JOB SPECIFICATION
CORROSION PROTECTION COATING OF U/G PLANT PIPING

SMMS DEPARTMENT
CFBC BASED CAPTIVE POWER PLANT

PROJECT: BINA REFINERY
OWNER : BHARAT OMAN REFINERIES LTD.(BORL)
PMC : ENGINEERS INDIA LTD.
JOB NO.: 6743

Rev. No	Date	Purpose	Prepared by	Reviewed by	Approved by
0	25.03.2006	ISSUED AS JOB SPECIFICATION			

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1.0 SCOPE

1.1 This specification shall govern the materials, application requirements, repairs, handling and other requirements for a hot melt protective coating system for under ground carbon steel piping to be installed under normal or average construction conditions in soil. The work includes the furnishing of all labour, materials, tools, and equipment and performance of all operations and incidentals necessary for coating, handling and storage of coated pipes. The work shall generally be performed in the following operations:

- Cleaning of external pipe surface
- Priming with synthetic primer (Type B)
- First Coat of Coal Tar Enamel
- First layer of inner wrapping with glass fibre
- Final coat (2^{nd} coat) of Coal tar enamel
- Outer wrap of coal tar enamel impregnated glass fibre.
- Conditioning of outer wrap surface by acrylic water-emulsion in latex paint.

1.2 After surface preparation and primer application, the pipes shall be coated by successive layers of coal tar enamel, glass fibre re-enforcement (first layer of inner wrap), coal tar enamel impregnated glass fiber outer wrap to obtain the total thickness of coating and wrapping 4.0mm. Allowance of 1.0mm may be considered on projected weld joints only.

1.3 The pipes shall be coated in a fully equipped coating plant and brought to site for laying. Site application or over the ditch application shall not be done.

2.0 REFERENCES

2.1 Indian Standards

IS No.	Title
IS 101	Methods of sampling and test for ready mixed paints, varnishes and related products
(Pt.1/Sec.5):1989	Part 1 Test on liquid paints (General and Physical), Sec 5 Test for Consistency *(third revision)*
(Pt 1/Sec.6):1987	Sec 6 Test for Flash Point. *(third revision)*
(Pt.2/Sec.2):1986	Part 2 Tests on liquid paints (chemical examination) Sec 2 Test for Volatile Matter. *(third revision)*
IS 101(Pt.3/Sec.1): 1986	**Part 3 Tests on paint film formation** Sec 1 Test for drying time. *(third revision)*
IS 101 (Pt.5/Sec.3): 1988	Part 5 Mechanical tests on paint films **Sec 3 Impact resistance (falling ball test)*(third revision)***
IS 1060 (Pt.1)	1966 Methods of sampling & tests for paper & allied products Part 1 1967 *(third revision)*
IS 1202 :1978	Method of testing tar and bituminous materials – Determination of specific gravity
IS 1203 :1978	Method of testing tar and bituminous materials – Determination of penetration.
IS 1205 :1978	Method of testing tar and bituminous materials – Determination of softening point.
IS 1211: 1978	Method of testing tar and bituminous materials – Determination of

	water content (Dean and Stark method)
IS 1212 :1978	Method of testing tar and bituminous materials – Determination of loss on heating
IS 1213 :1978	Method of testing tar and bituminous materials – Distillation test
IS 1217 :1978	Method of testing tar and bituminous materials – Determination of mineral matter (ASH)
IS 1448 (Pt.69) -:1969	**Method of tests for petroleum and its products** Part 69 Methods of test for flash and fire point by cleveland (open) cup method
IS 1607 :1977	**Methods for test sieving*(first revision)***
IS 1969:1985	**Methods for determination of breaking load and elongation of woven textile fabrics *(second revision).***
IS 7193:1994	**Glass fibre base coal tar pitch and bitumen felts (*first revision)***
IS 11080 :1984	**Methods for determination of porosity of paper**
IS 14164:1994	**Industrial application and finishing of thermal insulation materials at temperature above 80°C up to 750° C – code of practice**

2.2 AWWA C-203 (Latest Edition) - Coal tar protective coatings and linings for steel water pipelines

2.3 BS 4164 (Latest Edition) – Coal tar based hot applied coating materials for protective iron and steel , including a suitable primer.

3.0 GENERAL REQUIREMENTS

3.1 Minimum requirements of a suitable coating for underground steel pipelines should comprise of a relatively high melting point thermoplastic coal tar coating of known permanent low water absorption, resistant to product spillage and high electrical resistivity and conforming to the physical properties specified in Table 1 to 5 .

3.2 Material specifications given in this code are based upon the proven performance of such products during many years of service. The properties given in Tables 1 to 5 do not in themselves constitute a guaranteed performance except when they refer to coal tar enamel coatings. A material of unknown composition might be made to meet the requirements specified in this standard but would not necessarily be a good protective coating.

