



شرکت ملی گاز ایران

مدیریت پژوهش و فناوری

امورتدوین استانداردها

IGS

Iranian Gas Standards

## دستورالعمل

پوشش 3 لایه پلی اتیلن خطوط لوله قسمت (1)

3 LAYER POLYETHYLENE & ASSOCIATED COATING  
SYSTEM Part (1)

## **3 LAYER POLYETHYLENE & ASSOCIATED COATING SYSTEM**

### **Part-1**

**SPECIFICATION FOR EXTERNAL PROTECTION OF STEEL LINE PIPE & FITTINGS FOR SERVICE TEMPERATURE OF -30 TO + 80 DEG ( C ) USING 3 LAYER POLYETHYLENE & ASSOCIATED COATING SYSTEM .**

**PART 1 – REQUIREMENT FOR COATING MATERIALS & METHODS OF TEST PREPARED BY CORROSION PROTECTION STANDARD COMMITTEE**

### **FOREWORD**

**THIS STANDARD IS PART 1 OF A THREE - PART SPECIFICATION AND DEALS WITH THE PERFORMANCE REQUIREMENTS OF MATERIALS THAT CAN BE USED FOR THE PROTECTIVE EXTERNAL COATING ON LINE PIPE AND ASSOCIATED FITTINGS .**

**THE OTHER PARTS IN THE SERIES ARE :**

**PART 2 - FACTORY APPLIED COATINGS .**

**PART 3 - FIELD APPLIED COATINGS .**

**SPECIFICATION FOR EXTERNAL PROTECTION OF STEEL LINE PIPE AND FITTINGS FOR SERVICE TEMPERATURE 30°C TO +80°C , USING 3 LAYER POLYETHYLENE AND ASSOCIATED COATING SYSTEMS .**

**PART 1 - REQUIREMENTS FOR COATING MATERIALS AND METHODS OF TEST .**

## **SECTION ONE - GENERAL**

### **1. SCOPE**

- 1.1 THIS PART 1 OF N.I.G.C ENGINEERING STANDARD IGS-ES-TP-010 SPECIFIES MATERIALS FOR USE AS ANTI CORROSION COATINGS ON STEEL LINE PIPES . IT DEALS SPECIFICALLY WITH THE PROPERTIES, MINIMUM REQUIREMENTS AND RELATED METHODS OF TESTS TO ESTABLISH**

SUITABILITY FOR USE WITH PART 2 AND PART 3 OF THIS ENGINEERING STANDARD , WHICH DEAL WITH FACTORY APPLIED COATINGS AND FIELD APPLIED COATINGS RESPECTIVELY .

1.2 SECTION TWO OF THIS SPECIFICATION COVERS EPOXY POWDER , ADHESIVE AND POLYETHYLENE AND SECTION THREE COVERS FIELD APPLIED COATING MATERIALS .

## 2. REFERENCES

THE CODES AND STANDARDS REFERRED TO IN THIS ENGINEERING STANDARD ARE LISTED BELOW .

UNLESS OTHERWISE SPECIFIED , THE LATEST EDITIONS OF THE CODES AND STANDARDS INCLUDING ALL ADDENDA AND REVISIONS SHALL APPLY .

### AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM D 522  
ASTM D 570  
ASTM D 696  
ASTM D 746  
ASTM D 1002  
ASTM D 1525  
ASTM D 1673  
ASTM D 2240  
ASTM G 14

### BRITISH STANDARDS INSTITUTION

B.S. 3412

### DEUSCHES INSTITUT FUR NORMUNG

DIN 53122  
DIN 53155  
DIN 53380  
DIN 53455  
DIN 53495  
DIN 53479  
DIN 53481  
DIN 53482

DIN 53483  
DIN 53505  
DIN 53735  
DIN 55990 – T 2  
DIN 55990 – T 3  
DIN 55990 – T 8  
DIN 67530

**SWEDISH STANDARD**

SIS 055900

### **3. DEFINITIONS**

FOR THE PURPOSES OF THIS NIGC ENGINEERING CONSTRUCTIONS STANDARD THE FOLLOWING DEFINITIONS APPLY :

**NIGC :** NATIONAL IRANIAN GAS COMPANY .

**CONTRACTOR :** THE COMPANY WITH WHOM NIGC ENTERS INTO A CONTRACT TO WHICH THIS NIGC STANDARD APPLIES,INCLUDING THE CONTRACTOR'S PERSONAL REPRESENTATIVES .

**INSPECTOR :** THE PERSON APPOINTED BY NIGC AND NOTIFIED AND AUTHORIZED IN WRITING TO THE CONTRACTOR TO WITNESS AND CERTIFY ALL APPROVAL AND PRODUCTION TESTS .

**MANUFACTURER :** THE PRODUCER OF THE COATING MATERIAL BEING OFFERED FOR TEST .

### **4. COATING MATERIALS**

#### **4.1 SELECTION OF COATING MATERIALS**

**4.1.1 ONLY COATING SYSTEMS WHICH COMPLY WITH NIGC ENGINEERING CONSTRUCTION STANDARD IG-ES-TP-010 PART 1 SHALL BE USED .**

**4.1.2 THE COATING MATERIALS SUPPLIED SHALL BE CERTIFIED BY THE MANUFACTURER IN ACCORDANCE ENSURING THAT ALL COATING MATERIALS AND EQUIPMENT COMPLY WITH ALL OF THE PROVISIONS CONTAINED IN THIS SPECIFICATION ORIGINALLY AND PRIOR TO APPLICATION AND N.I.G.C MAY MAKE ANY INVESTIGATIONS NECESSARY , BY WAY OF TESTING , BATCH SAMPLING , MANUFACTURING AND FACTORY INSPECTION , TO SATISFY ITSELF OF COMPLIANCE BY THE CONTRACTOR .**

