

## ***CRYOGENIC PIPING SYSTEMS***

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## General introduction

### 1.1 LR Marine

LR Marine was founded in 2008 in Frederikshavn in Northern Jutland, in Denmark. The 5 founders of the company comprises a team of highly qualified and dedicated professionals offering a unique combination of technical insight, know how, project management skills and years of experience within the field of marine and off shore operations.

LR Marine was established primarily to assume the sales responsibility for all LOGSTOR Marine systems in Europe, and since January 1, 2012 the Geographical area has been expanded such that LR marine today is the world wide exclusive distributor for LOGSTOR Marine systems.

LR Marine operates world wide via a network of specialized Marine agents and regularly attend international exhibitions.

LR Marine is a total supplier of cost efficient, effective and sustainable solutions for marine and off shore businesses.

LR Marine core business and primary activities are within the fields of:

- Pipe systems
- Pre-insulated pipe systems
- Machinery units / Skids
- Cryogenic Tank Insulation
- Service and installation

### 1.2 LOGSTOR - LR Marine

LOGSTOR was founded in the early 60s, in Løgstør, Northern Jutland, in Denmark. The founder of the company invented the pre-insulated pipe for direct ground installation.

For the next 30 years the company grew in size and market position. The basic market was pipe systems for conveyance of Urban heating.

In 1992 LOGSTOR diversified into systems for industrial uses and developed a number of systems specifically directed to onshore, offshore and marine oil and gas applications.

LOGSTOR today is undisputed world leader in its field.

The entire range of products have unique properties superior to conventional products for the same applications.

- The casing system is completely water tight and protects the insulation from soaking and the media pipe effectively from corrosion
- The casing is practically diffusion tight
- The insulation capacity is outstanding so heat and cold losses are kept at a minimum.
- The insulation is so strong that above ground pipelines may be suspended on the outside of the casing and thus keeping it fully watertight
- The casing is extremely robust and endures heat, cold, sunlight and rough treatment for many, many years.



- The range of systems covers the conveyance of all kinds of fluids and gases in the temperature range of  $-200^{\circ}\text{C}$  to  $+280^{\circ}\text{C}$

#### LR Marine and its customers

Over 40 years experience has passed with the development and sale of complete pre-insulated pipe systems, known with a worldwide reputation. A well developed network of distributors and subsidiaries has resulted in thousands of kilometres of the characteristic LR Marine pipes being laid all over the world. Our distributors and subsidiaries represent us in over 30 countries around the world.

Since January 1, 2012 Sales of all LOGSTOR Marine systems world wide is exclusively handled by LR Marine, who regularly attend international exhibitions.

#### Extensive service

LR Marine's engineers and technicians provide an extensive service for any given project – right from initial planning to commission, engineering and follow-up servicing and training of fitters.

Years of experience of the installation of joints and devising customized solutions have given us the expertise to carry out installation work and supervision within our market areas.

Since January 1, 2015 LR Marine has had the rights to the manufacturing know-how of the pre-insulated Marine piping systems and has acquired its own manufacturing facilities as well as using other sub-suppliers to produce the pre-insulated pipes per LR Marine specifications. Type approvals from classification companies is also the property of LR Marine.

Since April 1, 2015 LR Marine has taken over the manufacturing facility in Wuxi, Shanghai province China. This facility is primarily serving the vast new build market on the ship yards in China but can also serve the retro-fit market in the rest of the world.

LR Marine also operates mobile production units for the execution of large orders in remote places and where savings in logistics justifies it.

LR Marine remains to have its head quarter in Aalborg Denmark and operates the various facilities/sites from here.

### 1.3 Introduction to the Cryogenic Pre-insulated Pipe System (PPS)

LR MARINE industrial systems are designed as complete systems for specific applications and as such, can only be used within those areas.

This catalogue describes the cryogenic pipe system programme for LNG conveyance in marine application. The system is referred to as “PPS”

The continuous or cyclic operating temperature is from -200° C to +120° C

The system is designed as a bonded system. In a bonded system there is a strong bond between the media pipe, the insulation and the outer casing. There can be no relative movement between them. Thermal contraction or expansion of the media pipe is transferred to the casing via the bond and shear stresses in the insulation. The system is fully water tight from the outside and remains so for many years due to its nature of being bonded.

The cryogenic system shall be suspended on supports and may not be buried directly in the ground, as it is common practice by heating systems.

FEM calculations and experience proves the PPS system to have significantly improved mechanical properties in relation to systems conventionally insulated with staggered layers of PUR half shells.

The analysis shows that the PPS system in general have lower displacement, strain, tensile stress and compression stress than the equivalent than a comparable conventional system.

The result is that the life expectancy of the LR MARINE PPS system is dramatically longer than for the conventional system

#### Carrier pipes

LR MARINE's PPS system is produced with carrier pipes and carrier pipe fittings according to customer specifications. LR MARINE can offer to either to produce based on Media pipes delivered by the customer or to purchase them according to customer specifications and deliver the complete product including quality assurance

The pipes are produced in fixed length of 6 meters or special spools on customer request

#### Insulation

The insulation is foamed PUR.

The foaming propellant and the cell gas is a mixture of CO<sub>2</sub> and Cyclopentane. The material is completely free of CFC or HCFC. The ODP and the GWP is 0

The insulation material is developed and documented with the right combination of toughness and flexibility properties necessary for cryogenic application

The insulation is homogenous without substantial irregularities and it contains no foreign matter, which could lead to the formation of cold bridges

## Casing

The casing on the PPS system is extruded from black coloured High Density Polyethylene (HDPE)

The HDPE materials used are chosen for their toughness and outstanding resistance against UV degradation, slow crack growth and rapid crack propagation. They are therefore well suited for service under as well tropical as arctic condition in a period exceeding 30 years.

Every pipe or fitting is delivered with a free media pipe end of 220mm. for welding

Casings in outer diameter up to 1400mm. are available

## Casing Joints

Joining of the casing ends of every pipe and fitting is done using the acknowledged LR MARINE electro fusion welded casing joints.

These joints possess the strength and rigidity which is crucial for a long and service free life of a system operating at cryogenic temperatures. They are 100% watertight and gastight.

The joints are foamed on site to make sure that no voids or cold spots are formed

LR MARINE delivers Factory made HDPE casing fittings for the insulation of bends and tee's and similar fittings. Also the casing fittings are joined by the LR MARINE electro welding technique.

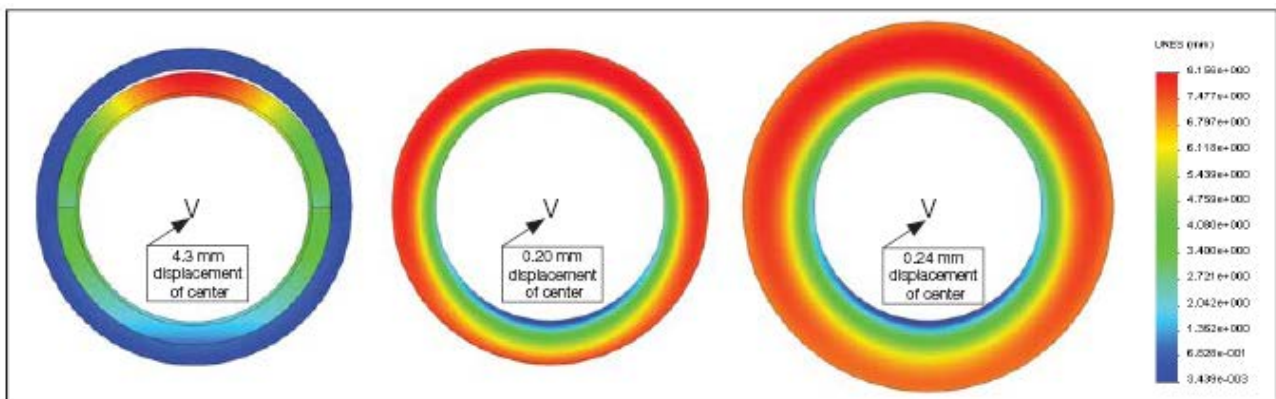
This solution offers great advantages in logistics and flexibility on site, but also factory pre-insulated fittings are available if the customer's specification requires it.