3.3 *Material Packaging*

3.3.1 All coating, primers and wrappers purchased or used under the specifications laid down in this standard shall be packed in suitable and approved containers. The containers shall be plainly marked with the name of the manufacturer, type of material, batch or lot number and date of manufacture.

3.4 *Approval of Materials*

3.4.1 Prior to use, all materials proposed to be used under these specifications shall be submitted for inspection and no material shall be used until it has been approved by the inspector.

4.0 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

4.1 **Purchaser** - The person, firm, corporation or government sub-division entering into a contract or agreement for the purchase of any material or of any work to be performed or both under this standard.

4.2 **Contractor** - The person, firm or corporation executing the contract or agreement with the purchaser to furnish any material or to perform any work under this standard.

4.3 **Inspector** - The inspector or engineer employed by the purchaser acting as his representative, their respective assistants properly authorized and limited to the particular duties assigned to them, or the purchaser himself acting as his own inspector.

4.4 **Blasting** - Blasting with steel grit in suitable combination with shots.

5.0 MATERIAL

The materials, commonly used for coating and wrapping of underground pipelines are as follows:

a) Coating Primer,
b) Coating enamel, and
c) Wrapping materials
d) Acrylic water base latex emulsion paint.

5.1 PRIMER

The primer shall be fast drying type unmodified pure Chlorinated Rubber based coal tar synthetic primer. The primer to be used in connection with hot applied coating is highly important and the first requirement is compatibility with the type of enamel being used.

5.1.1 *Synthetic Primer* - Fast drying synthetic primer shall consist of pure chlorinated rubber, synthetic plasticizer and solvents. They shall be suitably compounded to produce a liquid coating that may be readily applied cold by brushing or spraying and that shall produce a suitable and effective bond between the metal and subsequent coating of coal tar enamel. The primer used with coal tar enamel shall have the characteristics as specified in Table-1.

5.2 Enamel

5.2.1 The enamel shall consist of specially processed plasticized tar pitch, blended with inert and non-hygroscopic mineral fillers, properly graded, clean, dust free and without asphalt, to be applied at the recommended temperature.

5.2.1.1 The quality of coal tar enamel is liable to be affected by the quality of coal carbonized and the temperature of carbonization as well as by the subsequent methods of pitch processing and particulars of formulation. To rectify this defect, coal tar should be produced from coal that has a minimum heating value of 320 k j/g on a moisture - and mineral-matter-free basis and that has been carbonized in a slot-type coke oven at a temperature of not less than 900^{o}.C. The enamel shall have the characteristics as specified in Type 2 of BS 4164 in Table 2.

TABLE 1: CHARACTERISTICS OF FAST DRYING TYPE CHLORINATED RUBBER BASED SYNTHETIC PRIMER

FOR USE WITH COAL TAR ENAMEL

(Clause 5.1.1)

SL. NO.	CHARACTERISTICS	REQUIREMENT	TEST METHOD
i)	Flash Point (Abel), ^{0}C, *Min*	23	IS: 101 (Pt.1/Sec.6)
ii)	Viscosity (Flow time at 20^{0}C by No.3Flowcup), sec	35	IS: 101 (Pt.1/Sec.5)
iii)	Volatile matter (100-110^{0}C), percent loss by mass	50-75	IS: 101 (Pt.2/Sec.2)
iv)	Drying time (to touch) at 70% RH & 30 deg.C., mts., max.	20	IS:101 (Pt.3 / Sec.1)

5.3 **Wrapping Materials**

5.3.1 Inner *Wrap*

Inner wrap shall be Composed of chemically resistant boro-silicate of glass fibre tissue or cloth. The glass fibre tissue or cloth is a thin, flexible, uniform mat, composed of glass fibres in an open porous structure, may be bonded with a suitable inert material, compatible with coal tar enamel. The glass fibre tissue or cloth shall have the characteristics as specified in Table 3.

5.3.2 *Outer Wrap* : *Glass Fibre Outer Wrapping*

The outer wrap shall conform to glass fibre felt type 1, as specified in IS:7193-1994*. It shall consist of glass fibre, tissue, as specified in Table-5**,** impregnated with coal tar/enamel, as specified in Table 2. The resultant outer wrap shall be uniform, flexible and of uniform porosity to facilitate the release of hot gases and achieve better finishing. The outer surface of outer wrap shall be lightly dusted with talc, fine sand, or other approved mineral powder sufficient to prevent sticking in the rolls under conditions likely to be met at site. The inside surface shall receive minimum dusting, as excessive amount may impair the bond between outer wrap and enamel. The finished outer wrap shall have the characteristics as specified in Table 5.

