CONCRETE COATING FOR NEGATIVE BUOYANCY

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ABRACO

SEMINARIO REVESTIMENTOS 15-08-2019

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Concrete Weight Coating

- Targets: Negative buoyancy, Mechanical protection
- Where: Offshore, marsh areas and river crossing
- Process: Compression (Extrusion/Wrapping) and Impingement
- Raw materials: Cement, Aggregates, Iron Ore, water and steel wire mesh
- Features: Compressive strength, density, water absorption,
- Standards: ISO 21809-5
- State of the art

Concrete Weight Coating

"Concrete Weight Coating" is an heavy concrete that permits the pipeline engineer to meet "negative buoyancy" requirements of pipelines to be installed in swamp areas, rivers crossing and offshore. In addition to its primary function of adding weight to pipeline, concrete protects the pipe and its anticorrosion coating.

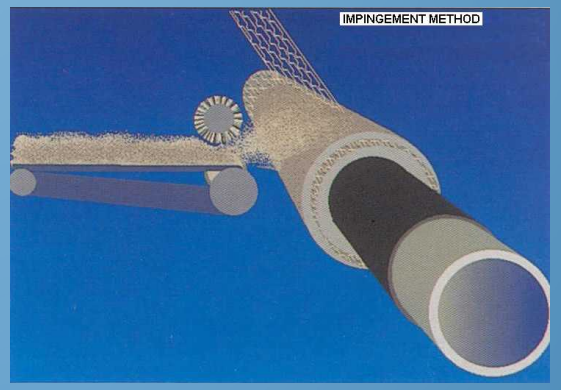
The concrete coating characteristics depends on different factors such as sea bottom conditions, water depth, currents, turbulences, fishing activities, pipe sizes, etc.

Concrete Weight Coating

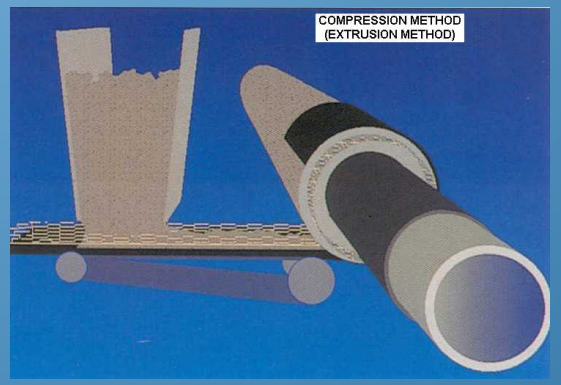
Application methods

Two methods are currently used to coat pipes with concrete:

IMPINGEMENT

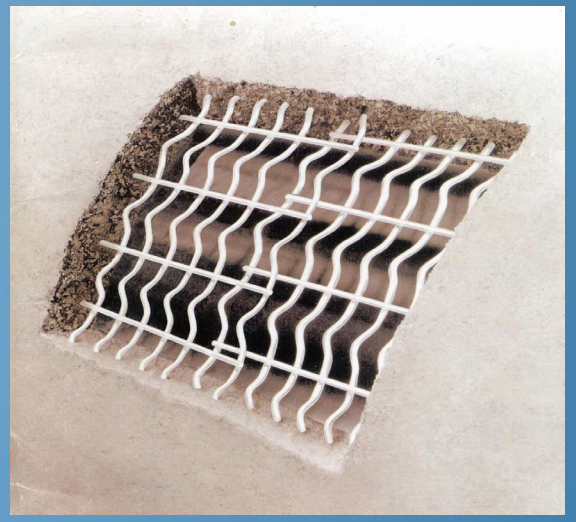


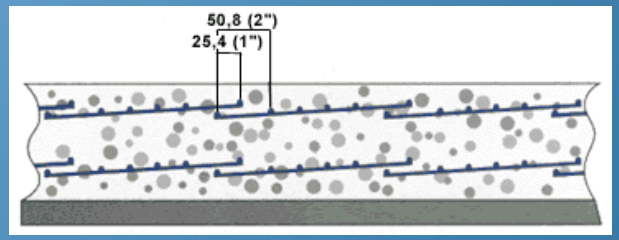
COMPRESSION (EXTRUSION/WRAPING)



