

Technical Seminar for Cathodic Protection to GOGC Design Unit Specialists

*Dr. Nick Kioupis, Cathodic & Lightning Protection
Section Head, DESFA*



WITHIN THE JURISDICTION OF THE MINISTRY OF ENVIRONMENT, ENERGY & CLIMATE CHANGE



Source of Development, Supplier of Energy



CRITERIA FOR THE SELECTION OF METALLIC PIPELINES COATINGS

GUIDELINES



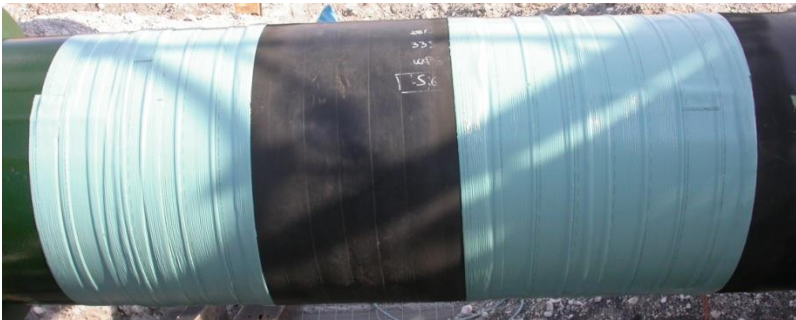
Critical coating technical parameters in relation to cathodic protection

- Dielectric strength
- Water absorption
- Cathodic disbonding
- Adhesion
- Oxygen permeability
- Resistance to microbial attack
- Method of application
- Mechanical properties
- Coating breakdown factor



Innovative improved coating materials for pipelines and related equipment

- **Viscoelastic Compounds**





OBJECTIVE

This guideline is intended for an usage by metallic pipelines users, designers or piping operators, to allow the selection of the correct coatings (type of use, cost, ease of application, ease of use) for pipes, fittings and accessories to afford protection against mechanical and/or corrosive action :

- from external sources (soil, atmosphere, water..)
- from the transported fluid (water, gas...).



External coating

The external coating must be chosen in the light of the hereafter reported factors:

- characteristics of the pipes;
- geographical and physical location;
- environment of the pipe;
- accessibility of the structure;
- proximity to other structures;
- operating temperature;
- ambient temperature and mechanical stresses during the application of the coating, transport, storage, installation and hydraulic testing;
- durability of the structure and cost of maintenance;
- any system of active protection;
- economic conditions.



The following specific factors are to be considered:

Underground pipes:

- nature of the ground: mechanical, physico-chemical and biological characteristics;
- mechanical stresses transmitted by the ground: dynamic and static loads and stresses from backfilling, penetration of roots;
- possible formation of electrochemical cells, presence of stray currents from d.c. or traction current installation, proximity of cathodic protection installation or cathodically protected structure, proximity of HV power transmission lines;



Underwater pipes, whether or not in underwater excavation:

- type of water: fresh, salt;
- mechanical stresses: shallow or at great depth, special laying condition or particular situation;

Overhead pipes:

- type of atmosphere: rural, mountainous, urban, marine, industrial;
- situation: overhead, in gallery, in tunnel, ventilated or not, humid atmosphere or not, etc.;
- mechanical stresses during installation;

Pipes coming out of the ground, or within the tidal range:

- nature of the ground, water and atmosphere;
- mechanical stresses;

Hot water or waste water pipes, when passing through walls:

- type of wall construction and others additional materials.



Internal coating

The coating must be chosen in relation to:

- the type of fluid to be carried: water, gas, oil, etc.;
- the characteristics of the fluid: chemical, physical, bacteriological composition;
- operating temperature and pressure;
- operating mode: temporary working or not, partially filled pipes or not, etc.

As regards the mentioned fluids, account must be taken above all of:

- water: tendency or not to form a protective metal oxide-calcium deposit;
- gas: dehydration-, desulphurization-, etc, treatments: presence of residual water, carbon dioxide, hydrogen sulphide and other sulphur-containing components and solid impurities;
- oil: presence or not of salt water, carbon dioxide, hydrogen sulphide, etc.



