DIFFERENCE BETWEEN ACCELERATED TESTS VS OUTDOOR WEATHERING TESTS

OUTDOOR COMPONENTS

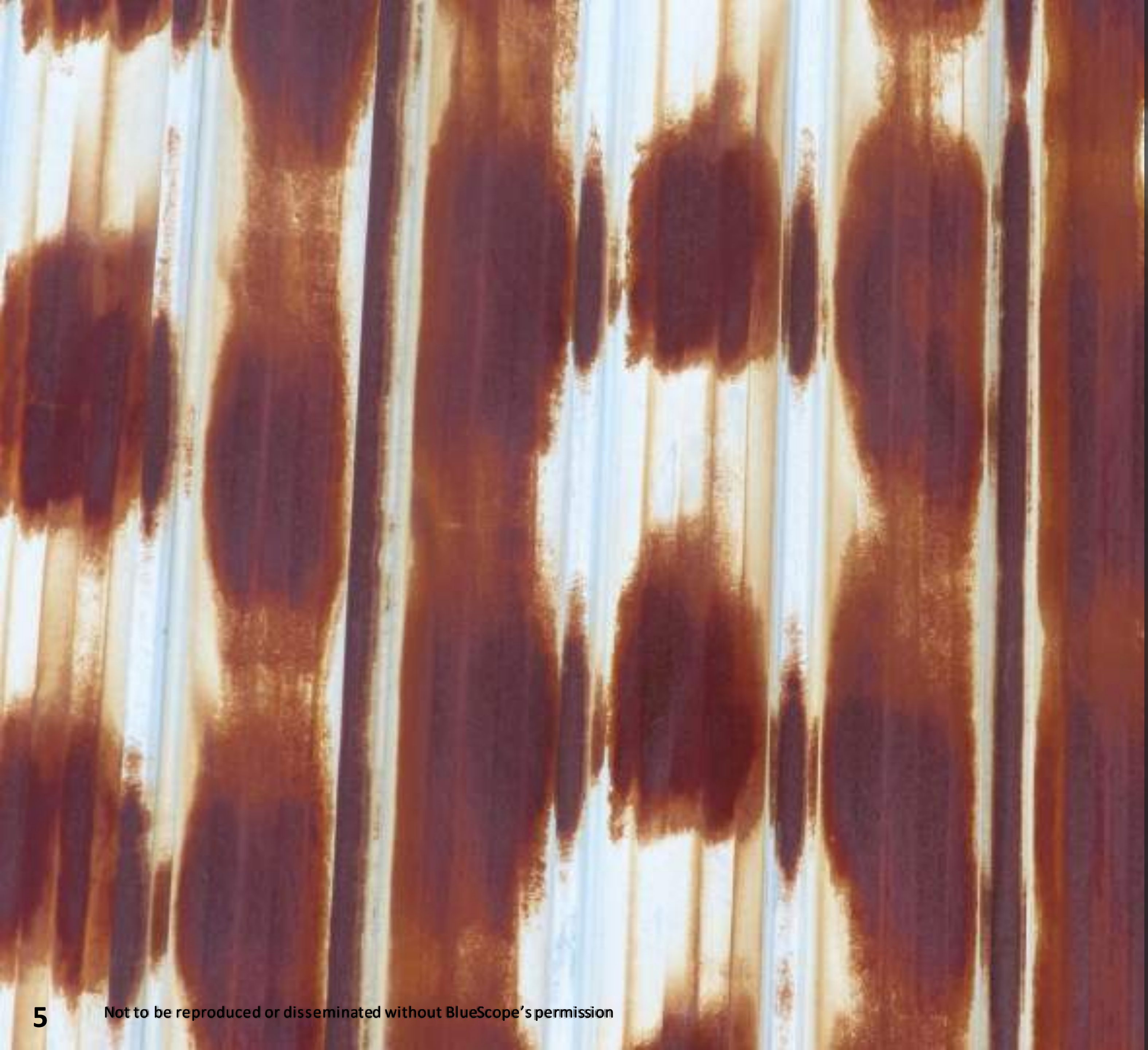
Source: BlueScope Inspection CS-ULT-05

EXPERIENCES DAILY WEATHERING

Source: Source: BlueScope Inspection CS-ULT-05

DETERIORATE OVER TIME

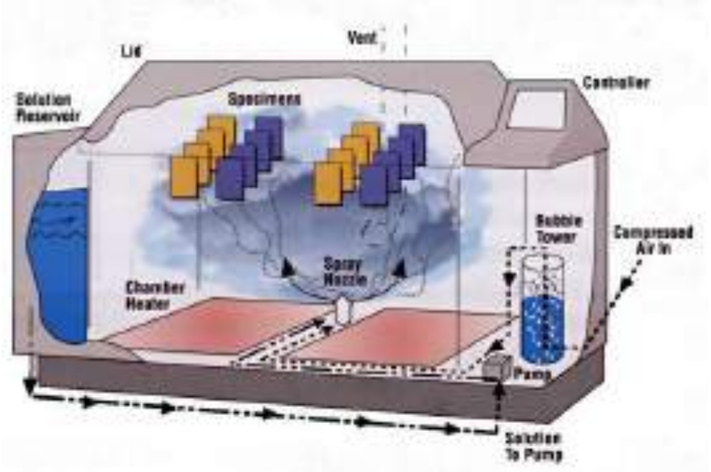
Source: Photo by [Tóth Viktor] from [Pexels]



ESPECIALLY CRUCIAL FOR COMPONENTS THAT ARE EXPECTED TO LAST

TO PROVE A MATERIAL CAN WITHSTAND WEATHERING

Source: BlueScope literature CS-ULT-3

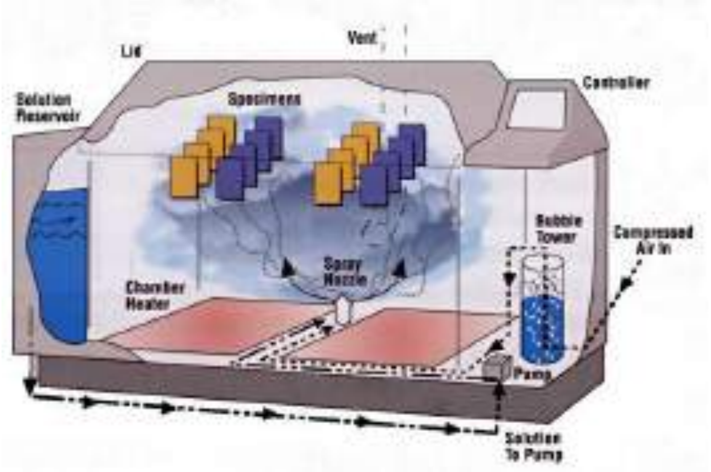


THERE ARE A FEW METHODS ADOPTED

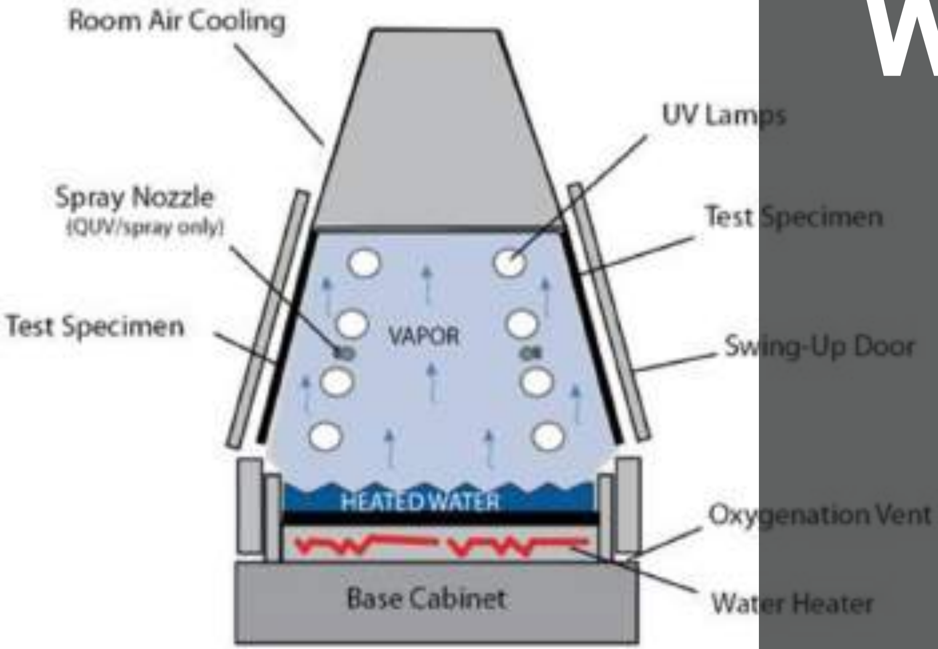
Source: https://www.heresite.com/what-is-salt-spray-testing-and-how-does-the-process-work/; https://slideplayer.com/slide/10740218/

ACCELERATED WEATHERING TESTS

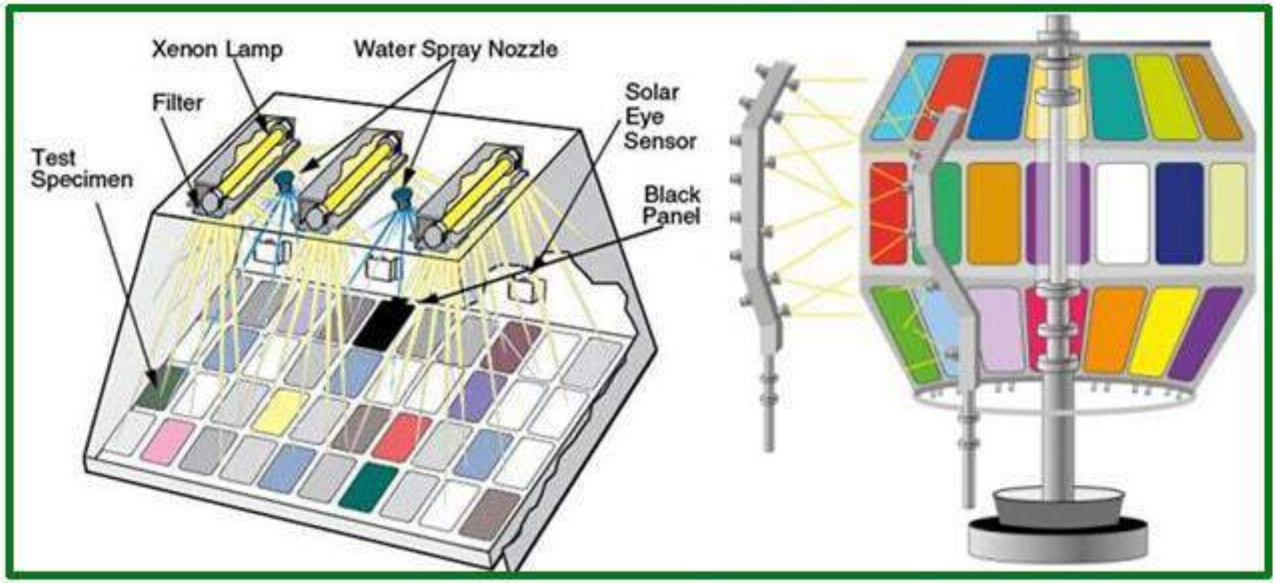
SALT SPRAY TEST



UV TEST



Source: https://www.uvtesting.com.au/

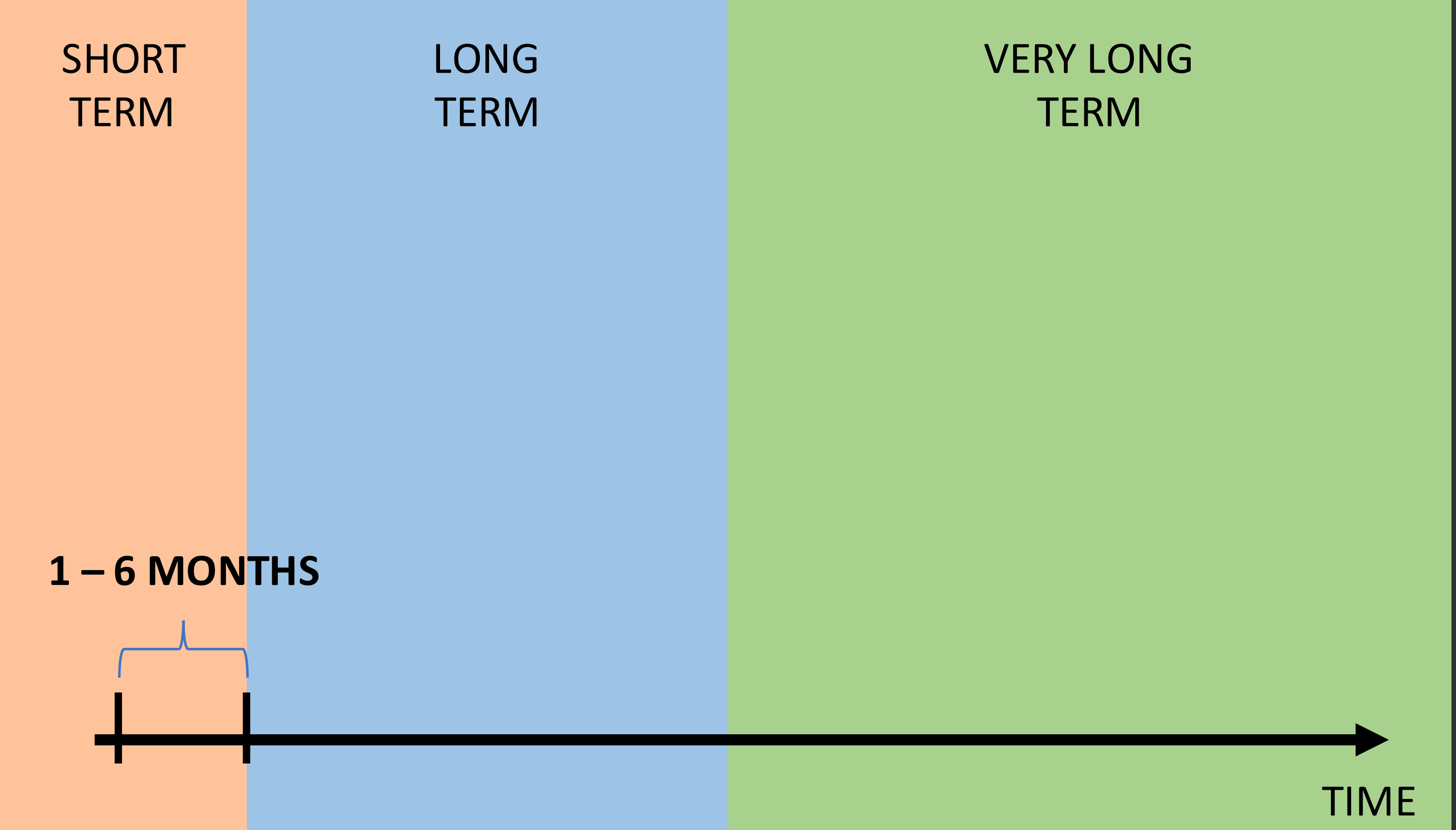


TESTS CONDUCTED IN A CHAMBER

Source: https://www.ascott-analytical.com/how-chambers-work/cct-chamber-acc30-salt-spray-vertically-down-how-it-works/; https://www.testlabs.my/update-and-stories/comparison-of-xenon-arc-chamber-and-quv-tester

A TYPE OF SIMULATION

Source: https://www.simscale.com/



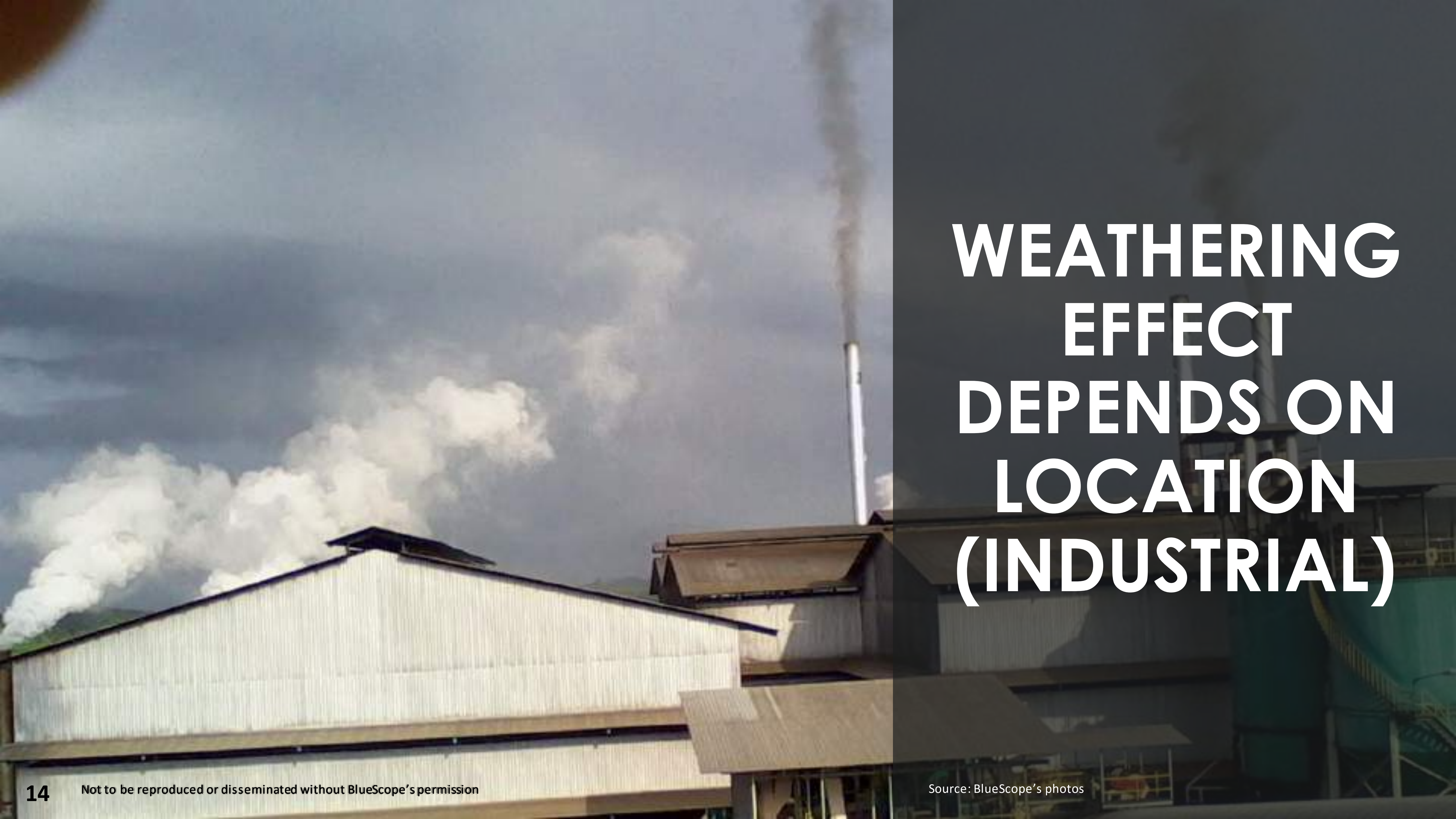
SHORT TERM AROUND 1 – 6 MONTHS

OUTDOOR WEATHERING TESTS

Source: BlueScope’s video.

