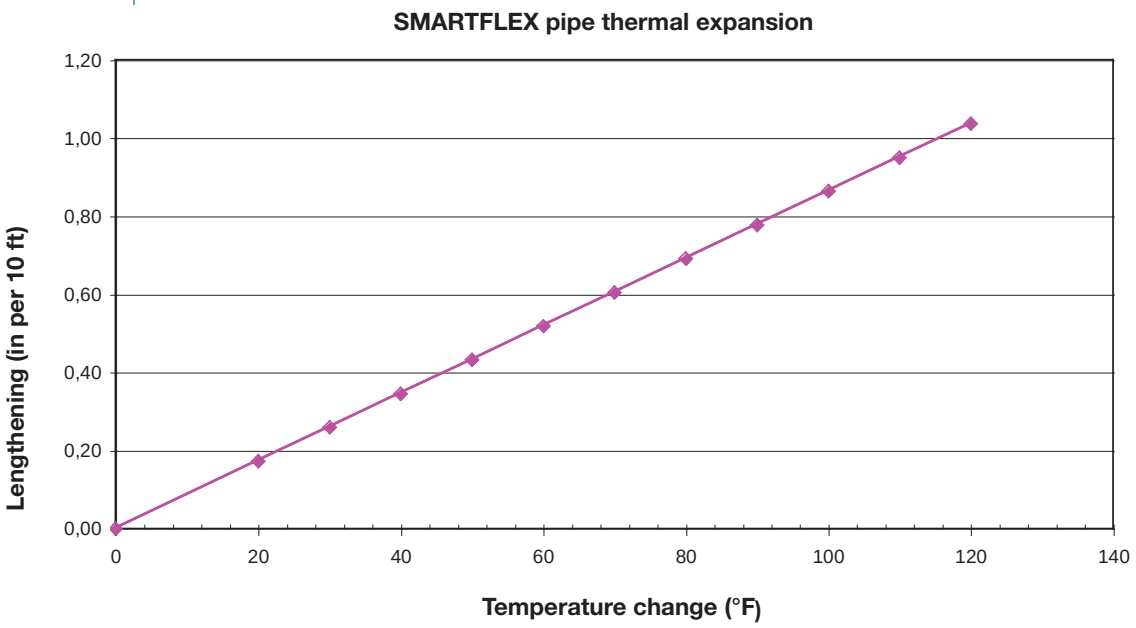
As can be seen, the coefficient α for plastics assumes a value 5 to 15 times greater than that of the most commonly used metallic materials. On the other hand, the elasticity modulus assumes values 100 to 200 times smaller (i.e. plastics show greater elasticity).

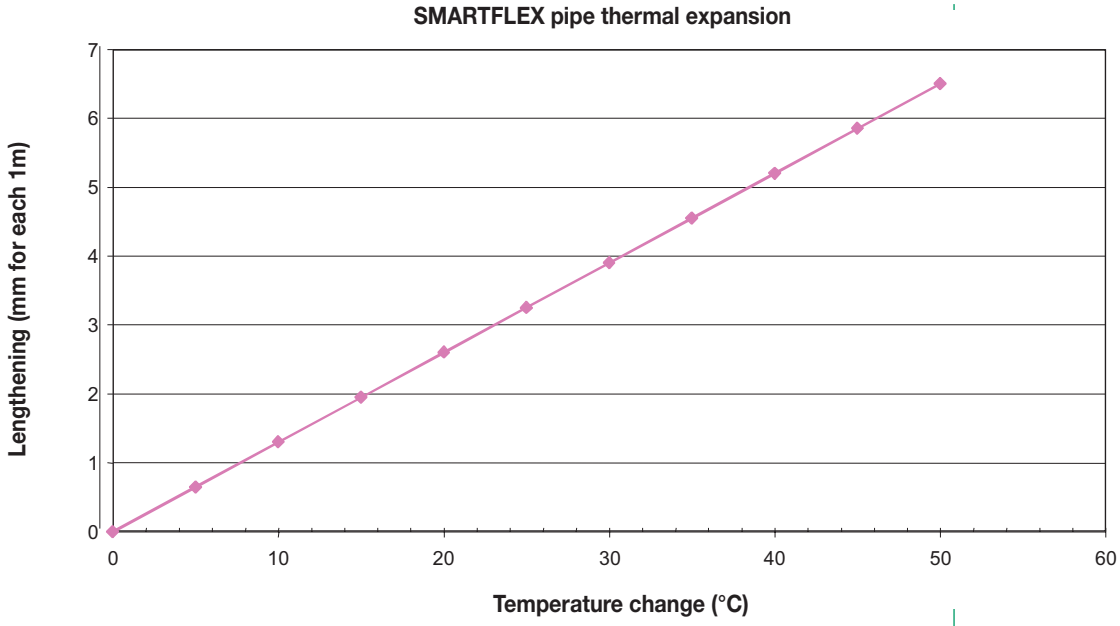
The following table shows the length and temperature changes for single wall pipes.

Table: length (mm per 1m and in per 10ft) and temperature (°C and °F) changes for single wall pipes.