Concrete Weight Coating

The concrete coating specification depends on different factors such as sea bottom conditions, depths, currents, turbulences, fishing activities, pipe sizes, etc.. An important coating elements is the **reinforcement**. The principal function of the reinforcement is to keep the concrete layer around the pipe, whatever the conditions. The coating is suffering badly during transportation, burying or by impact from anchors and towed fish-net. The coating properties, which are important, are the **compression strength, tensile strength and impact resistance. Intensive contact between concrete and reinforcement is imperative.** Concrete , including its consistency, bulk density, strength and durability, as well as reinforcement protection against corrosion, shall be met. Concrete shall comply with the following requirements: **minimum bulk density after curing shall be 2240 kg/m^3; water absorption by weight shall not exceed 5%**; durability at the operating temperature shall be equal to the operational life of the subsea pipeline; **minimum compressive strength in a 28 days after curing 40 MPa**. Concrete compressive strength shall be determined at testing of check specimens taken from the batches and cut out directly from the concrete coating in accordance with the requirements of EN 206, ASTM C39, ASTM C 42, BS 1881, BS 4019, BS 6089 or the national standards on agreement with the Register.



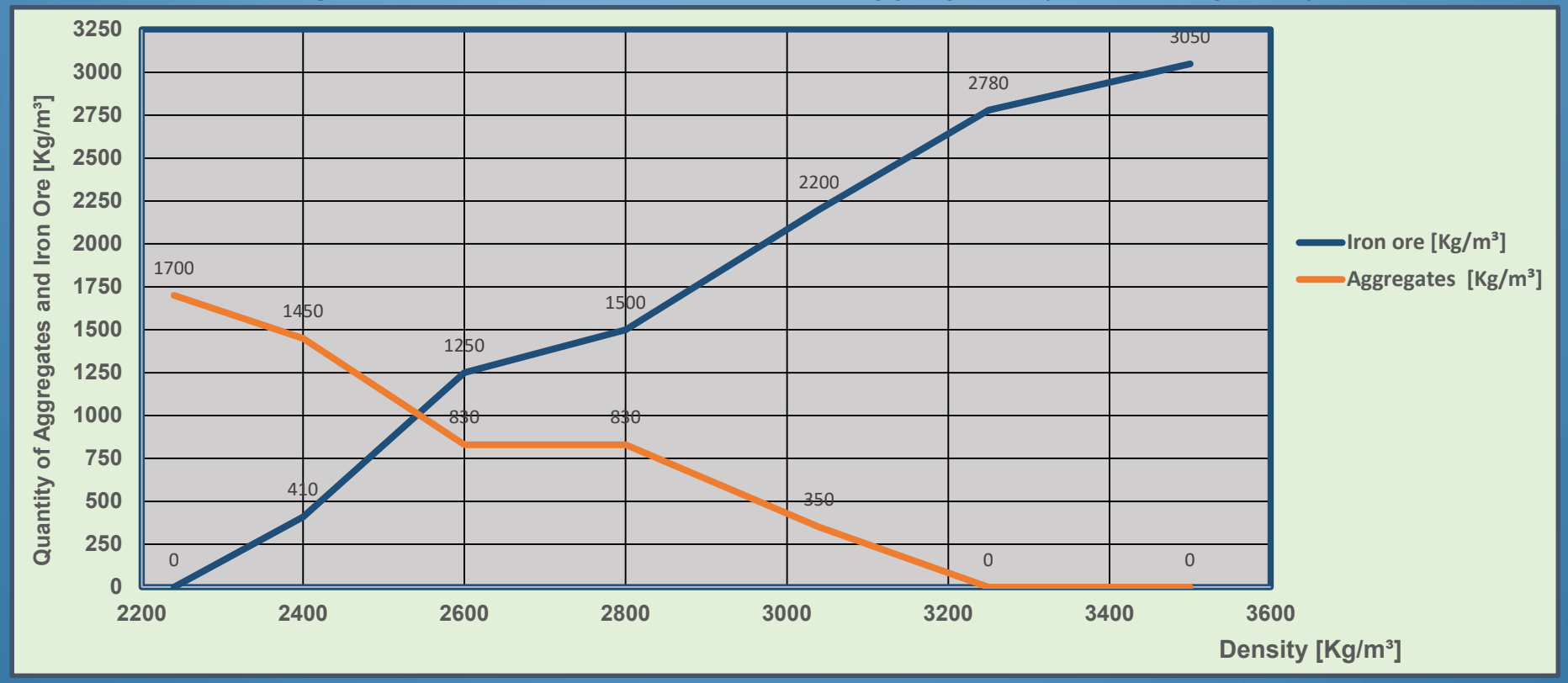


Concrete Weight Coating

DENSITY OF APPLIED CONCRETE COATING

- Minimum concrete density to be applied: 2240 Kg/m³ (140 pcf)
- Maximum concrete density to be applied: 3250 Kg/m³ (203 pcf)

