

# Polyurethane Coating and Lining on Ductile Iron Pipes

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**Abstract:** In this technical paper, we will discuss polyurethane linings and coatings to ductile iron pipe for transporting corrosive and abrasive fluids in a sub soil, that is extremely corrosive in nature. The capabilities of ECL (Electrosteel Castings Limited) in this regard will be discussed.

**Key words:** Polyurethane, lining, coating, ECL, ISI (Indian Standards Institution), test certificates, performance tests, provision, specification.

## 1. Polyurethane Linings and Coatings

Two types of “special lining and coatings” process are implemented at ECL (Electrosteel Castings Limited) Bansberia Works [1]:

A polyurethane epoxy coating (heavy duty) is applied to the outside wall of the pipe with a polyurethane lining (heavy duty) inside.

- ECL-Bansberia plant was built solely for the purpose of applying “special” types of coatings to ductile iron pipes manufactured at the ECL-Khardah Works. The “special” coatings are designed to give greater external corrosion protection for pipes to be installed in aggressive soil conditions or for greater internal corrosion protection for pipes transporting highly corrosive liquids.

- The pipes which undergo the “special” external coating process are delivered with cement mortar lining already having been applied at the Khardah Works but with the external surface of the pipe uncoated (i.e. no zinc or other external coating on the pipe). The “special” external coating is applied in accordance with BS EN 15189.

- The pipes which undergo the “special” internal lining process are delivered with an external zinc or

zinc/aluminium coating having previously been applied at the Khardah Works. The pipes are then internally lined with the “special” standard polyurethane lining. The “special” Internal Lining is applied in accordance with BS EN 15655 - 2018.

- The bare pipes which undergo both “special” internal lining and external coating are hydrostatically tested at the Khardah Works before being transported to the Bansberia Plant for the “special” coatings and linings.

## 2. Provisions for Polyurethane External Coating as per BSEN15189-2006

BS EN15189-2006, this document defines the requirements and test methods applicable to factory applied external polyurethane coating (heavy duty) corrosion protection of ductile iron pipes and fittings conforming to EN 545, EN 598 and EN 969 [2].

- Standard: BS EN 15189:2006 (for PU).
- Brand: PROTEGOL UR COATING 32-49 (for PU).
- Manufacturer: TIB Chemicals, Germany (for PU).

## 3. Testing Sample for Performance Tests

Samples of the following dimensions are cut from coated pipe for performing [Table 1]:

(A) Impact strength	600 mm × 150 mm
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**Table 1 Testing sample for performance tests.**

	Test	EN 15189 Ref. Clause	Test Method Ref. Clause of EN 15189	Sample
I	Chemical resistance	6.1	7.2.1	Detached film
II	Impact strength	6.2	7.2.2	Coated pipe sample
III	Indentation resistance	6.3	7.2.3	Coated pipe sample
IV	Elongation at break	6.4	7.2.4	Detached film
V	Specific coating resistance	6.5	7.2.5	Coated pipe sample
VI	Ratio of coating resistance	6.5	7.2.5	Coated pipe sample

**Table 2 Performance tests of PU coating.**

Sl No.	Test	Sample	Date of test	Duration	Result
1	Chemical resistance	Detached film	15.10.2013	200 days	Pass
2	Impact strength	Coated pipe sample	05.02.2013	-	Pass
3	Indentation resistance	Coated pipe sample	30.01.2013	2 days	Pass
4	Elongation at break	Detached film	05.02.2013	-	Pass
5	Specific coating resistance	Coated pipe sample	05.02.2013	100 days	Pass
6	Ratio of coating resistance	Coated pipe sample	05.02.2013	-	Pass