Temperature Change (°C)	Temperature Change (°F)	Length Variation (mm per 1m)	Length Variation (in per 10ft)
30	70	3.9	0.60
40	80	5.2	0.69
50	100	6.5	0.86

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





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

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

Where:

L	is the starting length
A_1 and A_2	are the primary and secondary sizes respectively
T_1 and T_2	are the working temperatures of the primary and the secondary installation respectively
T_0	is the temperature during bedding
α	is the linear thermal expansion coefficient
E	is the elasticity modulus

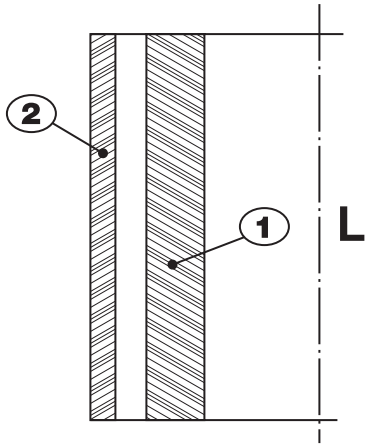
The results from the balance and congruence equations, as well as for the mechanical behaviour analogy for the two parallel springs, are:

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

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

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

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



1: Primary pipe
2: Secondary pipe

As an example, the following tables shows the thermal analysis of a TSMAD50, presuming that the installation temperature is fixed at 68°F (20°C), that the temperature of the primary pipe conveying relatively cold fluid is at 50°F (10°C) and that the temperature of the secondary pipe is variable (e.g. it could be exposed to sunlight) in case of L=1 m.

Temperature change (T1-T2) °F

	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

Temperature change (T1-T2) °C

	Temperature change (T1-T2) °C			
	20	**30**	**40**	**50**
Ftot (kg)	-7.5	11.0	29.5	48.0
F1 (kg)	70.6	115.1	159.6	204.2
F2 (kg)	-78.1	-104.2	-130.2	-156.2
ΔL1=ΔL2 (mm)	-0.16	0.23	0.61	0.99
σ1 (Mpa)	-1.46	-2.37	-3.29	-4.21
σ2 (Mpa)	-1.14	1.53	1.91	2.29

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 allow the compensation of thermal expansion:

- Changes in direction/offsets and
- 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. 6.2.2)
$$\ell = \sqrt{\frac{3 \cdot \alpha \cdot \Delta T \cdot L \cdot \frac{OD}{0.01}}{2}} \cong 12 \cdot \sqrt{OD \cdot \Delta L}$$

Where:

L	length of the pipe run
ΔL	dimensional variation
ΔT	temperature change
α	linear thermal expansion coefficient
OD	pipe outside diameter

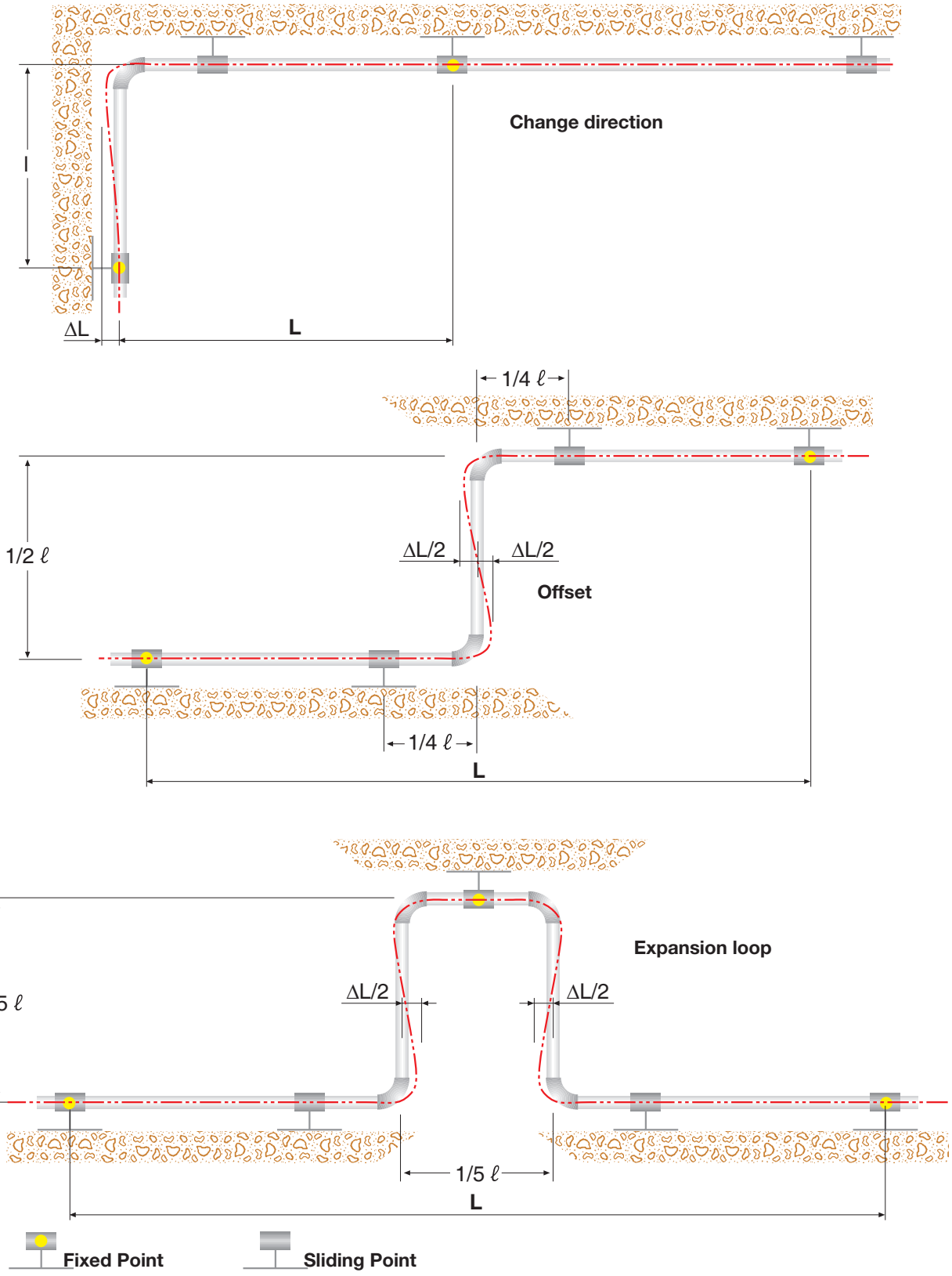
The following table shows the minimum length of the expansion loop according to the outside pipe diameter for various temperature changes. For temperatures other than those indicated, the linear interpolation will approximate the length of the loop within 5%.