## Supports

PPS shall be supported on the outside of the casing. The system is so strong that the supports may be placed at will anywhere on the pipes.

The insulation and casing are so strong and creep resistant that the support plates may be held in practical dimensions and that the support distances are within common practice.

The PPS design with a strong bond between media pipe, insulation and casing ensures low deformation and low creep so that no voids or cavities are formed due to unavoidable small deformation at the supports, as is the case in conventionally insulated systems with staggered layers of half shells.



The picture shows FEM of the stresses at supports in a conventional DN 500 pipe left and PPS in two different insulation series at the right.

It demonstrates that air gaps develop in the conventional system but not in the bonded PPS.



The axial shear strength of PPS between the media pipe and the casing is so high that it is advantageous to fix the support to the structure and let the pipe casing slide in the supports. The supreme abrasion resistance of the bimodal HDPE casing make it well suited for it, and experience shows that it is a technically and financially attractive alternative to the conventional clamped sliding supports.

LR MARINE supplies a complete range of supports in either galvanized or stainless steel. Supports designed for as well clamping as sliding are available in the program. The supports can be delivered designed for either standard or heavy-duty service.

## Material specifications

### 1.4 Insulation

The pre-insulated straight pipes and components for the PPS system are supplied with a special cryogenic polyurethane foam insulation.

The insulation material fulfils the requirements of EN 253 at temperatures up to +140°C

It is specially formulated to meet the service requirements down to – 200°C

Polyurethane foam is a reaction product of polyols, isocyanate, catalysts, stabilizers and propellants.

The foam is homogeneous with an average cell size of max. 0.5 mm.

#### Properties

Density	≥	85+-15% kg/m <sup>3</sup>
Closed cells	≥	88%
Water absorption if boiled	≤	10% (Vol)
Compressive strength 10% deformation (+23OC)	≥	0,5 N/mm <sup>2</sup>
Compressive strength 10% deformation (-180OC)	≥	1,3 N/mm <sup>2</sup>
Axial shear strength 23°C	≥	0.12 N/mm <sup>2</sup>
Tangential shear strength (+23°C)	≥	0.20 N/mm <sup>2</sup>
Thermal conductivity at +23°C	<	0.027 W/m°C
Thermal conductivity at -180°C	<	0.013 W/m°C
Operating temperature		-200°C to +120°C

The technical requirements are tested according to the EN 253, ISO 844, ASTM C 273, ISO 845, ASTM C 518 and ISO 4897

The material parameters are subject to revision due to technical developments.

#### Qualification

To qualify LR MARINE's pre-insulated pipe systems for LNG applications, LR MARINE/LOGSTOR carried out an elaborate test program at cryogenic temperatures.

The tests were made and documented by independent energy research institutes to verify the properties needed for the cryogenic application:

- The mechanical test and thermal properties mentioned above were tested and verified over the full temperature range.
- The materials were cycled between ambient and cryogenic temperatures to verify the bond strength between PUR and carrier pipe.
- A full-scale test of a 4" and 20" pre-insulated pipe loop cycled between -196°C and +65°C supported by FEM analyses.



## 1.5 Casing

The Pre Insulated Pipe system (PPS) is produced with a protective casing of High Density Polyethylene (HDPE)

The material for the casing is exclusively third generation bi-modular materials, either designated PE80 or PE100. This ensures that the casings are extremely resistant to stress cracking at all temperatures.

The casings are produced and tested in accordance with EN 253

### Mechanical properties of the HDPE material:

Density	> 940 kg/m <sup>3</sup>
Yield stress	> 19 N/mm <sup>2</sup>
Elongation at break	> 350%
Stress crack resistance (NCLT)	
4Mpa/2%Arkopal/80°C	> 300h
RCP crack arrest	< -30°C

### UV resistance:

Due to a combination of organic UV stabilizers and finely dispersed carbon black, the pipes withstands outdoor exposure for more than 30 years in most climates

### Thermal properties:

Coefficient of expansion	$2 \cdot 10^{-4} \text{ } ^\circ\text{C}^{-1}$
Thermal conductivity	0.43 W/m <sup>0</sup> C
Melt flow rate	0.3-0.8 g/10 min.

Material parameters are subject to revision due to technical developments.

## 1.6 Casing Joints and fittings

The joint casings and fittings casings are produced from the same raw materials as the straight pipe casings. This ensures full compatibility and weld ability and the same long life as the pipes.

## 2 Cryogenic Product Program

### 2.1 Cryogenic Pre-insulated Pipe System

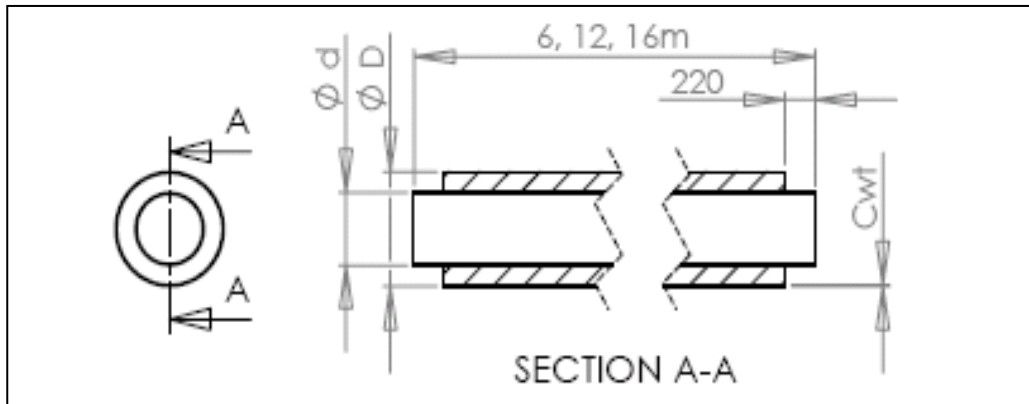
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<b>Application</b>	LR MARINE's Pre-insulated Pipe System is a complete transmission and distribution system for cryogenic mediums in the temperature range from - 200°C to +120°C above ground. The Pre-insulated Pipe System is the ideal solution for LNG terminal transfer pipelines and piping for marine application (LNG carriers etc).
<b>Description</b>	LR MARINE's Pre-insulated Pipe System operates as a bonded system in which the carrier pipe and jacket move axially as one single system when the carrier pipes temperature changes. The pre-insulated pipe is a sandwich construction with polyurethane insulation material (PUR) bonded to both the carrier pipe and the protective casing.
<b>Features and Benefits</b>	<ul style="list-style-type: none"> <li>▪ The insulation value is superior</li> <li>▪ The system is free of cold spots</li> <li>▪ The system is 100% watertight and diffusion tight</li> <li>▪ Pipe supports may be clamped randomly directly on casing</li> <li>▪ The low heat gain reduces the impact on the environment</li> <li>▪ Manufacturing in controlled environment improves Quality</li> <li>▪ It is robust to rough handling and service</li> <li>▪ Maintenance free</li> <li>▪ The installation is quick and cost effective</li> <li>▪ Ease overall project management</li> </ul>

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## Cryogenic Pre-insulated Pipe System



### HDPE Casing sizes:

The table values are typical values and may vary for different applications

S/N	Stainless Steel pipe		Nominal LNG casing size	Jacket Thickness mm	HDPE Casing pipes diameter Before foaming, mm		HDPE Casing pipes diameter After foaming, mm	
	DN	Diameter [mm]			minimum	Maximum	minimum	Maximum
1	15	21,3	90	3	92,3	94,5	92,3	94,5
2	25	33,7	110	3	110,8	112	111,1	113,6
3	40	48,3	160	3	162,3	163,6	162,7	165,5
4	50	60,3	180	3	180,8	182,1	181,4	184,6
5	65	76,1	200	3,2	199,6	200,9	200,9	204
6	80	88,9	225	3,2	225	226,3	226,6	229,8
7	100	114,3	280	4,4	280,1	281,7	282,3	285,8
8	150	168,3	355	5,6	355,2	357,5	355,4	365
9	200	219,1	400	6,3	400,1	402,3	400,1	410
10	250	273	450	7	450,1	452,3	450,1	460
11	300	323,9	500	7,8	500,1	502,3	500,1	511
12	350	355,6	560	8,8	560,1	562,5	560,1	575
13	400	406,4	590	9,6	590,1	592,8	590,1	600
14	450	457	630	9,8	630,3	632,8	630,3	646
15	500	508	710	10	710,1	713	710,1	727
16	600	610	800	12	800,2	803,7	800,2	817
17	650	660	900	12	900,2	905	900,2	915
18	750	762	1.000	14	1000,1	1004,9	100,1	1026

Note: This data is provided as an example only. Actual performance should be determined using the parameters relevant to the particular application.