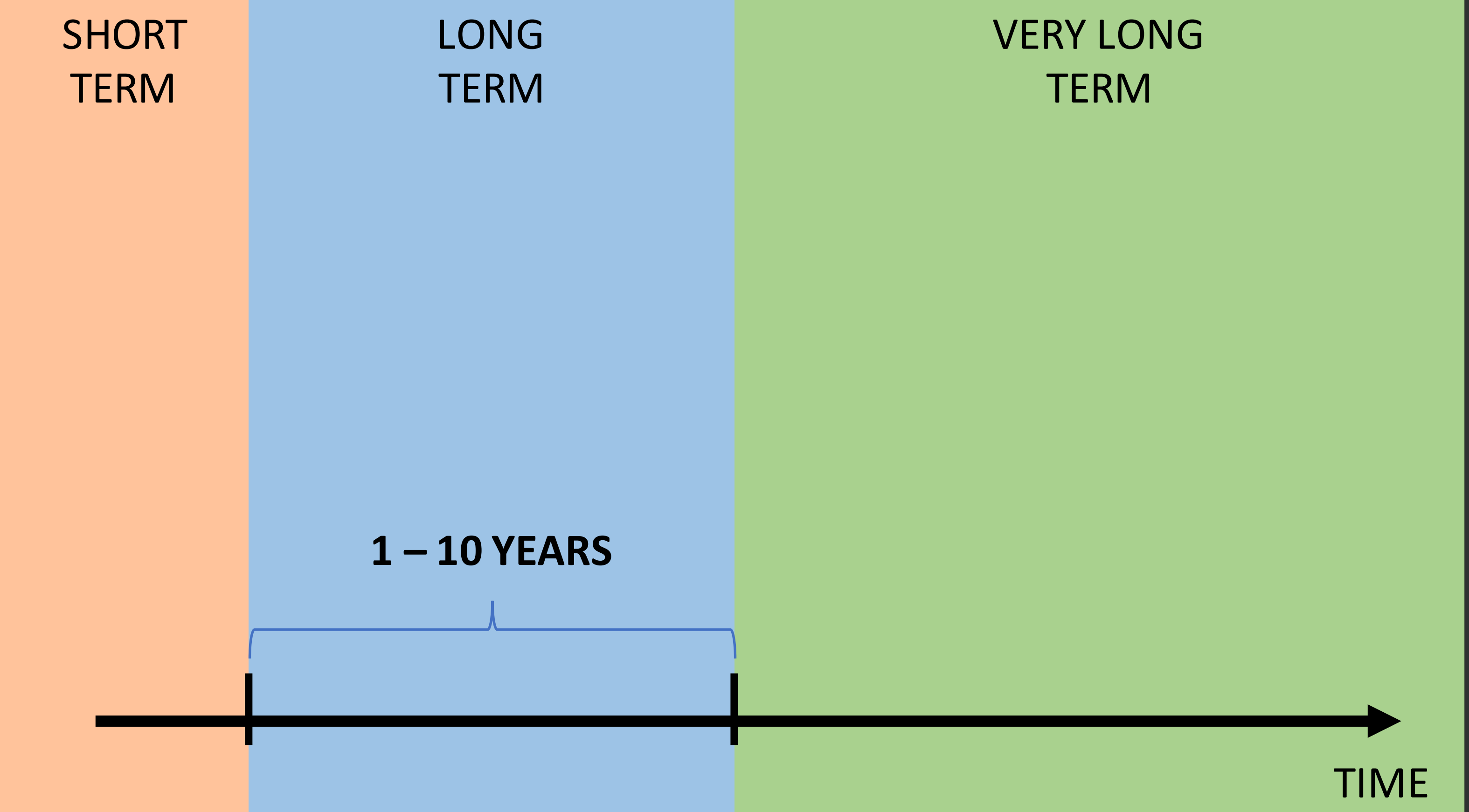
WEATHERING EFFECT DEPENDS ON LOCATION (MARINE)

Source: BlueScope’s photos



WEATHERING EFFECT DEPENDS ON LOCATION (INDUSTRIAL)

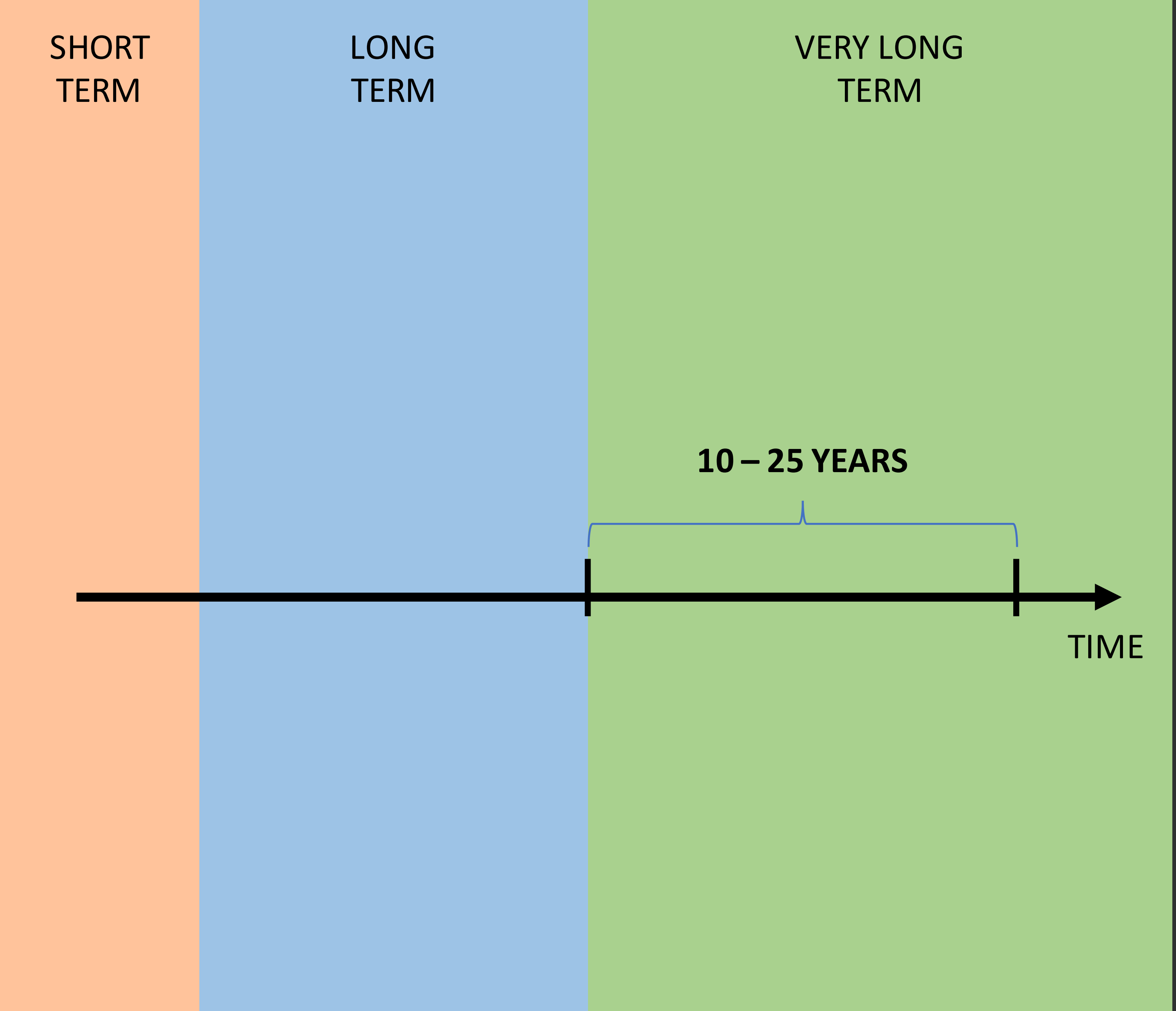
Source: BlueScope's photos



TYPICALLY TAKES 1 – 10 YEARS

INCLUDES STUDIES AT SPECIFIC PROJECT SITE

TO DETERMINE THE MATERIAL PERFORMANCE IN A SPECIFIC ENVIRONMENT



LONGER-TERM EXPOSURE IS AROUND 10 – 25 YEARS

INTERNATIONAL STANDARD

ISO 9223

Second edition
2012-02-01

Corrosion of metals and alloys — Corrosivity of atmospheres — Classification, determination and estimation

Corrosion des métaux et alliages — Corrosivité des atmosphères — Classification, détermination et estimation

Reference number
ISO 9223:2012(E)

© ISO 2012

ENVIRONMENT CLASSIFIED UNDER ISO 9223

INTERNATIONAL STANDARD

ISO 9223

Second edition
2012-02-01

Corrosion of metals and alloys — Corrosivity of atmospheres — Classification, determination and estimation

Reference number
ISO 9223:2012(E)

CORROSIVITY OF ATMOSPHERES

WHAT'S THE STANDARD ABOUT?

Table 1 — Categories of corrosivity of the atmosphere

Category	Corrosivity
C1	Very low
C2	Low
C3	Medium
C4	High
C5	Very high
CX	Extreme

CLASSIFIED BY FIRST YEAR EXPOSURE OF BASIC METALS

Table 2 — Corrosion rates, r_{corr}, for the first year of exposure for the different corrosivity categories

Corrosivity category	Corrosion rates of metals r_{corr}				
	Unit	Carbon steel	Zinc	Copper	Aluminium
C1	g/(m^2·a)	$r_{corr} \le 10$	$r_{corr} \le 0,7$	$r_{corr} \le 0,9$	negligible
	µm/a	$r_{corr} \le 1,3$	$r_{corr} \le 0,1$	$r_{corr} \le 0,1$	—
C2	g/(m^2·a)	$10 < r_{corr} \le 200$	$0,7 < r_{corr} \le 5$	$0,9 < r_{corr} \le 5$	$r_{corr} \le 0,6$
	µm/a	$1,3 < r_{corr} \le 25$	$0,1 < r_{corr} \le 0,7$	$0,1 < r_{corr} \le 0,6$	—
C3	g/(m^2·a)	$200 < r_{corr} \le 400$	$5 < r_{corr} \le 15$	$5 < r_{corr} \le 12$	$0,6 < r_{corr} \le 2$
	µm/a	$25 < r_{corr} \le 50$	$0,7 < r_{corr} \le 2,1$	$0,6 < r_{corr} \le 1,3$	—
C4	g(m^2·a)	$400 < r_{corr} \le 650$	$15 < r_{corr} \le 30$	$12 < r_{corr} \le 25$	$2 < r_{corr} \le 5$
	µm/a	$50 < r_{corr} \le 80$	$2,1 < r_{corr} \le 4,2$	$1,3 < r_{corr} \le 2,8$	—
C5	g/(m^2·a)	$650 < r_{corr} \le 1\,500$	$30 < r_{corr} \le 60$	$25 < r_{corr} \le 50$	$5 < r_{corr} \le 10$
	µm/a	$80 < r_{corr} \le 200$	$4,2 < r_{corr} \le 8,4$	$2,8 < r_{corr} \le 5,6$	—
CX	g/(m^2·a)	$1\,500 < r_{corr} \le 5\,500$	$60 < r_{corr} \le 180$	$50 < r_{corr} \le 90$	$r_{corr} > 10$
	µm/a	$200 < r_{corr} \le 700$	$8,4 < r_{corr} \le 25$	$5,6 < r_{corr} \le 10$	—

Source: https://www.ebay.com.sg/itm/STEEL-BENCH-BLOCK-JEWELERS-STEEL-BLOCK-HARDENED-METAL-WORKING-ANVIL-4-SQUARE/191186820964; https://www.aliexpress.com/item/4000393356213.html

Use Equation (1) for carbon steel:

$$r_{corr} = 1{,}77 \cdot P_d^{0{,}52} \cdot \exp(0{,}020 \cdot RH + f_{St}) + 0{,}102 \cdot S_d^{0{,}62} \cdot \exp(0{,}033 \cdot RH + 0{,}040 \cdot T)$$

$f_{St} = 0{,}150 \cdot (T - 10)$ when $T \leq 10$ °C; otherwise $-0{,}054 \cdot (T - 10)$

$N = 128$, $R^2 = 0{,}85$

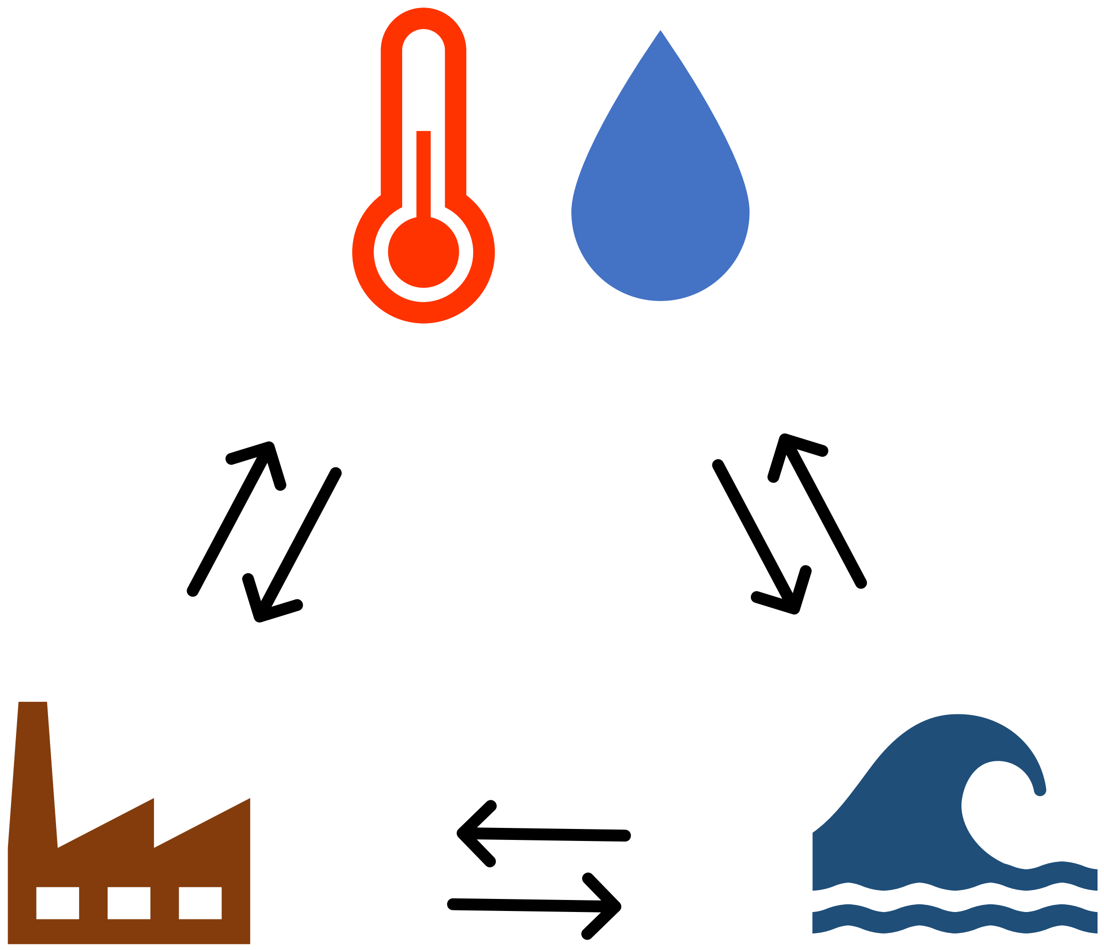
Table 3 — Parameters used in the derivation of dose-response functions, including symbol, description, interval and unit

Symbol	Description	Interval	Unit
T	Temperature	–17,1 to 28,7	°C
RH	Relative humidity	34 to 93	%
P_d	SO_2 deposition	0,7 to 150,4	mg/(m²·d)
S_d	Cl^- deposition	0,4 to 760,5	mg/(m²·d)

The sulfur dioxide (SO_2) values determined by the deposition method, P_d, and volumetric method, P_c, are equivalent for the purposes of this International Standard. The relationship between measurements using both methods may be approximately expressed as $P_d = 0{,}8\ P_c$ [P_d in mg/(m²·d), P_c in µg/m³].