**Table 3 Performance tests of PU coating with requisite clauses.**

Sl. No.	Parameter	Requirement	Clause	Test method	Clause
1	Chemical resistance	Less than 15% weight increase after immersion Less than 2% weight loss after drying	6.1	Immersion in deionised water EN ISO 62 method 2	7.2.1.1
		Less than 10% weight increase after immersion Less than 4% weight loss after drying		Immersion in diluted sulphuric acid 10% EN ISO 62 method 2	7.2.1.2
2	Impact strength	8 J/mm PU-coated pipe barrel 5 J/mm EP-coated spigot end (see EN 14901)	6.2	Dropping weight High voltage test	7.2.2
3	Indentation resistance	< 10% at 10 MPa	6.3	Indentation test	7.2.3
4	Elongation at break	> 2.5%	6.4	Tensile test	7.2.4
5	Specific coating resistance in 0.1 M NaCl	> $10^8 \Omega\text{m}^2$	6.5	Resostovotu test towel method or vessel method	7.2.5
6	Ratio of coating resistance	> 0.8	6.5	Res. 100 d/res. 70d	7.2.5

(B) Indentation resistance test 100 mm × 150 mm

(C) Specific coating resistance 175 mm × 200 mm

Detached PU film is collected from polymeric sheet of 100 mm × 500 mm attached to pipe body during coating for performing chemical resistance and elongation at break.

#### 4. Performance Tests of PU Coating

Performance tests were conducted at ECL, Khardah Works for performance requirements of EN 15189:2006 [Table 2, Table 3].

#### 5. Routine Tests of PU Coating

Routine tests were conducted at ECL, Khardah

Works for performance requirements of EN 15189:2006 [Table 4].

### 6. Type Test Certificates of Polyurethane Coated DI Pipes


Type Test Certificates for Polyurethane Coated DI pipes certified by NSF is attached below [Fig. 1].

### 7. Specifications for the EIL Project on Effluent Discharge Pipeline

It may be noted that the soil type along the pipe route is generally silty clay/clay/silty sand/sand/silt. The chemical characteristics for soil and ground water is ranging as follows [4].

**Table 4 Routine tests of PU coating.**

Sl. No.	Parameters	Requirements	Clause	Tests	Frequency	Clause
1	Surface preparation	SA 2.5 of EN ISO 8501-1	5.1	Visual	100%	7.1.1
2	Surface roughness	Ra > 10 µm	5.1	EN ISO 8503-1	min. 1/shift	7.1.1
3	Appearance and continuity	Uniform and smooth	5.2.1	Visual	100%	7.1.2
4	Minimum coating thickness	(x - 2σ) > 700 microns	5.2.2	Non destructive instruments error ± 10%	min. 1/shift	7.1.3
5	Pipe ends painted parts	Length depending on type of socket	5.3	Appropriate measures	10%	7.1.4
6	Repairs	Manufacturer's written instructions	5.4	High voltage test	100%	7.1.5
7	Marking	Legible and durable	5.5	Visual	10%	7.1.6
8	Non-porosity	No electrical break through at required test voltage	5.6	High voltage test instrument	1 per 1,000 pipes	7.1.7
9	Hardness	> 70 Shore D	5.7	Hardness test	min. 1/shift	7.1.8
10	Adhesion	> 8 MPa at 23 °C	5.8	Punch separation method acc. EN ISO 4624	1 per 1,000 pipes	7.1.9



**Addendum to Witness Test Reports**

NSF-WRC Unit 30 Fern Close, Pen-Y-Fan Ind Est, Oakdale, Newport, Gwent, NP11 3EH, UK