## 2.2 Casing joints and Straight couplings

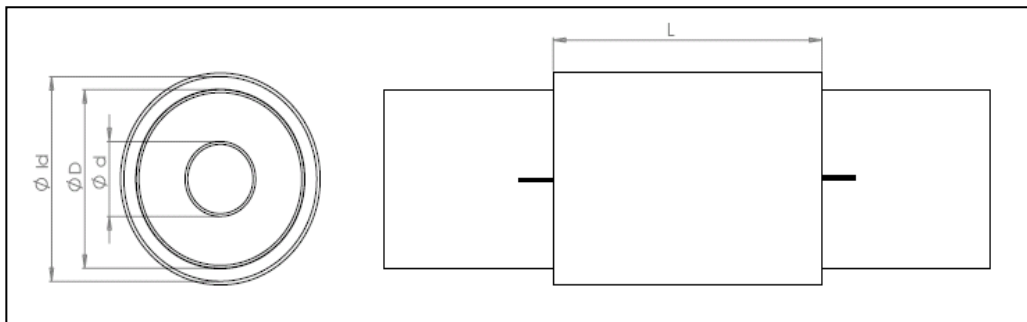
### Electric Welded “EW” Joints



<b>Application</b>	Electric Welded Joint systems are designed to join the HDPE casings of pre-insulated pipes, bends or T- Branches after welding the carrier pipe. EW may be used in direct sunlight and at ambient temperatures between $-40^{\circ}\text{C}$ and $+60^{\circ}\text{C}$
<b>Description</b>	<p>The EW Casing Joint is designed to join pre-insulated pipes with HDPE casing as one long uninterrupted unit.</p> <p>The joint casing is tubular and it therefore needs to be slit over the pipe casing before welding the carrier pipe.</p> <p>The EW Joint shall be placed and welded onto the casing across the exposed pipe ends of the pre-insulated pipes after welding the carrier pipe.</p> <p>The joint casing is heat shrinkable and is to be shrunk with a propane torch onto the weld heating elements.</p> <p>The weld pressure is applied by a solid stainless steel clamping ring.</p> <p>The joints are welded on the casing by fusion welding. The process is automatically compensated for the ambient temperature and climate. This ensures a correct welding under all climate conditions</p> <p>Before injecting the PUR foam insulation the complete connection (annulus) will be tested by applying overpressure (air).</p> <p>The insulation material is LOGTOR PUR foam of the same spec. as in the straight pipes</p> <p>The venting and foaming holes are closed with welded HDPE plugs.</p> <p>After completing the installation procedures the connection is 100% watertight and robust and the system is mechanically and thermally uninterrupted.</p>

**Features  
and  
Benefits**

- 100% watertight system
- 100% watertight connection
- Safe and fast installation
- Uniform U values the entire pipeline
- Ease project management
- Same tensile properties as entire pipeline



**EW Casing Joint standard**

Casing pipe OD (D) (mm)	Casing wall thickness (mm)	EW Joint Standard Length (mm)	EW Joint ID (mm)	Foam Volume (Ltr)
160	3	600	180	10,9
180	3	600	200	13,4
200	3,2	600	220	15,9
225	3,2	600	245	19,5
280	4,4	600	301	28,6
315	4,9	600	335	34,3
355	5,6	600	380	43,2
400	6,3	600	475	68,2
450	7,0	700	589	94,1
500	7,8	700	661	114,7
560	8,8	700	744	147,6
590	9,6	700	837	185,0
710	10,0	700	837	169,9
800	12,0	700	941	198,0
900	12,0	700	941	177,4
1000	14,0	700	1044	202,0

EW joints are also available in other length for special applications

## 2.3 Bends

### 2.3.1 Electric Welded Bend Field Joints, EWB



<b>Application</b>	<p>The Electric Welded Bend Joint EWB are designed as casings for field insulating media pipe bends after welding and to join the HDPE casings of pre-insulated pipes covering the media pipe bend.</p> <p>EWB may be used in direct sunlight and at ambient temperatures between – 40°C and +60°C</p> <p>The standard bend deviation is 90°, but any other deviation may be supplied on customer request</p> <p>The standard radius of the bends are 1.5 times the Carrier Pipe outside diameter.</p>
<b>Description</b>	<p>EWB is non shrinkable</p> <p>It fits in between two straight casing ends and it is joined using an EW short joint in every end</p> <p>Type A is available for all casing diameters.</p> <p>The fusion welding to the straight pipe casings are done using the EW welding technique. (Ref. Para 3.2 )</p> <p>The HDPE casing dimensions, tolerances and properties are identical to those of the Pre-insulated Pipe casing.</p> <p>Before injecting the PUR foam insulation the complete connection (annulus) shall be tested by applying an air overpressure.</p> <p>The insulation material is LR MARINE PUR foam of the same spec as in the straight pipes</p>

The venting and foaming holes are closed with welded HDPE plugs.

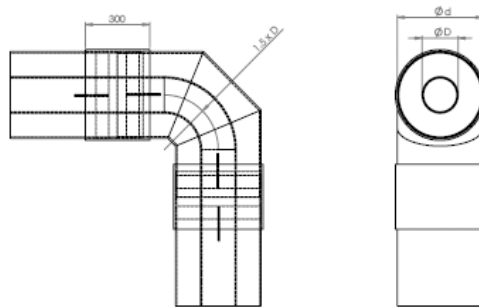
After completing the installation procedures the connection is 100% watertight and robust and the system is mechanically and thermally uninterrupted and continuous

**Features and Benefits**

- 100% watertight system
- 100% watertight connection
- Safe and fast installation
- Same U values the entire pipeline
- Fast delivery
- Light and easy to transport and handle
- Easy to adjust on site

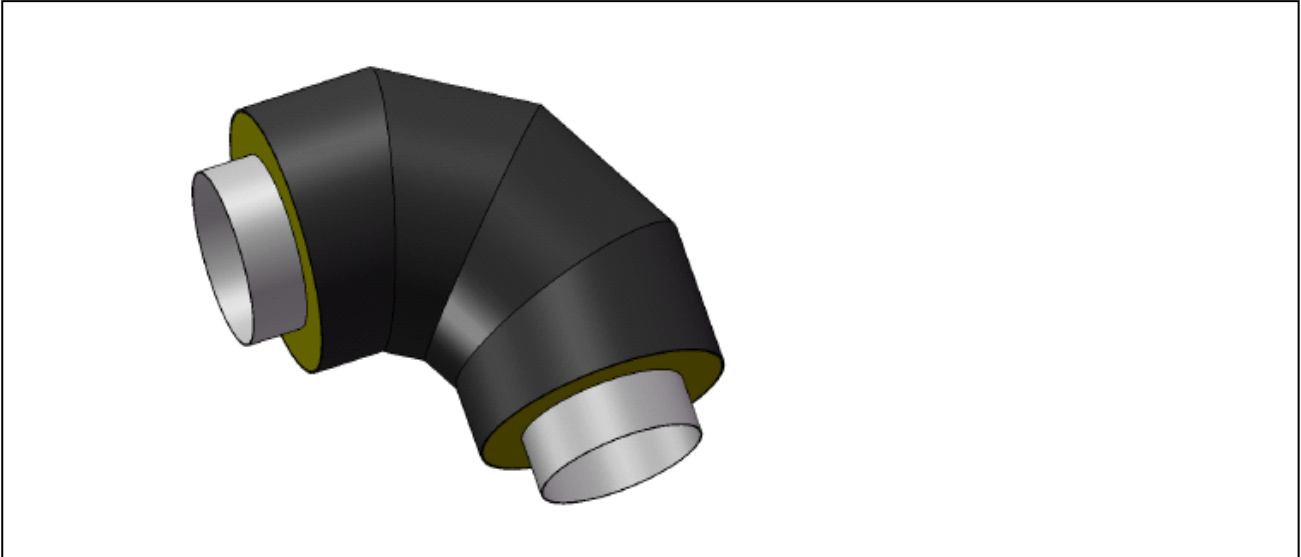
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**EWB**



