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RDSO Specification for Bipolar concrete penetrating corrosion inhibiting admixture to protect embedded steel reinforcement in concrete from corrosion.			

**RDSO SPECIFICATION No.  
M&C/PCN/126/2020  
(Rev.1.0)**



**SPECIFICATION FOR BIPOLAR CONCRETE  
PENETRATING CORROSION INHIBITING  
ADMIXTURE TO  
PROTECT EMBEDDED STEEL  
REINFORCEMENT IN CONCRETE  
FROM CORROSION**

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## **RDSO SPECIFICATION NO. M&C/PCN/126/2020**

# **SPECIFICATION FOR BIPOLAR CONCRETE PENETRATING CORROSION INHIBITING ADMIXTURE TO PROTECT EMBEDDED STEEL REINFORCEMENT IN CONCRETE FROM CORROSION**

### **0.0 FOREWORD:**

0.1 This specification prescribes the requirements and test methods of Physico – Chemical characteristics including Performance test for evaluating the efficiency of the product in the laboratory for protecting Steel Reinforcement Embedded in Concrete from corrosion.

### **1.0 SCOPE:**

This standard prescribes the requirements and methods of test for the material known as Bipolar Concrete Penetrating Corrosion Inhibiting Admixture (CPCIA). The CPCIA shall be Bipolar in nature and concrete penetrating type which upon addition into the concrete matrix inhibits the corrosion process. It need not be in direct contact with the steel. Its vapours penetrate through fissures, honeycomb structure of concrete, pure water solution added in concrete and seals steel reinforcement at both anodic & cathodic sites, for inhibition. This is due to the bipolar mechanism property of the system. Non-concrete penetrating, nitrite & nitrate corrosion inhibitors are excluded from this scope. The product shall be suitable to protect embedded steel reinforcement bars used in concrete structures from corrosion.

**NOTE: “Firm should comply Make in India Policy and Public Procurement (Preference to Make in India) Order-2017 under this specification” and subsequent Amendment done time to time.**

### **2.0 TERMINOLOGY:**

- 2.1 For the purpose of this standard the definitions as given in latest versions of ASTM-G1-03 (2017), ASTM-G3-14 (2019), ASTM-G109-2007 (2013), ASTM-C 1202-2019, JIS-Z- 1535, AASHTO T259 , IS:101(Part1/Sec.5)-89 Reaffirmed 2019 or its latest version , IS:456-2000, Reaffirmed 2016 or its latest version , IS:1202-97 or its latest version , IS:1448-2014 or its latest version, IS:1786-2008 or its latest version,IS:9103-99,Reaffirmed 2018 etc. or its latest version shall apply.
- 2.2 Rounding off, of observed values on different tests shall be in accordance with IS:2-1960 Reaffirmed 2016 or its latest version .

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### 3.0 SAMPLING

- 3.1 The representative samples of the material shall be drawn by the Purchaser or the Inspecting Authority as per the TABLE given below:

**Scale of Sampling for CPCIA**

No. of containers in (N)	No. of containers to be selected for sampling (N)
Up to 50	1
51-100	2
101-200	3
201-300	3
301-500	4
501-800	5
801-above	6

- 3.2 For Tender evaluation, the cost of 225 kg. of CPCIA in ready to use condition shall be taken into consideration for cost comparison.

### 4.0 PROPERTIES

- 4.1 **General :** The material shall comply with the requirements specified in Clause 5.0 , TABLE-I and TABLE-II of this specification.
- 4.2 Unless otherwise specified, the following testing conditions shall apply.
- 4.2.1 All the tests shall be conducted at room temperature ( $27 \pm 2$ )°C and Relative Humidity at (65±5) % in a well ventilated chamber free from draught and dust.

### 5.0 REQUIREMENTS

- 5.1 The admixture shall be supplied in One Pack.
- 5.2 There are two types of requirements that the material should meet in order to be considered for usage in the railways.
- 5.2.1 Properties which can be evaluated in short duration (can be performed at a labor at sites with proper testing facilities) as laid down in TABLE –I.