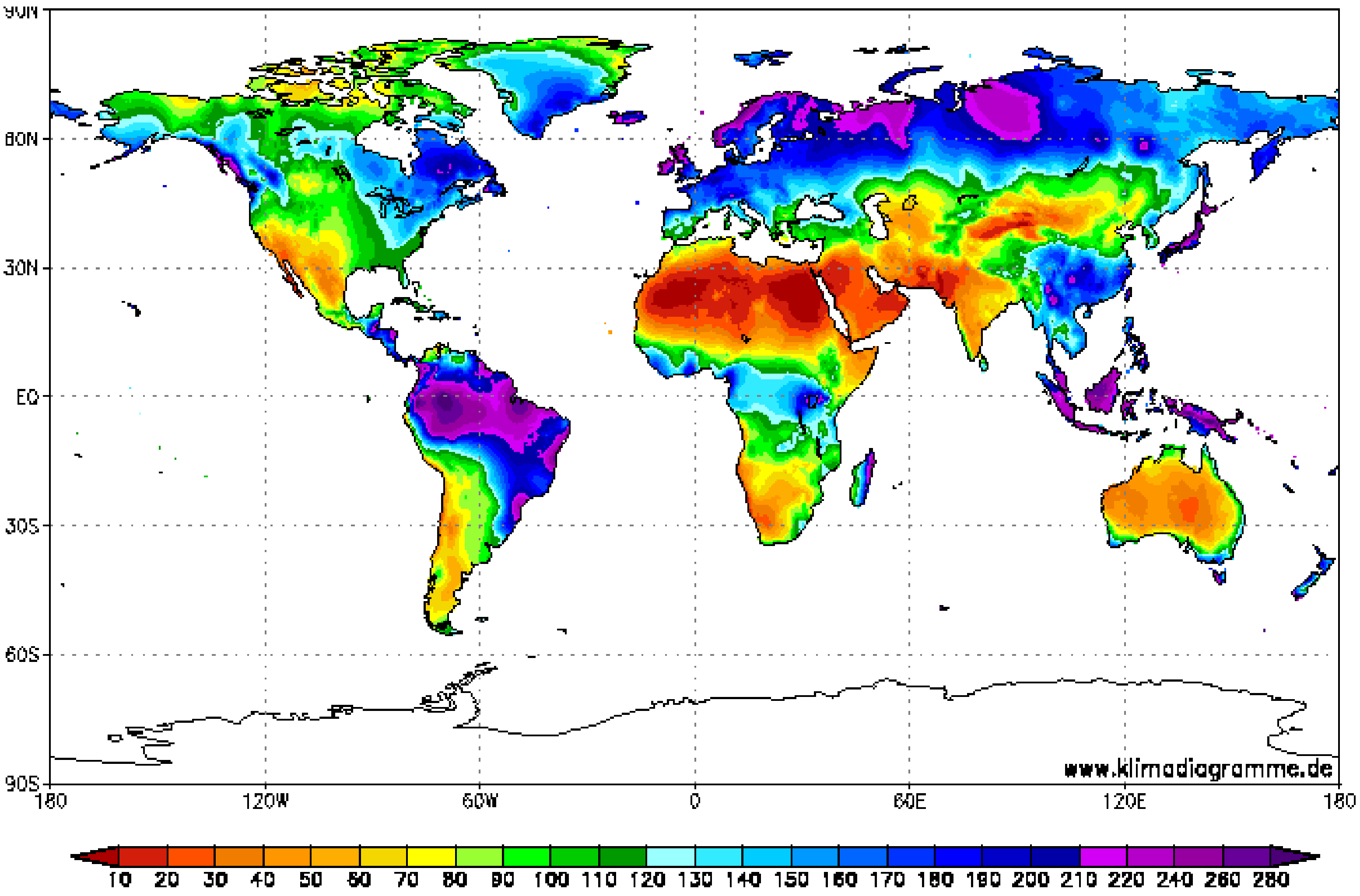
NOTE All parameters are expressed as annual averages.

CAN BE ESTIMATED USING AN EQUATION



3 KEY ELEMENTS

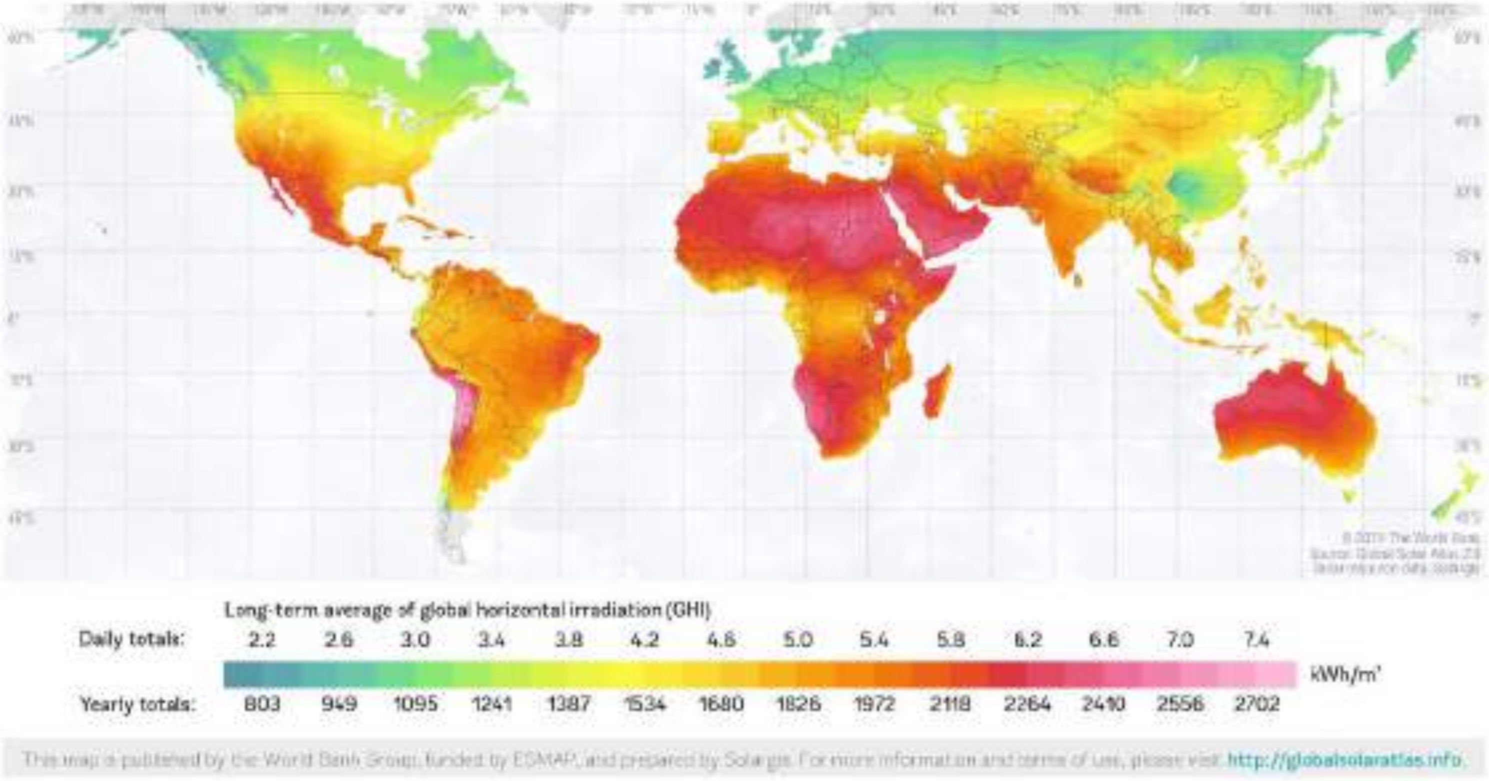
TIME OF WETNESS



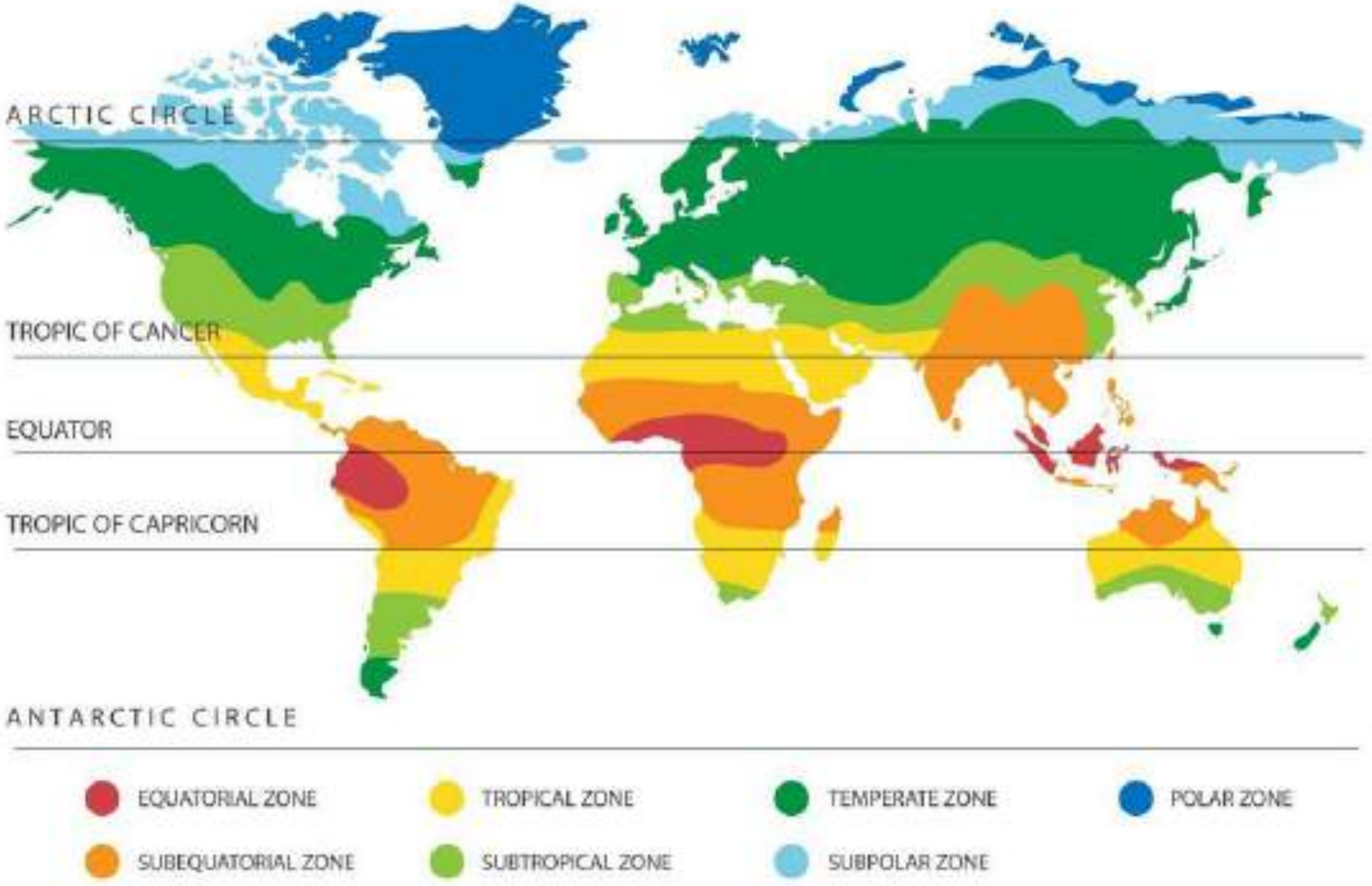
Daten: IPCC – Intergovernmental Panel on Climate Change

Source: https://line.17qq.com/articles/bobiopfz_p7.html

UV IRRADIATION

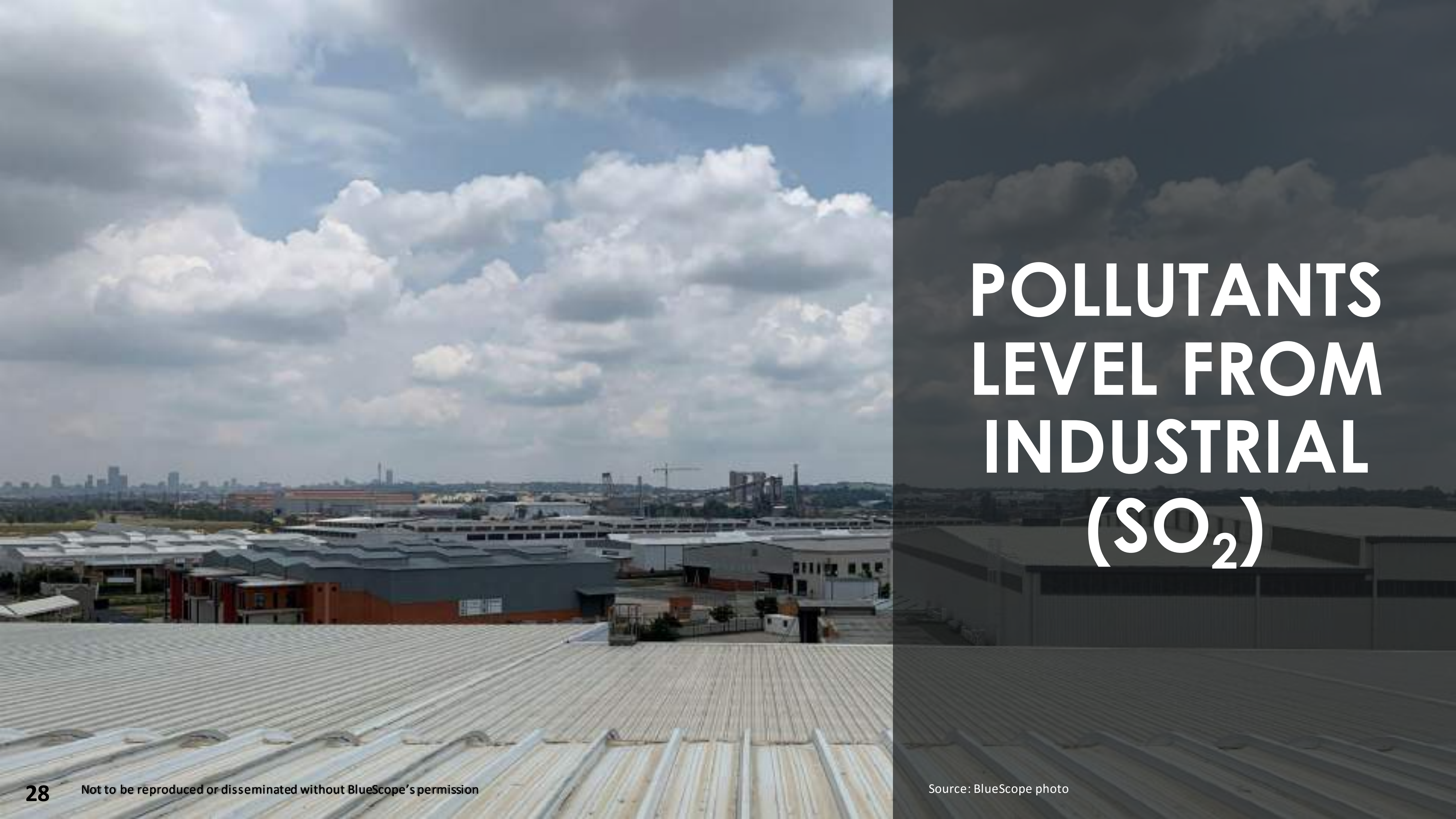


Source: https://globalsolaratlas.info/download/world



CLIMATE

Source: https://www.vectorstock.com/royalty-free-vector/world-climate-map-with-temperature-zones-vector-26226589



POLLUTANTS LEVEL FROM INDUSTRIAL (SO_2)

Source: BlueScope photo

SULFUR DOMINATED POLLUTANTS

Table B.3 — Grouping of pollution by sulfur-containing substances represented by SO_2