The component dimensions are specifically designed to suit the application in individual projects

### 3.3.2 Pre-insulated Bends



**Application** The Pre-insulated Bends are designed and delivered as a finished insulated bend to be directly welded onto two straight pipe ends

It may be used in direct sunlight and at ambient temperatures between  $-40^{\circ}\text{C}$  and  $+60^{\circ}\text{C}$

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#### **Description**

The LR MARINE “Pre insulated” bend is designed for safe and fast onsite installation.

It is available in all standard diameters.

The standard bend deviation is  $90^{\circ}$ , but any other deviation may be supplied on customer request

The standard radius of the bends are 1.5 times the Carrier Pipe outside diameter.

The HDPE casing dimensions, tolerances and properties are identical to those of the Pre-insulated Pipe casing.

The insulating material is identical to that of the straight pipes

The casing bend is produced from segmented HDPE casing pipes fused together by hot plate butt-welding.

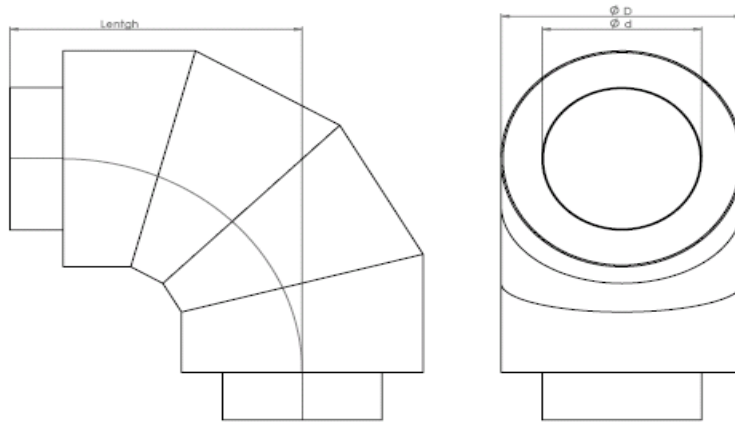
It shall be joined to the straight pipes using two EW joints (ref 3.2)

Compared to the EWB the Pre-insulated bends are heavy and bulky to handle



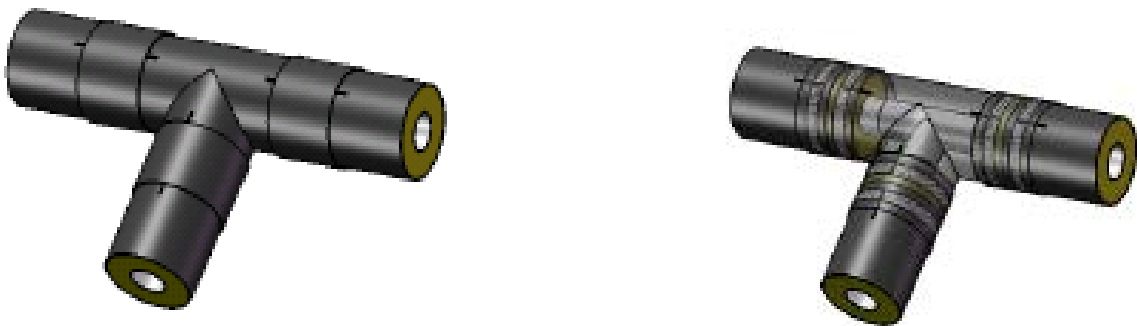
## Features and Benefits

- Bends are ready to be installed
- The installation requires less skill than EWB
- Reduce large volume insulation on location
- 100% watertight connection
- Safe and fast installation
- Uniform U values the entire pipeline



The component dimensions are specifically designed to suit the application in individual projects

## 2.4 T – Branches



## Application

The Electric Welded T- Joint EWT is designed as casings for field insulating media pipe branches after welding and to join the HDPE casings of pre-insulated pipes covering the media pipe branch.

EWT may be used in direct sunlight and at ambient temperatures between – 40°C and +60°C

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## Description

EWT is non shrinkable

It fits in between three straight casing ends and it is joined using an EW short joint in every end (see 3.2)

EWT is available for all casing diameters from  $\varnothing 200$  mm up to  $\varnothing 1400$  mm and all combinations of diameters for main and branch pipe

The standard branching angle is  $90^\circ$ , but any other configurations may be supplied on customer request

EWT is supplied on site as tubular items.

On site they are cut open assembled over the media pipe bend and welded in the length direction using extruder welding technique

The HDPE casing dimensions, tolerances and properties are identical to those of the Pre-insulated Pipe casing.

Before injecting the PUR foam insulation the complete T-connection (annulus) will be tested by applying overpressure (air).

The insulation material is LR MARINE PUR foam of the same spec as in the straight pipes

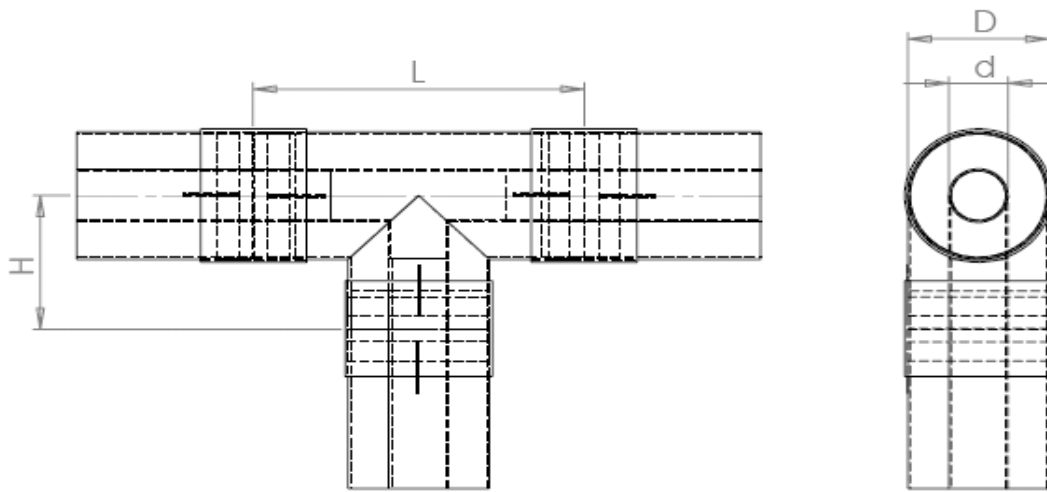
The venting and foaming holes are closed with welded HDPE plugs.

After completing the installation procedures the T-connection is 100% watertight and robust and the system is mechanically and thermally uninterrupted and continuous.