Summary table of the stresses and tests concerning the behaviour of the coating for underground pipes

	Transport, storage and handling	Installation	Hydrostatic tests	Operation	
Stresses involved	<p>Impacts (handling)</p> <p>Creep and penetration</p> <p>Friction</p> <p>Climatic alteration</p>	<p>Bending</p> <p>Shocks (backfilling)</p>	<p>Deformation of the pipe</p>	<p>Stresses from ambient environment</p> <p>Physico-chemical</p> <ul style="list-style-type: none"> - nature of the environment - chemical pollution - etc <p>Biological</p> <ul style="list-style-type: none"> - micro-organisms - etc <p>Mechanical</p> <ul style="list-style-type: none"> - soils stresses - etc <p>Thermal</p> <ul style="list-style-type: none"> - operating temperatures - etc 	<p>Presence of cathodic protection</p> <ul style="list-style-type: none"> - Water migration - Electroendosmosis - Detachment
Characteristics required	<p>Impacts strength</p> <p>Abrasion resistance</p> <p>Resistance to penetration under load</p> <p>Chemical stability of the coating</p>	<p>Flexibility</p> <p>Impacts strength</p>	<p>Flexibility</p> <p>Resistance to elongation</p> <p>Surface adhesion</p> <p>Crack resistance</p>	<p>Chemical composition of the coating</p> <p>Porosity, permeability</p> <p>Biological stability</p> <p>Adhesion to the steel, cohesion</p> <p>Cracking behaviour</p> <p>Resistance to elongation</p> <p>Thermal stability</p> <p>Behaviour in extreme temperatures and cycles</p>	<p>Adherence to the steel</p> <p>Chemical resistance to alkalis</p> <p>Low permeability to ionic substances</p>

Note: Stresses experienced by a coating and their transposition into typical test methods to evaluate the behaviour of the coating.



CRITERIA FOR THE SELECTION OF COATINGS FOR NON AND LOW ALLOY STEEL PIPES

The coatings which form the subject of this chapter apply to steel pipes either underground, immersed in fresh or salt water, belonging to transition zones (pipes coming out of the ground, subjected to tides), overhead, in a tunnel or installed in buildings.



1.2.1 International standards and draft standards

ISO 5256	Steel pipes and fittings for submerged pipelines. External and internal coating by bitumen or coal-tar derived materials.
ISO/DIS 5256	Steel pipes and fittings for onshore and offshore pipelines. External coating by bitumen or coal tar derived materials.
ISO/DIS 8324	Steel pipes and fittings for onshore and offshore pipelines. Internal lining with cement mortar.
ISO/DIS 10800	Steel pipes and fittings for onshore and offshore pipelines. External epoxy powder coating.
ISO/DIS 15741	Paints and varnishes. Friction-reduction coatings for the interior of pipelines for non-corrosive gases. Requirements and test methods.



1.2.2 European standards and draft standards

EN 10208/1	Steel pipes for pipelines for combustible fluids. Technical delivery conditions Part 1: Pipes of requirement class A.
EN 10208/2	Steel pipes for pipelines for combustible fluids. Technical delivery conditions Part 2: Pipes of requirement class B.
EN 10208/3	Steel pipes for pipelines for combustible fluids Technical delivery conditions Part 3: Pipes of requirement class C.
EN 10224	Non-alloy steel tubes and fittings for the conveyance of aqueous liquids including water for the human consumption. Technical delivery conditions.
pr EN 10311	Joints for the connection of steel tubes and fittings for the conveyance of aqueous liquids including water for the human consumption
EN 10240	Internal and/or external protective coatings for steel tubes. Specification for hot dip galvanized coatings applied in automatic plants.
pr EN 10285	Steel pipes and fittings for onshore and offshore pipelines. External three layer extruded polyethylene based coatings.
pr EN 10286	Steel pipes and fittings for onshore and offshore pipelines. External three layer extruded polypropylene based coatings.