TABLE 2 CHARACTERISTICS OF COAL TAR ENAMEL

SL. NO.	CHARACTERISTIC	REQUIREMENT	TEST METHOD
I		TYPE 2 120/5 Grade BS4164	(REFER TO APPENDIX A&B OR RELEVANT IS)
i)	Softening point (ring and ball), ^{0}C	120-130	IS: 1205
ii)	Filler content by ignition, percentage mass	25-35	IS: 1217
iii)	Fineness of filler, percentage passing 75 μm IS Sieve, *Min.*	90	IS: 1607
iv)	Specific gravity at 25^{0}C	1.4-1.6	IS: 1202

v)	Penetration, 10^{-1}mm: a) 25^0C, 100g, 5s b) 48^0C, 50g, 5s	 1-9 3-16	IS: 1203
vi)	Sag, mm, *Max* 80^0C for 24 h	1.5	A-2
Vii)	Deflection test (Initial test) a) First crack, mm, *Min* b) Disbonded area, mm^2, *Max*.	 12 3200	A-3
Viii)	Deflection test(After Heating) : a) First crack, mm, Min b) Disbonded are mm^2, *Max*.	 7.5 5200	A-4
Ix	Impact test: a) Direct impact, disbonded area, mm^2, *Max*. at 25°C	 10300	IS:101(Pt.5/Sec.3)
	b) Indirect impact disbonded area, mm^2, *Max*.	1300	
x)	Peel Test 30°C 40°C 50°C 60°C	No peeling allowed 3.0mm	A-5
xi)	Cathodic disbondment Test for 28 days at 23°C	5mm	APPENDIX-B
Xii)	Water absorption, 35 weeks	0.3%	
Xiii)	Spark test at 15kv low ampearage	No holidays	
Xiv	Low temperature cracking and disbonding at -20°C	None	
Xv)	Flow time, seconds at 240 deg. C	9 to 24	

NOTE: Bond testing may be done by deflection (Initial test), deflection (after heating) test or by the impact test depending upon the equipment available.

TABLE 3 PHYSICAL PROPERTIES OF INNER WRAP

SL. NO.	CHARACTERISTICS	REQUIREMENT		TEST METHOD
		Glass Fibre tissue	Glass cloth	
i)	Mass, g/m^2, *Min*	41	60	-
Ii)	Thickness, mm, *Min.*	0.325	0.05	-
Iii)	Breaking strength (in the longitudinal direction), N/cm, *Min.*	22.8	80.0	IS: 1969
Iv)	Tear strength, N, *Min* Longitudinal direction Transverse direction	0.98	 2.25 3.80	IS:1060 (Pt.1)
v)	Porosity in mm of water gauge measured at pressure difference across the sample at an air velocity of 1 m/s	0.6- 1.9	0.6min	IS: 11080
Vi)	Temperature resistance When dipped in hot coaltar at 288 ^{o} C. for 1 minute.	Un-Affected	Un-Affected	-

Vii)	Pliability When bent over a 3mm radius, after immersing in water for 10-15 minutes through a 90^0 arc.	No cracking	N.A.	
Viii)	Moisture absorption by wt. At relative humidity of 95% at 50 ^{o} C for 24 hrs.	5% max.	5% max.	

TABLE 4 **: CHARACTERISTICS OF COAL TAR IMPREGNANT**

SL. NO.	CHARACTERISTICS	REQUIREMENT	TEST METHOD
I)	Softening Point, ^{0}C	80-85	IS: 1205.
Ii)	Penetration at 25^0C/100g/5s, 10^{-1} mm	15-25	IS: 1203.

TABLE 5 : PHYSICAL PROPERTIES OF FIBRE-GLASS OUTER WRAP

Sl. No.	CHARACTERISTICS	REQUIREMENT	TEST METHOD (REFER TO IS)
i)	Nominal thickness, mm, min.	0.75	-
Ii)	Mass, g/m^2	550-730	
Iii)	Breaking strength N/150 mm of width, Min.	535	IS:1969
Iv)	Tear strength (Transverse), N, Min.	45	IS:1060(Pt.9)
v)	Inner diameter of core, mm	63-75	-

5.3.3 When unrolled at temperatures up to 50^{o}C, the wrapper shall not crack or stick to such an extent as to cause breaking or tearing.

5.3.4 All the outer wrappers shall be supplied in tightly wound tied rolls with a 75mm diameter core in widths and lengths as specified at time of purchase. The rolls shall be packed to exclude dust and dirt during shipping and handling, and shall have cardboard separations and end shields, adequate to prevent roll damage, when stacked. The rolls shall be clean, smooth and square cut and shall have no telescoping.