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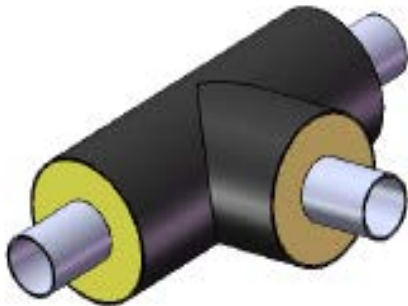
## Features and Benefits

- 100% watertight connection
  - Safe and fast installation
  - Uniform U values the entire pipeline
  - Light and easy to transport and handle
  - Easy to adjust on site
-



**The component dimensions are specifically designed to suit the application in individual projects**

## 2.4.1 Pre-insulated Branch Tee



### Application

The Pre-insulated Tee pieces are designed and delivered as a finished insulated components to be directly welded onto two straight pipe ends

The Pre-insulated Branch Tee may be used in direct sunlight and at ambient temperatures between  $-40^{\circ}\text{C}$  and  $+60^{\circ}$

### Description

The LR MARINE Pre-insulated T-piece is designed for safe and fast onsite installation.

It is available for all casing diameters from  $\varnothing 200$  mm up to  $\varnothing 1400$  mm and all combinations of diameters for main and branch pipe

The standard branching angle is  $90^{\circ}$ , but any other configurations may be supplied on customer request

The HDPE casing dimensions, tolerances and properties are identical to those of the Pre-insulated Pipe casing.

The insulating material is identical to that of the straight pipes

The casing T is produced of segmented hot plate butt-welding or extruder welding.

It shall be joined to the straight pipes using three EW joints short (ref 3.2)

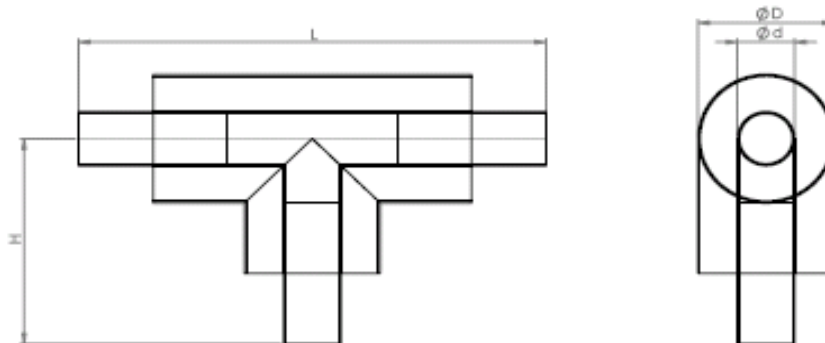
The use of pre-insulated Tee's avoid large volume insulation of bends onsite.

Compared to the EWT the Pre-insulated Tee's are heavy and bulky to handle

### Features and

### Benefits

- 100% watertight connection
- Safe and fast installation
- Uniform U values the entire pipeline



The component dimensions are specifically designed to suit the application in individual projects

## 2.6 Casing Reducer Field Joints EWR

Concentric Reducer



Excentric Reducer



**Application** Casing Reducer Field Joints EWR are used to join casings of differing OD.

EWR may be used in direct sunlight and at ambient temperatures between – 40°C and +60°C

### Description

EWR is non shrinkable

It fits in between Two straight casing ends and it is joined using an EW short joint of different diameter in every end (see 3.2)

EWR is available both as a concentric and as an excentric type

EWR is available for all casing diameters from ø200 mm up to ø1400 mm and all combinations of diameters for main and branch pipe

The Casing Reducer Field Joints are produced from HDPE casing pipes using hot expansion and hot plate butt fusion welding

EWR is supplied as part of the Pipe spools or as a tubular item to be installed on site.

On site they are cut open assembled over the media pipe and welded in the length direction using extruder welding technique

The HDPE casing dimensions, tolerances and properties are identical to those of the Pre-insulated Pipe casing.

The insulation material is LR MARINE PUR foam of the same spec as in the straight pipes

The venting and foaming holes are closed with welded HDPE plugs.

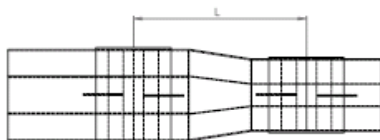
After completing the installation procedures the EWR-connection is 100% watertight and robust and the system is mechanically and thermally uninterrupted and continuous.

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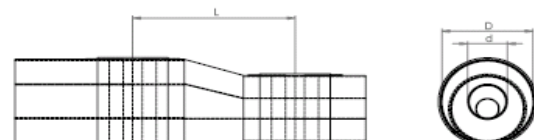
## Features and Benefits

- 100% watertight connection
  - Safe and fast installation
  - Uniform U values the entire pipeline
  - Light and easy to transport and handle
  - Easy to adjust on site
- 

Concentric

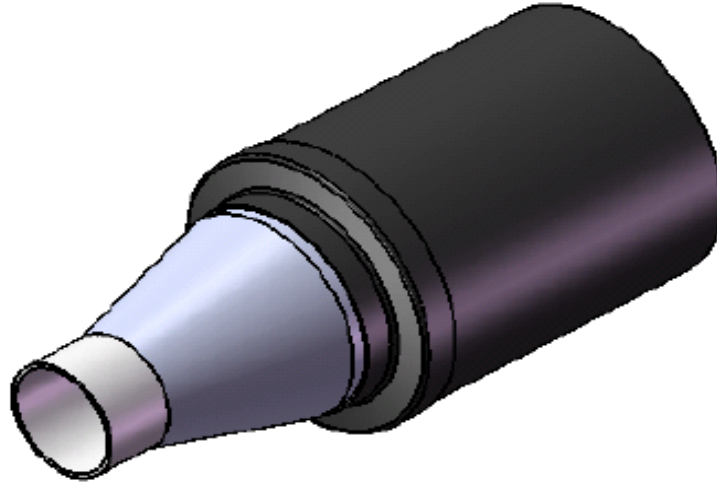


Excentric



The component dimensions are specifically designed to suit the application in individual projects

## 2.7 Cryogenic End-caps



**Application** The Heavy duty End-cap is used to terminate the insulation and to eliminate water ingress and control the temperature in the heat shrink area. This may for example be at flanges and valves

It is diffusion tight without further precautions.

The Heavy Duty End-cap may be used in direct sunlight and at ambient temperatures between  $-40^{\circ}\text{C}$  and  $+60^{\circ}\text{C}$

**Description** The Heavy Duty End-cap consists of a stainless steel cone which shall be pressed into the open pipe insulation and welded to the pipe exterior surface. It is insulated with prefabricated PUF half shell cones. The sealing between the pipe casing and the stainless steel cone is made with a heat shrinkable polymer End-cap.

After completing the installation procedures the end-cap is 100% watertight and robust against all normally occurring actions

It is available for all standard pipe dimensions

**Features**

**Benefits**

- 100% watertight system
- 100% watertight connection
- Very robust design

## 2.8 Sensor Cable Outlet

On some of the joints a thermal sensor is installed. The cables shall exit the HDPE casing through cable outlets, as shown on the following drawing:



The cable outlet is welded into the casing next to the fieldjoint. The cable exits through an 8 mm hole and is sealed with a shrink hose.



## 2.9 LNG BUNKER PIPES

In principle there are two piping systems that are applicable depending on the actual location of the piping system

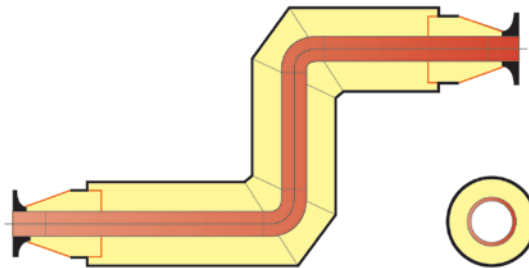
### 2.9.1 For installation on open deck or in vented channels.

#### Application

LR Marine offers a single pipe system with PUR insulation and covered by a weather resistant black HDPE casing.

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#### Description



#### Features and Benefits

- 100% watertight system
  - 100% watertight connection
  - Very robust design
-

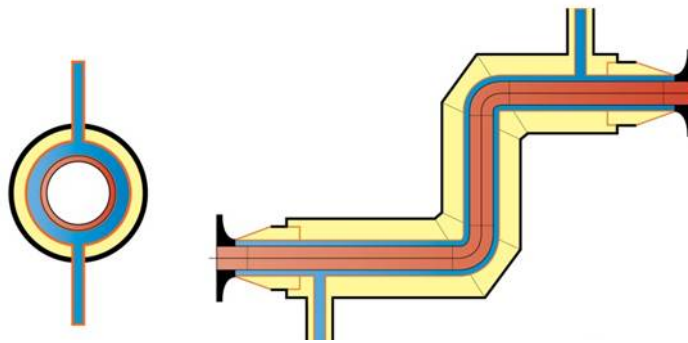
## 2.9.2 For installation inside vessel .