pr EN 10287	Steel pipes and fittings for onshore and offshore pipelines. External fused polyethylene based coatings.
EN 10288	Steel pipes and fittings for onshore and offshore pipelines. External two layer extruded polyethylene based coatings.
EN 10289	Steel pipes and fittings for onshore and offshore pipelines. External liquid applied epoxy and epoxy-modified coatings.
EN 10290	Steel pipes and fittings for onshore and offshore pipelines. External liquid applied polyurethane and polyurethane-modified coatings.
pr EN 10298	Steel pipes and fittings for onshore and offshore pipelines. Internal lining with cement mortar.
pr EN 10300	Steel pipes and fittings for onshore and offshore pipelines. External coatings by bitumen or coal-tar derived materials.
pr EN 10301	Steel pipes and fittings for onshore and offshore pipelines. Internal coating for the reduction of friction for conveyance of non-corrosive gases.
pr EN 10309	Steel pipes and fittings for onshore and offshore pipelines. External epoxy powder coating.
pr EN 10310	Steel pipes and fittings for onshore and offshore pipelines. Internal and external polyamide powder based coating.
EN 12068	Cathodic protection. External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection. Tapes and shrinkable materials.



German standards

DIN 30670	Umhüllung von Stahlrohren und -formstücken mit Polyethylen.
DIN 30671	Umhüllung (Außenbeschichtung) von erdverlegten Stahlrohren mit Duroplasten.
DIN 30673	Umhüllung und Auskleidung von Stahlrohren, -formstücken und -behältern mit Bitumen.
DIN 30675-1	Äußerer Korrosionsschutz von erdverlegten Rohrleitungen.
DIN 30678	Umhüllung von Stahlrohren mit Polypropylen.

1.3.1 External coatings for underground pipes and those coming out of the ground⁽¹⁾

Coating	Constitution	Minimum usual thickness [mm]	
Hydrocarbon materials	coal-tar or oil asphalt reinforced with cloth, fabric or glass composite	according to class and diameter	3.0 4.0 6.0
Polyethylene	powdering 2 or 3 layers extrusion 2 or 3 layers	$\Phi \leq 100$	1.8
		$100 < \Phi \leq 250$	2.0
		$250 < \Phi \leq 500$	2.2
		$500 < \Phi < 750$	2.5
		$\Phi \geq 750$	3.0
Polypropylene	extrusion 3 layers	$\Phi \leq 100$	1.2
		$100 < \Phi \leq 250$	1.5
		$250 < \Phi \leq 500$	1.8
		$500 < \Phi < 750$	2.0
		$\Phi \geq 750$	2.5
Thermosetting resins	powder epoxy	according to resin type	0.35 0.50
	liquid epoxy or modified liquid epoxy	as above	0.40 0.80 1.50
	liquid polyurethane modified liquid polyurethane	as above	1.00 1.50
Anti-corrosive tapes ⁽²⁾⁽³⁾	plastic tapes	total thickness	1.4
Shrink materials	bituminous tapes		3.0
	straight or split sleeves, tapes		1.5

(1) Solar protection is to be arranged for the part coming out of the ground.

(2) Generally applied with 50% overlap.

(3) Mainly used for repairs and remaking the coating at joints.



1.3.2 External coatings for underwater pipes, whether or not in underwater excavation, or in tidal zone

Coating	Constitution	Minimum usual thickness [mm]	
Polyethylene	extrusion 3 layers	$\Phi \leq 100$	2.5
		$100 < \Phi \leq 250$	3.0
		$250 < \Phi < 750$	3.5
		$\Phi \geq 750$	4.0
Polypropylene	extrusion 3 layers	$\Phi \leq 250$	2.0
		$250 < \Phi < 500$	2.5
		$\Phi \geq 500$	3.0
Thermosetting resins	powder epoxy	0.50	
	liquid epoxy or modified liquid epoxy	1.50	
	liquid polyurethane or liquid modified polyurethane	1.50	

Additional mechanical protection with reinforced concrete is recommended at least for the thermosetting resins and for the tidal zone.