Intermedium densities between 2240 and 3250 Kg/m³ will be reach with a variation percentage of iron ore instead of standard aggregates (sand and gravel)



Concrete Weight Coating

Raw Materials

Raw Material main characteristics

Properties and technical characteristics of raw materials for coating (cement, aggregates, reinforcement, water, etc.) shall comply with a performance specification, passport data and purchase specification.

Cement

Cement grades not less than 400 according to EN 197, BS 12 , ASTM C 150 , DIN 1164 or other national and international standards may be used for the concrete coating on agreement with the Register.

For submarine service conditions using concrete mixes containing Portland cement as the only cementitious material, the tri-calcium aluminate (Ca_3Al) content of the cement shall be less than or equal to 10,0 % and the alkali content shall not exceed 0,6 %, if potentially reactive aggregates are used.

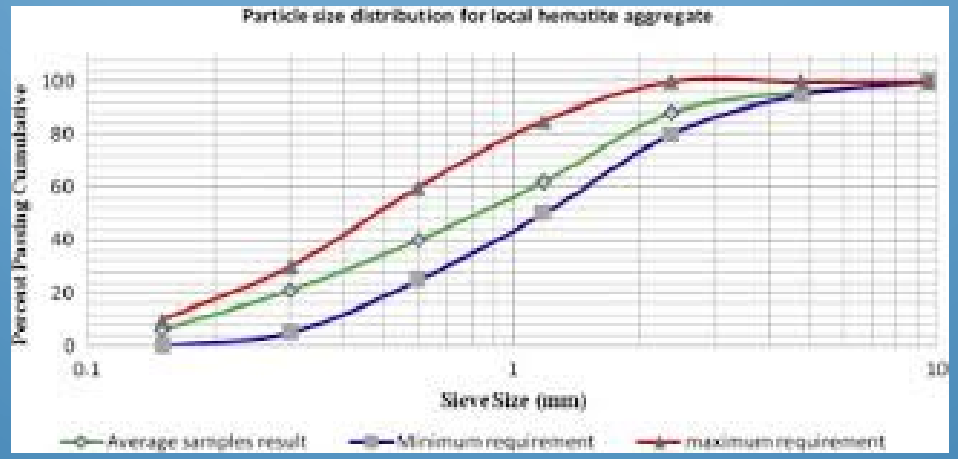
Water

Water for mixing concrete shall not contain harmful constituents in such quantities that could impair concrete curing, stiffening and strength or cause corrosion of reinforcing materials. Water for concrete mixing shall comply with the requirements of ASTM C 1602, EN 1008.

Concrete Weight Coating

Concrete aggregates

Concrete aggregates shall comply with the requirements of the national standards or regulations used in manufacture of the continuous concrete coatings. The aggregates shall not contain harmful constituents in such quantities that could affect the concrete strength, for example, in pipeline bending or cause corrosion of reinforcing materials in case of water permeability of the concrete. Use of aggregates with alkali-sensitive constituents is forbidden. The maximum grain size and grading 1 curve of the aggregate shall comply with EN 206, ASTM C 33 or other standards. The maximum grain size of gravel, iron or barium ore used as aggregates shall not exceed 10 mm .