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

Temperature Change	Length of pipe run (L)	OD							
		1”	1 1/4”	1 1/2”	2”	2 1/2”	3	4”	6”
ΔT = 50 °F		Minimum loop length [in.] (ℓ)							
	30 ft	17	19	22	24	27	29	32	39
	150 ft	39	43	49	55	60	65	72	87
	300 ft	55	61	69	77	84	92	102	123
ΔT = 70 °F		Minimum loop length [in.] (ℓ)							
	30 ft	21	23	26	29	32	35	38	46
	150 ft	46	51	58	65	70	77	85	103
	300 ft	65	73	81	91	100	109	121	146
ΔT = 90 °F		Minimum loop length [in.] (ℓ)							
	30 ft	23	26	29	33	36	39	43	52
	150 ft	52	58	65	73	80	88	97	117
	300 ft	74	83	92	104	113	124	137	165

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

Temperature Change	Length of pipe run (L)	OD							
		32	40	50	63	75	90	110	160
ΔT = 30 °C		Minimum loop length [cm] (ℓ)							
	10 m	48	54	60	67	73	80	89	107
	50 m	107	120	134	151	164	180	199	240
	100 m	152	170	190	213	232	255	281	339
ΔT = 40 °C		Minimum loop length [cm] (ℓ)							
	10 m	55	62	69	78	85	93	103	124
	50 m	124	139	155	174	190	208	230	277
	100 m	175	196	219	246	268	294	325	392
ΔT = 50 °C		Minimum loop length [cm] (ℓ)							
	10 m	62	69	77	87	95	104	115	139
	50 m	139	155	173	194	212	232	257	310
	100 m	196	219	245	275	300	329	363	438



6.3 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. 6.3.1) $$\sigma = -E \cdot \frac{\Delta L}{L} = -E \cdot \alpha \cdot \Delta T$$

Where:

ΔL	dimensional variation
L	pipe length
E	elasticity modulus
α	linear thermal expansion coefficient
ΔT	temperature variation

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 force σ by the pipe section A:

(Eqn. 6.3.2) $$F = \sigma \cdot A = -E \cdot \alpha \cdot \Delta T \cdot A$$

Where:

F	resulting force
σ	thermal stress
A	cross section
E	elasticity modulus

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

The following table shows the end pushing force according to the temperature change:

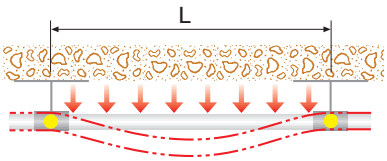
Table: thermal end-load (lb) – SMARTFLEX Single Wall Pipe

Temperature Change	OD [in]						
	1	1 ¼	1 ½	2	3	4	6
	thermal end-load (lb)						
50 °F	269	397	586	899	1746	2531	5194
70 °F	357	529	783	1199	2328	3375	6925
90 °F	448	661	979	1501	2910	4217	8655

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

Temperature Change	OD [mm]						
	32	40	50	63	90	110	160
	thermal end-load (kg)						
30 °C	122	180	266	408	792	1148	2356
40 °C	162	240	355	544	1056	1531	3141
50 °C	203	300	444	681	1320	1913	3926

If these pushing forces on the constraints are excessive, the compensation system must be used, as described in the preceding 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 6.3.3:

(Eqn. 6.3.3) $$F_{cr} = \frac{\pi^2 E I}{L^2}$$ or $$\sigma_{cr} = \frac{\pi^2 E I}{L^2 A}$$

Where:

E elasticity modulus
I moment of inertia
L maximum span length between two anchor points
A pipe section

Pipe buckling will be avoided if:

(Eqn. 6.3.4) $$\sigma < \frac{\sigma_{cr}}{\eta}$$

Where:

η safety coefficient (1,5)
σ thermal stress due to temperature changes

The result of combining equations 6.3.1, 6.3.3 and 6.3.4 is the maximum span length allowed between two anchored points:

(Eqn. 6.3.5) $$L < \sqrt{\frac{\pi^2 I}{\eta A \alpha \Delta T}}$$

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 DT ($\eta = 1.5$).