Report No	C123705/9	Page 1 of 8
Addendum to reports	C123705/1, C123705/3, C123705/5 and C123705/7	
Licence/Certificate No	N/A	
Client	Electrosteel Castings Limited Chak Bansberia, Bansberia Adconnagar, Hooghly West Bengal, India	
Authority & date	BSI Service Management Order Number: 7636211, 7636210 and 7987756	
Items tested	Special coatings for ductile iron pipes.	
Specification	BS EN 15189:2006 Clauses 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 6.1, 6.2, 6.3, 6.4 and 6.5 Type tests for product certification	
Results	- See Summary of Results on page 2	
Prepared by	Simon Warburton Laboratory Director	<i>S. Warburton</i>
Authorised by	Paul Davis Quality Manager	<i>P. Davis</i>
Issue Date	20/05/2013	
Conditions of Issue	<p><i>This test report relates to the inspection of a special coatings plant for the protection of ductile iron pipes at the manufacturer's premises against the requirements of the clauses of the standard detailed above Only. This test report does not represent NSF Certification or authorisation to use the NSF Mark. Authorisation to use the NSF Mark is limited to products appearing in the Company's Official NSF Listing (www.nsf.org). This test report relates only to those items that were tested at the manufacturer's premises during the visit.</i></p> <p>© NSF-WRC Ltd 2013</p>	

C123705/9 Special Coatings Plant Page 2 of 8

**TESTING, EXAMINATION AND ASSESSMENT OF DUCTILE IRON FITTINGS SUBMITTED AS AUDIT TEST SAMPLES**

**INTRODUCTION**

For the purposes of product certification the "special coatings" for ductile iron pipes, submitted on behalf of Elektrosteel, were tested and assessed against the requirements of BS EN 15189:2006 Clauses 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 6.1, 6.2, 6.3, 6.4 and 6.5 as indicated on the following pages of this Report. This request was made on a BSI Service Management Order.

It is emphasised that assessments were not made against the other clauses of the Specification.

The tests and assessments contained in this Report were witnessed by Simon Warburton of NSF-WRC at the Manufacturer's premises on 27<sup>th</sup> April 2013.

The plant at Hooghly is a new Elektrosteel plant which has been operational for only a few months. The plant was built solely for the purpose of applying "special" types of coatings to ductile iron pipes manufactured at the Elektrosteel Khardah Works. The "special" coatings are designed to give greater external corrosion protection for pipes to be installed in aggressive soil conditions or for greater internal corrosion protection for pipes transporting highly corrosive liquids.

Ductile iron pipes manufactured at the Khardah Works are transported by road to the "special coatings" plant at Hooghly.

Two types of "special coatings" process are used at the plant:

- A polyurethane epoxy coating (Heavy duty) is applied to the outside wall of the pipe with standard cement mortar lining inside, or
- A ceramic epoxy coating (Heavy duty) is applied inside with standard polyurethane epoxy coating applied externally.

The pipes which undergo the "special" external coating process are delivered with cement mortar lining already having been applied at the Khardah Works but with the external surface of the pipe uncoated (i.e. no zinc or other external coating on the pipe). The "special" external coating is applied in accordance with BS EN 15189.

The pipes which undergo the "special" internal coating process are delivered with an external zinc or zinc/aluminium coating having previously been applied at the Khardah Works. The pipes are then internally coated with the "special" heavy duty ceramic epoxy coating and externally coated with standard polyurethane epoxy coating. There is no current standard specifically written for internal ceramic epoxy coating of ductile iron pipes so the "special" internal Ceramic epoxy coating was assessed using a combination of the requirements of BS EN 598, ISO 7186, BS EN 15189 and the manufacturer's own standard.

The pipes are hydrostatically tested at the Khardah Works before being transported to the Hooghly Plant.

Calibration records for all of the equipment used to demonstrate the testing was inspected and found to be in order.