**4.1.3 THE CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING THAT THE RANGE OF VALUES FOR ANY MATERIAL UNDER CONSIDERATION WILL BE CAPABLE OF PROVIDING A FINISHED PRODUCT IN COMPLIANCE WITH PART 2 ( AND PART 3 WHERE APPLICABLE ) OF THIS STANDARD WHEN RELATED TO THE SPECIFIC MODE OF OPERATION TO BE USED .**

**4.1.4 IT IS INTENDED THAT THIS SPECIFICATION BE USED TO ENCOURAGE AND STIMULATE THE DEVELOPMENT OF PROGRESSIVELY BETTER EXTERNAL PIPELINE COATINGS . THUS , WHERE CERTAIN MINIMUM PERFORMANCE VALUES ARE STATED , SHOULD FUTURE COATING MATERIAL TEST SUBMISSIONS YIELD BETTER THAN SPECIFICATION REQUIREMENTS THEN , AFTER ECONOMIC EVALUATION . THESE NEW VALUES MAY BE ADOPTED AS THE MINIMUM REQUIREMENTS AND THE SPECIFICATION WOULD BE UPGRADED ACCORDINGLY .**

#### **4.1.5 MATERIALS HANDLING AND STORAGE**

**4.1.5.1 THE MATERIALS SHALL BE STORED IN THE MANUFACTURER'S ORIGINAL PACKAGING UNDER VENTILATED CONDITIONS AND AWAY FROM DIRECT SUNLIGHT. WHERE APPLICABLE AIRCONDITIONED STORAGE SHALL BE OBSERVED .**

**4.1.5.2 THE MATERIALS SHALL BE HANDLED IN SUCH A WAY THAT THEY DO NOT SUFFER ANY DAMAGE .**

#### **4.1 IDENTIFICATION OF MATERIALS**

**ALL MATERIALS SUPPLIED FOR COATING OPERATIONS SHALL BE SUITABLY MARKED GIVING THE FOLLOWING INFORMATIONS :**

- A) THE MANUFACTURER'S NAME AND ADDRESS .
- B) THE MATERIAL AND ORDER NUMBER .
  
- C) THE BATCH NUMBER .
  
- D) DATE OF MANUFACTURE AND STABLE WORKING SHELF LIFE ( INCLUDING STORAGE CONDITION LIMITS ) .

(E) DIRECTIONS FOR MIXING AND/OR THINNING WITH SOLVENTS AS REQUIRED . ( SEE SECTION 3 OF PART 1 ) .

(F) DIRECTIONS FOR HANDLING AND STORING OF THE COATING MATERIALS .

(G) INFORMATION AND WARNINGS ( IF NEEDED ) .

THE CONTRACTOR AND / OR PURCHASER SHALL REQUIRE THE MATERIAL MANUFACTURER TO SUPPLY CERTIFICATES . CONFIRMING THAT TESTS DETAILED IN THIS SPECIFICATION HAVE BEEN CARRIED OUT ON THE BATCHES SUPPLIED AND THAT THE MATERIALS MEET THIS SPECIFICATION . THESE CERTIFICATES SHALL BE MADE AVAILABLE FOR EXAMINATION BY N.I.G.C ON REQUEST .

#### 4.2 PRODUCTION DATA SHEETS

THE CONTRACTOR AND/OR PURCHASER SHALL BE RESPONSIBLE FOR OBTAINING DATA SHEETS FROM THE MATERIAL MANUFACTURER WHICH SHALL INCLUDE VALUES FOR ALL THE BASIC PROPERTIES OF THE MATERIAL AS SPECIFIED IN THE “ BASIC PROPERTIES “ CLAUSE IN THE APPROPRIATE SECTION OF THIS STANDARD .

## SECTION TWO - MILL APPLIED MATERIAL

### 5. EPOXY POWDER

#### 5.1 BASIC PROPERTIES AND TESTS FOR THE RAW POWDER .

##### 5.1.1 GENERAL

**5.1.1.1 EPOXY POWDER IS A THERMOSETTING PRIMER FOR USE AS PRIMER IN A THREE LAYER POLYETHYLENE COATING SYSTEM FOR STEEL PIPE . IT SHALL BE SPECIFICALLY FORMULATED AND DESIGNED SO AS TO BE SUITABLE FOR ELECTROSTATIC APPLICATION AND TO IMPROVE ADHESION OF THE COATING SYSTEM AND ALSO PROVIDE MAXIMUM CATHODIC DISBONDING RESISTANCE .**

**5.1.1.2 THE CONTRACTOR SHALL OBTAIN FROM THE MANUFACTURER , SPECIFIED AND QUALIFIED RANGES OF VALUES FOR ALL PROPERTIES LISTED IN TABLE 1 AND DETAILED IN 5.1.2 TO 5.1.4 INCLUSIVE THAT WILL ENSURE AN ACCEPTABLE COATING . THE FREQUENCY OF TESTING SHALL BE IN ACCORDANCE WITH 8 .**

**5.1.2 INFRA RED SCAN**

**USING AN APPROVED METHOD , AN INFRA RED SPECTROGRAM , PREFERABLY MADE BY USING A STANDARD KBR ( POTASSIUM BROMIDE ) DISC , SHALL BE OBTAINED FROM A FIRST BATCH OF THE POWDER EPOXY . THIS SHALL SUBSEQUENTLY BE USED FOR COMPARISON WITH TYPE SPECTROGRAM .**