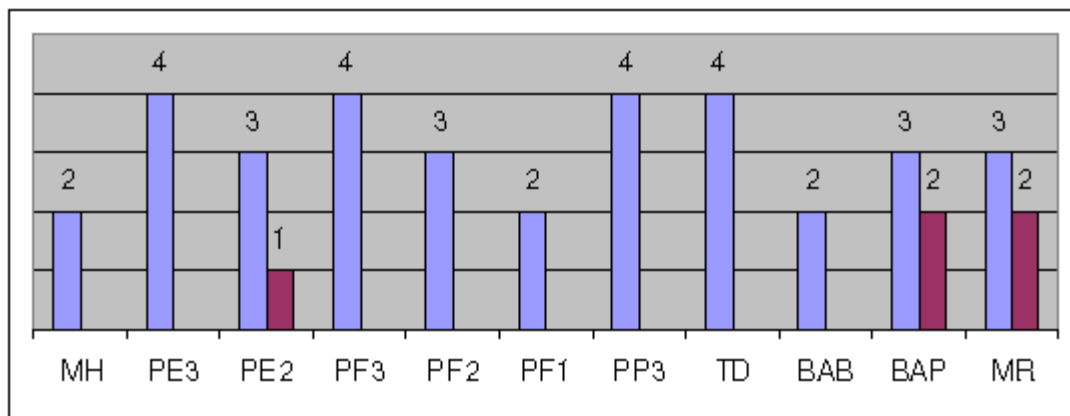
Hydrocarbon coatings, if necessary reinforced, may be used under water; the current tendency is to replace them with polyolefin or thermosetting coatings.



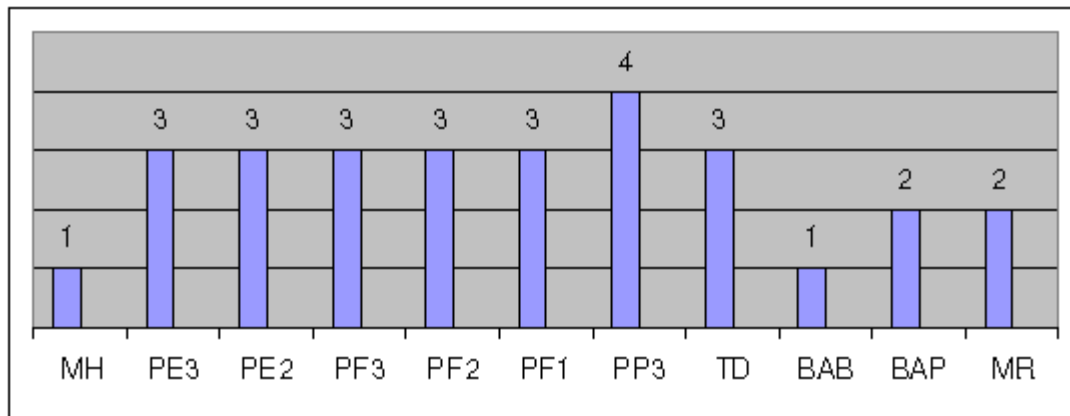
MH	= hydrocarbon materials		
PE	= extrusion polyethylene	PE3 = 3 layers PE2 = 2 layers	polymeric or mastic adhesive
PF	= fusion polyethylene	PF3 = 3 layers PF2 = 2 layers	PF1 = 1 layer
PP3	= extrusion polypropylene	3 layers	
TD	= thermosetting resins	epoxy powder liquid- or liquid-modified epoxy liquid- or liquid-modified polyurethane	
BAB	= bitumen anticorrosive tapes		
BAP	= plastic anticorrosive tapes		
MR	= shrink materials		