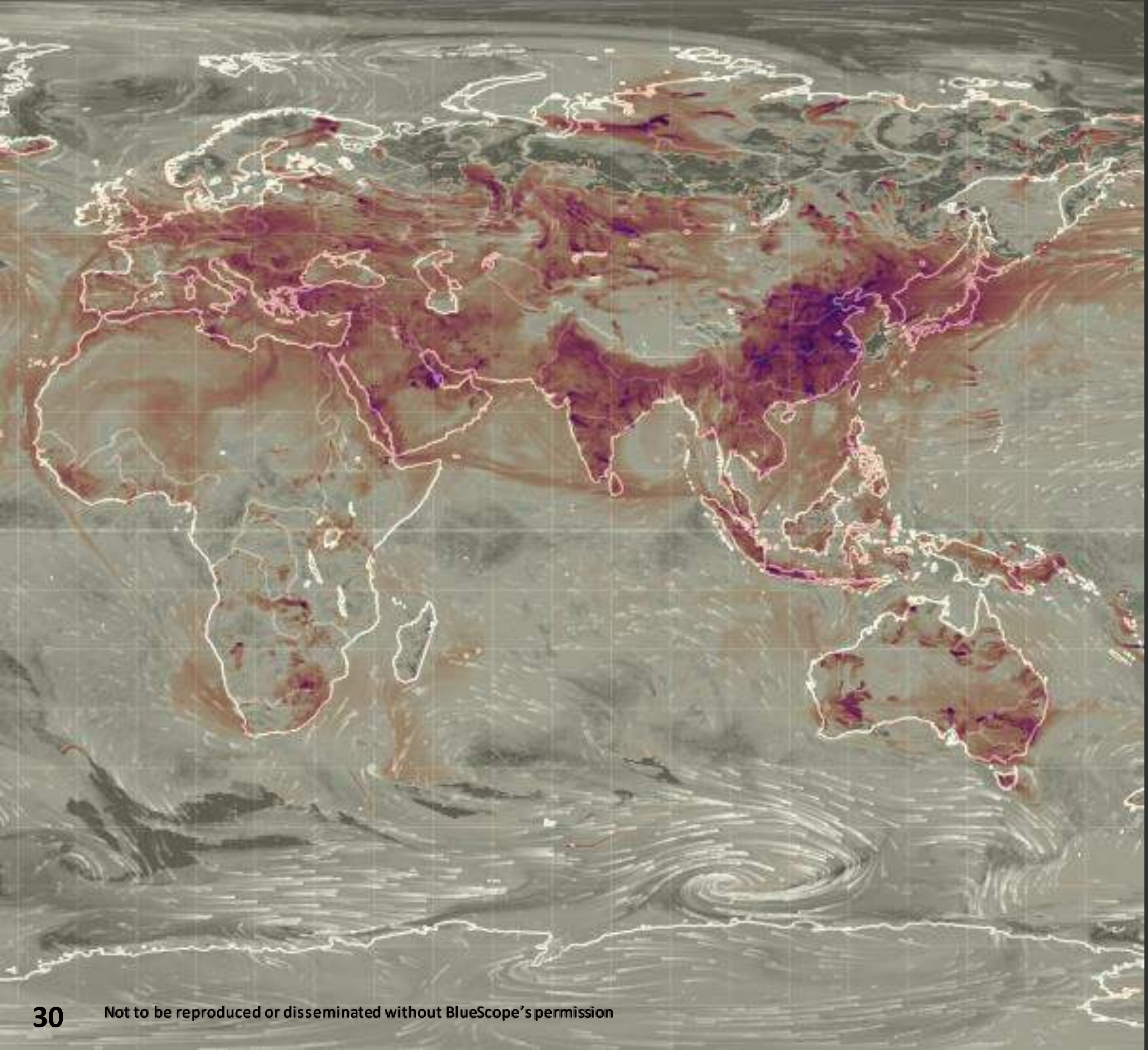
Deposition rate of SO_2 mg/(m^2·d)	Concentration of SO_2 µg/m^3	Level
$P_d \le 4$	$P_c \le 5$	P_0 Rural atmosphere
$4 < P_d \le 24$	$5 < P_c \le 30$	P_1 Urban atmosphere
$24 < P_d \le 80$	$30 < P_c \le 90$	P_2 Industrial atmosphere
$80 < P_d \le 200$	$90 < P_c \le 250$	P_3 Highly polluted industrial atmosphere

NOTE 1 Methods of determination of sulfur dioxide (SO_2) are specified in ISO 9225.

NOTE 2 The sulfur dioxide (SO_2) values determined by the deposition, P_d, and volumetric, P_c, methods are equivalent for the purposes of this International Standard. The relationship between measurements using both methods can be approximately expressed as: $P_d = 0{,}8\ P_c$. This conversional factor is based on the deposition rate measurements on alkaline surfaces.

NOTE 3 For the purposes of this International Standard, the sulfur dioxide (SO_2) deposition rate and concentration are calculated from continuous measurements during at least one year and are expressed as the annual average. The results of short-term measurements can differ considerably from long-term values. Such results are only used for guidance.

NOTE 4 The ranges given cover common levels in individual types of atmospheres. Extreme values are listed in Table B.2.



SO_2 WORLD MAP

Source:
https://en.wikipedia.org/wiki/Sulfur_dioxide#/media/File:SulufrDioxide2017.png

POLLUTANTS LEVEL FROM SALINITY

CHLORIDE DOMINATED POLLUTANTS

Table B.4 — Grouping of pollution by airborne salinity represented by chloride

Deposition rate of chloride mg/(m²·d)	Level
$S_d \leq 3$	S_0
$3 < S_d \leq 60$	S_1
$60 < S_d \leq 300$	S_2
$300 < S_d \leq 1\,500$	S_3

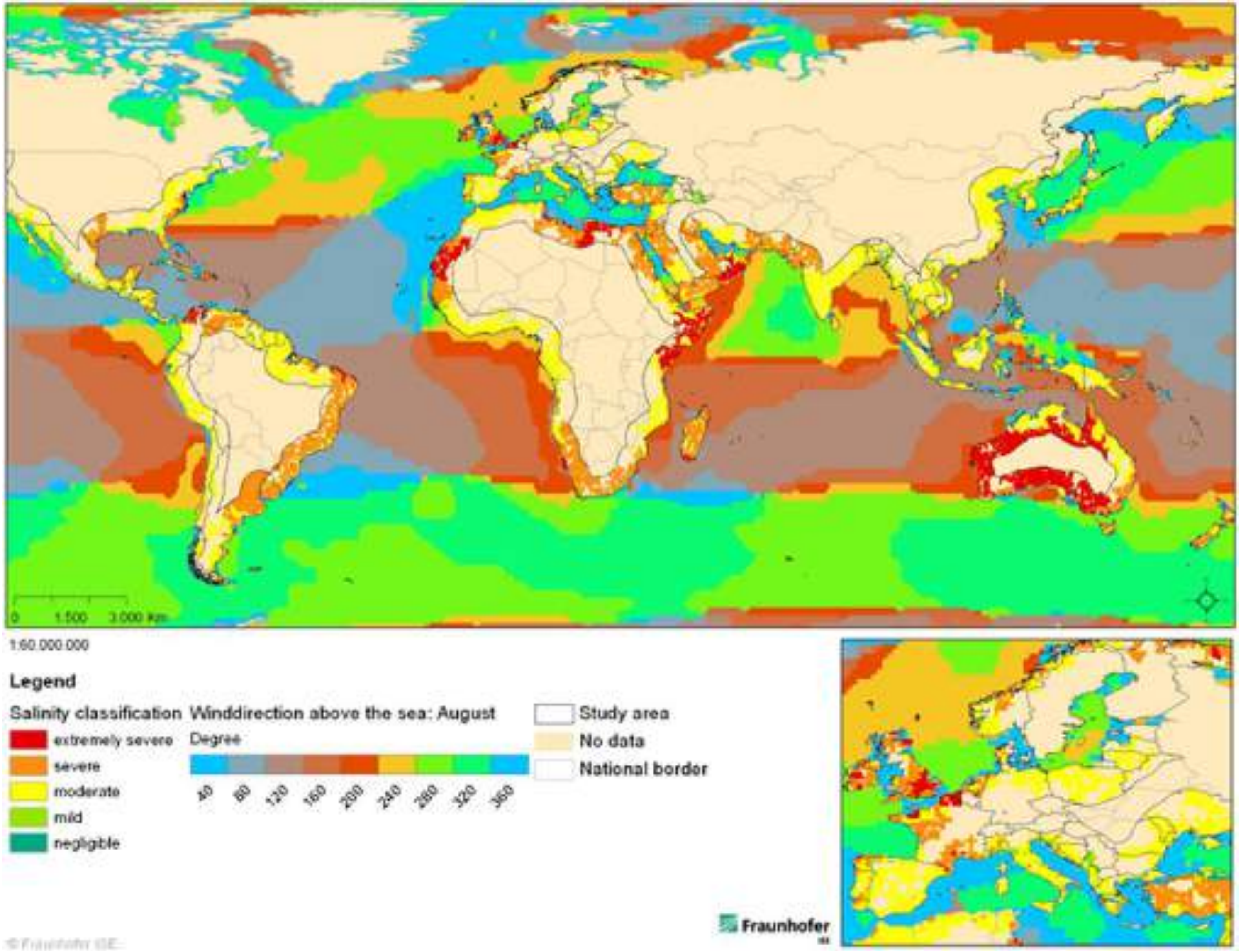
NOTE 1 The airborne salinity level according to this International Standard is based on the wet candle method specified in ISO 9225.

NOTE 2 The results obtained by applying various methods (i.e. dry plate method) for the determination of the salt content in the atmosphere are not always directly comparable and convertible. Derived conversion factors are given in ISO 9225.

NOTE 3 For the purposes of this International Standard, the chloride deposition rate is expressed as the annual average. The results of short-term measurements are very variable and depend very strongly upon weather effects.

NOTE 4 Extreme pollution by chloride, which is typical of strong marine splash and spray, is outside of the scope of this International Standard.

NOTE 5 The airborne salinity is strongly dependent on the variables influencing the transport inland of sea-salt, such as wind direction, wind velocity, local topography, distance of the exposure site from the sea, etc.



SALINITY WORLD MAP

OTHER POLLUTANTS

Table B.2 — Outdoor concentration of some of the most important pollutants in different types of environments

Pollutant	Concentration/deposition (yearly average value)	Source
SO_2	rural: 2 – 15 (µg/m³) urban: 5 – 100 (µg/m³) industrial: 50 – 400 (µg/m³)	The main sources for SO_2 are the use of coal and oil and emissions from industrial plants.
NO_2	rural: 2 – 25 (µg/m³) urban: 20 – 150 (µg/m³)	Traffic is the main source for NO_2 emissions.
HNO_3	rural: 0,1 – 0,7 (µg/m³) urban/industrial: 0,5 – 4 (µg/m³)	HNO_3 is correlated with NO_2. High concentrations of NO_2, organic compounds and UV light increase the concentration.
O_3	20 – 90 (µg/m³)	O_3 is formed in the atmosphere by an interactions among sunlight, oxygen and pollutants. The concentrations are higher in polluted rural atmospheres and lower in high-traffic urban areas.
H_2S	normally: 1 – 5 (µg/m³) industrial and animal shelter: 20 – 250 (µg/m³)	There are some natural sources, for instance swamps and volcanic activities. The pulp and paper industry and farming give the highest concentrations.
Cl_2	normally: 0,1 (µg/m³) some industry plants: up to 20 (µg/m³)	The main source is emissions from the pulp and paper industry.
Cl^-	0,1 – 200 (µg/m³) depending on geographic situation – in marine atmospheres 300 – 1 500 (µg/m³)	The main sources are the ocean and de-icing of roads.
NH_3	normally low concentrations: < 20 (µg/m³) close to source: up to 3 000 (µg/m³)	Fertilization in the agricultural area source and emissions from industry and food production can give the highest average values.
Particles-PM_{10}	rural: 10 – 25 (µg/m³) urban/industrial: 30 – 70 (µg/m³)	Rural: largely inert components Urban: high-concentration traffic areas, corrosive components Industrial: emissions from production can give high concentrations.
Particles (dust deposits)	rural 450 – 1 500 [mg/(m²·a)] urban/industrial: 1 000 – 6 000 [mg/(m²·a)]	Rural: largely inert components Urban and industrial:

Source: ISO 9223:2012

NO_2 FROM BURNING FUEL

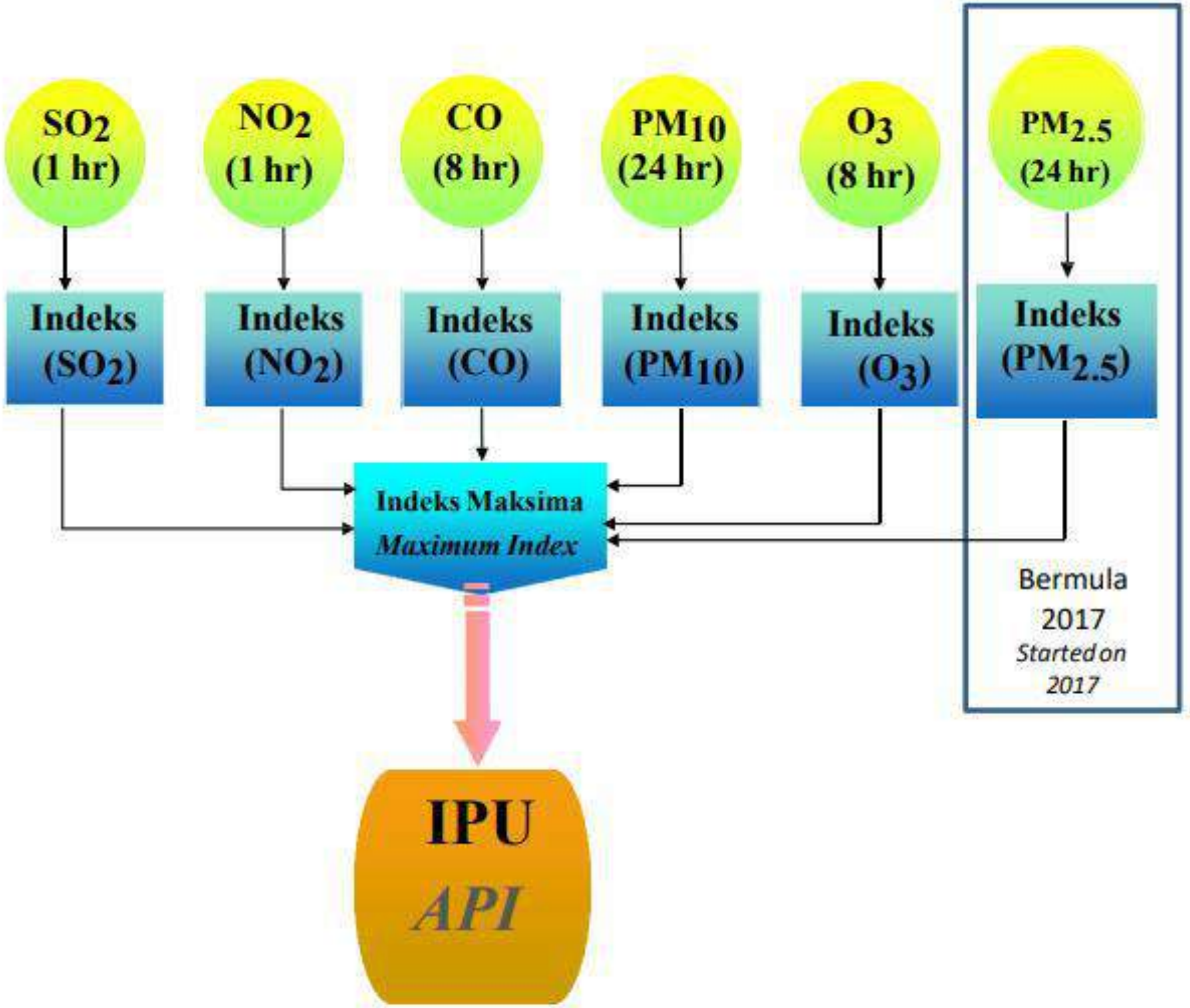
Source: Photo by Mikechie Esparagoza from Pexels

H_2S FROM LIVESTOCK FARMING

Source: Photo by Mark Stebnicki from Pexels

NH_3 FROM FERTILIZERS

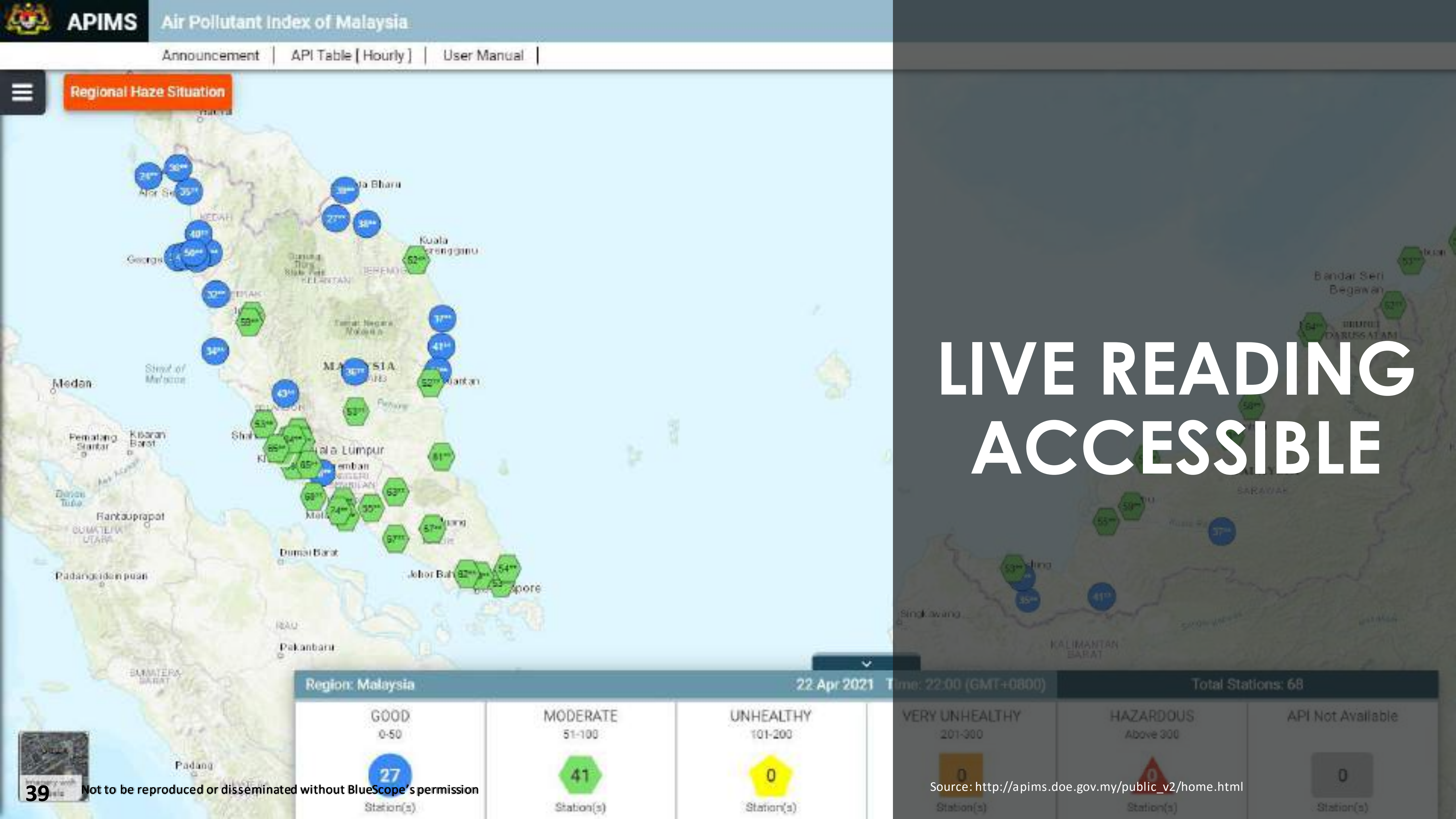
Source: https://www.hgtv.com/outdoors/gardens/planting-and-maintenance/how-to-fertilize-a-tree