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- 5.2.2 Properties which can be evaluated by performing long duration tests as laid down in TABLE-II.
- 5.2.3 All the tests performed under Indian tropical conditions, mentioned in TABLE-I and TABLE-II are mandatory requirements for the approval of Product/ Manufacturer.
- 5.2.4 Approving authorities certificate for long term tests and Suppliers test certificate meeting the short term requirements may be accepted by the purchaser. However, short term tests may be cross checked with NABL accredited laboratory if desired.
- 5.3 The recommended dosage of CPCIA in concrete shall be preferably 1% (w/w of Cement) or as recommended by the manufacturer.
- 5.4 Tests specified in TABLE -II shall be performed in triplicate.

**TABLE –I**

**REQUIREMENT OF BIPOLAR CONCRETE PENETRATING CORROSION INHIBITING ADMIXTURE (Short Term Tests)**

S. N.	Characteristics	Requirements	Methods of Tests
1.	Appearance	Brownish Liquid free from any visible residual deposits	Visually
2.	Odour	Mild Ammonical Odour	By smell
3.	Skin Irritation	No irritation	By applying on reverse of the palm for 05 Minutes.
4.	pH i) As in Supplied condition ii) 1% Dilution ,w/w	i) 9.0-11.0 ii) 9.0-11.0	pH meter / Standard pH paper
5.	Specific Gravity at 27 ± 2°C	1.04-1.06	IS 1448-2014 or its latest version
6.	Viscosity of the material as in Supplied condition, By Ford Cup No 4, at 27 ± 2°C	10 -20 Second.	IS: 101(Pt.1/Sec.5)- 1989, Reaffirmed 2019 or its latest version
7.	Accelerated Corrosion Test, for 21 Hours. i) Raw water without CPCIA* ii) Raw water with CPCIA*	i) Excessive corrosion spots. ii) There shall not be more than 1-2 corrosion spots.	APPENDIX-I

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**TABLE –II**

**REQUIREMENT OF BIPOLAR CONCRETE PENETRATING CORROSION INHIBITING  
ADMIXTURE ( Long Term Tests)**

SN	Characteristics	Requirements	Methods of Tests
1.	Immersion Test for 720 Hours (Rebar weight loss method ) i) With out CPCIA* ii) With 1% CPCIA*	i) 40.00 mpy, Max. ii) 2.00 mpy, Max.	APPENDIX-II and ASTM G 1-03 (2017)
2.	Effect of Concrete Admixture on Compressive Strength i) With out CPCIA* ii) With 1% CPCIA*	Concrete strength in sample with CPCIA* should be $\geq$ concrete strength in sample without CPCIA*	APPENDIX- III & IS 9103-1999, Reaffirmed 2018 or its latest version
3.	Polarization test by Tafel polarization with 3.5% Sodium Chloride, for 20 days i) With out CPCIA* ii) With 1% CPCIA*	Rate of corrosion shall be  i) 45 mpy, Max. ii) 9 mpy, Max.	APPENDIX-IV and ASTM-G 3-14 (2013) and IS 9103-1999, Reaffirmed 2018 or its latest version
4.	Effect of CPCIA* on corrosion of Embedded Steel Rebars exposed to Chloride environments after 09 cycles ( 14 days wetting and 14 days drying) as per ASTM G- 109. i) With out CPCIA* ii) With 1% CPCIA*	Rate of corrosion shall be  i) 25.00 Coulombs, Max. ii) 0.50 Coulombs, Max.	APPENDIX-V and ASTM G-109-2007 (2013)
5.	Chloride Migration Profile properties of concrete with and with out CPCIA  i) Chloride % in concrete at 30 mm depth after 90 days. ( For all types of cements e.g. OPC,PPC,PSC, SRC )  ii) Ability to resist chloride ion penetration (RCPT) ( For all types of cements e.g.OPC,PPC,PSC, SRC )  a) Concrete Grade M-30, Water cement ratio: 0.45  b) Concrete Grade-M-40, Water cement ratio: 0.40	With out CPCIA*                      With 1% CPCIA*                                      CPCIA*  Chloride % shall be  0.025%, Max.Nil  Resistance to chloride ion penetration shall be  1650    1000 Coulombs, Max.Coulombs, Max.  1550    1000 Coulombs, Max.Coulombs, Max.	APPENDIX-VI and AASHTO T-259  i) IS:456-2000, Reaffirmed 2016 or its latest version  ii) ASTM C-1202- 2019

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## **NOTE:**

- 1.CPCIA\* : Concrete Penetrating Corrosion Inhibiting Admixture. The CPCIA shall be used as 1% w/w of cement or as recommended by the manufacturer for conducting the tests mentioned in TABLE-II except Immersion test for 720 hrs. mentioned at Sl.No. 1 where it shall be used as 1% w/w of water or as recommended by the manufacturer.
2. Wherever required, rebars conforming to IS: 1786-2008 or its latest version shall be used for testing purposes .