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

Temperature Change [°F]	OD							
	32	40	50	63	75	90	110	160
	Maximum span length [in] (L)							
ΔT = 85 °F	16	19	24	31	37	44	54	77
ΔT = 105 °F	13	17	21	26	31	38	46	67

Table: maximum span length between two anchor points (cm)

Temperature Change [°C]	OD							
	32	40	50	63	75	90	110	160
	Maximum span length [cm] (L)							
ΔT = 30 °C	40	49	62	78	93	111	136	196
ΔT = 40 °C	34	43	54	67	80	96	118	171

6.4 SUSPENDED PIPE INSTALLATIONS

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

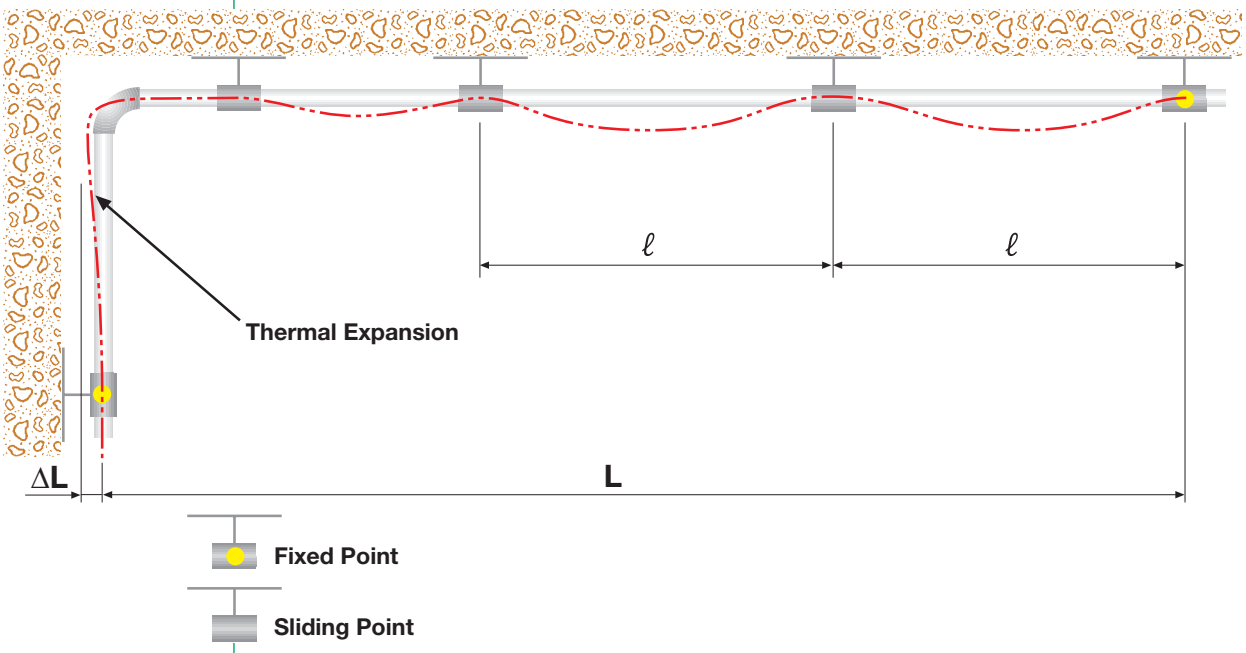
In general, supported applications can be divided into two classes:

A – INSTALLATIONS WHERE THERMAL EXPANSION IS ALLOWED

If thermal expansion is allowed, anchoring points must be positioned to compensate the length variation due to temperature. Once this has been done, the installation designer shall evaluate the deflection due to pipeline weight (including the weight of the fluid) and the presumed value that shall be lower than admitted 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. 6.4.1) $$\Delta y = \frac{5 \cdot g \cdot \ell^4}{384 \cdot E \cdot I}$$

Where:

q	total weight per unit length	$= W + \pi \cdot \rho \cdot g \cdot \frac{ID^2}{4} + (N/m)$
W	weight of the pipe per unit length (N/m)	
ρ	density of internal fluid (kg/m³)	
ℓ	span length (m)	
q	load per unit length (N/m)	
g	standard acceleration of gravity (m/s²)	
E	creep modulus of the pipe at average temperature at 10 years (Pa)	

ID internal diameter (m)
OD outside diameter (m)
I moment of inertia = $(\pi/64) \cdot (OD^4 - ID^4)$ $(m^{\wedge 4})$

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 (6.4.1).