FUN FACT
API TAKES INTO ACCOUNT SO_2 & NO_2 EMISSIONS

Source: http://apims.doe.gov.my/public_v2/pdf/API_Calculation.pdf; http://apims.doe.gov.my/public_v2/home.html

LIVE READING ACCESSIBLE



Source: http://apims.doe.gov.my/public_v2/home.html

GENERAL DESCRIPTION OF DIFFERENT CORROSIVITY CATEGORIES

Table C.1 — Description of typical atmospheric environments related to the estimation of corrosivity categories

Corrosivity category[a]	Corrosivity	Typical environments — Examples[b]	
		Indoor	Outdoor
C1	Very low	Heated spaces with low relative humidity and insignificant pollution, e.g. offices, schools, museums	Dry or cold zone, atmospheric environment with very low pollution and time of wetness, e.g. certain deserts, Central Arctic/Antarctica
C2	Low	Unheated spaces with varying temperature and relative humidity. Low frequency of condensation and low pollution, e.g. storage, sport halls	Temperate zone, atmospheric environment with low pollution ($SO_2 < 5\ \mu g/m^3$), e.g. rural areas, small towns Dry or cold zone, atmospheric environment with short time of wetness, e.g. deserts, subarctic areas
C3	Medium	Spaces with moderate frequency of condensation and moderate pollution from production process, e.g. food-processing plants, laundries, breweries, dairies	Temperate zone, atmospheric environment with medium pollution (SO_2: $5\ \mu g/m^3$ to $30\ \mu g/m^3$) or some effect of chlorides, e.g. urban areas, coastal areas with low deposition of chlorides Subtropical and tropical zone, atmosphere with low pollution
C4	High	Spaces with high frequency of condensation and high pollution from production process, e.g. industrial processing plants, swimming pools	Temperate zone, atmospheric environment with high pollution (SO_2: $30\ \mu g/m^3$ to $90\ \mu g/m^3$) or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas without spray of salt water or, exposure to strong effect of de-icing salts Subtropical and tropical zone, atmosphere with medium pollution
C5	Very high	Spaces with very high frequency of condensation and/or with high pollution from production process, e.g. mines, caverns for industrial purposes, unventilated sheds in subtropical and tropical zones	Temperate and subtropical zone, atmospheric environment with very high pollution (SO_2: $90\ \mu g/m^3$ to $250\ \mu g/m^3$) and/or significant effect of chlorides, e.g. industrial areas, coastal areas, sheltered positions on coastline
CX	Extreme	Spaces with almost permanent condensation or extensive periods of exposure to extreme humidity effects and/or with high pollution from production process, e.g. unventilated sheds in humid tropical zones with penetration of outdoor pollution	Subtropical and tropical zone (very high time of wetness), atmospheric environment with very high SO_2 pollution (higher than $250\ \mu g/m^3$) including accompanying and production factors and/or strong effect of chlorides, e.g. extreme industrial areas,

GENERAL DESCRIPTION OF DIFFERENT CORROSIVITY CATEGORIES

Table 1. Corrosivity category

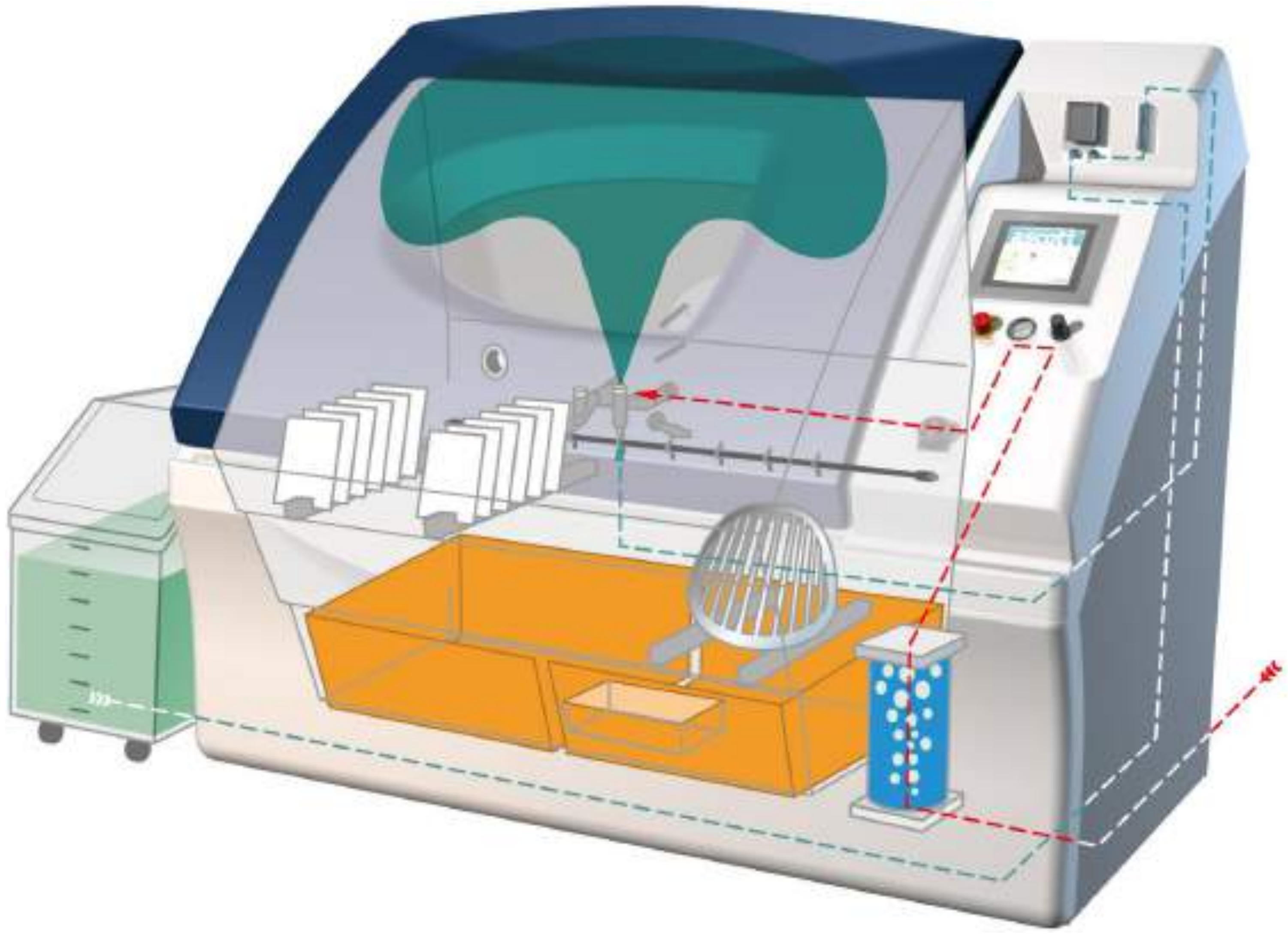
Corrosivity category	Description	Corrosion rate/mild steel[b] (μm/y)	Types of atmosphere[a]					
			Rural	Urban	Industrial	Marine	Pollution and humidity	Sea front
C1	Very low	≤ 1.3						
C2	Low	> 1.3 to 25						
C3	Medium	> 25 to 50			Low SO_2	Low salinity		
C4 (T)	High or tropical	> 50 to 80			Moderate SO_2	Moderate salinity		
C5-I	Very high - industrial	> 80 to 200			High SO_2			
C5-M	Very high - geothermal, marine	> 80 to 200				High salinity		High salinity

NOTE A severe industrial environment occurs as a result of the release of corrosion substances such as chemicals and solvents into the surrounding atmosphere. The choice of a C5-I product will be influenced by the particular chemicals or solvents causing the contamination, and requires consideration on an individual basis.

[a] See Annex B

[b] See ISO 9223

Source: MS 2383:2020



①

SALT SPRAY TEST

Source: https://www.ascott-analytical.com/how-chambers-work/cct-chambers-salt-spray-mode-how-it-works/

Designation: B117 – 18

Standard Practice for
Operating Salt Spray (Fog) Apparatus[1]

Reconfirmed 2017

Australian Standard™

Methods of test for metallic and related coatings

Method 3.1: Corrosion and related property tests—Neutral salt spray test (NSS test)

INTERNATIONAL STANDARD

ISO 9227

Fourth edition
2017-03

Corrosion tests in artificial atmospheres — Salt spray tests

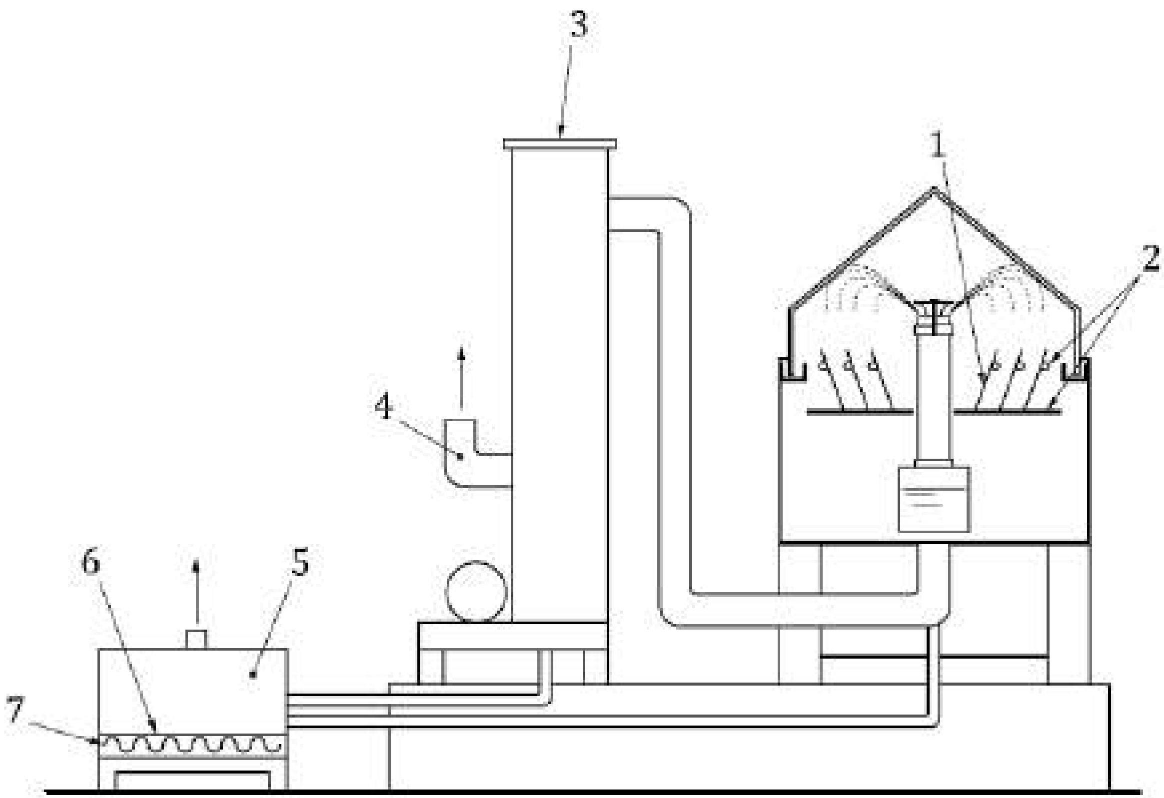
Essais de corrosion en atmosphères artificielles — Essais aux brouillards salins

SALT SPRAY TEST METHOD

Source:

SALT SPRAY TEST SETUP

ISO 9227:2017(E)



Key

1 test specimen
2 test specimen support
3 exhaust air treatment unit
4 air-outlet port
5 drain-treatment unit
6 salt tray
7 heating elements

Figure A.2 — Schematic diagram of one possible design of spray cabinet (side view)

Source:

Salt spray was first used for corrosion testing around 1914. In 1939, the neutral salt spray test was incorporated as ASTM B117.[1] This traditional salt spray specifies a continuous exposure to a 5% salt fog at 35°C. During the course of 80 years of use, there have been many modifications and refinements to B117. In spite of all these refinements, there has long been general agreement that "salt spray" test results do not correlate well with the corrosion seen in actual atmospheric exposures. Nevertheless, B117

3. Significance and Use

3.1 This practice provides a controlled corrosive environment which has been utilized to produce relative corrosion resistance information for specimens of metals and coated metals exposed in a given test chamber.

3.2 Prediction of performance in natural environments has seldom been correlated with salt spray results when used as stand-alone data.

3.2.1 Correlation and extrapolation of corrosion performance based on exposure to the test environment provided by this practice are not always predictable.

3.2.2 Correlation and extrapolation should be considered only in cases where appropriate corroborating long-term atmospheric exposures have been conducted.

AS 2331.3.1

1 SCOPE

This Standard sets out the method for the neutral salt spray (NSS) test for the assessment of corrosion resistance of inorganic and organic coatings on metallic substrates.

NOTES:

1 The method does not specify the type of test item, the exposure period or the assessment criteria. Such details are normally specified in the relevant product Standard or determined by agreement between the purchaser and the supplier.

2 It is important that the results obtained from the test are not regarded as having a direct correlation with environments in which items may be exposed in service or as indicating the relative corrosion resistance of different coatings.

3 The test procedures described in this Standard do not necessarily include all of the

ISO 9227:2012

The salt spray methods are all suitable for checking that the quality of a metallic material, with or without corrosion protection, is maintained. They are not intended to be used for comparative testing as a means of ranking different materials relative to each other with respect to corrosion resistance or as means of predicting long-term corrosion resistance of the tested material.