5.4 Conditioning of outer wrap: surface. After application, and following final inspection, the outside surface of the outer wrap is to be given a finish coat of acrylic water-emulsion latex paint.

6.0 APPLICATION TO EXTERIOR SURFACES

6.1 Method of Application - All the cleaning, priming , coating and wrapping should be carried out by suitable machines in a fully equipped automatic coating plant under controlled conditions. The coated pipes shall be brought to the site. After laying and welding, the weld joints shall be coated with heat shrinkable sleeves conforming to DIN 30672 Stress Class 'C'

6.1.1 The inner wrap shall be mechanically applied by continuous end feed machine or by a lathe-type machine or by other approved application equipment. Application shall be simultaneous with the first coat of coal tar enamel. The roll of inner wrap shall be under tension sufficient to embed the

fibreglass mat or glass cloth in the enamel before the latter sets or cools. The wrapper shall not be pulled through the hot enamel to the metal surface.

6.2 General Procedure of Application

6.2.1 *Material and Workmanship*

All material furnished by the supplier shall be of specified quality as per the document laid down in this standard. All work shall be done in a thorough workmanlike manner. The entire operation of priming the pipe, heating and applying the coating shall be performed under the supervision of experienced men skilled in the application of protective coating.

6.2.2 Equipment

The equipment of cleaning, priming, coating and wrapping shall be in such condition as to permit the applicator to follow the procedure and obtain results prescribed in this standard.

6.2.3 Cleaning

6.2.3.1 Pipe surfaces shall be thoroughly cleaned and dried before the primer is applied, and shall be free of dirt, grease, oil rust, scale or other foreign matter. The pipe shall be cleaned by Combination of Grit and shot blasting only.

6.2.3.2 Before Grit/shot blasting, all oil and grease, if present on the metal surface, should be removed by using a suitable solvent and clean rags. The use of dirty, oily rags should not be permitted. All other foreign matter, which cannot be removed by blast cleaning, should be removed by suitable means. The surfaces then should be thoroughly cleaned by blast cleaning and the operation should remove mill scale, rust or any other superficial impurities from the surfaces exposing base metal presenting a greyish metal appearance except that slight shadows, streaks or discoloration caused by rust stains or mill scale oxides need not be removed. Blasted surfaces which rust before the priming coat has been applied should be cleaned of this superficial rust by wire brushing or emery papering at the discretion of the Engineer. If the rust formation is heavy, that is if the pipes have been exposed overnight without priming, the same can be re-blasted once again at the discretion of the Engineer.

6.2.3.3 Adequate moisture separators should be used so as to remove effectively oil and moisture from the air supply of the blasting unit.

6.2.3.4 After cleaning the pipes shall be protected from and maintained free from all oil, grease and dust that may fall on the pipes from outside sources till the pipe has received its final coat of enamel.

6.2.3.5 Any pipe, that show deep pitting after blasting has been done, should be set aside pending examination by the Engineer for approval for reconditioning or rejection.

6.2.4 *Priming*

6.2.4.1 one uniform coat of primer, compatible with the type of enamel to be used and free from floods or runs, shall be applied immediately after pipe has been cleaned and dried.

6.2.4.2 Primer coverage shall be such as to ensure maximum bond between the steel surface and the enamel coating.

6.2.4.3 Atmospheric conditions, type and coverage of primer determine the drying time. If the primer coat is found to be unsatisfactory, the pipe shall be re-primed.

6.2.5 *Coating*

6.2.5.1 The primed pipe surface shall be free from moisture or any foreign matter immediately prior to the application of the hot coating.

6.2.5.2 All enamel coating shall be broken into lumps suitable for the heating equipment employed and shall be free of any foreign material.

6.2.5.3 The loaded heating kettle shall be brought to application temperature in a manner to prevent damage to the coating material.

6.2.5.4 The Kettles shall be equipped with mechanically operated agitators so as to supply uniform hot material to the coating and/or wrapping machines. Kettles shall not be used as a continuous coating supply source by adding unmelted coating material after application temperature has been reached. Kettles shall be completely emptied of one charge and cleaned when necessary before re-charging.

6.2.5.5 Application temperature of enamel is normally 230^{o}C. - 250^{o} C. In low ambient temperatures one would expect to operate at 250^{o}.C. while in warm weather it should be 230^{o}C. Any enamel which has been held in the melting kettle at application temperature for four hours or more, without being circulated, should be rejected. The maximum temperature in the melting kettle should never exceed 270^{o}C. at any time. Enamel which has been heated above this temperature should be rejected.