**5.1.3 THERMAL ANALYSIS**

**THERMAL ANALYSIS DATA FOR EACH BATCH SHALL BE MADE AVAILABLE SHOWING , BY USE OF A DSC ( DIFFERENTIAL SCANNING CALORIMETER ) THE GLASS TRANSITION OF THE RAW POWDER AND ALSO THE ENTHALPY OF THE CURING POWDER . THE GLASS TRANSITION TEMPERATURE OF THE FULLY CURED POWDER SHALL ALSO BE QUOTED . THE REFERENCE CURVE SHALL BE PROVIDED AS PART OF THE PRODUCTION DATA SHEET . THE LIMITING VALUES OF  $\Delta H$  , TG1 AND TG2 SHALL BE IDENTIFIED BY THE MANUFACTURER .**

**5.1.4 STABILITY**

**AFTER AGING FOR AT LEAST 180 DAYS , AT 25°C IN A HERMETICALLY SEALED CONTAINER , FROM THE DATE OF DELIVERY , THE POWDER SHALL NOT EXHIBIT ANY SIGNIFICANT CHANGE EITHER FROM THE PROPERTIES IDENTIFIED ABOVE INCLUDING TABLE 1 OR FROM THOSE IN 4.2 .**

**TABLE 1**

**TYPICAL VALUES OF RAW EPOXY POWDER PROPERTIES**

<b>PROPERTY</b>	<b>UNIT</b>	<b>TEST METHOD</b>	<b>TYPICAL VALUE</b>
1) GLOSS AT 60° ANGLE	%	DIN 67530	65 ± 5
2) GEL TIME	SEC	DIN 55990 – T8*	43 ± 10
3) DENSITY	GR / CM <sup>3</sup>	DIN 55990 – T3	1, 5
4) PARTICLE SIZE	%	DIN 55990 – T2	90 BETWEEN 10 TO 80 MICRONS
5) MOISTURE CONTENT	% WEIGHT	ACCEPTABLE METHOD TO NIGC	0.5 MAX.
SHELF LIFE AT 35°C & % 60 HUMIDITY	MONTH	-	12 MIN.
THEORITICAL COVRAGE	GR/M2	ACCEPTABLE METHOD TO NIGC	90 GR/FOR 60 MICRONS DFT
DRY FILM THICK	MICRON	-	MIN. 60

## 5.2 BASIC PROPERTIES AND TESTS FOR CURED COATIG .

### 5.2.1 GENERAL

5.2.1.1 THE TESTS DEFINED IN 5.2.2 TO 5.2.6 SHALL BE CARRIED OUT , ON A LABORATORY COATED STEEL PLATE WITH A COATING THICKNESS OF 60 MICRONS .

PRIOR TO COATING , THE STEEL SURFACE SHALL BE BLAST CLEANED TO A LEVEL OF SWEDISH STANDARD SIS 055900 SA 2-1/2 AND SURFACE PROFILE OF APPROXIMATELY 50 MICRONS PEAK TO VALLEY HEIGHT ( L=17,5<sup>mm</sup> , CUT OFF 2,5<sup>mm</sup> )



**5.2.1.2 THE CONTRACTOR SHALL ENSURE THAT THE POWDER MANUFACTURER SHALL CARRY OUT THE TESTS SPECIFIED IN 5.2.2. TO 5.2.6 INCLUSIVE , ON EACH BATCH .**

**5.2.2 APPEARANCE**

**THE COATING SHALL EXHIBIT UNIFORM APPEARANCE .**

**5.2.3 THERMAL ANALYSIS**

**GLASS TRANSITION TEMPERATURE ( G.T.T ) SHALL BE MEASURED ON A PREPARED LABORATORY SAMPLE FOR RECORD AND CHECKING PURPOSES .**

**THE TYPICAL VALUE OF G.T.T IS ABOVE 100°C .**

**5.2.4 FLEXIBILITY / BENDING**

**THE FLEXIBILITY / BENDING SHALL BE MEASURED IN ACCORDANCE WITH DIN 53152 ; - TYPICAL VALUE < 5<sup>mm</sup> .**

**5.2.5 HARDNESS**

**THE HARDNESS OF THE CURED EPOXY FILM SHALL BE MORE THAN 85 BUCHOLTS MIN. WHEN TESTED IN ACCORDANCE WITH DIN 53155 .**

**5.2.6 IMPACT RESISTANCE**

**THE IMPACT RESISTANCE OF THE CURED EPOXY FILM SHALL BE MIN. 120 KG / CM AT 20°C IN ACCORDANCE WITH ASTM G14 TEST METHOD . ( TEST PANEL THICK .3<sup>mm</sup> )**

**6. BONDING AGENT COPOLYMER ( ADHESIVE )**

**6.1 BASIC PROPERTIES AND TESTS FOR BONDING AGENT ( ADHESIVE ) .**

**6.1.1 GENERAL**

**6.1.1.1 THIS ADHESIVE IS USED AS SECOND LAYER IN A THREE .LAYER POLYETHYLENE COATING SYSTEM FOR STEEL PIPES . IT SHALL BE AN ETHYLENE BASE COPOLYMER , SPECIFICALLY FORMULATED AND DESIGNED SO AS TO BE SUITABLE FOR EXTRUSION APPLICATION .**

**6.1.1.2 THE CONTRACTOR SHALL OBTAIN FROM THE MANUFACTURER SPECIFIED VALUES FOR ALL PROPERTIES LISTED IN TABLE 2 IN ACCORDANCE WITH 6.1.1.3.**

**6.1.1.3 THE CONTRACTOR SHALL ENSURE THAT THE ADHESIVE MANUFACTURER SHALL CARRY OUT THE TESTS NO. 1 , 2 , 6 , 7 IN TABLE 2 FOR EACH BATCH AND THE REMAINING TESTS SHALL BE CARRIED OUT AS TYPE TESTS TWICE PER EACH ORDER AS A MINIMUM .**

**6.1.2 THE ADHESIVE SHALL BE UNCOLOURED AND MADE OF RAW MATERIAL WITH THE BEST QUALITY TO PROVIDE THE FOLLOWING PROPERTIES :**

- EXCELLENT PEELING RESISTANCE
- EXCELLENT MECHANICAL STRENGTH
- EXCELLENT THERMAL STABILITY

- STRONG ADHESION TO FUSION BONDED EPOXY FILM AS WELL AS TO STEEL SURFACE .