## **6.0 SAFETY TO CONSTRUCTION MATERIAL:**

CPCIA should not degrade, or damage the construction materials.

- i) Concrete
- ii) Aggregates
- iii) Steel reinforcement
- iv) Form work/Shuttering

## **7.0 SAFETY FOR APPLICATION:**

The CPCIA should not cause harm to personnel by mean of inhalation or skin contact. All precautionary measures shall be intimated by the manufacturers clearly in writing along with instructions of usages. However final decision about adoption of such measurers shall lie with the Railways and shall depend upon the conditions prevailing on the Railways at the time.

## **8.0 WASTE WATER DISCHARGE:**

The waste discharge shall be in accordance with the laws of pollution control in force from time to time.

## **9.0 PACKING:**

The material shall be packed in suitable air tight Polyethylene containers preferably of capacity 20 kg / 200kg or as agreed by Purchaser and Supplier

## **10.0 MARKING:**

- 10.1 Each container shall be legibly and indelibly marked with the following:
  - a) Name of the Material
  - b) Name of the Manufacturer
  - c) Volume / weight of Material
  - d) Specification Number
  - e) Batch No. or Lot No. in CODE or otherwise
  - f) Month and year of Manufacture

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## **11.0 INSPECTION**

- 11.1 At the time of initial approval of the product or firm, full testing as mentioned in Clause 5.2.3 shall be carried out.
- 11.2 In case of Acceptance testing, Inspecting Authority shall draw the sample as per Clause 3.1, from the batch under consideration and the material shall be tested for the tests stipulated in TABLE-I.
  - 11.2.1 Long duration tests need substantial amount of time. The testing facilities for these tests may not be available in each and every lab therefore, Approving authority's certificate for long term tests as stipulated in TABLE-II & Supplier's test certificate/NABL accredited laboratory test certificate meeting the short term tests as stipulated in TABLE-I may be accepted by the purchaser for acceptance of the material. However if desired by the purchaser, long term tests may also be organized to be carried out at any IITs / NABL accredited laboratory.

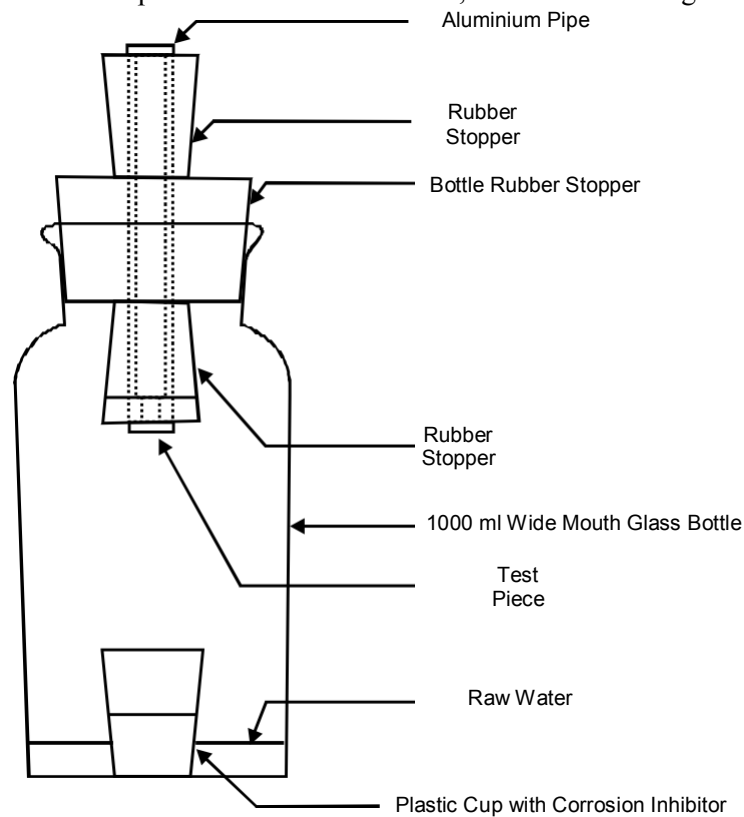
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## APPENDIX-I