Concrete Weight Coating

Steel Reinforcement

Steel reinforcement for the concrete coating shall consist of cylindrical cages manufactured by resistance welding of longitudinal and hooped mild steel reinforcement or other reinforcement as required by the procedure approved by the Register. Steel reinforcement may also be applied in the form of wire mesh (steeled or woven) which includes helicalically woven stripes (helical mesh) reinforcement. Diameter, surface condition, strength characteristics and marking of steel reinforcements shall comply with the requirements of international and national standards (e.g., EN 10080, BS 4482 and BS 4483, DIN 488) . The bars for the values shaped like a welded cage shall be not less than 5 mm in diameter. The maximum spacing between hooped bars is 120 mm. The minimum ratio between cross-sectional area of longitudinal and hooped reinforcement to the concrete coating area shall be **0,08 % and 0, 5 %** respectively. If a helical reinforcing mesh is used , the required number of layers depends on the concrete thickness and is determined according to the table below. The minimum distance from the reinforcement steel cage/mesh of the concrete weight coating to corrosion protection coating of the pipe shall be equal to 15 mm. The minimum thickness of the concrete layer above the reinforcement cage/mesh shall be the same.
The reinforcement shall be electrically isolated from the pipe and the pre-coating. This isolation shall be tested twice per production shift with a calibrated instrument. The resistance shall be greater than **10 000 Ω**.

Recommended number of layers of helical reinforcing mesh

Concrete thickness, in mm	Number of layers
< 60	1
61 — 100	2
101 — 140	3
> 140	4

Concrete Weight Coating

TENARIS shows the calculation method used to define characteristics of wire mesh (reinforcing concrete) to be used as reinforcement in the concrete weight coating.

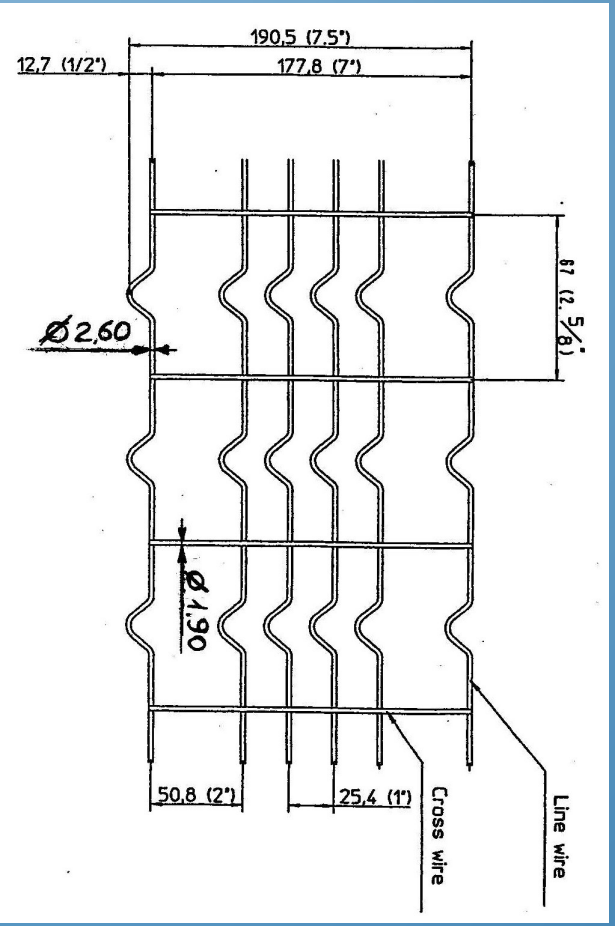
EXAMPLE

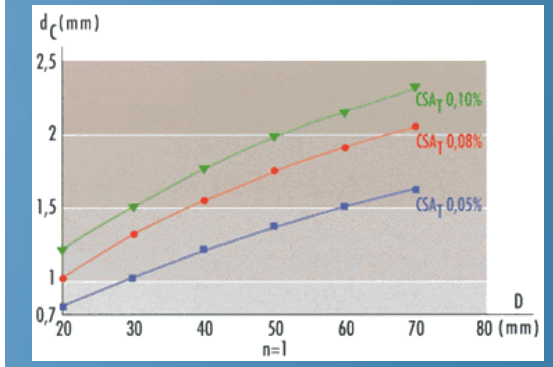
The requirement is for a:

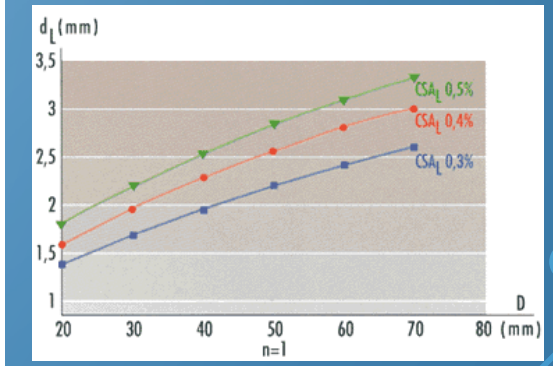
a) Longitudinal direction Cross Section Area ≥ **0,5%**
b) Transverse direction Cross Section Area ≥ **0,1%**