### Application

For this application LR Marine offer a special dual wall piping system where the internal stainless steel pipe is for transporting the LNG and the external pipe system is for venting and Gas detection.

The double wall stainless Steel pipe system is insulated with PUR foam and covered by a HDPE jacket. To meet the IMO653. Low flame spread requirement the HDPE casing is externally covered by a 0,4mm Stainless Steel cladding

### Description




---

### Features and Benefits

- 100% watertight system
  - 100% watertight connection
  - Very robust design
-

### 3.0 General environmental measures

In general, handling and Installation of Pre Insulated Pipe systems can be done at almost all environmental conditions, as long as the work place can be kept dry and protected against heavy wind conditions, by a tent or other means of appropriate environmental shielding.

#### 3.1 General winter measures.

At ambient temperatures lower than +10° C, the measures described below should be regarded, when

- Handling
- cutting and adapting
- installing and on site foaming of HS joints

preinsulated pipe systems.

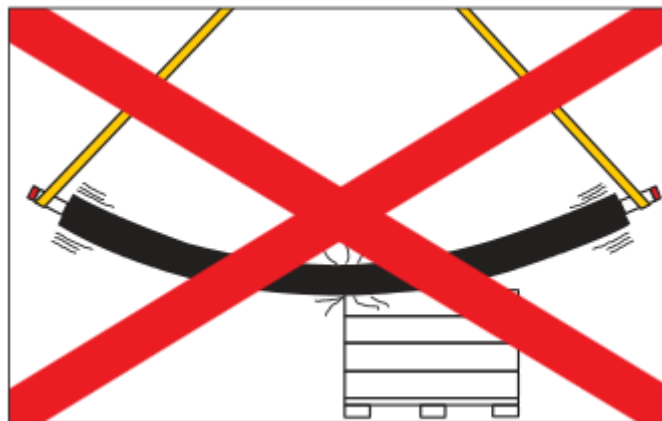
All plastic materials become more rigid/sensitive towards wrong treatment at low temperatures. During the foaming process inner stresses have been induced to the outer casing which are affected by handling and working.

Note! When working with pipes in cold periods/areas follow the given instructions, even though the sun is shining. A cold pipe is not heated to summer conditions, just because the temperature suddenly rises.

The preheating rules at outdoor temperatures below +10°C also apply to foaming and application of sealing strips/mastic etc.

##### 3.1.1 Handling.

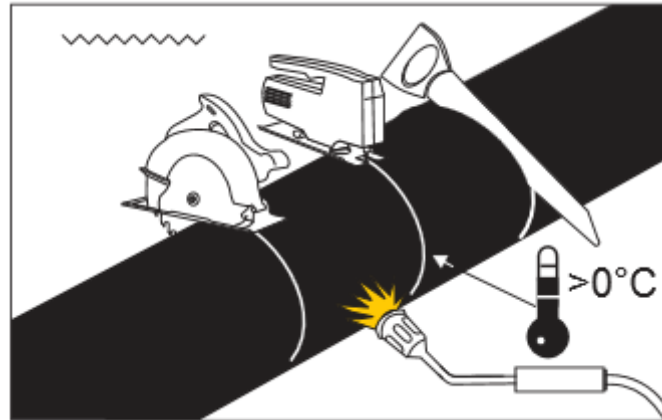
Do not expose the outer casing to extreme influences - e.g. impacts, shocks, large deflections and strong compressive forces - when handling it in cold periods/areas



### 3.1.2 Cutting and Adaption

Prior to cutting preheat the outer casing with a soft gas flame to frostfree condition. Notice that the heat relatively slowly penetrates the plastic material. Do not superheat, especially not on locations where plastic weldings are later carried out.

Use a tent and a heating gun, if large wall thicknesses and diameters are to be preheated



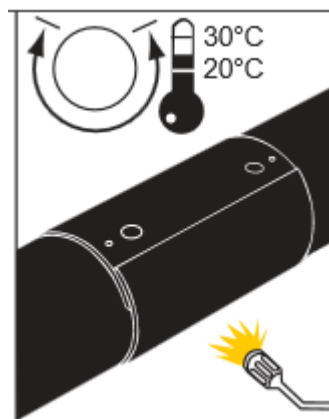
### 3.1.3 Storage and use of foaming liquids

Foaming liquids should be stored at 15-25°C.

Under winter conditions this means: indoors or in suitable heated storage containers.

### 3.1.4 Foaming preparations

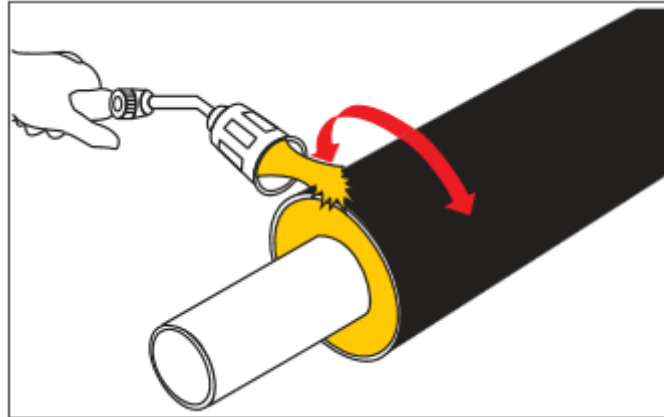
If job-site temperature is less than +10°C, then preheat the joint parts with a soft gas flame to 20-30°C, just before filling in the foam liquid.



### 3.1.5 Sealing strip

Should be stored at temperatures of 10-20°C to prevent it from becoming rigid and cold to work with. (The adhesiveness is reduced).

At installation temperatures below 10° C the outer casing ends must be preheated, before installing sealing strip. Also preheat the flanges of steel fittings to achieve a good adhesiveness



#### 4.1 General design philosophy

Insulation is most efficiently applied by a combination of the following methods:

- In-workshop insulation of straight pipes and on-site insulation of joints.
- In-workshop insulation of spools and on-site insulations of joints.

The ease of in-house handling and insulation of straight pipes, using on-site straight joints and special joints for tees, elbows and reductions, should be taken into account during the layout and sectioning of the pipe-arrangement.

In-house insulation of spools (i.e. combinations of straight pipes and fittings) is also available. Spool- welds subject to inspection, leak-test, NDT or similar, shall be tested prior to insulation.


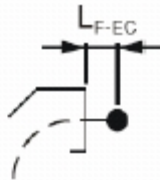
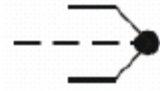
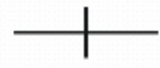
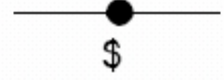
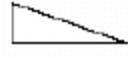

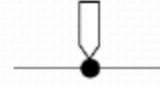



The joint area is left un-insulated by stopping the insulation 150 mm from the end of the cargo-pipe. This leaves 300 mm free pipe for installation work and the joint is covered on-site by insulation shells, foaming and jacket material with a watertight connection to the pre-insulated spool or pipe.

The insulation is terminated by a stainless steel low temperature end cap (EC-LT) ensuring a vapor and watertight system.

Some simple design rules should be followed in order to achieve an optimal insulation of the pipe – arrangement.