SALT SPRAY TEST METHOD

Source: http://www.paintinfo.com/TechInfo/Introduction%20to%20Cyclic%20Corrosion%20Testing.pdf; ISO 9227:2012; AS 2331.3.1

5% NaCl
35°C
250hours wetting time

SALT SPRAY TEST PARAMETERS

Source: SIRIM Test report Ref: 2018CE0327

MS 2383

Table 4. Exposure duration for neutral salt spray tests

Corrosivity Category	Exposure duration (h)
C2	100
C3	500
C4 (T)	1 000
C5-I	2 000
C5-M	2 000

1 SALT SPRAY TEST (SST)

SALT SPRAY TEST DURATIONS

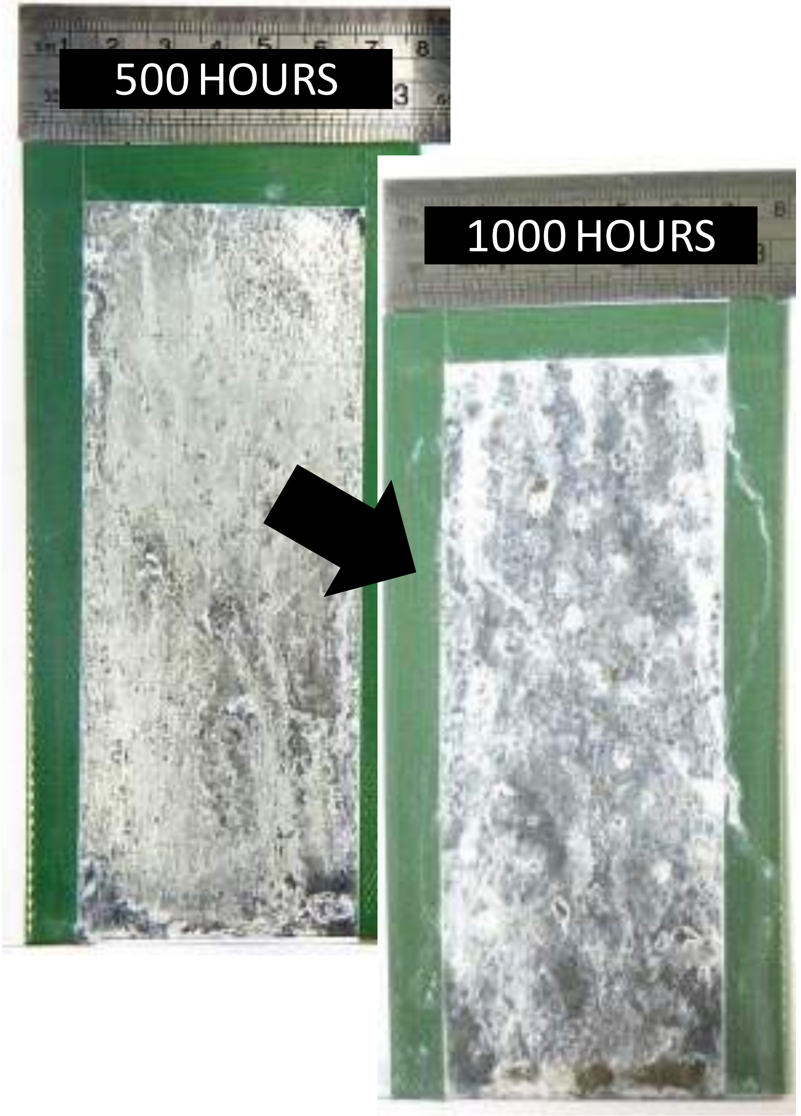
Source: SIRIM Test report Ref: 2018CE0327

1 SALT SPRAY TEST (SST)

EXAMPLE OF SALT SPRAY TEST RESULT

Source: SIRIM Test report Ref: 2018CE0327

① SALT SPRAY TEST (SST)



EXAMPLE OF SALT SPRAY TEST RESULT

Source: SIRIM Test report Ref: 2018CE0327

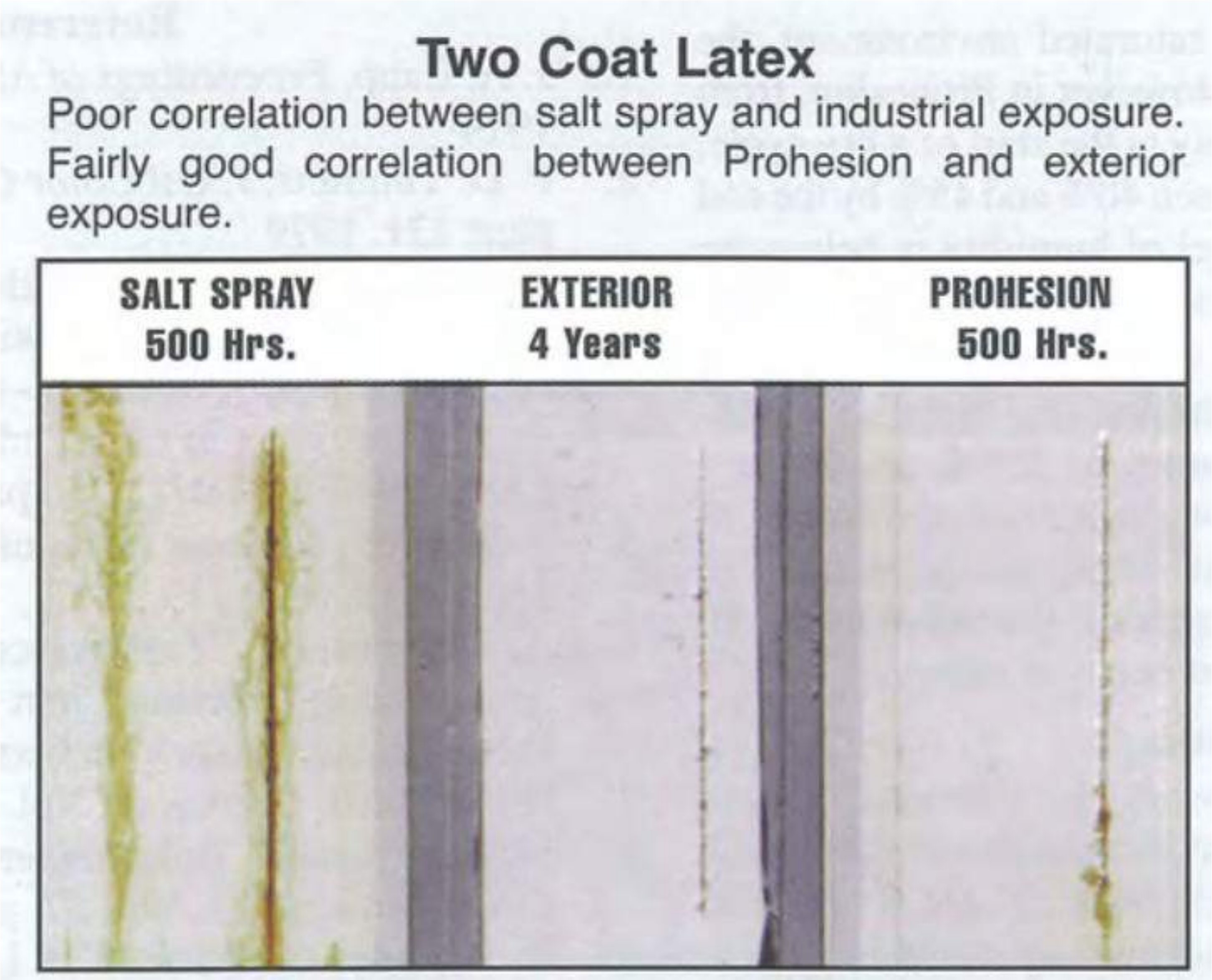
1 SALT SPRAY TEST (SST)

EXAMPLE OF SALT SPRAY TEST RESULT

Source: SIRIM Test report Ref: 2018CE0327

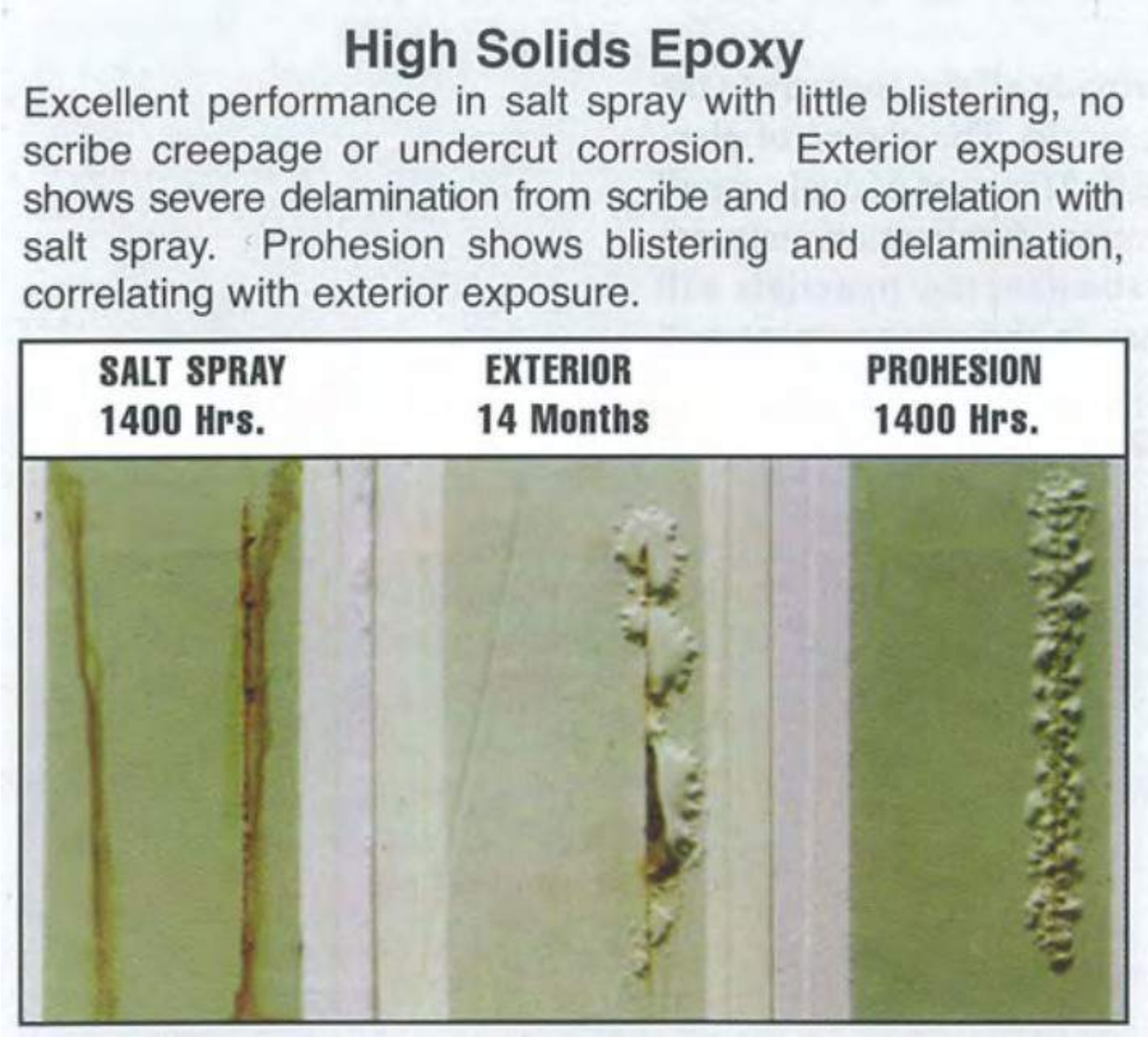
EXAMPLE OF SALT SPRAY TEST RESULT

Source: SIRIM Test report Ref: 2018CE0327



SHORTFALL OF SALT SPRAY TEST

Source: https://www.q-lab.com/documents/public/dbdbd3fd-1e74-4749-9f3c-f5de2f0f1035.pdf



High Solids Epoxy

Excellent performance in salt spray with little blistering, no scribe creepage or undercut corrosion. Exterior exposure shows severe delamination from scribe and no correlation with salt spray. Prohesion shows blistering and delamination, correlating with exterior exposure.

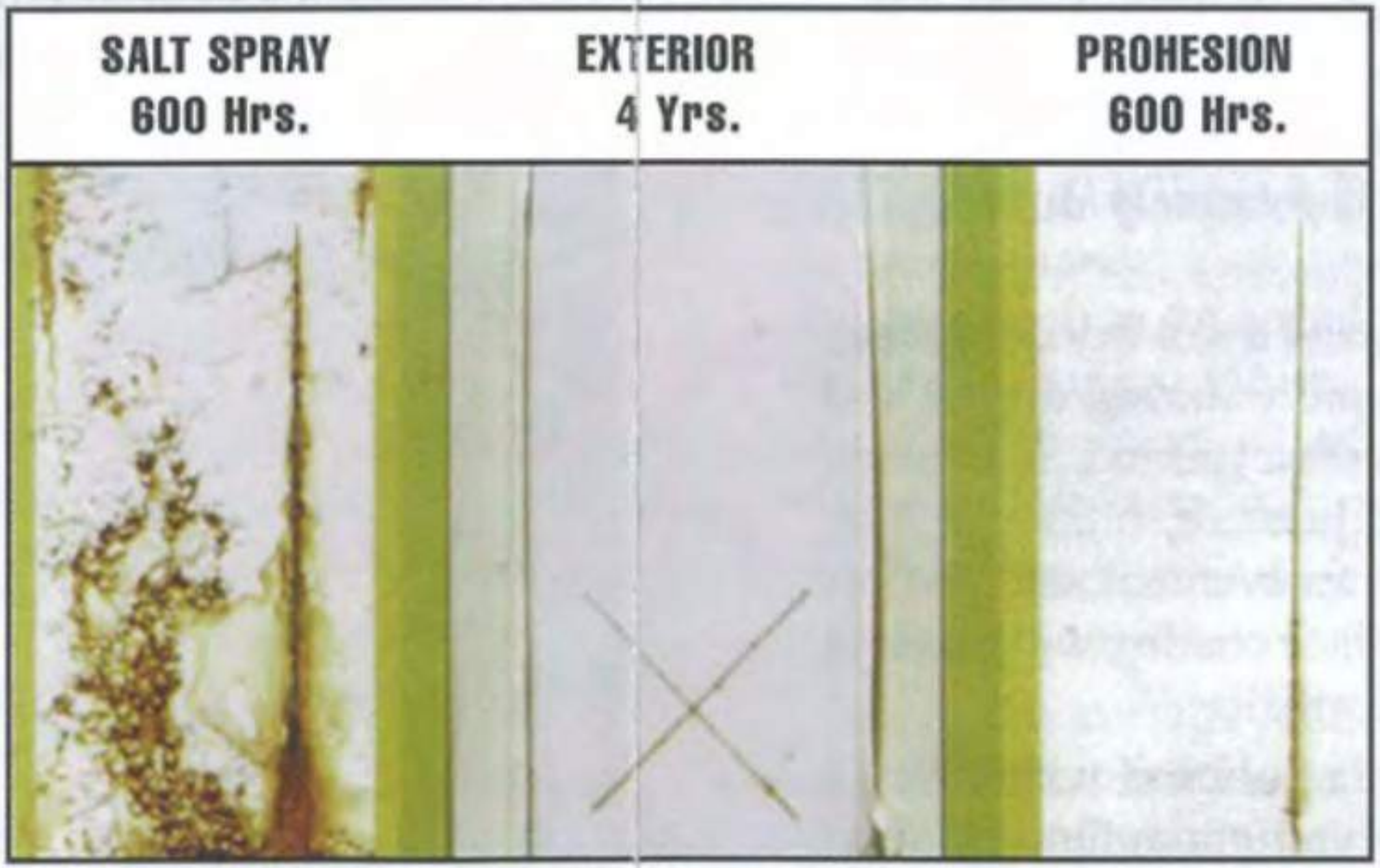
SALT SPRAY 1400 Hrs.	EXTERIOR 14 Months	PROHESION 1400 Hrs.

SHORTFALL OF SALT SPRAY TEST

Source: https://www.q-lab.com/documents/public/dbdbd3fd-1e74-4749-9f3c-f5de2f0f1035.pdf

Medium Oil Alkyd, Inhibitor B

A sharp contrast between industrial site exposure and salt spray. Salt spray shows complete failure. Prohesion and Exterior exposures show good performance.



① SALT SPRAY TEST (SST)

SHORTFALL OF SALT SPRAY TEST

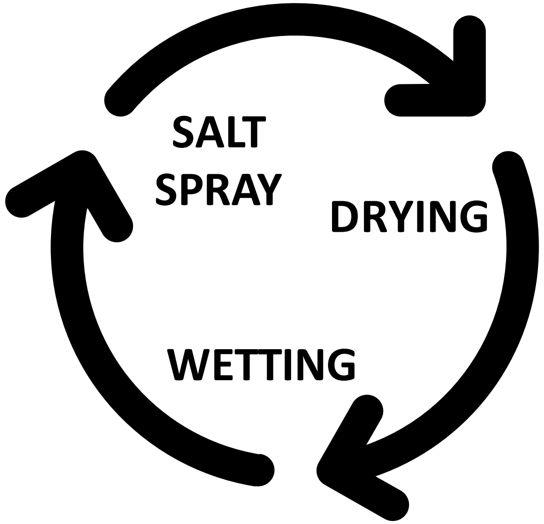
Source: https://www.q-lab.com/documents/public/dbdbd3fd-1e74-4749-9f3c-f5de2f0f1035.pdf

SALT SPRAY TEST

Test condition:

Duration of exposure	**: 250 hours**
Temperature exposure zone	: 35ºC
Salt solution used	: 5% of NaCl
pH of collected solution	: 6.2 ~ 6.8
SG of collected solution	: 1.03
Volume of salt collected in ml/h/80 cm2	: 1.8 ml/hr

PROHESION TEST

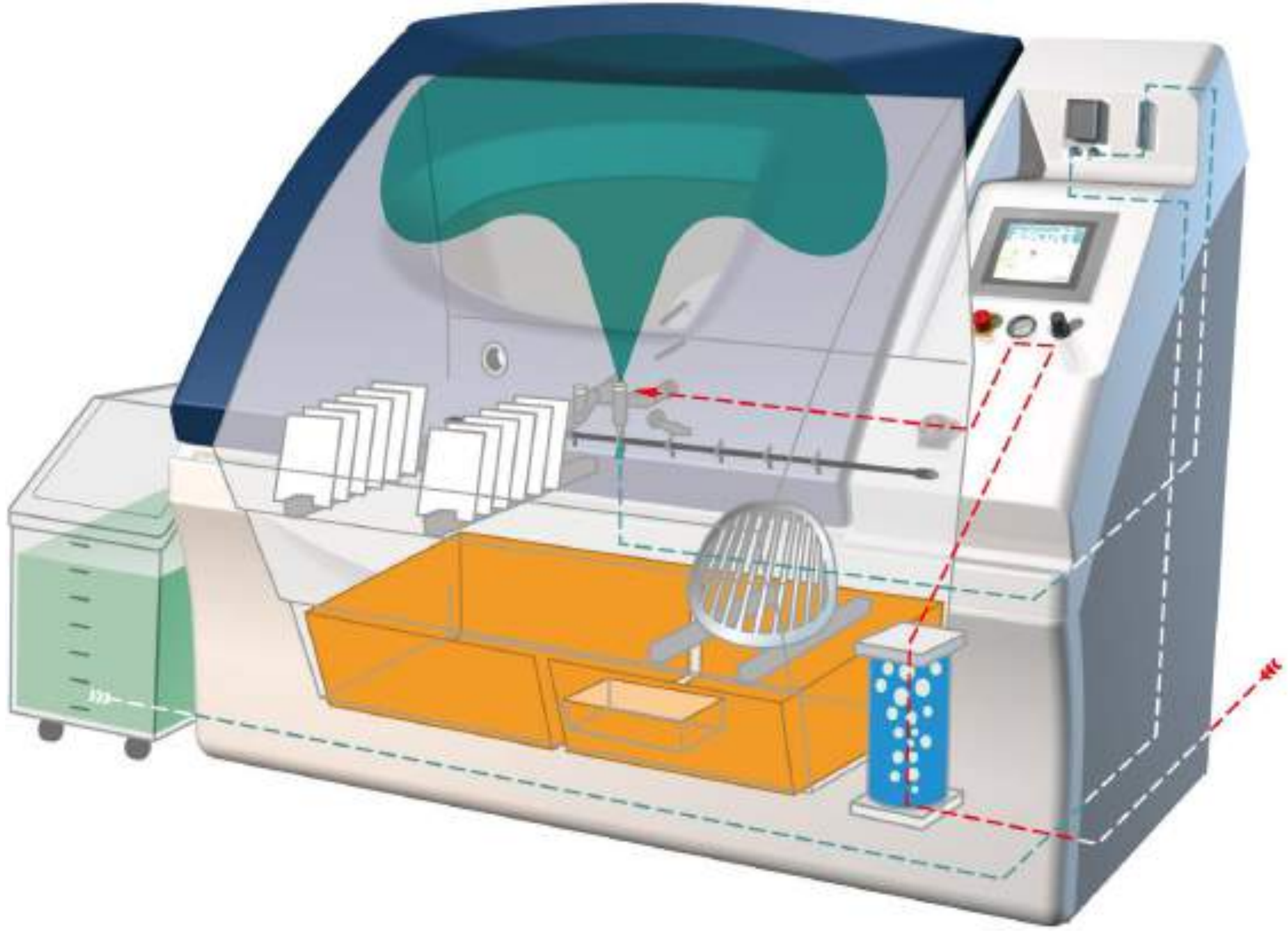


1) A spray cycle at ambient temperature was selected and a weak solution of Harrison's mixture would be used.
2) An elevated temperature drying cycle was required, with an air temperature within the chamber variable from 23° C to 55° C.
3) Air introduction to the test chamber was required during the drying cycle.
4) A facility to allow cyclic wetting and drying cycles from a minimum of one hour to a maximum of ten hours was essential.
5) The test samples should be placed on racks on the cabinet walls so that the surfaces of all panels were exposed to the spray.