**Fig. 1 Type test certificates of polyurethane coated DI pipes [3].****7.1 Soil**

- Sulphate ( $\text{SO}_3^-$ ): Nil to 95 (mg/L)
- Chloride: 164-506 mg/L
- pH: 7 to 9

**7.2 Ground Water**

- Sulphate ( $\text{SO}_3^-$ ): Nil to 95 (mg/L)
- Chloride: 108-347 mg/L
- pH: 7 to 9

**Table 5 Chemical Resistance Test for PU Lined DI Pipe.**

Property	Unit	Test method	Clause	Requirement
Mass change after 100 days in deionised water at 50 °C	%	Immersion test	7.2.3.2	Less than 15% weight increase
Mass change after subsequent drying	%	EN ISO 62, method 3		Less than 2% weight loss
Mass change after 100 days in 10% sulphuric acid at 50 °C	%	Immersion test	7.2.3.2	Less than 10% weight increase
Mass change after subsequent drying	%	EN ISO 62, method 3		Less than 4% weight loss

The use of polyurethane coating as per BS EN 15189:2006 has been stipulated having a coating of 1,000 micron.

## 8. Provisions for Polyurethane Internal Lining as per BSEN15655-1:2018

BS EN15655-1:2018, this document defines the requirements and test methods applicable to factory applied internal polyurethane heavy duty corrosion protection of ductile iron pipes and fittings conforming to EN 545, EN 598 and EN 969 [5].

- Chemical resistance (Clause 6.1) [Table 5]

The chemical resistance is determined by the change in weight of the polyurethane lining in neutral or acid conditions. When tested in accordance with 7.2.3 the weight increase respectively, weight loss shall meet the requirements given in Table 3 when compared to the original weight.

- Indirect impact strength (Clause 6.2)

Due to handling activities, the PU-lined pipes may fall or get impacts from outside with minor plastic deformations which can cause damages on the lining. The minimum impact strength shall be determined in accordance with the test method defined in 7.2.4 with an impact energy  $E$  of at least 50 J. The lining shall subsequently show no damage when tested in accordance with 7.1.8 Water use efficiency, Flood and Drainage.

- Resistance to ovalization (Clause No. 6.3)

The requirements of EN 545 or EN 598 shall be applied.

- Elongation at break (Clause No. 6.3)

The elongation at break shall be assessed by testing in accordance with the test method defined in 7.2.6.

The lining shall have a minimum elongation at break of 2.5%.

- Glass transition temperature (Clause No. 6.3)

The lining material shall conform to the limits of change in glass transition temperature ( $\Delta T_g$ ) determined by DSC (Differential Scanning Calorimetry).

- Specific electrical resistance of the lining (Clause No. 6.3)

The specific lining resistance of the polyurethane lining shall be assessed by testing in accordance with the test method defined in 7.2.7.

The specific lining resistance of the polyurethane lining after immersion in a 0.1 M NaCl solution for 100 days shall be at least  $108 \Omega \text{ m}^2$ . The resistance after 100 days shall not be less than 80% of the value after 70 days if the surface resistance of the lining after 100 days is only one decimal power above the minimum permissible value for 100 days. The test shall be carried out at room temperature ( $23 \pm 2$ ) °C.

- Abrasion resistance (only for waste water application) (Clause No. 6.7)

When tested in accordance with 7.2.8, the pipes shall not have an abrasion depth greater than 0.2 mm after 100,000 movements (50,000 cycles).

Note: In order to test the abrasion resistance of fittings, straight fittings as flanged pipes, etc. may be lined as fittings and tested according to 7.2.7.

- Materials in contact with water intended for human consumption (Clause No. 6.8)

When used under the conditions for which they are designed, in permanent or in temporary contact with water intended for human consumption, the polyurethane lining applied on ductile iron pipes and

fittings shall not change the quality of that water to such an extent that it fails to comply with the requirements of national regulations.

For this purpose, reference shall be made to the relevant national regulations and standards, transposing EN standards when available, dealing with the influence of materials on water quality and to the requirements for external systems and components as given in EN 805.

## 9. Type Test Certificates of Polyurethane Lined DI Pipes

Type Test Certificates for Polyurethane Lined DI pipes certified by Bureau Veritas is attached below [Fig.2]

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**BUREAU VERITAS**

INSPECTION REPORT N°  
ECL/BVIL-KOL/ARABIAN/3288/IR/001

BVIL Job nr: IND.K.4.16.0366

PROJECT: Review of Test for Polyurethane Internal Coating as per Ministry of Public Works, Kuwait requirement

BV Client: M/s. Electrosteel Castings Limited.