6.2.5.6 While the enamel may be kept in a kettle up to a maximum temperature of 257^{o}C. the manufacturer should guarantee proper flow for application by standard machines even at the lowest enamel application temperature of 230^{o}C, at an ambient temperature of 7^{o}C.

6.2.5.7 When the enamel has reached application temperature it should be applied to the primed pipe through a standard flood box. Simultaneously with the flood, the glass fibre / glass cloth inner wrap and outer wrap should be applied under tension, the wrapping having a minimum overlap of 12mm. There should be approximately 0.8mm of enamel between the pipe surface and the inner wrap.

6.2.5.8 Enamel should not be applied to the primed pipe when the pipe metal temperature is below 7 ^{o} C.

6.2.6 Handling

6.2.6.1 The coated pipe shall be handled at all times with equipment, such as wide belt slings and wide padded skids, designed to prevent damage to the coating. Bare cables, chains, hooks, etc. shall not be permitted to come in contact with the coating.

6.2.6.2 When transported by rail, all coated pipe shall be carefully loaded on properly padded saddles. Pipes shall be separated so that they do not bear against each other and securely fastened to prevent movement in transit.

6.2.6.3 In truck shipment; the coated pipe shall be supported in wide cradle of suitably padded timbers, hollowed out on the supporting surface to fit the curvature of pipe and securely fastened to prevent movement in transit.

6.2.6.4 Along the trench side, coated pipe should be suitably supported off the ground to avoid damage to the coating.

6.2.7 *Lowering and Back - filling*

6.2.7.1 While lowering, the coated pipe shall neither be hoisted from the trench side to the trench by means of wide belt slings. Chains, cables, tongs, or other equipment likely to cause damage to the coating shall not be permitted, nor moved by dragging or skidding of the pipe. The underside of the pipe should be inspected while lowering and any damage shall be repaired before the coated pipe is lowered into the trench.

6.2.7.2 Where the trench traverse rocky ground or hard objects that could penetrate the protective coating, a layer of soft earth or sand, not less than 75mm thick, shall be placed at the bottom of the trench prior to lowering. After lowering, backfilling should be done in such a manner that the protective coating is not damaged in any way.

7.0 FIELD PEEL TEST ON COATED PIPES

The bond test to be conducted in the shop or field on the coated pipes shall be performed using a knife with a moderately stiff steel blade and handle. The total length shall not exceed 178mm. The dimensions of the exposed blade shall be 16mm to 19mm wide, 3.2mm thick and approximately 76mm in length. The blades front edge shall be ground square and then sharpened by a suitable means to produce 40 deg. To 50 deg. Beveled edge over the entire front edge. The peel test shall be conducted at 10 deg. C-27deg C. If the coating temperature measured with a surface thermometer is above 27 deg. C or below 10 deg. C, pour sufficient hot or cold water over the test area to adjust the enamel and substrate temperature within this range**.** Using a knife as described above, heated if necessary(but not so much as to cause the enamel to fume) and ensuring knife blade to pipe contact, make two parallel cuts through the coating or lining, approximately 4 in.(102mm) long and 16mm to 19mm) apart. Place the cutting edge of the knife blade beveled edge up on the enamel between and at the beginning of the parallel cuts. Push the knife at an approximate 45 deg angle into the enamel between the parallel cuts, apply an even pressure and loosen the enamel from the pipe for a length of about 13mm.

Applying an even, steady pressure is necessary to avoid imparting shock stresses within the enamel between the parallel cuts, thereby causing a shattering separation of the enamel from the pipe that may be erroneously interpreted as bond failure. With the knife blade placed under the loosened end of the enamel, grasp the strip of loosened enamel between the knife blade and the thumb. Apply a slow, steady upward pull. The bond is satisfactory if the length of peel is no greater than the width of cut before the enamel breaks.

If the peel length exceeds the cut width, the test is a failure and two additional tests shall be made at two different locations on the same pipe section, a minimum of 0.9m from the point of test failure. If both tests are satisfactory, the pipe section shall be approved. If either additional test fails, the pipe section shall be rejected.

8.0 DESIGN CONSIDERATIONS

8.1 The following factors should be considered before taking up the work of pipe coating/wrapping:

a) *Nature of soil* - The pipe coating system shall depend upon the type of soil.
b) Past history of corrosion condition of the same pipeline or other pipelines running in that area,
c) Environment,
d) Pipe dimensions and material,
e) Transport facilities, and
f) Feasibility of providing cathodic protection.

8.2 Thickness of coal tar enamel coated pipes shall be measured with a Digital thickness gauge for determination of the thickness as per the specification.

9.0 ELECTRICAL INSPECTION

9.1 All coated and wrapped pipes shall be tested with an approved high voltage Holiday Detector equipped with a positive signaling device to indicate any faults, holes, breaks or conductive particles in the protective coating.