Maximum Span Length

OD		Maximum span length (ℓ)	
in	mm	in	cm
1	32	26	66
1¼	40	30	77
1½	50	35	89
2	63	41	104
2½	75	46	118
3	90	52	133
4	110	60	152
6	160	77	196

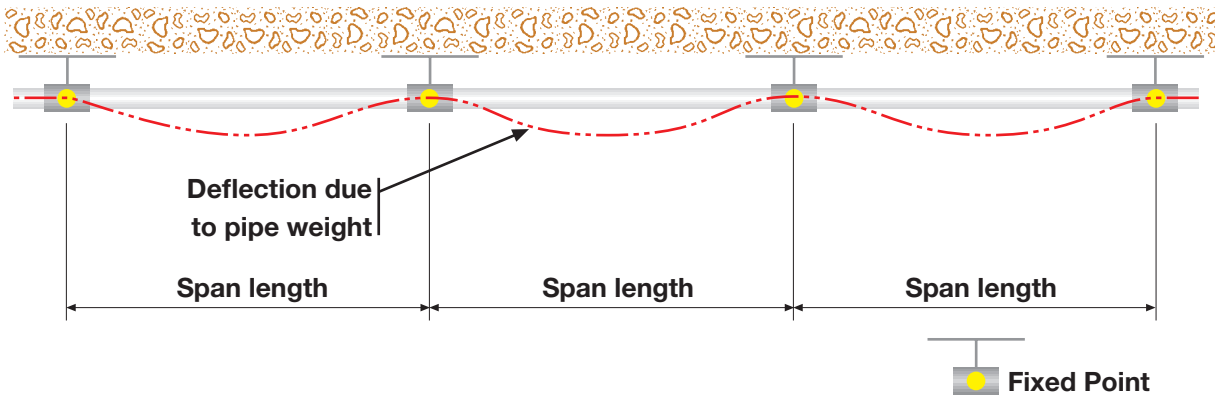
CAUTION:

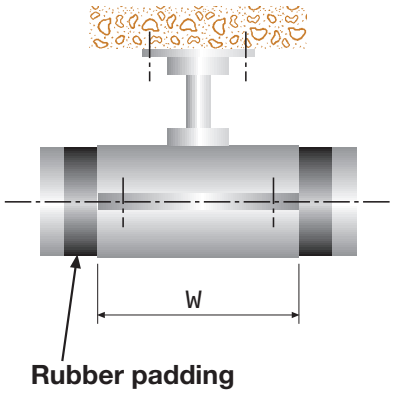
In the previous calculation, each span between two supports was considered as a single uniformly loaded beam with fixed ends at each span and the benefits of having adjoining segments have not been taken into consideration.

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 abovementioned analysis will then be conservative.

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" (110mm) for up to 4" (110mm) diameter pipes
- w = pipe OD for pipes with a diameter larger than 4" (110mm)

6.5 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 screwing up the fitting. The following table shows the maximum Nominal Torque values recommended.

Thread (in)	Nominal Torque N • m
½ 1"	80
2"	100
3"	130
4"	150

WARNING

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

7 • SMARTFLEX PRESSURE TEST

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 utilized as the 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.

85 $^{+0}_{-0.7}$ psi/20 min		Gaseous Fluids		Liquid Fluids	
	Pre-conditioning (1)	**Test Pressure**	**Test Duration**	**Test Pressure**	**Test Duration**
Primary pipe	7 $^{+0}_{-0.5}$ bar/20 min	87 psi (6 bars)	2 hours	174 psi (12 bars)	2 hours
Secondary pipe	6 $^{+0}_{-0.5}$ bar/20 min	58 psi (4 bars)	2 hours	87 psi (6 bars)	2 hours
Rubber entry boots		5 psi (0.3 bar)	2 hours	5 psi (0.3 bar)	2 hours

1) The pre-conditioning phase is not included in the barcode of the PRESSURE TEST CARD and shall be carried out with pressure feed not regulated by the pressure test unit. The pressure test unit shall be connected at the end of the pre-conditioning phase.

The pressure test shall be carried out on line sections with a maximum length of 100 metres 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) interfaced with the welding unit. Barcode PRESSURE TEST CARDS are available for test performing.

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

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

Precondition the piping system for the time and at the pressure rate specified in the table above.

After the preconditioning, reduce the pressure rate in the system down to the test pressure specified in the table. Then, the pressure source shall be disconnected to ensure the test is being conducted on a closed system.

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.