The following symbols are used to illustrate the design rules:

Straight pipe	
Insulated pipe	
Welding	
Elbow	
Tee	

Termination (EC-LT)	
Termination EC-LT (bend)	
Termination HDHEC	
Termination Special	
Fieldwelding	
Reduction	
Flange	
Weldolet or boss	
Supports	
Preinsulation	
Anchor	

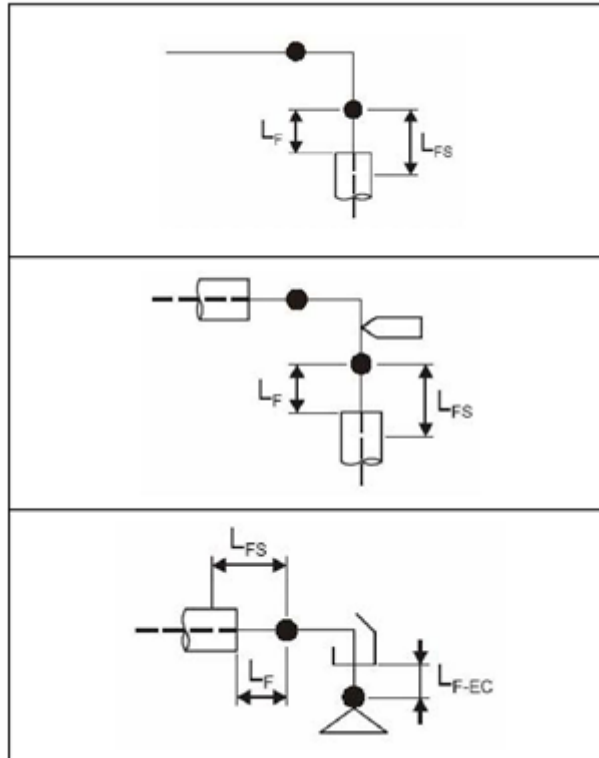
LF = 150 mm, length free end LFS = 300 mm, length from free end to support LF-EC = 50 mm,  
Length free end to termination

#### 4.1.1. Straight pipes

Straight pipes are to be insulated in-house

#### 4.1.2. Elbows

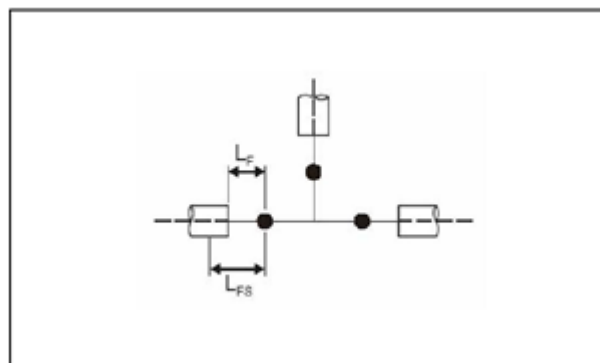
In order to insulate an elbow in general at least 150 mm un-insulated straight pipe followed by 150 mm pre-insulated straight pipe must be available:



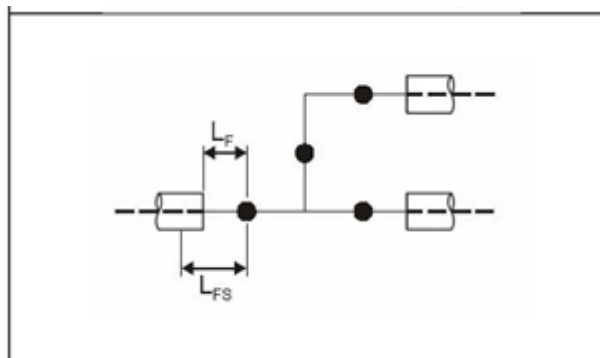
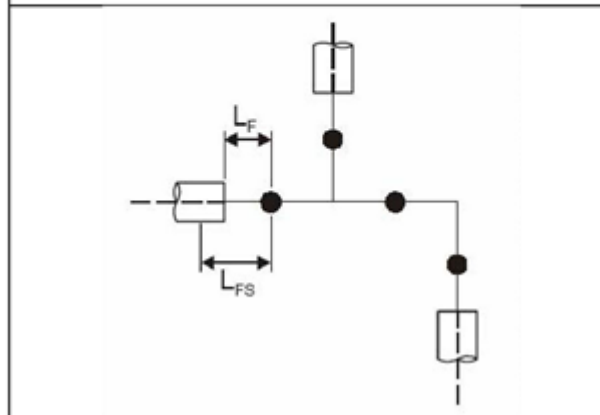
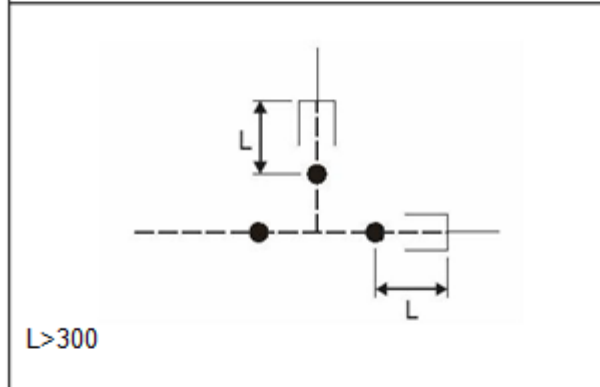
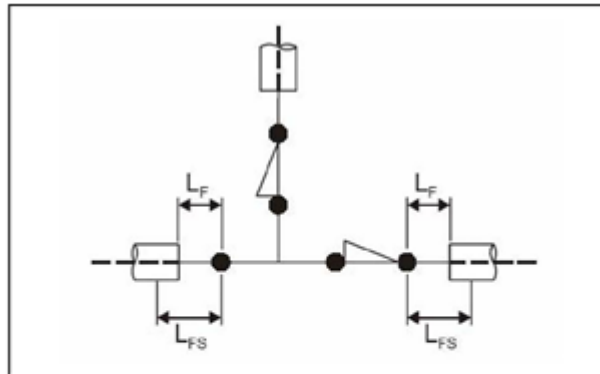
#### 4.1.3. Tees

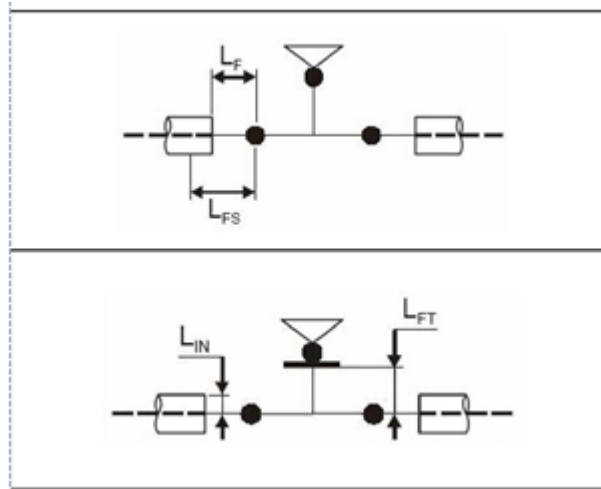
A tee is insulated by installing the jacket tee from the branch side. In general at least 300 mm are necessary in order to join the jacket tee to the pre- insulated pipe.

$L > 300$









#### 4.1.4. Weldolets or bosses

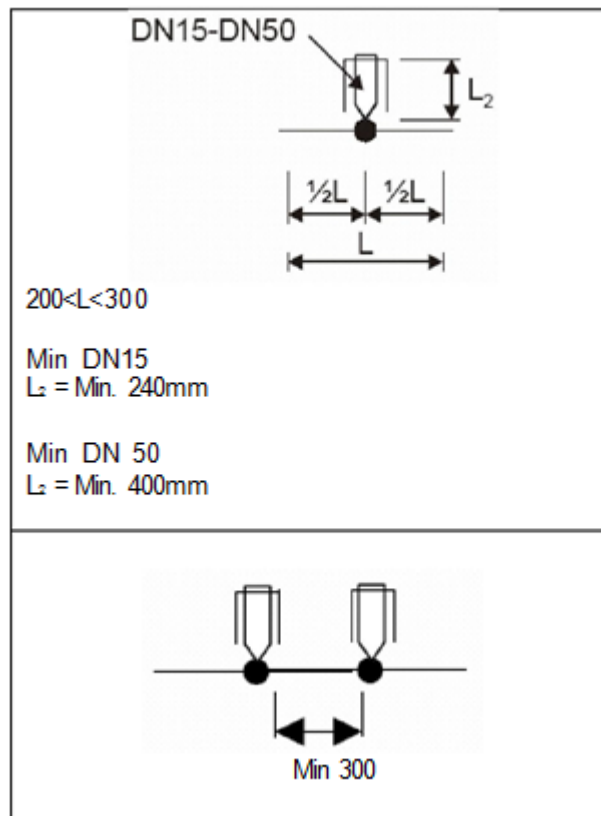
Weldolet or bosses are defined as small branches welded to the surface of the straight pipe. In general no component must be placed closer than 300 mm from weldolet or boss.