9.2 The applied output voltage of the holiday detector shall have a spark discharge at least twice the thickness of the coating to assure adequate inspection voltage and compensate for any variation in coating thickness.

9.3 When selecting test voltages, consideration should be given to the tolerance of coating thickness and the voltage should be selected on the basis of maximum coating thickness likely to be encountered.

Max. Thickness of Coating (mm)	*Max. Suggested Test Voltage(kv)*
2.25	*8.00*
3.00	*10.00*
3.75	*12.00*
4.50	*14.50*
5.25	*17.00*
6.00	*20.00*

9.4 The test shall be carried out in co-ordination with the coating / wrapping manufacturers.

10. 0 MEASUREMENT

10.1 All measurements for piping shall be taken over the finished surface in meters, corrected to nearest centimetre along the centre line of piping, through all fittings, coated and wrapped, or otherwise, such as valves, flanges, elbows, bends, tees & reduces.

10.2 Coating and wrapping of valves, flanges or other fittings shall be measured through` Such valves, flanges or other fittings as per 9.1 above and in addition extra measurements shall be allowed as follows:

a) For each coated and wrapped valve and venturi including flanges and body 1.5 linear metres of piping of connected line size up to 300mm line size and 2.00 linear metres for larger sizes.

b) For each pair of coated and wrapped flanges including orifice plate and flanges, 0.80 linear meters of piping of connected lines etc.

c) For all coated and wrapped bends and elbows twice the actual length of such fittings, of concerned connected line sizes, as measured along their centre lines.

d) For all coated and wrapped reducers, actual length of longer size (along the centre line of piping)

e) For all coated and wrapped tees, the formula 2 (D_1+D_2) shall apply where D1 and D_2 are coated and wrapped diameters of the two pipelines forming the tees.

f) Any other special fittings not covered under above shall be specified and measured separately on number basis.
(For further details please refer IS: 14164-1994).

11.0 Protective coating for Field joints of pipes after laying at site:

After laying and welding, the weld joints shall be coated with Heat shrinkable sleeves conforming to DIN 30672 stress class `C'.

12.0 Coating Repair(as per clause 3.12 of AWWA C203)

All the areas of the coal tar enamel system that are damaged flawed or exhibit holidays shall be repaired using materials from the same manufacturer as those used to coat the pipe. Damaged areas are categorised into three types (1) pin point or bubble type (2) exposed metal type or (3) Extensive damage type. The detailed procedures shall be followed as per AWWA C-203(latest edition) clause 3.12.1, 3.12.2, 3.12.3 and 3.12.4.

A P P E N D I X A

(*Clause 0.5)*

TESTS ON COAL TAR MATERIALS - TESTING PROCDURE

A-1. PREPARATION OF TEST PLATES

A-1.1 Test Plates - Steel plates of suitable sizes shall be free of all oil and grease. One side of each plate shall be blasted to a uniform grey surface, with rust, mill scale and all other foreign matter completely removed. A profile of 3 mills (0.075 mm) is intended.

A-1.2 Priming of Test Plates - All test plates prepared as specified in **A-1.1** shall be primed using the coverage recommended by inspector/manufacturer. The primer shall be applied with a clean flat-bristle brush of 25mm width. Plates shall be primed and dried while laying horizontally in a well ventilated room.

A-1.2.1 Conditioning - These plates shall be kept in room, for drying where temperature shall be controlled between 21 to 33 ^{o}C. and 66 percent maximum relative humidity.

A-1.3 APPLICATION OF ENAMEL

A-1.3.1 *Preparation of Enamel for Testing* - About 13 kg of enamel shall be broken into pieces approximately 100mm in maximum cross-section. This shall be rapidly melted over a large gas burner in a metal container of uniform cross-section of not less than 200mm, nor more than 300mm in diameter.

A-1.3.2 Initial *Heating* - Immediately upon reaching the specified application temperature, the enamel shall be applied to the primed test plates required for the following tests:

a) High temperature test (see **A-2**);

b) Deflection test (initial test) (see **A-2**) and;

c) Peel test (see **A-5**).

A-1.3.3 *Two Hour Heating* - The remaining enamel in the container (about 9 kg) shall be maintained at the specified application temperature for 1 hour. The enamel shall be stirred with a metal bar at intervals of 15 minutes during the heating period. A 6 mm thick steel plate shall be interposed between the container and the gas flame to avoid superheating.

After a 2-hour heating period, this enamel shall be applied to test plates required for the deflection test (see **A-4**).

A-1.3.4 The application temperatures and method of application shall be as recommended by the inspector/ the coating manufacturer.

