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مشخصات فنی مواد و دستورالعمل

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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

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IGS-TP-010(0) : Part 2

KEY CHANGES

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TABLE 1 – Liquid Epoxy Properties

Item	Property	Unit	Requirement	Test Method
1	Density	g/cm ³	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 ³	as per manufacturer's specification ± 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 μ m mesh Maximum powder retained on 250 μ 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 ²	> 10 ⁸	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 ₂) (DSC analysis)	°C	≥ 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

Item	Property	Unit	Requirement	Test Method
1	Density at 23 ± 2 °C	gr/cm ³	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 ³	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 st layer) , mm (µm)	Powder Epoxy Resin (1 st layer) , mm (µm)	Adhesive (2 nd 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_z) 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 / cm² .

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 ± 2 °C - at 80 ± 3 °C	N/mm N/mm	15 3	Annex C ISO 21809-1
5	Impact resistance , min - at 23 ± 2 °C - at -30 ± 3 °C	J/mm	7 3	Annex E ISO 21809-1 CSA Z245.20-06
6	Elongation at break at 23 ± 2 °C , min	%	400	ISO 527
7	Indentation , max : - at 23 ± 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	Ωm^2	10^8	DIN 30670
11	*Cathodic disbondment , max : - at 23 ± 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 ²	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 _z) : - 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 ± 2 °C - at -30 ± 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 ± 2 °C - at 80 ± 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 ± 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 ± 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 ± 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	Δ 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 cm² , 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 cm² . 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 cm² , 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 cm² , 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 cm² 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 .