PRESSURE TEST CARD
SMARTFLEX Primary Pipe Testing

Test pressure	5 bar
Test duration	2 h
Test procedure number	0017

14211609000176016105004928

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

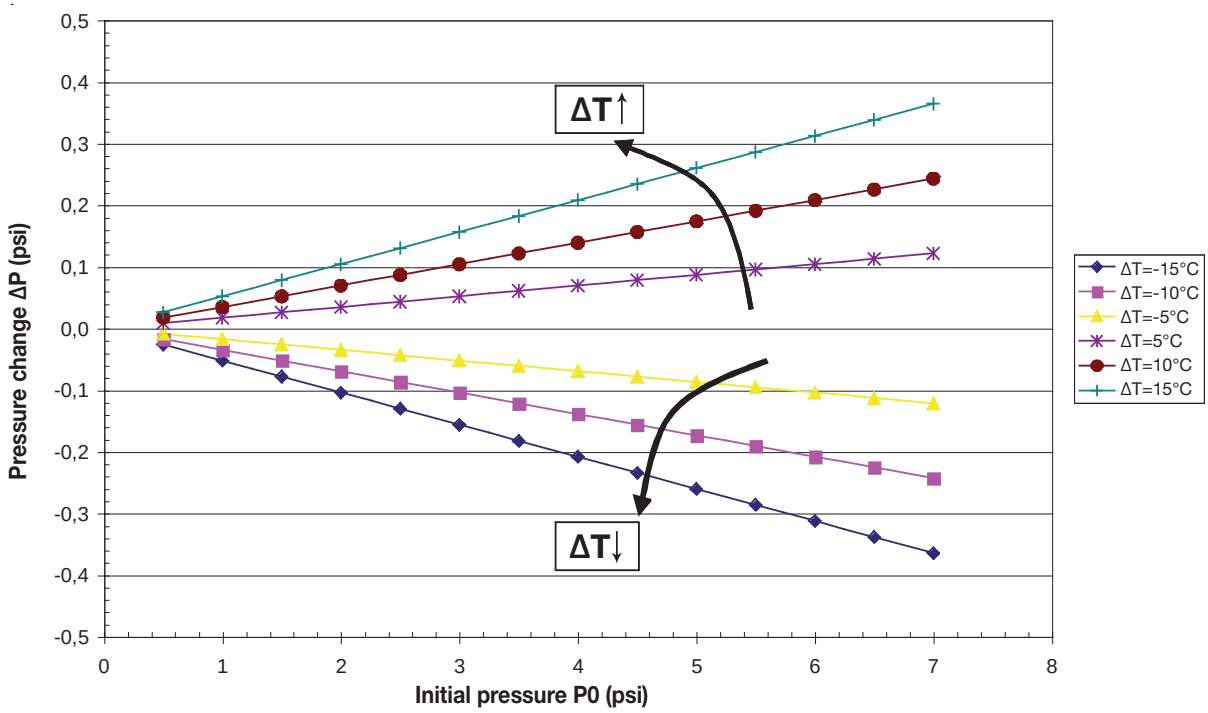
Pressure change due to temperature (only for gaseous fluids) is 0.35% for °C and 0.17% for °F. [e.g. ± ΔT = -18°F (-10 °C) will cause ΔP= -3.5%, hypothesizing that the temperature at the start of the test is around 60°F (+15°C)]. A net pressure change (after temperature compensation) of -2% is typically 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)						
	-15	-10	-5	0	5	10	15
	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

Initial pressure (bar)	Temperature variation ΔT (°C)						
	-15	-10	-5	0	5	10	15
	Final pressure (bar)						
0.5	0.47	0.48	0.49	0.50	0.51	0.52	0.53
1	0.95	0.97	0.98	1.00	1.02	1.03	1.05
1.5	1.42	1.45	1.47	1.50	1.53	1.55	1.58
2	1.90	1.93	1.97	2.00	2.03	2.07	2.10
2.5	2.37	2.41	2.46	2.50	2.54	2.59	2.63
3	2.84	2.90	2.95	3.00	3.05	3.10	3.16
3.5	3.32	3.38	3.44	3.50	3.56	3.62	3.68
4	3.79	3.86	3.93	4.00	4.07	4.14	4.21
4.5	4.27	4.34	4.42	4.50	4.58	4.66	4.73
5	4.74	4.83	4.91	5.00	5.09	5.17	5.26
5.5	5.21	5.31	5.40	5.50	5.60	5.69	5.79
6	5.69	5.79	5.90	6.00	6.10	6.21	6.31
6.5	6.16	6.27	6.39	6.50	6.61	6.73	6.84
7	6.64	6.76	6.88	7.00	7.12	7.24	7.36

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 fluid loss at any welded assembly

Considering that the electro-fusion 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.
- f 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 alarms may cause future damage.

8 • WATER HAMMER EFFECT

Piping is subject to sudden pressure increase above their 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. 8.1) $$\Delta P = \rho \cdot c \cdot \Delta v$$

Where:

ΔP	pressure peak [Pa]
ρ	fluid density [kg/m^3]
Δv	fluid flow change [m/s]
c	velocity of the shock wave in the pipe [m/s]; c depends on the elasticity of both the fluid and the pipe wall

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

(Eqn. 8.2) $$c = \sqrt{\frac{\frac{E_p}{\rho}}{\frac{E_p}{E_w} + \frac{D_m}{t}}}$$