A-2 HIGH TEMPERATURE (SAG TEST)

A-2.1 Depending upon the laboratory equipment available, prepare two test plates in accordance with one of the following methods:

a) Method A - Use 30 x 100 x 5 mm plates. Enamel one side in the manner previously described. Scribe three lines at 75mm intervals across the enamel surface.

b) Method B - Use 300 x 300 x 3mm plates. Enamel one side in the manner previously described, with a 12 mm uncoated border left around the four edges of the plates. Scribe lines 25mm apart across the face of the enamel surface and continues on the uncoated surface of the plate to the edges.

A-2.2 Procedure - The plates prepared by either method shall be stored in vertical position so that the scribed lines are horizontal in the chamber in which the temperature shall be controlled at the temperature and for the period specified for the appropriate grades in Tables 5 and 6. At the end of this period, the plates shall be removed and cooled to room temperature. The average of the sag of the scribed lines on two plates shall be recorded as sag of the enamel.

A-3 DEFLECTION TEST (INITIAL TEST)

A-3.1 Conditioning - These test pieces shall be stored in a chamber in which the temperature shall be controlled at 4°C. After a 6-hour period, the plates shall be tested for deflection on equipment in this chamber.

A-3.2 Procedure - The plates shall be supported on 3 mm radius knife edges which are spaced on 240 mm centres. The deflecting load shall be centrally applied across the plate by a 12 mm radius mandrel at the rate of 25 mm per minute (to produce tension in the enamel) until cracking occurs, as indicated by an electrical holiday detector. The deflection producing the initial cracking shall be recorded and deflection shall then be continued to a maximum distance of 37 mm. The specimen shall then be removed from the machine for examination. All disbonded enamel shall be removed from the plate and the area of metal exposed on the four plates shall be measured. The average initial cracking and disbonded area shall be recorded.

A-4 DEFLECTION TEST (AFTER HEATING)

A-4.1 Test Pieces - Four plates 250 x 100 x 1.5mm shall be enamelled on one side with enamel that has been maintained at the specific application temperature for 2 hours as described in **A-1.3.3.**

A-4.2 Procedure - Testing procedure as given in **A-3.2.**

A-5 PEEL TEST

A-5.1 Test Pieces - Two plates of 300 x 300 x 12mm shall be enamelled on one side in the manner previously described (see **A-1.3.**).

A-5.2 Conditioning - These plates shall be allowed to cool to room temperature. The condition of the bond shall be tested at temperatures of 27°C, 38°C, 49° C, 60°C and 71°C. Allow a tolerance of $\pm$1°C on these temperature requirements.

A-5.3 Procedure

A-5.3.1 Bond *(Initial)* - One test plate shall be tested directly. The plate shall be heated by immersing it for a period of approximately 1/2 hour in the water bath maintained at the selected temperature. At the end of each heating, the plate shall be removed from the bath and immediately tested for peel. This shall be done as follows:

a) With a knife edge, cut two parallel lines through the enamel approximately 2mm apart and approximately 100mm in length;
b) With the edge of the knife blade, cut under the enamel strip at one end and loosen the enamel from the full width of the strip for about 12mm; and
c) Place the knife under the loosened end and with a firm grip and apply a slow, steady pull upward on the enamel strip.

Adhesion of the enamel at each of the indicated test temperatures, to the extent of preventing peeling, stripping or lifting of not more than 3mm, shall be recorded as no peeling. The use of the water bath for the 27°C test may be omitted when the room temperature closely approximates 27°C.

A-5.3.2 Bond*(after 72 Hours at 71°C).*- The second test plate shall be stored in a horizontal position, with the enamelled side up, in a chamber the temperature of which shall be controlled for 72 hours at 71°.C. At the end of this period, the plate shall be removed and cooled to room temperature and tested for condition of bond over a temperature range of 27-71°C as above (see **A-5.3.1.**).

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units		
Quality	**Unit**	**Symbol**
Length	Metre	M
Mass	Kilogram	Kg
Time	Second	S
Electric Current	Ampere	A
Thermodynamic temperature	Kelvin	K
Luminous intensity	Candela	Cd
Amount of substance	Mole	Mol
Supplementary Units		
Quality	**Unit**	**Symbol**
Plane angle	Radian	Rad
Solid angle	Steradian	Sr

DERIVED UNITS

Quantity	**Unit**	**Symbol**	**Definition**
Force	Newton	N	1 N = 1 kg.m/s^2
Energy	Joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb= 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	Hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

APPENDIX-B
Cathodic Disbonding Test

1.0 APPARATUS

1.1 Stabilized D.C. power unit, having a controlled voltage output between 0 and 10V and a current capacity sufficient to supply 20mA simultaneously to each test site in circuit.