$200 < L < 300$

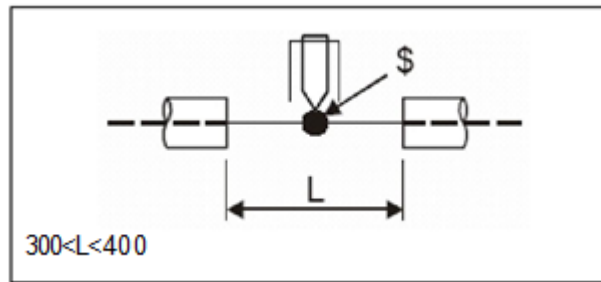
Min DN15  $L_2 = \text{Min. } 240\text{mm}$

Min DN 50  $L_2 = \text{Min. } 400\text{mm}$

Min 300

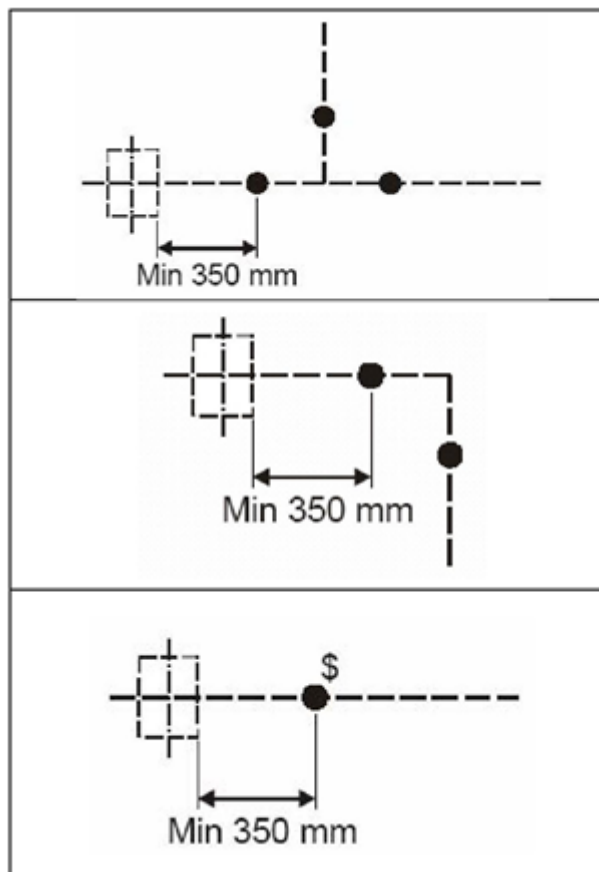


$300 < L < 400$



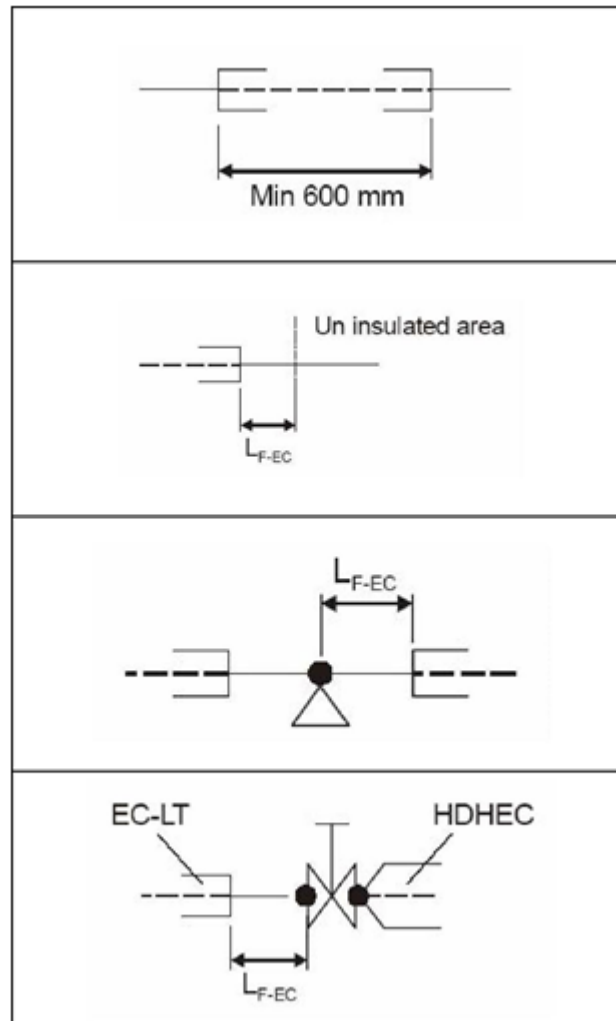
#### 4.1.5. Supports

Support can be placed anywhere on the straight jacket. The load transferred to the jacket should not exceed 0,22 MPa and the support shall be able to compensate for the tolerance of the outer diameter of the insulation system. In general supports must not be placed closer than 350 mm from a component or field welding.



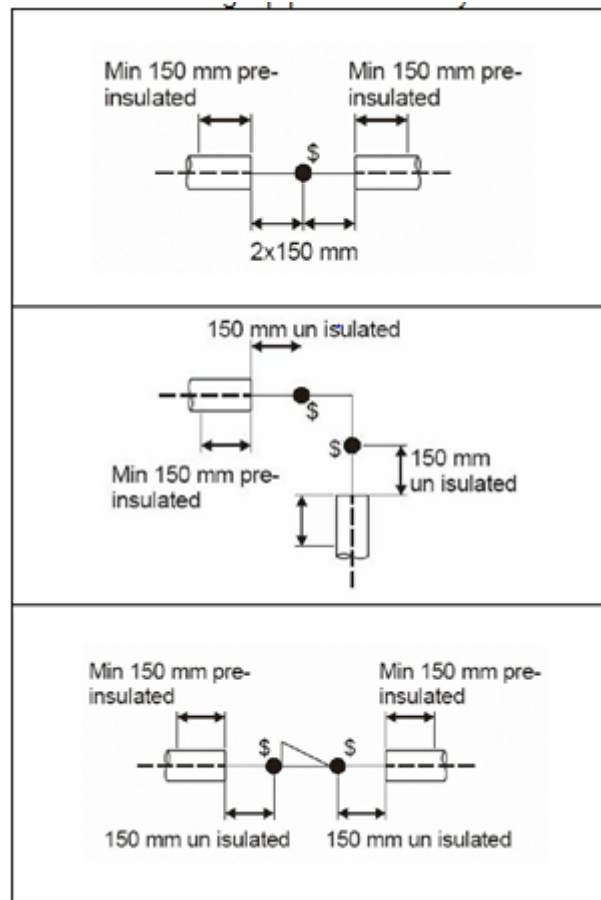
#### 4.1.6. Terminations

The insulations are terminated with a special stainless steel low temperature end cap (EC-LT). This end cap is use at all places where the insulation is terminated.



#### 4.1.7. Field weldings

Field weldings can be assembly and welding of two straight pipe-ends, on-site welding and insulation of elbows to straight pipe-ends or on-site welding and insulation of reductions to straight pipe-ends. In all cases 150 mm un-insulated followed by at least 150 mm insulated straight pipe is necessary



#### 4.1.8. Special solutions

Solutions not covered by the above mentioned general rules should be reviewed in close corporation with the design people at LR MARINE. On exceptional case to general design philosophy above, proper measurements shall be taken after consultation with yard