The product chooses by TENARIS is the following:

Manufacturer: BEKAERT
Type: New Armapipe:
mesh 67 mm x 25,4 mm
line wire diameter 2,6 mm
cross wire diameter 1,9 mm







Concrete Weight Coating

WIRE MESH "BEKAERT" type NEW ARMAPIPE

CROSS SECTION AREA

Item	Description	Unit		
1	Anticorrosion coated pipe diameter	mm	615.6	
2	Concrete thickness	mm	**97**	
3	Line wire diameter	mm	2.60	
4	Stay wire diameter	mm	1.90	
5	Number of layers	n°	2	
6	Number of line wires for 1 meter of applied wire-mesh	n°	78.74	
7	Area of the line wires for 1 m of wire-mesh	mm²	487.73	
8	Area of 1 meter of concrete in the section perp. to the line wire	mm²	97,000	
9	**C.S.A in the section perp. to the line wire**	**%**	**0.503**	**≥0.5**
10	Number of stay wires for 1 meter wire-mesh	n°	29.85	
11	Number of stay wires applied in the circular corona	n°	77.96	
12	Area of the stay wires in the circular corona	mm²	221.05	
13	Area of the concrete of the circular corona	mm²	217,154	
14	**C.S.A in the section perp. to the stay wire**	**%**	**0.102**	**≥0.1**
15	**RESULTANT C.S.A**	**%**	**0.605**	
			25,4 mm	
	New Armapipe 25,4x67		overlap	

CROSS SECTION AREA CALCULATION

In the table above the data will be interpreted as follows:

Row n°1 Pipe diameter including anticorrosion 609.6 mm + 2 x 3 mm = 615,6 mm
Row n°2 Concrete weight coating thickness required (97 mm)
Row n°3 Diameter of line wire 2,60 mm
Row n°4 Diameter of stay (cross) wire 1,90 mm
Row n°5 Number of layers of wire mesh to be applied in the concrete coating
Row n°6 Number of line wires present in a one meter longitudinal section of concrete weight coating applied
Row n°7 Surface of line wires present in a one meter longitudinal section of concrete weight coating applied [mm²]
Row n°8 Surface of one meter longitudinal section of concrete weight coating applied [mm²]
Row n°9 Cross section area Longitudinal direction obtained with a quotient between row n°7 and row n°8 [%]
Row n°10 Number of stay (cross) wires present in a one meter transverse section of concrete weight coating applied
Row n°11 Number of stay (cross) wires present in the transverse section (circular corona) of concrete weight coating applied
Row n°12 Stay (cross) wires surface present in the transverse section (circular corona) of concrete weight coating applied [mm²]
Row n°13 Surface of transverse section (circular corona) of concrete weight coating applied [mm²]
Row n°14 Cross section area Transverse direction obtained with a quotient between row n°12 and row n°13 [%]
Row n°15 Sum of longitudinal direction Cross section area and transverse direction Cross section area obtained with the addition of row n°9 and row n°14 [%]

Concrete Weight Coating

FEATURES/CHARACTERISTICS			
Property	**Test method**	**Requirements**	**Tolerance**
Density	ASTM C642 EN 12390-7	Range: 2240-3040 Kg/m^3	±5 %
Shear Strength	As per 21809-5 Annex B	≥ 0.5 MPa	N/A
Compression Strength	ASTM C39, ASTM C42, ASTM C1604 or EN 12390-3	≥ 40 MPa	N/A
Water Absorption	As per 21809-5 Annex A	≤ 5%	N/A
Impact resistance	DNV-RP-F111	≥ 12 KJ	N/A