- HOMOPOLAR BOND WITH THE POLYETHYLENE TOP COAT ( THIRD LAYER ) .

**6.1.3 STABILITY**

**AFTER AGING FOR AT LEAST 180 DAYS , AT 30°C IN A SEALED AND U.V RESISTANT CONTAINER , FROM THE DATE OF DELIVERY , THE ADHESIVE SHALL NOT EXHIBIT ANY SIGNIFICANT CHANGE EITHER FROM THE PROPERTIES IDENTIFIED ABOVE INCLUDING TABLE 2 OR FROM THOSE IN 4.2 .**

**TABLE 2  
PHYSICAL PROPERTIES OF ADHESIVE**

<b>PROPERTY</b>	<b>UNIT</b>	<b>TEST METHOD</b>	<b>VALUE</b>
1) DENSITY	G / CM <sup>3</sup>	DIN 53479	0.900 – 0.950
2) MELTING INDEX ( 2.16 KG/190°C )	G/ 10 MIN.	DIN 53735	5– 8
3) ELONGATION	%	DIN 53455	AS PE ( TOP ) COAT
4) MELTING POINT	C°	DSC	95 ( MIN. )
5) COMONOMER CONTENT	%	-	9 ( TYPICAL )

## 7. POLYETHYLENE

### 7.1 BASIC PROPERTIES AND TESTS FOR POLYETHYLENE

#### 7.1.1 GENERAL

7.1.1.1 POLYETHYLENE IS A THERMOPLASTIC RESIN FOR USE AS TOP COAT IN A THREE LAYER POLYETHYLENE COATING SYSTEM FOR STEEL PIPE . IT SHALL BE SPECIFICALLY FORMULATED AND DESIGNED FOR EXTRUSION APPLICATION .

7.1.1.2 THE CONTRACTOR SHALL OBTAIN FROM THE MANUFACTURER SPECIFIED VALUES FOR ALL PROPERTIES LISTED IN TABLE 3 IN ACCORDANCE WITH 7.1.1.3.

7.1.1.3 THE CONTRACTOR SHALL ENSURE THAT THE POLYETHYLENE MANUFACTURER SHALL CARRY OUT THE TESTS NO. 1 , 2 , 7 , 10 , IN TABLE 3 FOR EACH BATCH AND THE REMAINING TESTS SHALL BE CARRIED OUT AS TYPE TESTS TWICE PER EACH ORDER AS A MINIMUM.

**7.1.2 THE POLYETHYLENE SHALL BE MADE OF RAW MATERIAL WITH THE BEST QUALITY TO PROVIDE FOLLOWING PROPERTIES :**

- EXCELLENT PEELING RESISTANCE
- EXCELLENT MECHANICAL STRENGTH
- EXCELLENT THERMAL STABILITY
- EXCELLENT IMPACT RESISTANCE
- EXCELLENT PENETRATION RESISTANCE
- STRONG ADHESION TO ADHESIVE LAYER
- EXCELLENT STABILITY AGAINST ULTRA VIOLET RAYS .

**7.1.3 THE POLYETHYLENE SHALL BE ADEQUATELY WEATHER - RESISTANT AND STABLE FOR FABRICATION AND USE , FOR THIS PURPOSE THE NATURE AND QUANTITY OF ANTIOXIDANT SHALL BE IN ACCORDANCE WITH BS 3412 – 76 .**

**7.1.4 COLOUR**

**THE POLYETHYLENE SHALL BE UNIFORM IN COLOUR AND FREE FROM OBVIOUS FOREIGN MATTERS ; THE COLOUR SHALL BE BLACK USING CARBON BLACK ; THE CARBON BLACK CHARACTERIZATION , DISPERSION AND CONTENT SHALL BE IN ACCORDANCE WITH BS 3412 – 76 .**

**7.1.4 STABILITY**

**AFTER AGING FOR AT LEAST 180 DAYS , AT 30°C IN A SEALED AND U.V RESISTANT CONTAINER , FROM THE DATE OF DELIVERY , THE POLYETHYLENE SHALL NOT EXHIBIT ANY SIGNIFICANT CHANGE EITHER FROM THE PROPERTIES IDENTIFIED ABOVE INCLUDING TABLE 3 OR FROM THOSE IN 4.2 .**

**TABLE 3**  
**PHYSICAL PROPERTIES OF BLACK POLYETHYLENE**

<b>PROPERTY</b>	<b>UNIT</b>	<b>TEST METHOD</b>	<b>VALUE</b>
1) DENSITY ( BASE MATERIAL )	G / CM <sup>3</sup>	DIN 53479	0.933 MIN.
2) MELTING INDEX ( 2 , 16 KG / 190°C )	G / 10 MIN.	DIN 53735	0.3 ( TYPICAL )
3) ELONGATION	%	DIN 53455	500 – 700
4) ULTIMATE STRENGTH	N / MM <sup>2</sup>	DIN 53455	15
5) HARDNESS	SHORE . D	DIN 53505	55
6) VICAT SOFTENING POINT	°C	DIN 53460	115 ( MIN. )
7) MELTING POINT	°C	DSC	125
8) LOW TEMPERATURE RITTLNESS	°C	ASTM D 746	-70 NO. FRACTUR
9) STRESS CRACKING RESISTANCE ( METHYL – ETHYL – CETON )	HOUR	ASTM D 1693	> 1000
10) CARBON BLACK CONTENT	%		2.5 MIN.