### **MODIFIED ACCELERATED CORROSION TEST (BASED ON JAPANESE STANDARD JIS Z 1535)**

#### **TEST PROCEDURE:**

Attach steel test pieces conforming to IS: 1786-2008 or its latest version (of size Approx. 15mm dia and 12mm thickness drilled from one side c/c to a dia of 10mm and a depth of 10 mm to hold the aluminium pipe) after thorough cleaning to white metal by using 1000 grade grit paper and subsequently polishing with 3/0 grade and finally with 4/0 grade grit paper to the Aluminium pipe with the help of cello tape so that it is firmly attached. The aluminium pipe is then slid upwards till the test piece rests in the slot provided in the rubber cork, as shown in the figure.



Assembly with Corrosion Inhibitor

Pour 100 ml of tap water in both the bottles. Fill the plastic cup with 25 ml CPCIA solution as in supplied condition. In one of the bottles place the plastic cup with the CPCIA solution so that the cup is placed in the tap water. Allow to remain for 18 hours at ambient temperature. After 18 hrs. add chilled water having temperature below 1.0 °C into the aluminium pipes and allow to remain for 3 hrs. The temperature of the chilled water in the aluminium pipes shall be maintained at  $2.0 \pm 0.5$  °C by frequently changing the chilled water with the help of the pipette. Observe the steel test pieces after the experiments i.e. 18+3=21 hrs., for any corrosion spots.



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## APPENDIX-II

### IMMERSION TEST (REBAR WEIGHT LOSS TEST) (AS PER ASTM- G -1)

#### TEST PROCEDURE:

Take six pieces of Tor steel rebar conforming to IS: 1786-2008 or its latest version of size Approx. 40 mm length and 10 mm dia .Clean the rebar of any rust, mill scale etc., with the help of steel wire brush, till it has overall a shining surface. Now clean all the six pieces with solvent such as benzene/acetone to remove any loose rust /dust from the surface. Dry at  $(100 \pm 2)$  °C for 15 minutes in an oven. Cool and take the weights of all the six pieces and record it.

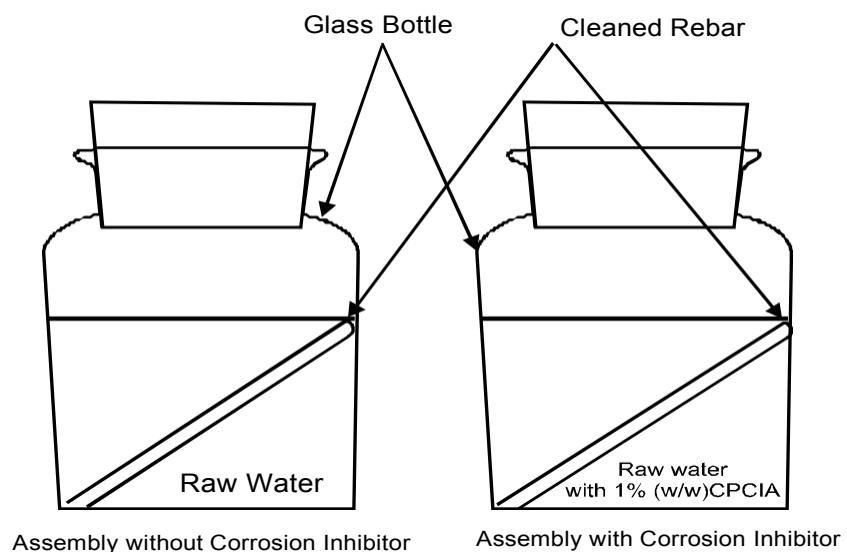
Take six transparent glass/plastic bottles of approx. 150±10 ml with air tight caps. Clean all the bottles with tap water and then fill them with 100 ml of tap water so that the bottles are approx. three fourth filled. In three of the six bottles, add CPCIA 1%, w/w or as recommended by the manufacturer of the water in the bottle. Now put one cleaned and weighed rebar test piece completely immersed in water/water + CPCIA, in all the six bottles and close the cap.