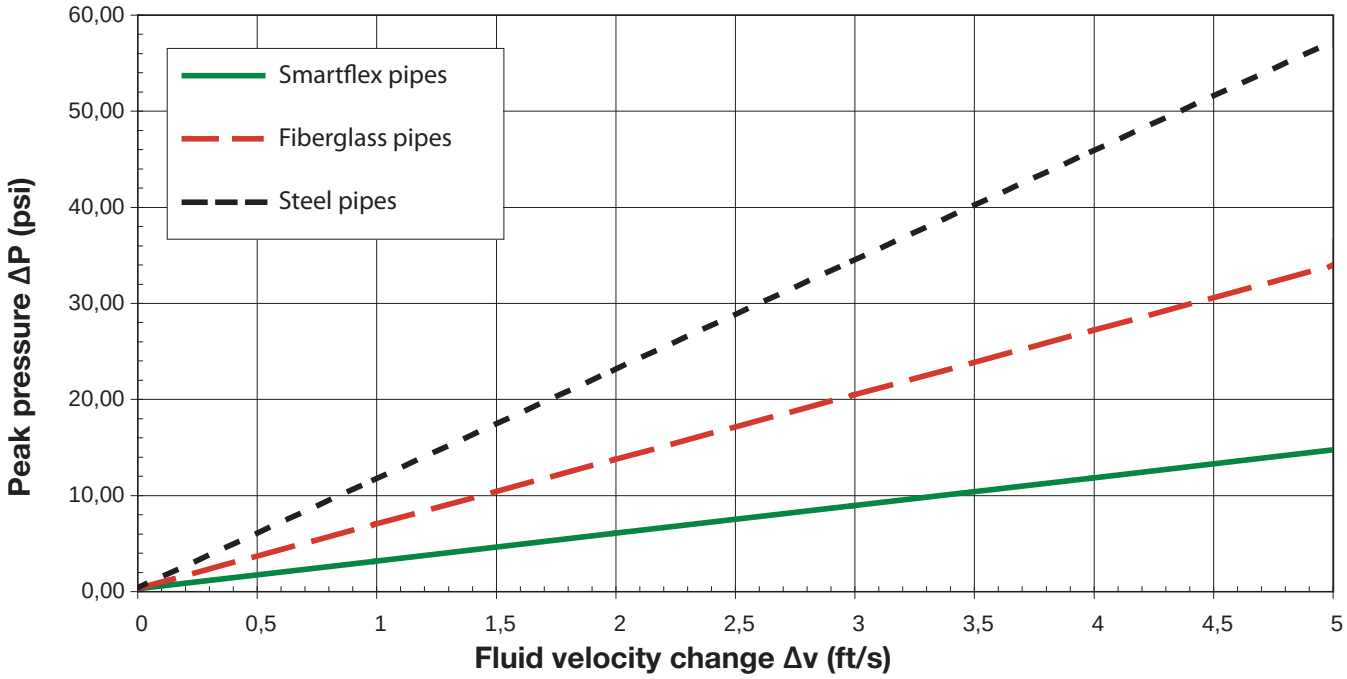
Where:

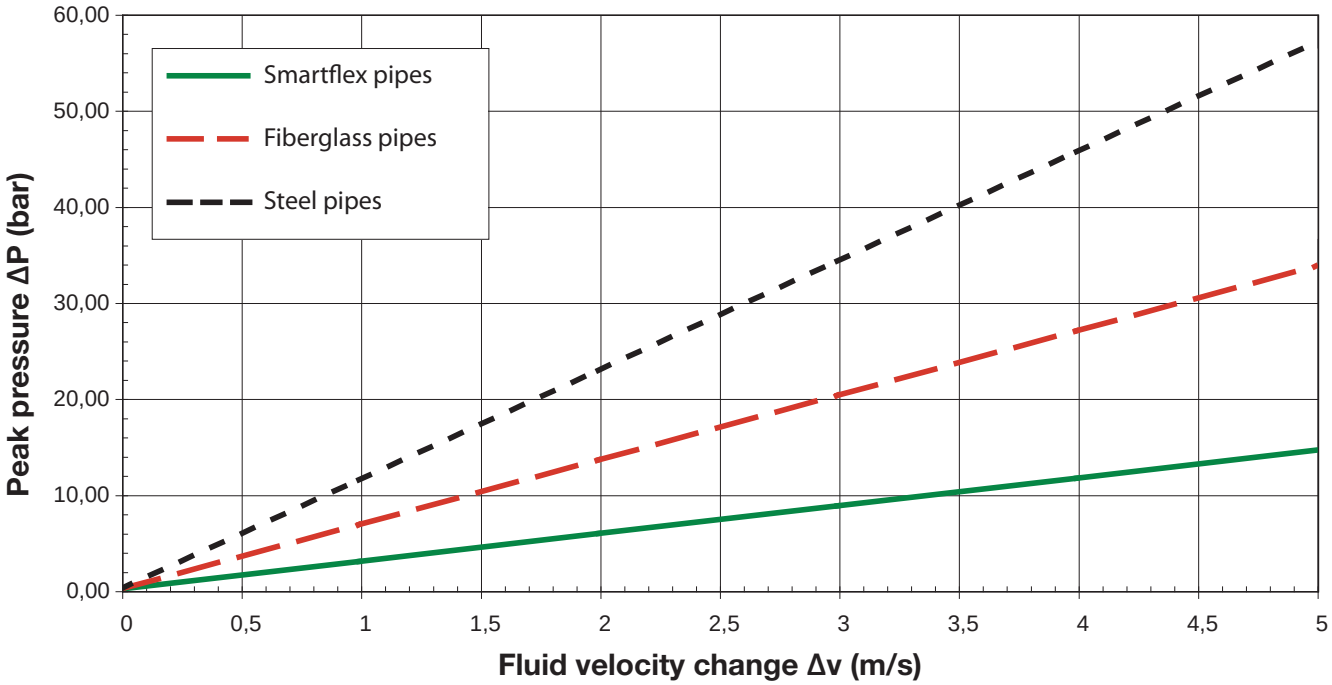
Ew	water elasticity modulus [Pa]
Ep	elasticity modulus of the pipe material [Pa]
Dm	average pipe diameter [mm]
t	pipe thickness [mm]

SMARTFLEX™

The following diagram shows the peak pressure generated after a sudden movement (e.g. gate closing where Dv = v due to the complete stop of the flow), 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





9 • FREQUENTLY ASKED QUESTIONS

General Questions

Does NUPIGECO develop and manufacture its own piping systems?