## 8. QUALITY CONTROL REQUIREMENTS

BEFORE DISPATCH , THE MATERIALS MANUFACTURER SHALL CARRY OUT SAMPLING AND TESTING OF THE MANUFACTURED MATERIALS COVERED BY THIS SPECIFICATION IN ACCORDANCE WITH 5.1.1.3 , 6.1.1.3 AND 7.1.1.3 .

## 9. QUALITY SYSTEMS

9.1 THE CONTRACTOR SHALL SET UP AND MAINTAIN SUCH QUALITY ASSURANCE AND INSPECTION SYSTEMS AS ARE NECESSARY TO ENSURE THAT THE GOODS OR SERVICES SUPPLIED COMPLY IN ALL RESPECTS WITH THE REQUIREMENTS OF THIS ENGINEERING STANDARD .

9.2 N.I.G.C. SHALL HAVE THE RIGHT TO UNDER TAKE INSPECTION OR TESTING OR RAW MATERIALS OR PURCHASED COMPONENTS BEFORE APPLICATION .



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## مشخصات فنی مواد و دستورالعمل

اصلاحیه شماره 2 مربوط به پوشش 3 لایه پلی اتیلن خطوط لوله

**Amendment No. 2 to Three Layer Polyethylene Coating System**

## Foreword

This amendment cancels and replaces amendment No. 1 related to IGS-ES-TP-010:1372 .  
Amendment No. 1 has been revised and updated on the basis of ISO 21809-1 , CSA Z245.20 ,  
CSA Z245.21 .

This amendment is summarized as follows :

### IGS-TP-010(0) : Part 1

#### KEY CHANGES

Amendment No. 2 Section	IGS-ES-TP-010	Previous Amendment	IGS-ES-TP-010 Page	Previous Amendment Page	New Page
TABLE 1 – Liquid Epoxy Properties	Added	---	---	1	1
TABLE 2 – Raw Epoxy Powder Properties	Substituted	Modified	8	2	2
TABLE 3 – Adhesive Properties	Substituted	Modified	11	3	3
TABLE 4 – Black Polyethylene Properties	Substituted	Modified	13	4	4

### IGS-TP-010(0) : Part 2

#### KEY CHANGES

Amendment No. 2 Section	IGS-ES-TP-010	Previous Amendment	IGS-ES-TP-010 Page	Previous Amendment Page	New Page
TABLE 2 Minimum Coating Thickness	Modified	---	15	5	5
TABLE 2 Liquid Epoxy Thickness	Added	---	---	5	5
Clause 7.2 – Blast Profile and Methods	Modified	Modified	6	5	5
Clause 7.7 – Chemical Treatment requirements	Added	Modified	---	5	5
TABLE 3 – Coating Requirements and Test Methods for Coating Procedure Approval Tests	Modified	Modified	18	6	6
TABLE 4 – Requirements for Inspection of Surface Preparation	Added	Modified	---	8	8
TABLE 5 – Requirements for Inspection and Testing of Applied Coating	Added	Modified	---	9	9
ANNEX A – 3LPE Coating Repair Procedure for the Coating Plant	Added	Added	---	---	11

**TABLE 1 – Liquid Epoxy Properties**

<b>Item</b>	<b>Property</b>	<b>Unit</b>	<b>Requirement</b>	<b>Test Method</b>
1	Density	g/cm <sup>3</sup>	as per manufacturer's specification ± 0.05	ISO 2811
2	Solid content of base and hardener	% mass	≥95	ISO 3251
3	Minimum glass transition temperature (DSC analysis)*	°C	≥95 manufacturer's specification	ISO 11357
4	Gel time(s) at 205 °C	---	within the manufacturer's specification	manufacturer's specification

\* Curing condition (procedure as manufacturer's specification)



**TABLE 2 – Raw Epoxy Powder Properties**

Item	Property	Unit	Requirement	Test Method
1	Density	g/cm <sup>3</sup>	as per manufacturer's specification $\pm 0.05$	ISO 8130-2
2	Gel time	sec	within 20% of manufacturer's specification	ISO 8130-6
3	Particle size : Maximum powder retained on 150 $\mu$ m mesh Maximum powder retained on 250 $\mu$ m mesh	%	3.0 0.2	CSA Z245.20-06
4	Specific coating resistance after 100 days of exposure in 3% NaCl solution at 23 °C	ohm.m <sup>2</sup>	> 10 <sup>8</sup>	NFA 46-710
5	3.0° flexibility test at 23 °C , 0 °C and -20 °C	---	no cracking	CSA Z245.20.06
6	Cathodic disbandment after 28 days at 65 °C in 3% NaCl solution at -1.5 volts (calomel electrode) potential , initial defect diameter Do = 6 mm , max	mm	7	CSA Z245.20
7	Moisture content , max	% by mass	0.5	ISO 21809-1
8	Degree of cure (differential thermal analysis)	°C	-2 °C $\leq \Delta T_g \leq$ +3 °C	ISO 21809-1
9	Glass transition temperature (Tg <sub>2</sub> ) (DSC analysis)	°C	$\geq 95$	ISO 21809-1
10	Water resistance , 1000 hrs at 80 °C	---	no blistering , swelling < 5% , loss of hardness < 10%	ASTM D 870
11	Adhesion to pipe surface , max	---	rating 2	CSA Z245.20-06