Concrete Weight Coating

Density	ASTM C642 EN 12390-7	Range: 2240-3040 Kg/m^3	±5 %

Concrete Weight Coating

NEGATIVE BUOYANCY					
NB=((Wwst+m + αβWc + (Dc^2 - Dst^2)*3,1416/4 * γm * 2*l)*1/L) - Dc^2 * 3,1416/4 * γw					
Items	Symbol	Unit	Value min	Value average	Value max
Negative Buoyancy	NB	Kg/m	66.18	73.53	80.89
Weight of steel pipe including anticorrosion coating and reinforcement	Wwst+m	Kg		513.76	
Weight reduction factor from fresh to cured for 28 days	α			0.967	
Weight increase factor between fresh concrete and concrete satured with water; this factor shall be deduced from absorption tests	β			1.05	
Specific gravity of concrete coating	γc	Kg/m³		2240	
Weight of freshly concrete coating: including reinforced if wire mesh is used	Wc	Kg		1542.07	
External concrete coated pipe diameter: average of 5 equally spaced measurements on the pipe length	Dc	m		0.3511	
External steel pipe diameter	Dst	m		0.2191	
Specific gravity of field joint filling material	γm	Kg/m³		500	
Length of concrete cut back at each end of the pipe	l	m		0.38	
Length of steel pipe	L	m		12	
Specific gravity of sea water	γw	Kg/m³		1050	
Wall Thickness of steel pipe		m		0.0079	
Thickness of anticorrosion coating		m		0.0025	
Specific gravity of steel		Kg/m³		7850	
Specific gravity of anticorrosion coating		Kg/m³		960	
Concrete coating thickness		m		0.0635	

NEGATIVE BUOYANCY

(submerged weight)

Negative buoyancy is the weight of coated pipe (steel pipe, anticorrosion coating, concrete weight coating and field joint coating) less the positive buoyancy of coated pipe when it is considered as a closed cylinder submerged in water. The cut back in each end filled up with field joint coating material shall also be taken into consideration.

Concrete Weight Coating

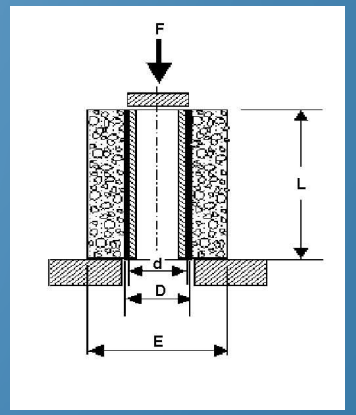
Shear Strength	As per 21809-5 Annex B	≥ 0.5 MPa	N/A

SHEAR STRENGTH

between applied concrete and anticorrosion coating surface

In order to calculate the shear strength resistance between concrete and polyethylene anticorrosion coating the following calculation should be made:

$$S = \frac{F}{\pi \times D \times L}$$



Where:

S = Shear stress resistance between concrete and anticorrosion coating [Kg_f/cm^2]

F = Applied load [Kg_f]

L = Specimen length [cm]

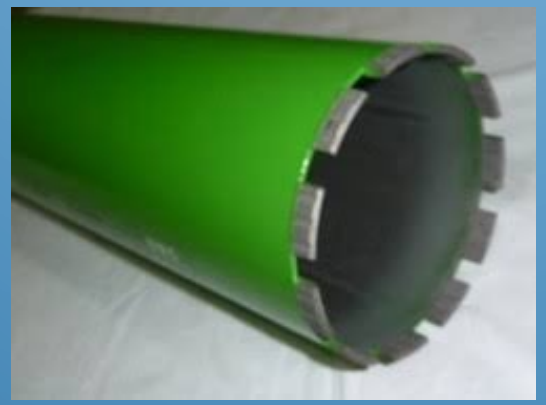
D = Concrete internal diameter [cm]

E = External concrete diameter [cm]

d = Pipe nominal diameter [cm]