Yes, it does! NUPIGECO develops, designs and manufactures all its products at the company's manufacturing plants in Italy, Brazil and U.S.A.

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 vapours 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 NUPIGECO 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 vapours 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 vapours 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 NUPIGECO to enter, store and retrieve all the specific site installation data.
- UNI EN ISO 9001:2000 and UNI EN ISO 14001:2004 certified production facilities.

Why are SMARTFLEX pipes non-conductive?

As demonstrated by extensive tests, SMARTFLEX pipes are inherently safe as regards electrostatic risk.

What is the ITS system?

ITS is an Internet based Interactive Tracking System provided by NUPIGECO. 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.).

Installation Process

What is the recommended backfill material?

Sand and pea gravel. Please refer to the SMARTFLEX Technical Catalogue, section 3.2.

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 (8 bars) and 58 psi (4 bars) respectively.

Are both BSP and NPT threaded fittings available for the SMARTFLEX piping system?

Yes, they are! All SMARTFLEX threaded fittings are available in both BSP and NPT threads.

Can the interstitial space be monitored?

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

What is the pipe's bending radius?

Nominal pipe diameter (in)	Nominal pipe diameter (mm)	Minimum bending radius (ft)	Minimum bending radius (mm)
1"	32	2 1/4	580
1 1/2"	50	3	900
2"	63	4	1100
3"	90	5	1600

What is the new 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 bio fuels?

Yes, it is! The SMARTFLEX piping system is suitable for the conveyance of bio fuels (e.g. E85, biodiesel etc.).

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

Yes, it is! NUPIGECO created a multilayer pipe (SMARTFLEXUrea) 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 316) for this application.

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

No, it isn't! Prior to commencing the electro-fusion welding procedure any residual hydrocarbons (liquid or vapour) 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 SSEL8403 simply use the download cable provided to transfer the data to a computer and a printer utilizing an appropriate cable. For model SSEL8404 the data can be directly transferred to a computer or wireless printer via Bluetooth (the wireless printer is available on request with the latest model SSEL8404).

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 (3.8 bars), 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 electro-fusion welding technology. Mechanical systems are also available.

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.

Are the welding units and monitoring systems available in 110 and 220-volt versions?

Yes, they are! Please refer to the SMARTFLEX Product Catalogue.

Does NUPIGECO provide a leak monitoring system?

Yes, it does! It is an over-pressure system that contains a leak monitoring unit (SMSD), 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 and alcohol mixtures?

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 bio fuels.

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, SMANIF). As the test pressures vary for the two pipelines, please refer to the Technical Catalogue, 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 electro-fusion welding can be carried out?

From +14°F to +113°F (-10 C° to +45 °C).

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

20" (50 cm).

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" (5 cm) of compacted backfill or 1" (2.5 cm) 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 electro-fusion welding process be restarted?

The electro-fusion 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 fibreglass pipe, how does the installer(s) determine 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 fibre-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 lengthening (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 +39 0331344211 or at infoid@nupigeco.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.

9 • FREQUENTLY ASKED QUESTIONS

SMARTFLEX™

CERTIFICATIONS

Is the SMARTFLEX piping system EN14125 certified?

Yes, it is! NUPIGECO manufactures a specifically designed single and double wall piping system named TSMAH and TSMAHD to satisfy the requirements of the new EN14125 standard. Moreover, TSMAU pipes are certified for load, vent and vapour recovery.

Is the SMARTFLEX piping system UL971/ULc certified?

Yes, it is! NUPIGECO created a specially designed single and double-wall piping system named SUPERSMARTFLEX (TSMAXP and TSMAXPD) to satisfy the requirements of the new UL971 and ULC standards.

Is the SMARTFLEX piping system KIWA certified?

Yes, it is! NUPIGECO created a specially designed single and double-wall piping system named TSMA and TSMAD to satisfy this standard.

Is the SMARTFLEX piping system IP Second Edition certified?

Yes, it is! NUPIGECO created a specially designed single and double-wall piping system named TSMA and TSMAD to satisfy this standard.

nupigeco

Registered Office and Headquarters
via Stefano Ferrario
21052 Busto Arsizio (VA) Italy
ph. +39 0331 344211
fax +39 0331 351860
info@nupigeco.com
www.nupigeco.com

Production, Operations and Administration Centre
via dell'Artigianato 13
40023 Castel Guelfo (BO) Italy
ph. +39 0542 624911
fax +39 0542 670851
infoid@nupigeco.com
www.nupigeco.com

Production Facility
via Colombarotto 58
40026 Imola (BO) Italy
ph. +39 0542 624911
fax +39 0542 670851
infoid@nupigeco.com
www.nupigeco.com

Nupi Americas, Inc.
1511 Superior Way,
Houston - TX 77039 - U.S.A.
ph. +1 281 590 4471
fax +1 281 590 5268
info@nupiamericas.com
www.nupiamericas.com

nupi AMERICAS