After 30 days (720 hrs.), take out all the six test pieces and put them in Clark solution ( prepared by dissolving 20 gms. of Antimony trioxide and 50 gms of Stannous chloride in 1000 ml of Con. Hydrochloric acid, S.G. 1.18) so that corrosion products are dissolved. After complete removal of corrosion products (in 5 minutes approximate), take out the test pieces and wash in running water and finally with distilled water. Then wash the test pieces, with solvent such as benzene/acetone. Dry at  $(100 \pm 2)$  °C for 30 minutes in an oven. Cool and take the weights of all the six pieces and record it.

Calculate the corrosion rate in mpy, by using the formula Corrosion rate

$$(\text{mpy}) = 534 (W1-W2) / DAT$$

Where W1-W2 is the weight loss in mg., D is the density of steel , A is the area in sq. inch and T is the time of exposure in hrs



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## APPENDIX-X

### TEST FOR EFFECT ON COMPRESSIVE STRENGTH BY ADDITION OF CPCIA

#### TEST PROCEDURE:

Cast three concrete blocks of size 100mm x 100mm x 100mm each with out and with CPCIA 1% ( w/w) of cement or as recommended by the manufacturer, by casting the concrete of M 20 grade IS 9103-1999 Reaffirmed 2018.

The above casted blocks shall be demoulded after 24 hrs. . These blocks shall be moist cured for 28 days. After completion of the curing period, the blocks of each type shall be tested for compressive strength in compression testing machine (Universal Tensile Machine) and data recorded.

## APPENDIX-IV

### BRIEF OUTLINES OF ELECTROCHEMICAL POLARIZATION TEST CONDUCTED ON STEEL REBARS EMBEDDED IN CONCRETE ( AS PER ASTM G 3-14 (2019))

Cast three concrete cylinders, of size 75mm dia and 150mm length each without and with CPCIA 1% ( w/w) of cement or as recommended by the manufacturer, by casting the concrete of M 20 grade as per IS 9103-1999 Reaffirmed 2018, and placement of one cleaned rebar conforming to IS:1786-2008 of size 375 mm length and 12 mm dia ( preferably cleaned by pickling in Hydrochloric acid 20% (v/v) approximately, till surface shines and washed in running water) in each block .

The above casted blocks shall be de molded after 24 hrs. These blocks shall be moist cured for 28 days. After completion of the curing period, the blocks shall be subjected for Polarization test for 20 days as per ASTM G-3-14 (2019) and observations recorded.

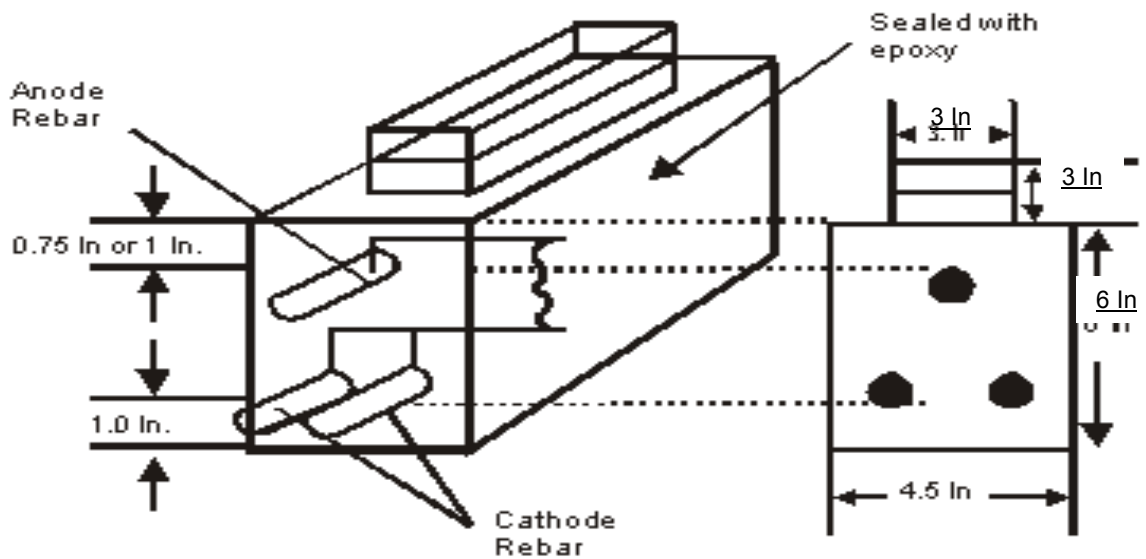
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## APPENDIX-V