Adhesion



Impact resistance



1 = below average

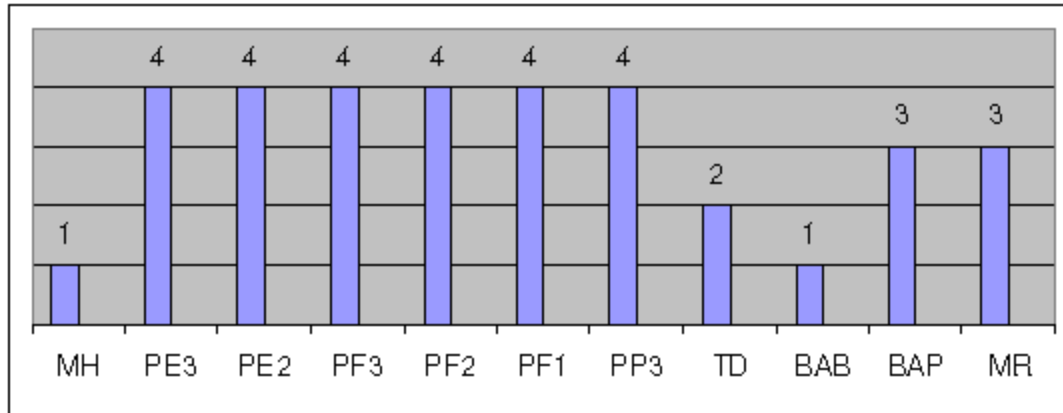
2 = average

3 = good

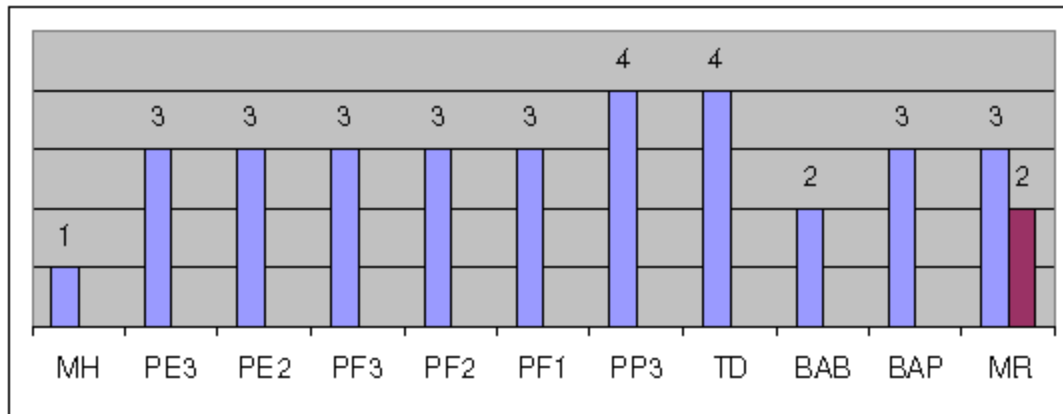
4 = excellent



Flexibility (elongation)