Manufacturer: M/s. Electrosteel Castings Limited.

Inspection requested by: M/s. Electrosteel Castings Limited.

P/o nr: (ECL to BVIL)

P/o nr: N/A (Client to ECL)

SUPPLY / SUBJECT OF INSPECTION	PO Qty	From Accepted Qty	Offered Qty	Accepted Qty	Balance Qty
Study of MPW, Kuwait test table for Polyurethane Internal Lining and review of test performed by Electrosteel Castings Ltd (ECL).					

DOCUMENTS OF REFERENCE : See continuation sheet for additional documents: ☐ Yes ☒ No

Title	Reference n°	Rev.	Approved by	Date
Review Scope of Work	Vide mail		ECL	18.06.16
MPW, Kuwait Test Table	151-3288	--	MPW, Kuwait	04.08.15

INSPECTIONS : Results of inspection : ☒ Satisfactory ☐ Unsatisfactory

Inspection place & Date or Period:  
Electrosteel Castings Ltd, Khairah on 22<sup>nd</sup> & 25<sup>th</sup> October, 2016.

Stage of inspection : ☒ Before manufacturing ☐ During manufacturing ☐ Final ☐ Packing

Type of inspection : ☐ Pre-inspection meeting ☒ Document and QC record review ☐ Visual examination, checks ☐ Witnessing tests ☐ Manufacturing progress status ☐ Vendor assessment ☐ Final inspection ☐ Packing (for details see continuation sheet)

Stamping : ☒ No ☐ ☐ ☐

Non Conformities Reports (NCR):  
☐ NCR's issued during reported period : Nil

List of outstanding NCR's : N/A

Main Conclusions & Remarks: (for details see continuation sheet)  
Documents reviewed as per the requirement of the Ministry of Public Work (MPW), Kuwait specification test table (Ref: 151-3288) and found complying with the requirements of MPW, Kuwait Specification.

Next visit scheduled: N/A

## 10. Result of Type Test for Polyurethane Internal Coating

Details of inspection activities carried out with respect to scope of work documents reviewed were mentioned below [Table 6].

## 11. Specifications for the EIL Project on Effluent Discharge Pipeline

The characteristics of fluid properties as provided by EIL for Ankleshwar Facility is provided below [Table 7].

As per the provided effluent characteristics the use of polyurethane lining with 1,500 micron thickness has been stipulated.

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**BUREAU VERITAS**

INSPECTION REPORT N°  
ECL/BVIL-KOL/ARABIAN/3288/IR/001

BVIL Job nr: IND.K.4.16.0366

Description of the inspections carried out:

> Introduction  
At the request of M/s. Electrosteel Castings Limited, Kolkata, the undersigned Bureau Veritas Surveyor have visited the Khairah works of Electrosteel Castings Limited, Kolkata for review of test results w.r.t. Polyurethane Internal Lining on DI Pipes as per BVIL Scope of work.

Attendees:  
• Mr. Sanjib Das - Electrosteel Castings Ltd.  
• Mr. Kinjal Banerjee - Bureau Veritas (I) Pvt. Ltd., Kolkata

BVIL Scope of Work:  
BVIL Scope of work is limited to review of documents as mentioned in ECL forwarding letter in order to confirm Polyurethane Internal Lining compliance with the requirements of MPW, Kuwait specification test table (Ref: 151-3288).

> Applicable Documents & Status of Approval (Type of documents reviewed & endorsed)  
As mentioned in Details of Inspection below.