**TABLE 3 – Adhesive Properties**

<b>Item</b>	<b>Property</b>	<b>Unit</b>	<b>Requirement</b>	<b>Test Method</b>
1	Density at 23 ± 2 °C	gr/cm <sup>3</sup>	0.900-0.950	ISO 1183
2	Melt flow rate (2.16 kg /190 °C)	gr/10minutes	0.5-2	ISO 1133
3	Elongation at break at 23 ± 2 °C , min	%	600	ISO 527
4	Melting point (DSC) , min	°C	105	ISO 3146
5	Vicat softening temperature A /50 (9.8 N) , min	°C	95	ISO 306
6	Tensile strength , at 23 ± 2 °C , min	MPa	8	ISO 527
7	Water content , max	Weight %	0.1	ISO 15512

**TABLE 4 –Black Polyethylene Properties**

Item	Property	Unit	Requirement	Test Method
1	*Density at 23 ± 2 °C (base resin) , min	gr/cm <sup>3</sup>	0.940	ISO 1183
2	Melt flow rate (2.16 kg /190 °C)	gr/10minute	0.3 – 0.8	ISO 1133
3	Elongation at break at 23 ± 2 °C , min	%	600	ISO 527
4	Yield strength at 23 ± 2 °C , min	MPa	15	ISO 527
5	Hardness Shore D , min	---	55	ISO 868
6	Vicat softening temperature A /50 (9.8 N) , min	°C	115	ISO 306
7	Melting point , min	°C	125	ISO 3146
8	Low temperature brittleness (-70 °C or lower)	---	no fracture	ASTM D 746
9	Stress cracking resistance (methyl-ethyl-ketone) , min	hour	1000	ASTM D 1693
10	Carbon black content	% by mass	2–2.5	ASTM D 1603
11	Water content , max	weight %	0.05	ISO 15512
12	Oxidation – Induction time , at 210 °C , min	minute	30	ISO 11357
13	**UV resistance and thermal ageing	%	△MFR ≤35	Annex G ISO 21809-1

\* Preparation of the test specimen compression moulded sheet annealed for 30 minutes at 100 °C .

\*\* 2mm thick compression moulded sheet , specimen ISO 527-2 , strained at 50 mm/min.

**TABLE 2 – Minimum Coating Thickness**

Pipe Diameter , mm (in)	Liquid Epoxy (1 <sup>st</sup> layer) , mm (µm)	Powder Epoxy Resin (1 <sup>st</sup> layer) , mm (µm)	Adhesive (2 <sup>nd</sup> layer) , mm (µm)	Total Thickness , mm
Up to DN 250 (10)	0.025 (25)	0.150 (150)	0.150 (150)	2.0
DN 250 (10) up to DN 500 (20)	0.025 (25)	0.150 (150)	0.150 (150)	2.5
DN500(20) up to DN 900 (36)	0.025 (25)	0.150 (150)	0.150 (150)	3
>DN900 (36)	0.025 (25)	0.150 (150)	0.150 (150)	3.5

**7.2** Pipes shall be blast cleaned to Sa 2½ as a minimum (SIS 055900) . The surface profile after blasting shall be between 60 µm and 100 µm (R<sub>z</sub>) height , measured by a Talysurf instrument or Replica method. The blast cleaning medium used shall be agreed with NIGC . The surface shall be angular shape not rounded .

### 7.7 Chemical Treatment

After blast cleaning and before application of the epoxy primer , linepipes shall be subject to chemical pretreatment using an approved phosphoric acid solution .

The surface to be coated shall be heated to a temperature of 45 – 65 °C and treated with a low pressure (0.5 – 2.0 bar) spray application of a max. 10% v/v solution of an approved acid washing material and process . A uniform PH of 1 or less shall be maintained over the entire surface of treated area . The acid washed pipe surface shall remain wetted for 10 – 30 seconds and then rinsed with clean water before its starts to dry out .

High-pressure water rinses at 700 – 1000 psi (50 – 70 bar) shall be used to remove any treatment residue . The water used shall meet the following requirements :

Chlorides shall not exceed 10 ppm , sulfates shall not exceed 40 ppm , and nitrates shall not exceed 10 ppm . The total of these salts shall not exceed 60 ppm . The water shall not be reused . Soluble salts (Chloride contamination) on the steel surface shall be checked using an approved salt detector instrument measuring conductivity SCM400 or equivalent . Soluble salt content shall not exceed 2 micrograms / cm<sup>2</sup> .

After chemical pretreatment and before coating application , preheating shall be exclusively performed by induction coil (electrical) .

**TABLE 3 – Coating Requirements and Test Methods for Coating Procedure Approval Tests**

Item	Property	unit	Requirement	Test method
1	Surface preparation	---	As specified in 7.2	Visual inspection
2	Coating thickness	---	As specified in Table 2	Electro-magnetic thickness gauge . The gauge shall be calibrated daily with the standard calibrated plates . Annex A ISO 21809-1
3	Porosity (Holiday detection test) with maximum speed of 0.3 m/s and with 5 kV + 5 kV/mm , max	kV	25	DIN 30670
4	Peel strength (Adhesion) , min: - at $23 \pm 2$ °C - at $80 \pm 3$ °C	N/mm N/mm	15 3	Annex C ISO 21809-1
5	Impact resistance , min - at $23 \pm 2$ °C - at $-30 \pm 3$ °C	J/mm	7 3	Annex E ISO 21809-1 CSA Z245.20-06
6	Elongation at break at $23 \pm 2$ °C , min	%	400	ISO 527
7	Indentation , max : - at $23 \pm 2$ °C - at $80$ °C	mm mm	0.2 0.4	Annex F ISO 21809
8	Thermal cycle resistance	---	No crack	Cycle : -30°C 1hour +60 °C 1 hour No. of cycles:100