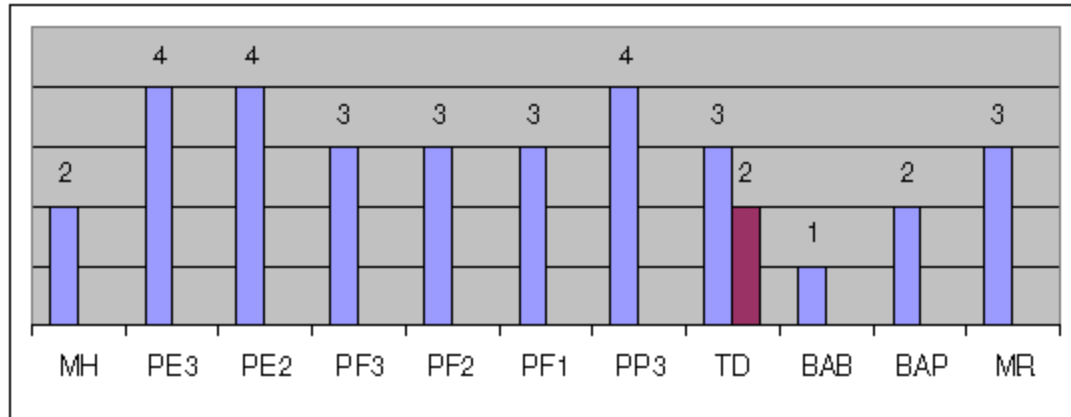


Indentation resistance

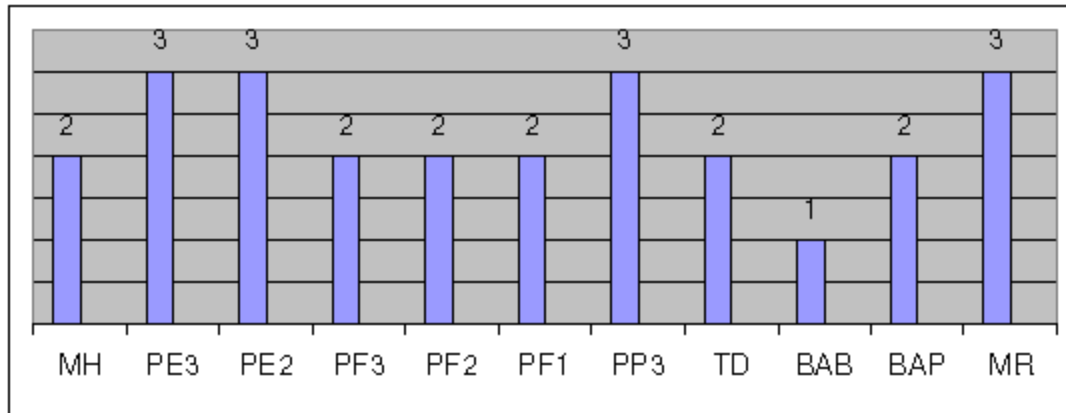




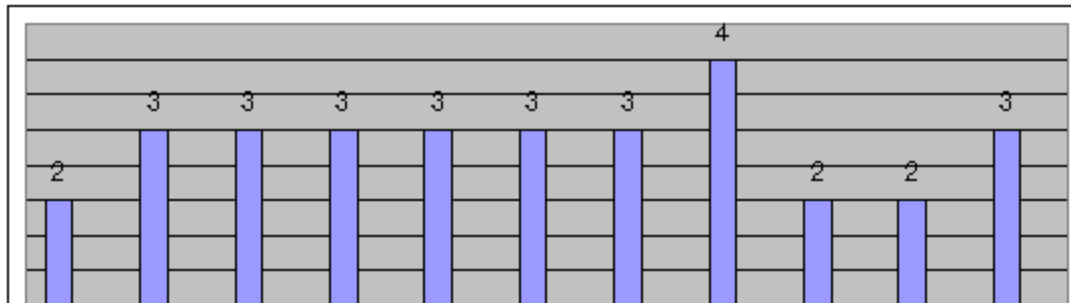
Impermeability to water



Impermeability to water vapour

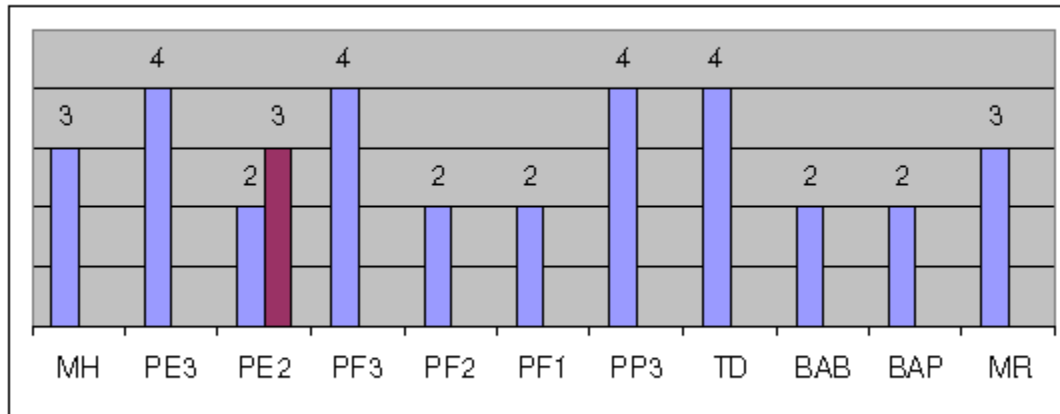


Impermeability to oxygen



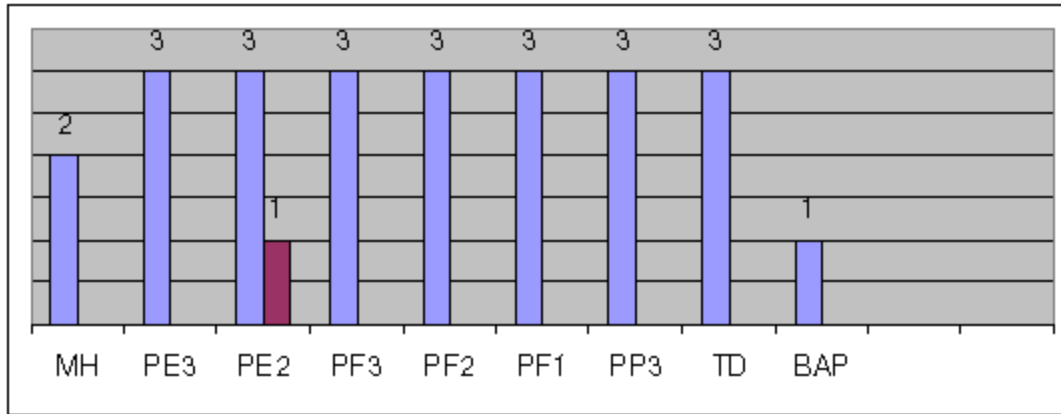


Resistance to the detachment under cathodic polarisation

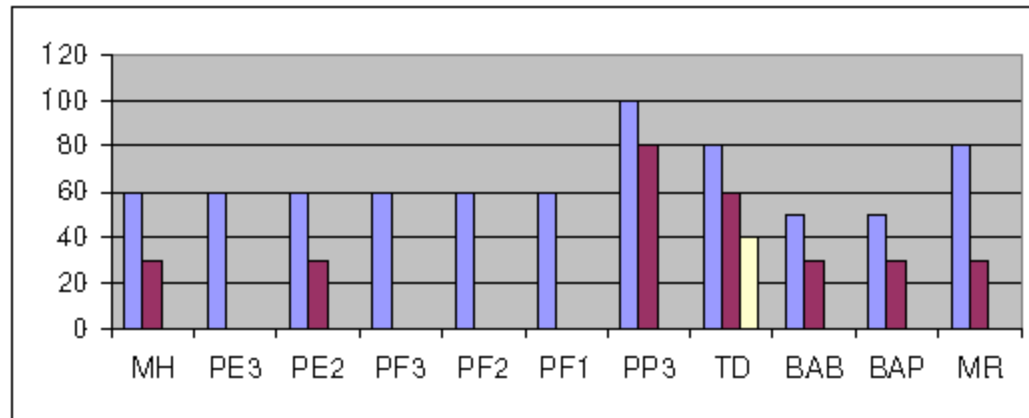




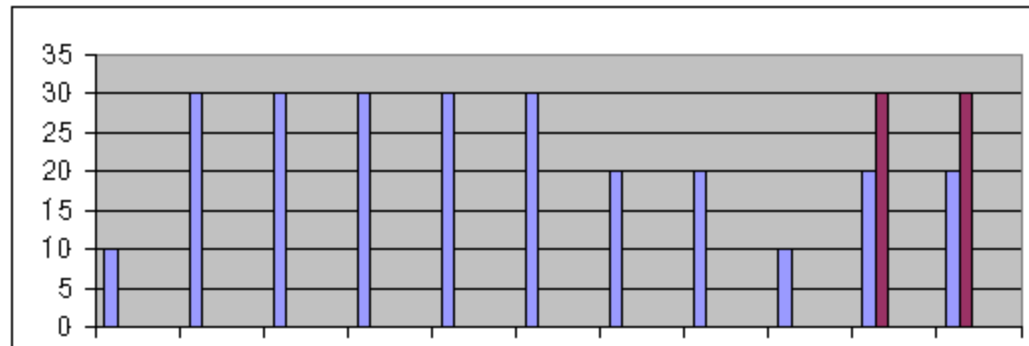
Suitability for outdoor storage



Maximum operating temperatures [+ °C]



Minimum operating temperatures [- °C]





1.5 COATINGS OF WELDED JOINTS FOR NON OR LOW ALLOY STEEL PIPES

The coating materials used for coating weld zones must meet two conditions:

- be suitable for protecting the pipes in the conditions of use (installation and operating temperature in particular);
- be compatible with the coating previously applied.