### BRIEF OUTLINES OF LONG TERM CORROSION TEST (AS PER ASTM G 109 – 2007 (2013))

Three specimens each of control concrete and that of CPCIA admixed concrete (1% w/w of cement or as recommended by the manufacturer) should be cast as per the size 280mmx150mmx115mm and with placement of three cleaned reinforcement bars conforming to IS: 1786-2008 (preferably cleaned by pickling in Hydrochloric acid 20% (v/v) approx, till surface shines and washed in running water) of size 12mm and length 375 mm as per the details shown in the drawing. Admixture shall be added as per manufacturers recommended dosage. All the casted concrete samples shall be moist cured for 28 days.

Ponding of samples with 3% NaCl solution as shown in the drawing to be continued and measuring of voltage across 100 ohm resistor to be continued beginning of the second week of ponding. Calculate the current  $I_c$  from the measured voltage and record. Also measure the corrosion potential of the bars against reference electrode. The experiment should be continued till the macrocell current reaches a value of 10  $\mu$ A. After the experiment break the specimens and examine the rebars for extent of corrosion, measure the corroded area and record.



Note - All Measurements in In. (25.4 mm = 1 In.)  
FIG. 3 Concrete Beam

APPENDIX-VI

**BRIEF OUTLINES OF RESISTANCE OF CONCRETE TO  
MIGRATION OF CHLORIDE ION TEST ( As per AASHTO -  
T-259 )**

**A. CHLORIDE ION PENETRATION  
(SALT PONDING TEST) (As per IS: 456-  
2000, Reaffirmed 2016 or its latest version )**

Cast three concrete blocks of size 300mmx300mmx75mm each without and with CPCIA 1% ( w/w) or as recommended by the manufacturer, by using the concrete mix as under:

	M 30	M 40	
i) Cement, grade 53 -----:	50	50	Kg.
ii) Sand coarse	: 104	87	Kg.
iii) Aggregate, M1, passes through 20 mm and retained on 10 mesh : 160		134	Kg
iv) Water (Subject to 55±5 slump)	: 24	20	Kg.
v) CPCIA	: 0.5	0.5	Kg.
or as recommended by the manufacturer with each type of cement given below:			

- i) Ordinary Portland Cement
- ii) Portland Pozzolana Cement
- iii) Portland Slag cement
- iv) Sulphate resisting Cement

AASHTO T259 test (commonly referred to as the salt ponding test) is a long-term test for measuring the penetration of chloride ions into concrete. Three slabs of 75 mm thick and having a surface area of 300 mm square shall be casted. These slabs are moist cured for 14 days and then stored in drying room at 50 percent relative humidity for 28 days. The sides of the slabs are sealed but the bottom and top face are not. After the conditioning period, a 3 percent NaCl solution is ponded on the top surface for 90 days, while the bottom face is left exposed to the drying environment (see figure1).

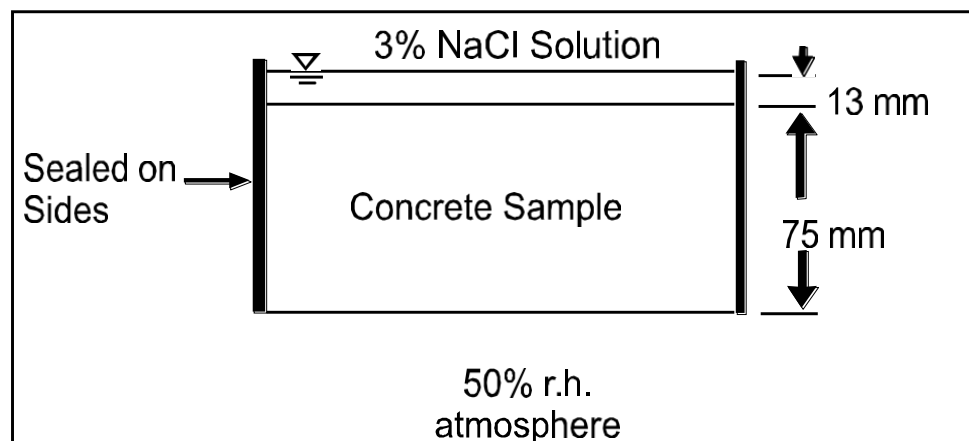


Figure 1 AAS–TO T259 (Salt ponding) test setup

At the end of this time (90 days) the slabs are removed from the drying environment and the chloride concentration of 10 mm thick slices is then determined (AASHTO T259) .Two or three slices are taken at progressive depth. The salt ponding test does provide a crude one- dimensional chloride ion ingress profile. Test results should meet the requirements as stipulated in IS: 456-2000 Reaffirmed 2016