1.2 Digital voltmeter, range 1.999V(3 1/2 digit), input impedance 10^3M ohm accuracy 0.1% $\pm$ digit at 23$\pm$1deg.C. Maximum offset input current not greater than 10A to 11A.

1.3 Variable resistor, range 5k ohm $\pm$ 10%, 1 W for each test site.

1.4 Fixed resistor, 10 ohm $\pm$ 1%, 1W for each test site

1.5 Fixed resistor, 510 ohm $\pm$ 2%, 1W for each test site.

1.6 Flaw Detector

Fitted with a soft metallic bristled straight brush approximately 75mm long and 6mm wide with bristles 6mm. long, adjusted to provide a voltage of 10KV, so arranged that the maximum short circuit current is not greater than 8mA

1.7 Reference Electrode, saturated calomel type, constructed from glass or plastics with porous plug, of diameter less than 10mm.

1.8 Platinum wire, of 0.8mm. diameter, one 75mm length for each test site.

1.9 Rigid plastics tube, of 50mm. nominal bore, one 60 mm. length for each test site.

1.10 Elastomeric adhesive, for fixing the plastics tube solution containers to the test surface.

NOTE- Suitable materials are two part polysulphide rubber and silicone rubber or epoxy based adhesive.

1.11 Twist drill, of 6mm diameter

1.12 Lint-free paper towel

2.0 REAGENTS

2.1 Sodium Chloride Solution(3% m/v)

2.2 Phenolphthalein Acid/base Indicator

3.0 SAMPLE REPARATION

3.1 Prepare one test plate, measuring at least 200mm x 100mm x 15mm. Free the surface of the steel plate from all oil and grease, then blast it to a uniform steel grey finish, removing rust, scale and all other foreign matter so that the peak to trough profile is 50-75 Microns. prime it and Coat it with Coal tar enamal material coating and wrapping as per the manufacturer's guidelines. To ensure freedom from accidental damage test the prepared plate with the flaw detector.(see 1.6)

Note- It is important to ensure that blasted steel surfaces are free from traces of previous coating materials and do not subsequently become contaminated with oil or grease.

3.2 Flaw Detection

Examine the prepared plate for evidence of cracking by means of the flaw detector(see 1.6). If the flaw detector is not equipped with voltage indication, set it to give a 12mm spark in air to a steel plate. pass the flaw detector over the coated specimen at approximately 6mm distance from the coated steel surface. Ignore edge effects.

4.0 PROCEDURE

Affix two plastic tubes(1.9) perpendicular to the coated surface using a suitable elastomeric adhesive(1.10). Place them at a minimum distance of 33mm from the panel ends and from each other with their centres on the centre line of the panel width. Leave overnight to allow the adhesive to cure fully.

Drill a 6mm hole through the coating material(1.11) to the metal surface in the centre of each test site, as a pre-damaged area.

Fill each plastic tube(1.9) to a depth of approximately 50mm. with sodium chloride solution(2.1) and connect the apparatus as shown in Figure 1. Connect the voltmeter(1.2) as shown in Figure 2 and with the porous tip of the reference electrode(1.7) placed within 10mm. of the hole in the coating material, adjust the variable resistor(1.3) unit the voltmeter reads -1.500V with respect to the calomel electrode.

At intervals of 24 hour record, the voltmeter reading and adjust the variable resistor to correct any drift from the -1.500V setting.

Continue the test for 28 days, maintaining the temperature at 30 $\pm$ 5□C. After this period assess disbonding at both test sites by the method described in 5.0.

5.0 ASSESSMENT

Remove the plastics tube from each test site and wipe along the surface of the coating using a lint free paper towel(1.12) and cathode area material.

Make two parallel incisions through the coating and 12.5mm apart across the panel so as to include the pre-damaged area. The cuts should extend 50mm on each side of the pre-damaged area.

Using a square ended pellets knife insert it into the centre portion of the pre-damaged area, between the parallel cuts, down to the metal. Using a gentle levering action, lift the strip of coating. If possible, with a slow peeling action and then grip the coating between the blade and thumb and continue the peeling action until the coating breaks.

Repeat the peeling test in the opposite direction and then repeat the procedure at an angle of 90 deg. C to the first test.

Apply one spot of phenolphthalein acid/base indicator(2.2) to the exposed metal surface at the outside edge and allow it to flow towards the pre-damaged area. The purple boundary indicates the extent of disbonding.

6.0 REPORTING

Report the extent of disbonding as the radius in millimeters from the edges of the pre-damaged areas. Alternatively, if the coating is strongly adhering to the steel substrate, take the average distance at which the coating breaks as the extent of disbonding. The extent of disbonding shall not be more than 5mm radius from the edge of the 6mm holiday.