The conditions of application are those defined in the specifications for the corresponding materials or otherwise those agreed between the concerned parties (manufacturer of the coating and user).

The applied coating must cover the original coating over a sufficient length so that at overlapping it meets the values required in the specifications for the materials concerned.



1.5.1 External coatings of welded joints for underground, underwater pipelines

The main materials used are anticorrosive tapes and shrinkable products, or a combination of the two types.



1.5.1.1 Anti-corrosive tapes

- *Plastic tapes*
 - *Adhesive tapes by pressure*, made of a backing generally of plastic, covered on one of its surfaces with a thin adhesive layer. They are applied by pressure on a priming layer.
 - *Laminated types*, made of a plastic backing together with an elastomer, self-adhesive or not, on one of the two faces. They are applied over a priming layer.
- *Bitumen tapes*, made of a plastic or textile backing covered on one or both surfaces with a very thick insulating compound made mainly of hydrocarbon products (coal-tar, oil asphalt). They are generally hot-applied over a priming layer.



1.5.1.2 Shrink materials

- *Straight sleeve*, to be slipped onto the pipe before welding.
- *Split sleeve*, made of a sheet to wrap around the item to protect and seal at the overlap by a suitable arrangement, such as self-adhesive tape, sealing strip, etc: this system, whether or not cut to the sizes of the pieces to protect, enables applying the protection without having access to one of the ends of the pipe or accessory.
- *Preshaped set*, adapted for coating pieces of complicated shapes, such as pipeline accessories (branch connections, flanges, ...) or the ends of the pipe sleeves for example; the set can comprise apart sleeves (straight or split), sealing cups and plugs, I-shaped pieces, etc, depending on the shape of the piece to protect.
- *Shrink tape*, made of a backing precoated with an adhesive to helically apply around the pipe or the section of pipe to coat.



1.5.1.3 Filling-in products

These products intend to facilitate, thanks to their very large workability, application of the tapes and shrink products on uneven surfaces (weld beads, branch connections, flanges, taps, etc). They occur in different shapes (tape, plug, mastic, etc). They must be compatible with all the other parts of the applied system; their use must not adversely affect the quality of the coating once finished.



- Fittings: Bend, Tee, Taper, Y-shaped, Blank flange, etc.
- Taps, Valves.
- Instruments of regulation: Suction cup, Regulator of pressure or discharge, Air-valve.
- Mechanical joints: Flange, Opposition-Flange, Bolts and Nuts.

2.3.1.1 External coatings for underground fittings and those coming out of the ground ⁽¹⁾

Coating	Constitution	Minimum usual thickness [mm]	
Hydrocarbon materials	coal-tar or oil asphalt reinforced with cloth, fabric or glass composite	according to class and diameter	3.0 4.0 6.0
Polyethylene ⁽²⁾	powdering 1; 2 or 3 layers	$\Phi \leq 100$ $100 < \Phi \leq 250$ $250 < \Phi \leq 500$ $500 < \Phi < 750$ $\Phi \geq 750$	1.8 2.0 2.2 2.5 3.0
Polypropylene ⁽²⁾	powdering 1; 2 or 3 layers	$\Phi \leq 100$ $100 < \Phi \leq 250$ $250 < \Phi \leq 500$ $500 < \Phi < 750$ $\Phi \geq 750$	1.2 1.5 1.8 2.0 2.5
Thermosetting resins	powder epoxy ⁽²⁾	according to resin type	0.35 0.50
	liquid epoxy or liquid modified epoxy	as above	0.40 0.80 1.50
	liquid polyurethane or liquid modified polyurethane	as above	1.00 1.50
Anti-corrosive tapes ⁽²⁾⁽³⁾	plastic tapes	total thickness	1.4
Shrink materials ⁽⁴⁾	bituminous tapes		3.0
	straight or split sleeves, tapes		1.5

- (1) Solar protection is to be arranged for the part coming out of the ground.
 (2) These coatings are generally applied in the factory.
 (3) Generally applied with a 50% overlap.
 (4) Mainly used for repairs and remaking the coating at joints.