## Continued

Item	Property	Unit	Requirement	Test Method
9	Product stability during extrusion of the PE top layer process	%	$\Delta MFR \leq 20$	ISO1133
10	Specific electrical resistance (Coating resistivity) , min	$\Omega m^2$	$10^8$	DIN 30670
11	*Cathodic disbondment , max : - at $23 \pm 2$ °C /28 days , -1.5 V - at 80 °C / 28 days / -1.5V	mm mm	5 12	Annex H ISO 21809-1
12	Hot water soak test , at 80 °C / 28 days	---	No loss of adhesion (Rating 1)	Annex J NACE RP 0394 : 02
13	Degree of cure of the epoxy as first layer	°C	$\Delta Tg \leq +3$ for FBE Scratch test for liquid epoxy	Annex D ISO 21809-1
14	Flexibility at $0$ °C $\pm$ $3$ °C	%	No cracking at 2.5 degree per pipe diameter length	Annex I ISO 21809-1

\* The hole diameter shall be equal to  $3 \times$  total coating thickness .

**TABLE 4 –Requirements for inspection of surface preparation**

Item	Property	Unit	Test Method	Requirement	Frequency Qualification	Frequency production
1	Bare pipe	---	Visual inspection	Free from dent , porosity , corroded debris	each pipe	each pipe
2	Surface condition before blasting	---	Visual inspection	Free of contaminations	each pipe	each pipe
3	salt content after blasting , max	mg/m <sup>2</sup>	Conductive measurement , ISO 8502-9	20	3 pipes at start up and 1 pipe / shift*	3 pipes at start up and 1 pipe / 4h
4	Humidity	---	Calculation	as determined at time of measurement	1 / shift*	1 / 4h
5	Pipe temperature before blasting , min	°C	thermocouple	3above the dew point	1 pipe / shift*	1 pipe / 4h
6	Size , shape and properties of abrasive	---	Visual + certification ISO 11124 resp. ISO 11126	compliance to APS**	1 / day	1 / shift*
7	Water soluble contamination of abrasives , max	µS/cm	ASTM D 4940	Conductivity 60	1 / day	1 / shift*
8	Surface roughness of blasted surface (R <sub>z</sub> ) : - liquid - powder	---	ISO 8503-4	40 µm to 100 µm 60 µm to 100 µm	3 pipes / shift*	each pipe
9	Visual inspection of blasted surface	---	ISO 8501-1	grade Sa 2½	3 pipes / shift*	each pipe
10	Presence of dust after dust removal , max	---	ISO 8502-3	class 2	3 pipes / shift*	each pipe
11	Pipe condition prior to coating	°C	monitoring	no rust , pipe temperature at least 3 above the dew point	3 pipes / shift*	each pipe
12	Temperature of extruded adhesive and polyethylene	---	thermometer	compliance to APS**	3 / shift*	continuous
13	Preheating temperature before coating	---	thermometer	compliance to APS**	3 / shift*	continuous

\*Shift : every 8 working hours .

\*\* APS (Application Procedure Specification) :

Document describing procedures , methods , equipment and tools to be used for coating application according to clause 9.2 of ISO 21809-1 : 2007.

**TABLE 5 – Requirements for inspection and testing of applied coating**

Item	Property	Unit	Test Method	Requirement	Frequency Qualification	Frequency production
1	Epoxy thickness , min	µm	ISO 2808	FBE : 150 Liquid epoxy : 25	1 pipe at start up and 1 pipe / shift*	1 pipe at start up and 1 pipe / shift*
2	Adhesive thickness , min	µm	ISO 2808	150 on pipe body	1 pipe at start up and 1 pipe / shift*	1 pipe at start up and 1 pipe / shift*
3	Degree of cure	°C	Annex D ISO 21809-1	$\Delta T_g \leq +3$ for FBE Scratch test for liquid epoxy	1 pipe / shift*	1 pipe / shift*
4	Appearance and continuity	---	Visual Annex B ISO 21809-1	Uniform colour , free of defects and discontinuities , delaminations , separations and holidays	continuous	continuous
5	Total thickness of coating**	mm	Annex A ISO 21809-1	See Table 2	3 pipes / shift*	each pipe
6	Impact resistance , min - at $23 \pm 2$ °C - at $-30 \pm 3$ °C	J/mm	Annex E ISO 21809-1 CSA Z245.20-06	7 3	3 pipes at start up and 1 pipe / 50 km	3 pipes at start up and 1 pipe / 50 km
7	Peel strength (Adhesion) , min - at $23 \pm 2$ °C - at $80 \pm 3$ °C	N/mm N/mm	Annex C ISO 21809-1	15 3	3 pipes / shift* 3 pipes at start up and 1 pipe / 50 km	3 pipes / shift* 3 pipes at start up and 1 pipe / 50 km
8	Indentation , max : - at $23 \pm 2$ °C - at $80$ °C	mm mm	Annex F ISO 21809-1	0.2 0.4	3 pipes at start up and 1 pipe / 50 km	3 pipes at start up and 1 pipe / 50 km
9	Elongation at break*** at $23 \pm 2$ °C , min	%	ISO 527	400	3 pipes at start up and 1 pipe / 50 km	3 pipes at start up and 1 pipe / 50 km
10	Cathodic disbondment , max : - at $23 \pm 2$ °C / 28 days , - 1.5 V - at $80$ °C / 28 days / - 1.5V	mm mm	Annex H ISO 21809-1	5 12	3 pipes at start up and 1 pipe / 50 km	3 pipes at start up and 1 pipe / 50 km
11	Flexibility at $0$ °C $\pm$ $3$ °C	%	Annex I ISO 21809-1	No cracking at 2.5 degree per pipe diameter length	1 pipe / order	1 pipe / order
12	In process degradation of polyethylene***	%	ISO 1133	$\Delta$ MFR $\leq$ 20 for PE between raw and extruded material	3 pipes / order	3 pipes / order
13	Cutback	mm	Measuring	100 $\pm$ 7 up to 20" 150 $\pm$ 10 for $\geq$ 20"	3 pipes / shift*	all pipes
14	Hot water soak test , at $80$ °C / 28 days	---	Annex J NACE RP 0394 : 02	No loss of adhesion (Rating 1)	3 pipes at start up and 1 pipe / 50 km	3 pipes at start up and 1 pipe / 50 km
15	Glass transition temperature (DSC) , min	°C	Annex D ISO 21809-1	95	1 pipe / shift*	1 pipe / shift*

\*Shift : every 8 working hours .