Concrete Weight Coating

Compression Strength	ASTM C39, ASTM C42, ASTM C1604 or EN 12390-3	≥ 40 MPa	N/A



Concrete Weight Coating

Water Absorption	As per 21809-5 Annex A	≤ 5%	N/A

Concrete Weight Coating

Impact resistance	DNV-RP-F111	≥ 12 KJ	N/A

Concrete Weight Coating

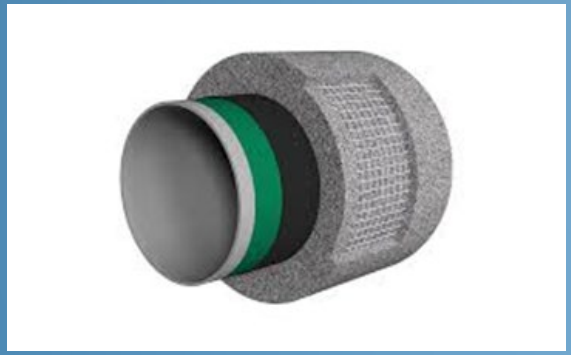
STANDARDS

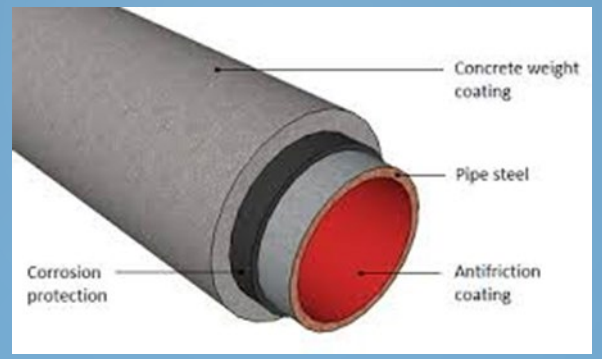
ISO 21809-5:2017, Petroleum and natural gas industries -External coatings for buried or submerged pipelines used in pipeline transportation systems - Part 5:External concrete coating.

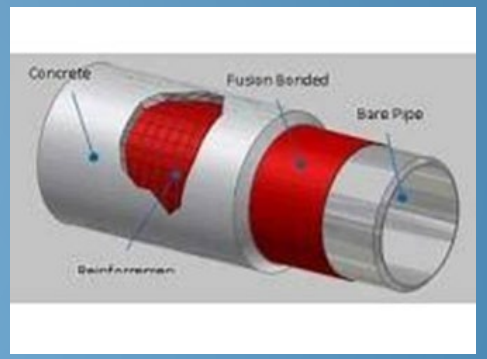
AS 1303 Steel Reinforcing Wire for Concrete
AS 3972 Portland and Blended Cements
ASTM A82 Steel Wire, Plain for Concrete Reinforcement
ASTM A185 Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A615M Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C33 Standard Specification for Concrete Aggregates
ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C87 Standard Test Method for Effect of Organic Impurities in Fine Aggregates on Strength of Mortar
ASTM C125 Standard Terminology Relating to Concrete and Concrete Aggregates
ASTM C136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C227 Standard Test Method for Potential Alkali Reactivity of Cement Aggregate Combinations
ASTM C294 Standard Descriptive Nomenclature for Constituents of Concrete Aggregate
ASTM C295 Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C642 Standard Test Method for Density, Absorption and Voids in Hardened Concrete
BS 1881 Methods of Testing Concrete
BS 3148 Methods of Test for Water for Making Concrete (including notes on the suitability of the water)
BS 4482 Hard Drawn Mild Steel Wire for the Reinforcement of Concrete
BS 4483 Specification for Steel Fabric for the Reinforcement of Concrete
BS 4449 Specification for Carbon Steel Bars for Reinforcement of Concrete
ISO 4012 Concrete. Determination of Compressive Strength of Test Specimen.

Concrete Weight Coating

Product







Industrial Application

Cage steel reinforcement

Concrete Weight Coating

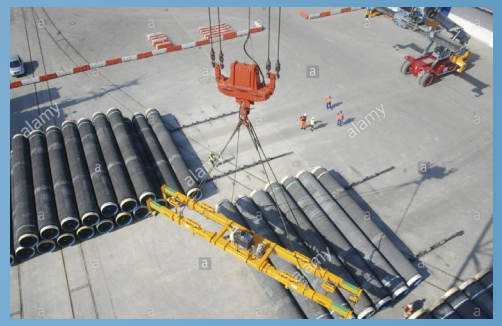
Curing and storage at site

Anodes Installation

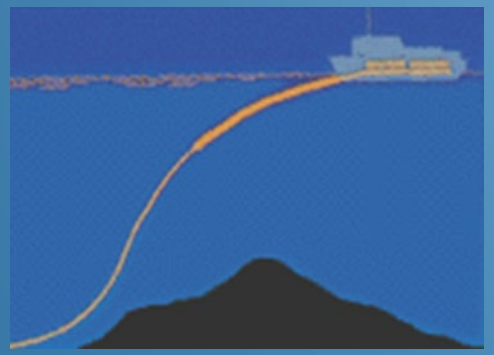
Concrete Weight Coating

Movement and transport






Installation (laying)





Concrete Weight Coating

Thanks for your patience!!!

Questions?

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