## B. Electrical Indication of Concrete’s Ability to Resist Chloride Ion Penetration (Rapid Chloride Permeability test) (As per ASTM C-1202- 2019)

Cast three concrete cylinders of size 50 mm thick, 100 mm diameter without and with CPCIA 1% ( w/w) or as recommended by the manufacturer, by using the concrete mix as under.

	M 30	M 40	
i) Cement, grade 53	: 50	50	Kg.
ii) Sand coarse	: 104	87	Kg.
iii) Aggregate, M1, passes through 20 mm and retained on 10 mesh	: 160	134	Kg.
iv) Water (Subject to 55±5 slump)	: 24	20	Kg.
v) CPCIA	: 0.5	0.5	Kg.

or as recommended by the manufacturer with each type of cement given below

- i) Ordinary Portland Cement
- ii) Portland Pozzolana Cement
- iii) Portland Slag cement
- iv) Sulphate resisting Cement

As per ASTM C 1202-2019 a test, a water-saturated, concrete specimen is subjected to a 60 V applied DC voltage for 6 hrs. using the apparatus shown in Figure 2. In one reservoir is a 3.0% NaCl solution and in the other reservoir is a 0.3 M NaOH solution. The total charge passed is determined and this is used to rate the concrete’s resistance to chloride ion penetration.

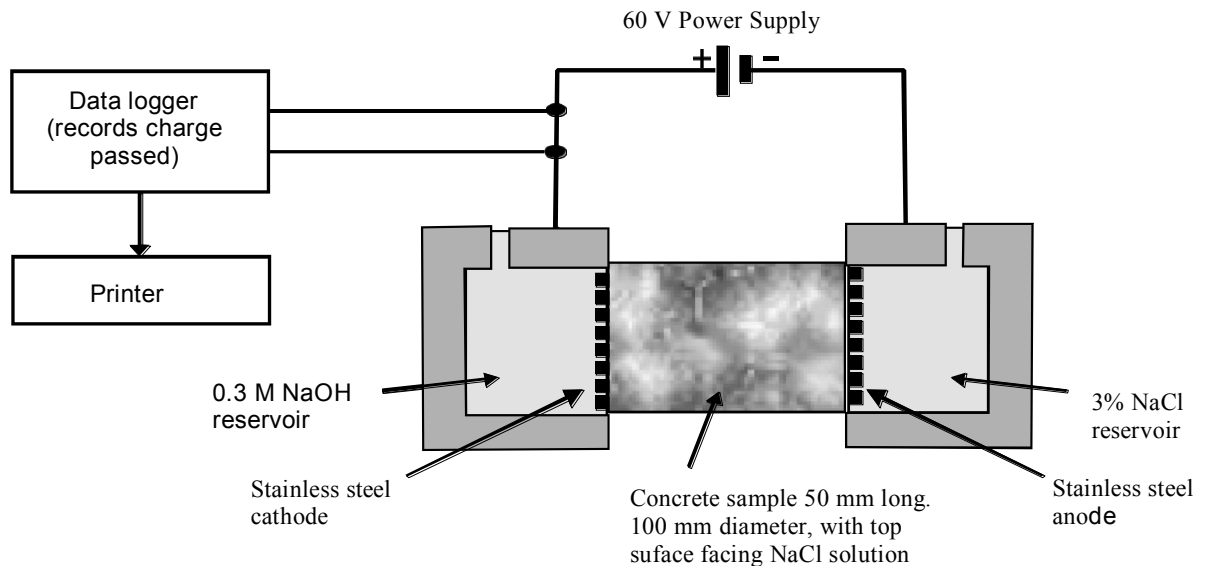


Figure : AASHTO T277 (ASTM C1202) test setup.