\*\* The total thickness may be reduced by a maximum of 10 % on the weld seam for SAW welded pipes .

\*\*\* In case of change in batch of PE , retest shall be carried out .



**Note 1 : Material Approval**

1.1 For any order of three layer polyethylene coating of pipes , the coater shall submit manufacturer's raw material test certificate , test reports and technical data sheets showing , at least , the properties described in Tables 1 or 2 and 3 and 4 .

1.2 For any FBE raw material designation supplied from any manufacturer , a full set of tests as specified in Table 1 or 2 shall be performed by the coater in a reputable lab in IRAN or abroad .

The test certificates are considered to be valid for 5 years .

Test reports shall be submitted by the coater for each order .

1.3 For any adhesive or PE raw material designation supplied from any new manufacturer which supplied material for the first time for NIGC or NIGC subcontractor orders , a full set of tests as specified in Tables 3 and 4 shall be performed in a reputable lab in IRAN or abroad .

Test reports shall be submitted by the coater for each order .

1.4 A certificate of analysis (COA) should be issued by the manufacturer of each component . The manufacturer shall supply an inspection certificate for each batch .

1.5 Each batch of all coating materials shall be accompanied by a certificate of analysis (COA) according to EN 10204 , 3.1.B stating that all the tests have been carried out and results are in accordance with the manufacturer's product specifications and requirements of Table 1, Table 2 and Table 3 .

**Note 2 : Retest**

In case of failure in any required test , the Coater shall test two additional linepipes , one linepipe before and one after the failed one . If the follow – up tests are successful , all coated linepipes since the last acceptable test shall be considered satisfactory , except for the failed linepipes that will be rejected .

If any of the follow – up tests also fail to meet the requirements of this specification , all coated linepipes since the last acceptable test shall be rejected .

## **ANNEX A**

### **"3LPE COATING REPAIR PROCEDURE FOR THE COATING PLANT"**

#### **1. SCOPE**

In case of the 3LPE coating of pipe is damaged during production , handling , loading and unloading at the coating plant , the damage to the coating shall be repaired according to this Annex :

#### **2. COATING REPAIR MATERIAL**

Since the repair materials are required to be approved by NIGC , a copy of technical specification and data sheets of the repair materials including PE melt stick , filler mastic , repair patch and heat shrinkable sleeve shall be submitted to NIGC for review and approval .

#### **3. QUALIFICATION OF REPAIR PROCEDURE**

The repair procedure shall be qualified at the presence of NIGC inspector . In this case a line pipe with damaged coating shall be repaired in accordance with the instructions recommended by the repair material manufacturer . The repaired area shall then be inspected for minimum thickness , adhesion and holiday detection and if satisfactory results achieved , the repair procedure will be considered acceptable . The inspection findings shall then be recorded and signed by both parties and kept as a proof of repair procedure qualification .

#### **4. ACCEPTABLE NUMBER OF REPAIRS IN A LINE PIPE**

The maximum acceptable number of damage in any coated line pipe , may be up to three points , provided that the total damaged areas do not exceed 200 cm<sup>2</sup> , however the total number of pipes with coating repairs , shall not exceed 2% of total number of coated pipes in any individual order .

#### **5. UNREPAIRABLE DAMAGE**

The following damage are not allowed to be repaired :

**5.1** If in every 200 pipes the damage to the coating , is reached to the FBE layer in only one pipe .

**5.2** No repair will be allowed on coating edges at either sides of pipe coating .

**5.3** The maximum surface of 3 repaired areas in any line pipe , shall not exceed 200 cm<sup>2</sup> . In such cases the pipe coating shall be fully stripped and the pipe recleaned and recoated.

## 6. REPAIRABLE DAMAGE

The damage which is allowed to be repaired is limited to the following :

### 6.1 Minor Damage

If the damaged depth is less than 1.5 mm and the related area is less than 5 cm<sup>2</sup> , the damage may be repaired by PE melt stick .

### 6.2 Intermediate Damage

If the damaged depth is less than the thickness of PE and adhesive layers (3 mm maximum) and the maximum area of the damages does not exceed 50 cm<sup>2</sup> , with the biggest dimension of 10 cm , the damage shall be repaired by filler mastic and repair patch .

### 6.3 Major Damage

If the damage depth is less than the thickness of PE and adhesive layers (3 mm maximum) and the maximum area of the damage does not exceed 100 cm<sup>2</sup> with the biggest dimension of 30 cm , the damage shall be repaired by filler mastic together with a wraparound heat shrinkable sleeve .

Note : Any repair activities shall be performed fully in accordance with the instructions recommended by the repair material manufacturer .

## 7. REPAIR QUALITY CONTROL

All repaired areas shall be subjected to visual inspection , thickness measurements , holiday inspection and adhesion when repair patch is used . In case of any failure , the repaired portion shall be removed , recleaned and repaired again .

Repair material shall be suitable for maximum operating pressure and also other physical properties to be matchable with 3 layer polyethylene coating .

The coater shall obtain the approval of NIGC for type and technical properties of repair material .