> Details of inspection activities carried out with respect to scope of work  
Documents Reviewed as mentioned below:

Sl. No.	Properties	Reference Standard	MPW Requirement	Test Results	Document Review Status
1	Thickness	MPW & BSEN15655	Minimum 1000 micron	DN200: 1105 micron DN400: 1070 micron DN800: 1065 micron	Reviewed and Accepted
2	Adhesion	BSEN15655 Clause 7.1.9	Greater Than 8 MPa	DN200: 9.5 MPa DN400: 9.4 MPa DN800: 10.5 MPa	Reviewed and Accepted
3	Hardness	BSEN15655 Clause 7.1.8	Greater Than 70 Shore D	DN200: 75 Shore D DN400: 74 Shore D DN800: 79 Shore D	Reviewed and Accepted
4.1	Chemical resistance to effluents (immersion in DM water at 50 deg C)	BSEN15655 Table 2	Less than 15% weight increase after immersion for 100 days Less than 2% weight loss after drying for 100 days	DN200: 4.1% increase DN400: 4.0% increase DN800: 3.6% increase DN200: 0.56% decrease DN400: 0.51% decrease DN800: 0.46% decrease	Reviewed and Accepted
4.2	Chemical resistance to effluents (immersion in 10% dilute sulfuric at 50 deg C)	BSEN15655	Less than 10% weight increase after immersion for 100days Less than 4% weight loss after drying for 100 days	DN200: 4.4% increase DN400: 5.2% increase DN800: 4.7% increase DN200: 0.63% decrease DN400: 0.73% decrease DN800: 0.66% decrease	Reviewed and Accepted
5	Indirect Impact Strength	BSEN15655	No porosity at 50 J	No porosity at 51.5 J	Reviewed and Accepted

Fig. 2 Type test certificates of polyurethane lined DI pipes [6].

**Table 6 Result of type test for polyurethane internal coating.**

Sl. No.	Properties	Reference standard	MPW requirement	Test results	Document review status
1	Thickness	MPW & BSEN15655	Minimum 1,000 micron	DN200: 1,105 micron DN400: 1,070 micron DN800: 1,085 micron	Reviewed and Accepted
2	Adhesion	BSEN15655 Clause 7.1.9	Greater Than 8 MPa	DN250: 9.5 MPa DN400: 9.4 MPa DN800: 10.5 MPa	Reviewed and Accepted
3	Hardness	BSEN15655 Clause 7.1.8	Greater Than 70 Shore D	DN250: 75 Shore D DN400: 74 Shore D DN800: 79 Shore D	Reviewed and Accepted
4.1	Chemical resistance to effluents (immersion in DM water at 50 °C)	BSEN15655 Table 2	Less than 15% weight increase after immersion for 100 days Less than 2% weight loss after drying for 100 days	DN200: 4.1% increase DN400: 4.0% increase DN800: 3.6% increase DN200: 0.56% decrease DN400: 0.51 % decrease DN800: 0.46 % decrease	Reviewed and Accepted
4.2	Chemical resistance to effluents (immersion in 10% dilute sulfuric at 50 °C)	BSEN15655	Less than 10% weight increase after immersion for 100 days Less than 4% weight loss after drying for 100 days	DN200: 4.4% increase DN400: 5.2% increase DN800: 4.7% increase DN200: 0.63% decrease DN400: 0.75% decrease DN800: 0.66% decrease	Reviewed and Accepted
5	Indirect Impact Strength	BSEN15655	No porosity at 50.0 J	No porosity at 51.5 J	Reviewed and Accepted
6	Ovalization resistance	BSEN15655	No damage at minimum 4% Ovalization for DN200 6% Ovalization for DN400 8% Ovalization for DN800	No damage at 4.8% for DN200 6.4% for DN400 9.0% for DN800	Reviewed and Accepted
7	Rlongation at Break	BSEN15655	> 2.5%	4.2% for DN200 5.2% for DN400 4.1% for DN800	Reviewed and Accepted
8	Abrasion resistance (50,000 cycles)	BSEN15655 & BSEN598	< 0.20 mm	0.09 mm	Reviewed and Accepted
9	Light aging resistance (outside Storage for 6 months)	BSEN15655	Adhesion (> 8 MPa)	DN250: 9.3 MPa DN400: 8.9 MPa DN800: 9.3 MPa	Reviewed and Accepted
10	Resin Content of PU material	MPW	85% minimum	More than 85%	Manufacturer confirmation was noted

**Table 7 Effluent characteristics from Ankleshwar facility.**

S. No.	Parameter	Unit	Value
1	pH	mg/L	6.00 to 9.00
2	COD (Chemical Oxygen Demand)	mg/L	500
3	BOD <sub>3</sub> days, 27 °C (Biochemical Oxygen Demand)	mg/L	100
4	Total dissolved solids	mg/L	~10,000
5	Total suspended solids	mg/L	100
6	Sulphides, as S	mg/L	5
7	Phenolic compounds (as C <sub>6</sub> H <sub>5</sub> OH)	mg/L	5
8	Oil and grease	mg/L	10
9	Total residual chlorine	mg/L	1
10	Fluoride	mg/L	15
11	Free ammonia	mg/L	~
12	Nitrate nitrogen	mg/L	50

Table 7 to be continued

13	Ammonical nitrogen	mg/L	50
14	Total Kjeldahl Nitrogen	mg/L	50
15	Vanadium	mg/L	0.2
16	Selenium	mg/L	0.05
17	Iron	mg/L	3
18	Copper	mg/L	3
19	Zinc	mg/L	15
20	Chromium 6+	mg/L	0.1
21	Lead	mg/L	0.1
22	Cadmium	mg/L	0.05
23	Temperature	°C	Not more than 5 °C above ambient water
24	Arsenic	mg/L	0.2
25	Mercury	mg/L	0.01
26	Manganese	mg/L	2
27	Nickel	mg/L	3

## 12. ISI (Indian Standards Institution) Marking of DI Pipes

The ISI marking of DI pipes is mandated by the order of Ministry of Commerce and Industry (Department of Industrial Policy and Promotion) dated 25th June 2009.

So, even if a customer does not ask for ISI marked DI pipes, there is no way but the DI pipe manufacturers are bound to supply ISI marked DI pipes as per this order.

In the said Gazette in Sl. No. 3 under heading “Prohibition regarding manufacture, storage, sale and distribution etc.” it is written that [7]:

### Quote:

(1) No person shall by himself or through any person on his behalf manufacture or store for sale, sell or distribute ductile iron pressure pipes and fittings which do not conform to the specified standard and do not bear Standard Mark of the Bureau on obtaining certification marks license:

Provided that nothing in this Order shall apply in relation to export of ductile iron pressure pipes and fittings meant for export, which conform to any specification required by the foreign buyer and such specification shall not in any case be less than the

specified standard.

(2) The sub-standard or defective ductile iron pressure pipes and fittings, which do not conform to the specified standard shall be deformed by the manufacturer beyond use and disposed off as scrap within three months.

### Unquote :

## 13. Conclusions

Polyurethane Lining should be adopted for corrosive and abrasive fluids and the thickness should be determined based on fluid properties.

Polyurethane Coating should be adopted for corrosive sub-soil and the thickness should be determined based on sub-soil properties.

## References

- [1] <https://www.electrosteel.com/>.
- [2] BS EN15189-2006. Ductile Iron Pipes, Fittings and Accessories—External Polyurethane Coating for Pipes—Requirements and Test Methods.
- [3] <https://www.wrcplc.co.uk/wrc-nsf.aspx>.
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- [5] BS EN 15655-1:2018. Ductile Iron Pipes, Fittings and Accessories -Requirements and Test Methods for Organic Linings of Ductile Iron Pipes and Fittings.
- [6] <https://www.bureauveritas.co.in/>.
- [7] <https://bis.gov.in/>.