These essential conditions were incorporated together with other features which we considered vital in any form of spray chamber. The Mebon Prohesion Cabinet was then produced.

SHORTFALL OF SALT SPRAY TEST

Source: https://www.q-lab.com/documents/public/dbdbd3fd-1e74-4749-9f3c-f5de2f0f1035.pdf



②

CYCLIC CORROSION TEST

Source: https://www.ascott-analytical.com/how-chambers-work/cct-chambers-salt-spray-mode-how-it-works/

ASTM INTERNATIONAL

Designation: G85 – 11

Standard Practice for Modified Salt Spray (Fog) Testing[1]

1

AS 2331.3.13—2006
Reconfirmed 2017

Australian Standard®

Methods of test for metallic and related coatings

Method 3.13: Corrosion and related property tests—Wet (salt fog)/dry/humidity

CYCLIC CORROSION TEST METHOD

Source: ASTM G85; AS 2331.3.13

CYCLIC CORROSION TEST METHOD

CYCLE E

(Normative)

E1 SALT FOG TEST SOLUTION

The spray solution shall be prepared as described in Appendix F by dissolving sodium chloride in water to give a concentration of (50 ±10) g/L. The pH of the solution shall be in the range of 6.0 to 7.0.

E2 CYCLE

The cabinet shall be set up to perform the following cycle:

Step	Time h	Temperature °C	Condition	Notes
1	4	35 ±2	Salt fog	
2	2	60 ±2	Dry off	
3	0.5	40 ±2		
4	2	50	Wet: 95% RH or over	Repeated up to the required duration (4000 h)
5	Go back to step 1			

NOTE: This cycle corresponds with the CCT-1 cycle.

E3 SALT FOG DEPOSITION RATE

The salt fog deposition rate shall be 1 mL/h to 2 mL/h, when the salt fog is collected over a 24 h period (see Clause 9).

E4 DURATION

Unless otherwise agreed, the cycle shall be repeated for 4000 h.

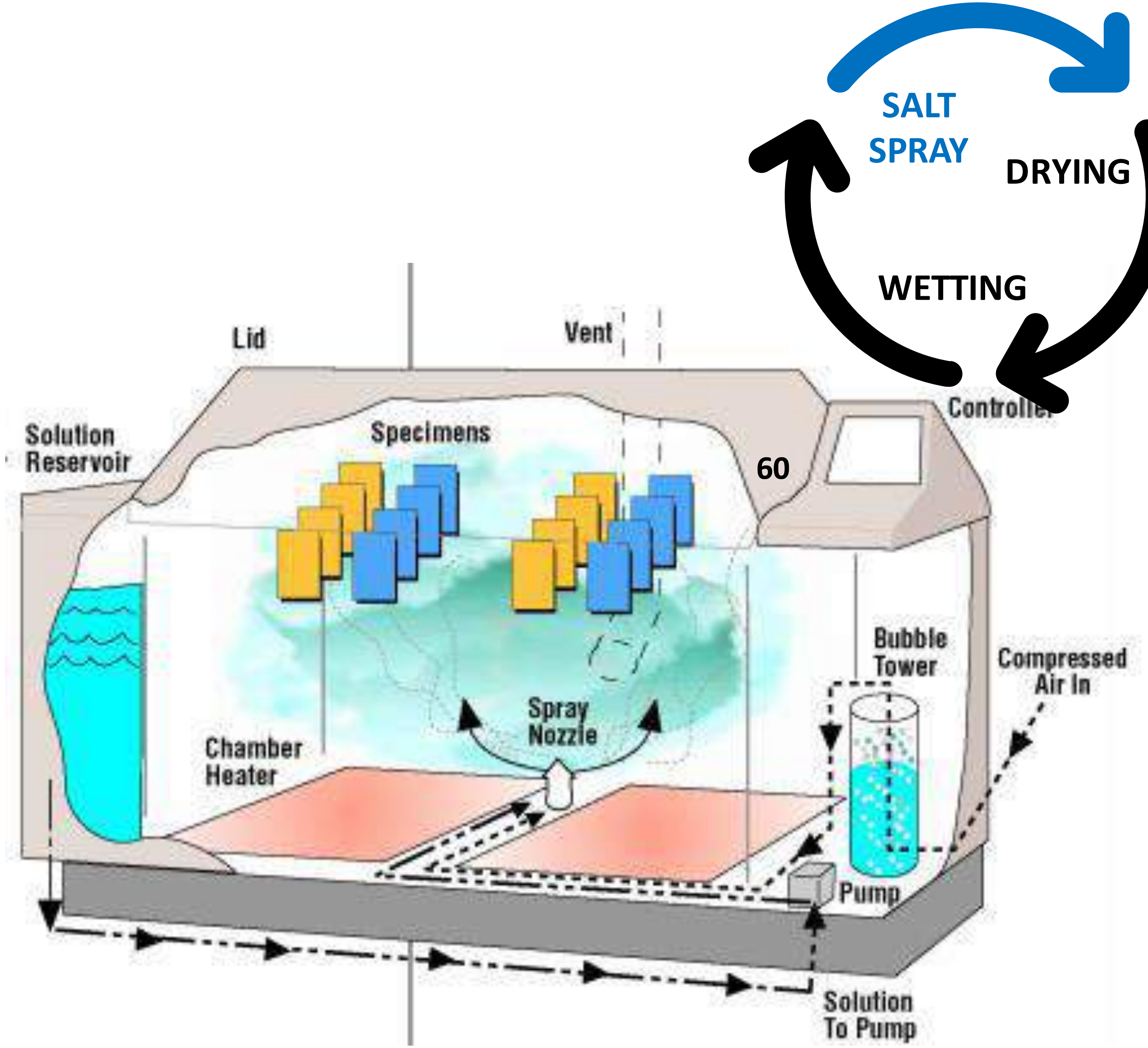
Source:

CYCLIC CORROSION TEST METHOD

Table 1 — Test conditions

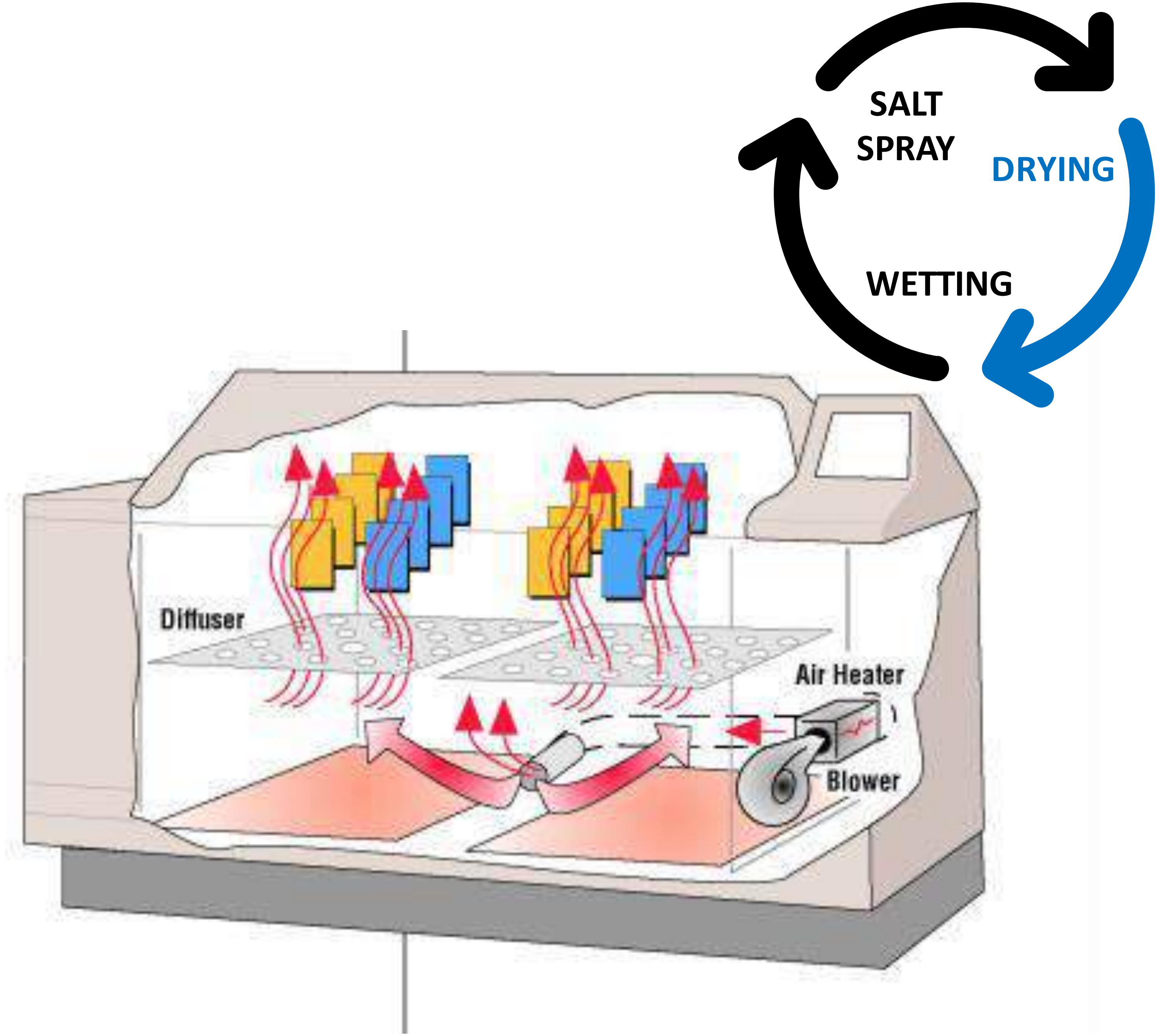
1	**Salt mist conditions** 1) Temperature 2) Salt solution	 35 °C ± 1 °C pH 6,5 to 7,2, salt concentration 50 g/l ± 5 g/l as described in Clause 4
2	**"Dry" conditions** (The air is purged under dry conditions.) 1) Temperature 2) Relative humidity	 60 °C ± 1 °C < 30 %
3	**"Wet" conditions** (Condensation on the test specimens shall not occur under wet conditions.) 1) Temperature 2) Relative humidity	 50 °C ± 1 °C > 95 %
4	**Period and content of a single exposure cycle**	Total period 8 h, as follows: Salt mist spray 2 h "Dry" conditions 4 h "Wet" conditions 2 h (These times include the time for reaching the specified temperature for each condition.)
5	**Time to reach the specified condition** (i.e. period taken for temperature and humidity to reach the specified values once the test condition has begun)	Mist to "Dry" < 30 min "Dry" to "Wet" < 15 min "Wet" to Mist < 30 min (Mist conditions are attained almost instantaneously once this condition begins.)
6	**Angle at which test specimens are supported**	20° ± 5° to the vertical
NOTE The ± tolerances given are the allowable operational fluctuations, which are defined as the positive and negative deviations from the setting of the sensor at the operational control set point during equilibrium conditions. This does not mean that the set value may vary by plus/minus the amount indicated from the given value.		

Source: AS 2331.3.13



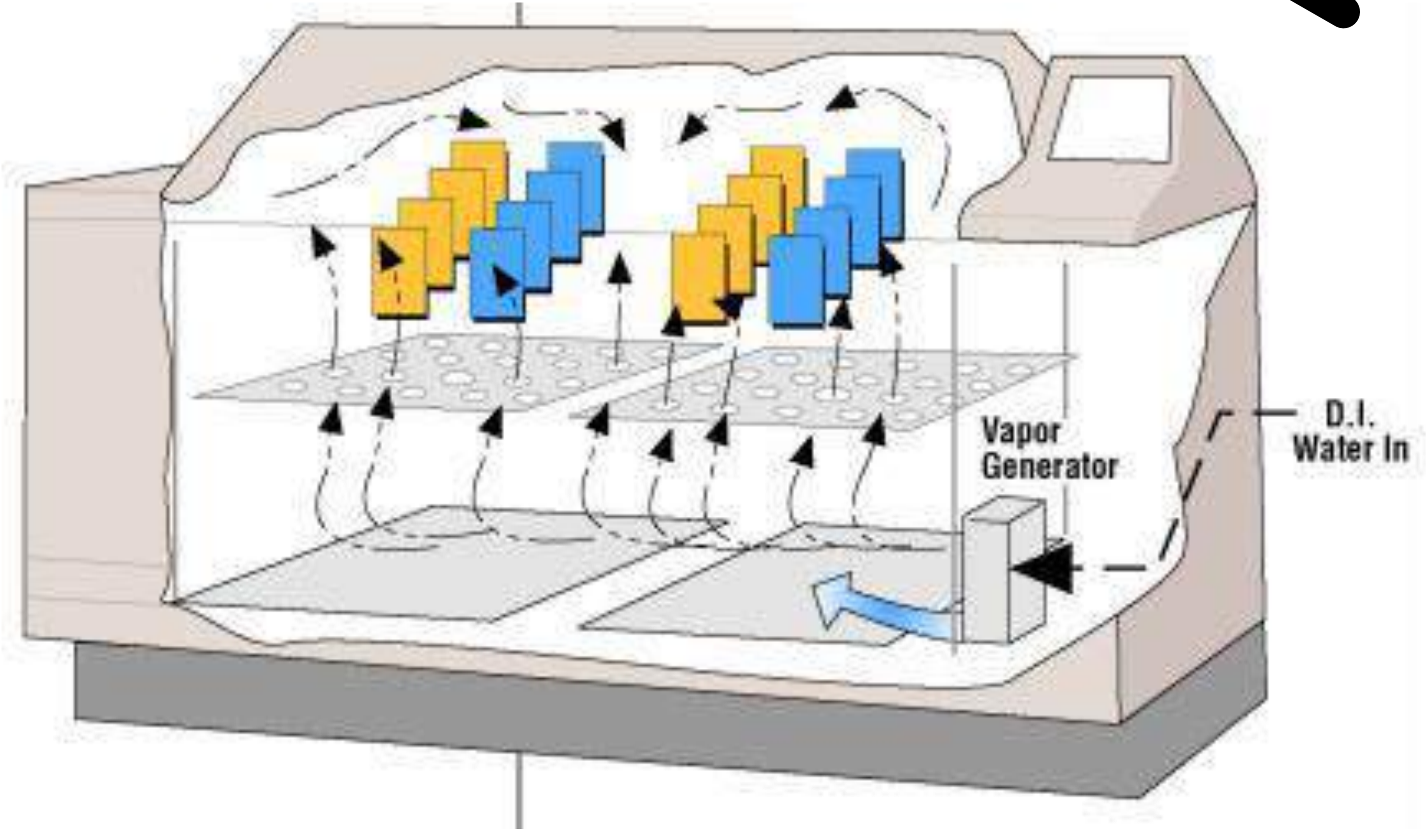
CYCLIC CORROSION TEST (SALT SPRAY)

Source:



CYCLIC CORROSION TEST (DRYING)

Source:



CYCLIC CORROSION TEST (HUMIDITY)

Source:

CYCLIC CORROSION TEST DURATIONS

AS/NZS 2728

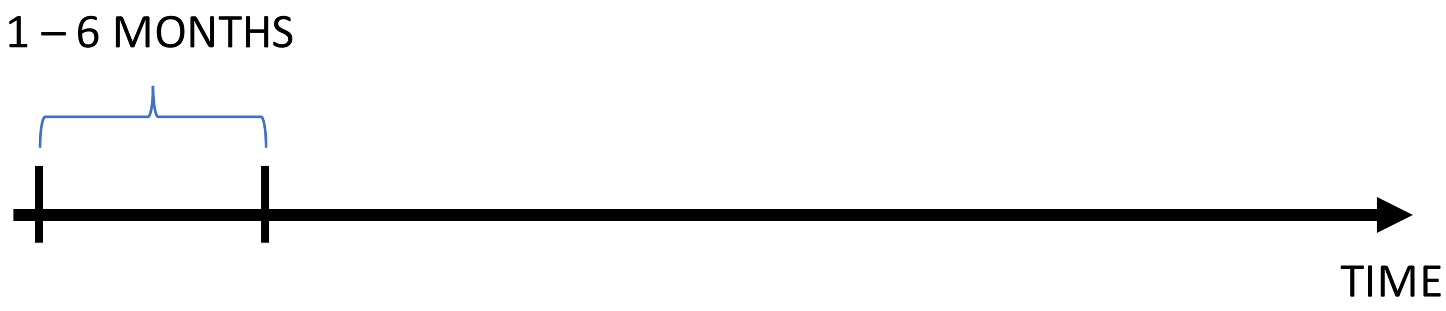
TABLE II

EXPOSURE REQUIREMENTS FOR ACCELERATED CORROSION TESTS

Product type	Exposure, h			
	Salt spray		Cyclic corrosion	
	Test method AS 2331.3.1 (NSS test) for steel substrates	Test method AS 2331.3.2 (ASS test) for aluminium substrates	Test method AS 2331.3.13 for steel substrates (CCT1 cycle)	Test method AS 2331.3.13 for aluminium substrates
2	100	100	200	N/A
3	500	500	1000	N/A
4	1000	1000	2000	N/A
5	2000	1000	4000	N/A
6	2000	1000	4000	N/A

Source: AS/NZS 2728:2013

CYCLIC CORROSION TEST DURATIONS



MS 2383

Table 6. Exposure duration for cyclic corrosion test

Corrosivity Category	Exposure duration (h)
C2	200
C3	1 000
C4 (T)	2 000
C5-I	4 000
C5-M	4 000

Source: MS 2383:2020

EXAMPLES OF CYCLIC CORROSION TEST RESULTS

Source:

SALT SPRAY TEST (SST)

CYCLIC CORROSION TEST (CCT)

2 CYCLIC CORROSION TEST (CCT)

SST VS CCT AT 1000 HOURS

Source: SIRIM Test report Ref: 2018CE0327

SALT SPRAY TEST (SST)

CYCLIC CORROSION TEST (CCT)

2 CYCLIC CORROSION TEST (CCT)

SST VS CCT AT 2000 HOURS

Source: SIRIM Test report Ref: 2018CE0327

③

OUTDOOR WEATHERING TEST

Source:

TABLE J1

CHARACTERIZATION OF NEW ZEALAND CORROSION TEST SITES

Criteria	Owner/Site					
	BRANZ	Works consultancy services	PPG	New Zealand Steel	Pacific Coil Coaters	
	Judgeford	Central labs Gracefield Lower Hutt	South Manukau heads (see Note 1)	Rotorua (geothermal)	Coastal Muriwai (see Note 2)	Penrose Auckland
Rating as to ISO 9223	C2	C3	C4	C5	C4	C3
Latitude/longitude	41.11/174.56	4.14/174.55	37.04/174.33	—	35°49.37'S/174°25.51'E	36.56/174.51
Distance to sea, km	11 to NW 15 to SSW	17 to NW 1 to S	0.05 (see Note 3)	90	1	1.2
Average annual rainfall, mm	1300 (see Note 4)	1350	1350	1500	1242	1250
Average annual sunshine, h	1900 (see Note 4)	2000	2200	2200	2048	2100
Mean temperature °C	13	13	15	13	14.9	15
Solar radiation, mWh/cm²	360	370	390	420	390	420
Range Annual Humidity						
—winter, %	84	83	86	87	75.6	86
—summer, %	77	78	82	78	84.2	76
—annual, %	79	80	83	82	83	80
Time of wetness—annual (number of hours the relative humidity exceeds 80%)	—	—	—	—	—	—
Airborne atmospheric chloride, mg/m². day	—	—	—	—	—	—
Airborne atmospheric sulfur dioxide, mg/m². day*	—	—	—		—	—
One year corrosion rate, μm/y (g/m².y)—						
—Mild steel	19 (153)	21(167)	42(327)	—	78.5	29(229)
—Copper bearing steel (CSIRO)	—	—	43.5 (340.1)	—	—	—
—Zinc	0.77 (5.5)	1.0 (7.0)	4.15 (29.6)	—	5.44	0.84 (6.0)
—Wire on bolt	(see Note 6)	—	—	—	—	—

TEST SITES

Source:

TEST SITES

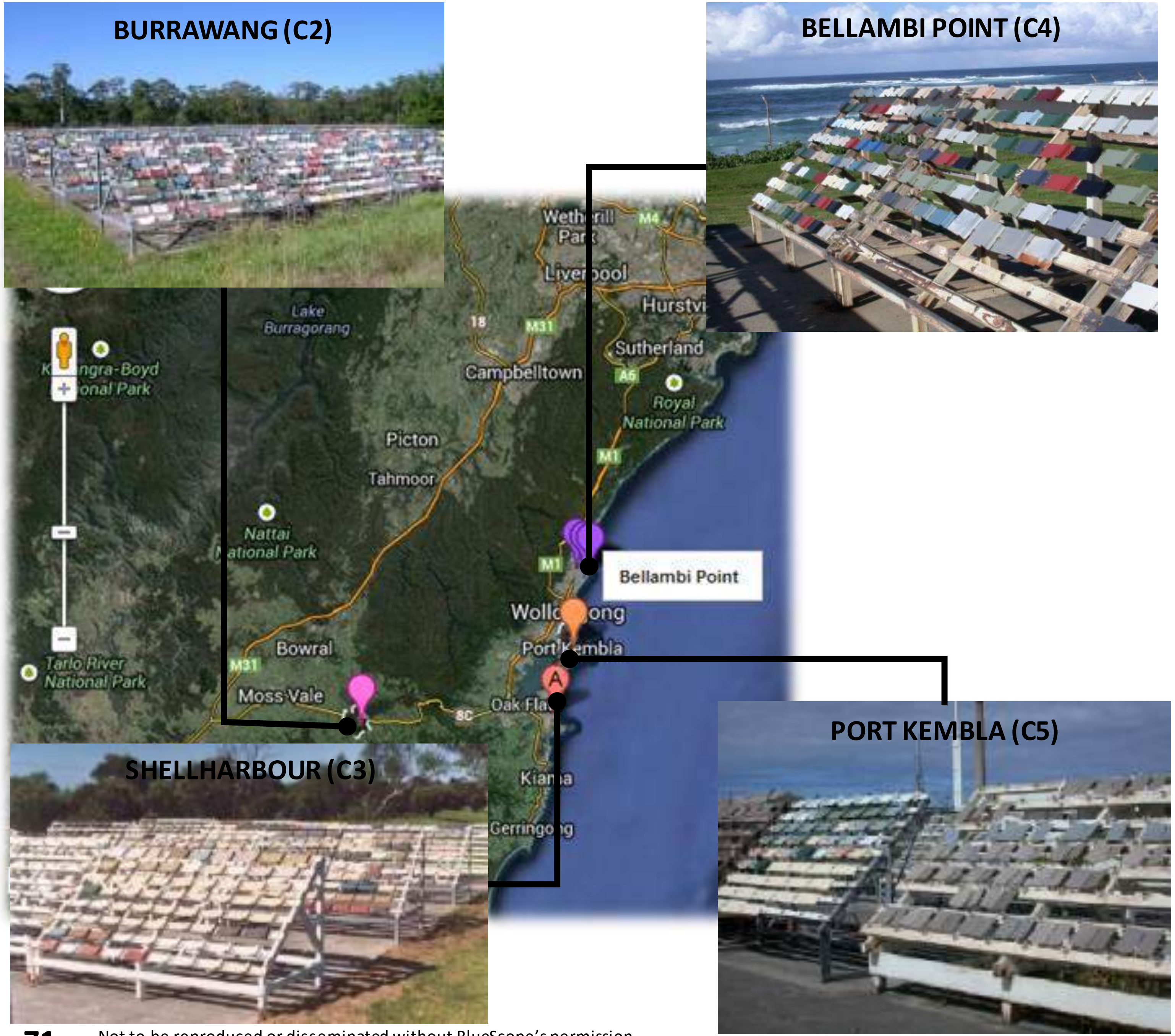
TABLE J2

CHARACTERIZATION OF AUSTRALIAN CORROSION TEST SITES

Criteria	Owner/Site				
	BlueScope Steel			CSIRO	Belmont (Beach) NSW
	Bellambi Point	Shellharbour	Port Kembla	Flinders marine site	
Rating as to ISO 9223	C4	C3	C5	C4	C5
Latitude/longitude	34.6/150.8	34.6/150.8	34.5/150.9	38.29/145.2	32.0/152.4
Orientation	—	—		N	Any
Distance to sea, km	0.05	0.3	0.05	0.1	0.2
Direction of prevailing winds	NE/S	NE/SE	NE/SE	W	
Degree of industrialization	Nil	Nil	Low	Nil	Nil
Average annual rainfall, mm	1580	1580	1277	750	1142
Annual mean temperature—					
—at 9 a.m., °C	17	17	17.6	14	16.7
—at 3 p.m., °C	19	19	19.4	16	19.8
—overall, °C	17	17		15	
Solar radiation, mWh/cm^2	460	460		430	480
Average humidity—					
—winter, %	—	—		—	
—summer, %	—	—		—	
—annual, %	62 to 67	60 to 67		67	65
Time of wetness—annual (number of hours the relative humidity exceeds 80%)	—	—		—	5650
Airborne atmospheric chloride, mg/m^2.day*	—	—		31.4 (16.7)	250-350
Airborne atmospheric sulfur dioxide, mg/m^2.day	—	—		—	—
One year corrosion rate, μm/year (g/m^2.y)—					
—mild steel	35.5 (275.8)	18.1(140.6)	(120.5)	30.9 (240.1)	100–600 (300)
—zinc	4.94 (35.3)	1.64 (11.7)	7.9	6.22 (44.4)	3.0–7.1 (5.7)

* Mean value over year. Standard deviation in brackets to indicate variability.

Source:



③ OUTDOOR WEATHERING TEST

TEST SITES OWNED BY BLUESCOPE

Source:

TEST SITES (C4)

Source:

3 OUTDOOR WEATHERING TEST

TEST SITES (C4)

TABLE III

RATING OF SEVERE UV DURABILITY TEST SITES IN AUSTRALIA IN TERMS OF SOLAR WEATHERING INDEX

Site	Latitude degrees	Sunshine daily average h	Solar radiation (average daily) MJ/m^2	Annual rainfall mm	Solar weathering index $10^{-7}\beta\Sigma f\ln(n-2)$*
Birdsville	26	>10	23.4	23.4	14.0
Rockhampton	23	8.3	22.68	2268	9.3
Darwin	12	8.5	21.24	2124	9.4
Townsville	19	8.1	20.88	2088	9.2

* These figures were derived from information in an article titled 'Solar Weathering Indices for Australian Sites' by K. G. Martin (Division of Building Research Technical Paper No. 18, 1-33 (1977), and which is available from the CSIRO Division of Building Construction and Engineering, Highett, Melbourne.

Ave. Daily Solar Radiation ~22.68MJ/m^2

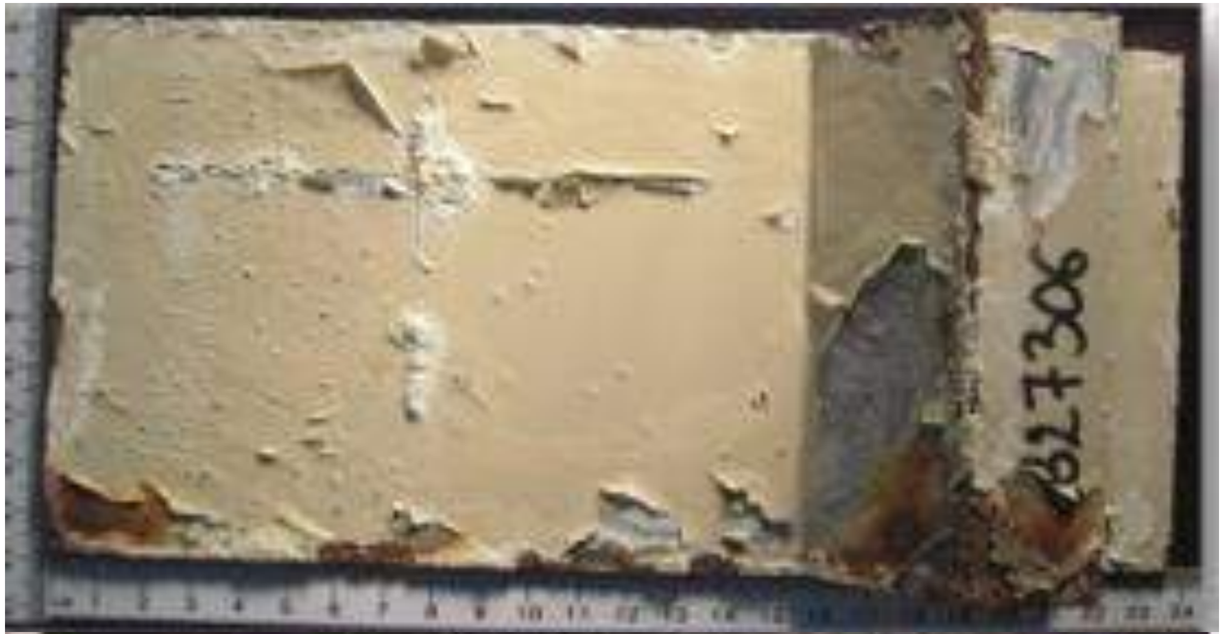
Rockhampton is located 638km north of Brisbane and just a few kilometers north of the Tropic of Capricorn.

Source:

ISO 9223 C2 | ISO 9223 C3 | ISO 9223 C4

EXAMPLES OF OUTDOOR EXPOSURE TEST RESULTS

Source:



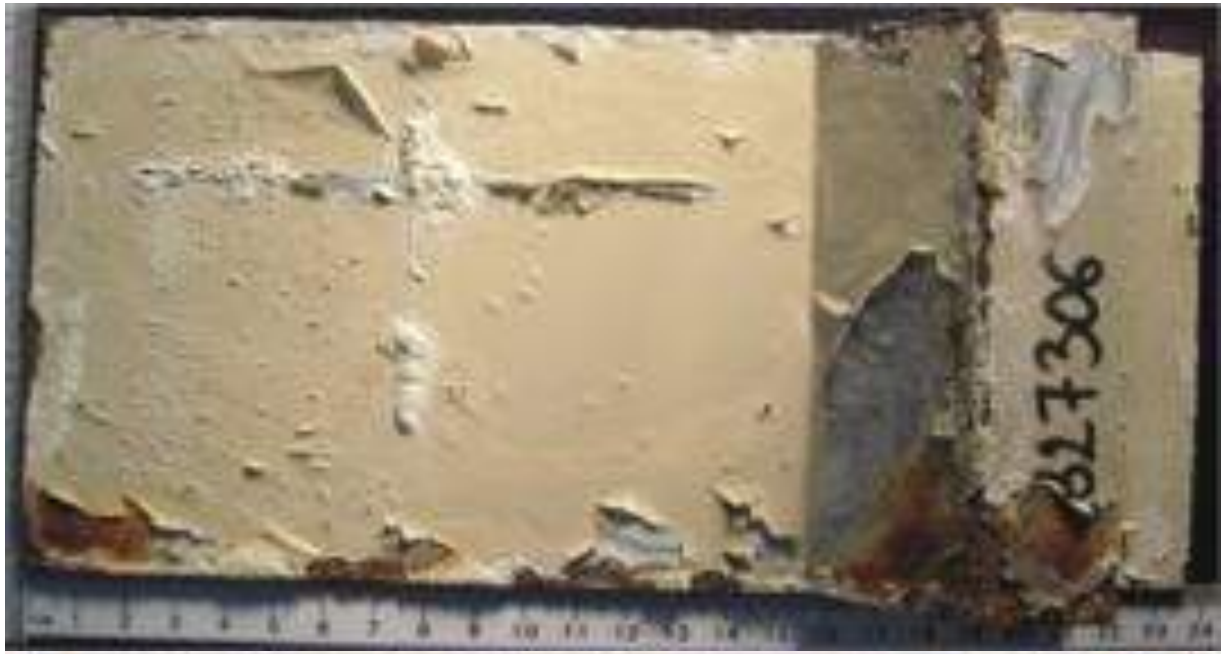
ISO 9223 C4 – 45 months (unwashed) at Muriwai

Salt Spray Test (SST) – 2000 hours

OUTDOOR WEATHERING TEST VS SALT SPRAY TEST

Source:

OUTDOOR WEATHERING TEST VS CYCLIC CORROSION TEST



ISO 9223 C4 – 45 months (unwashed) at Muriwai

Cyclic Corrosion Test (CCT) – 2000 hours

Source:

4

PROJECT SITE CASE STUDIES

Source: https://www.ascott-analytical.com/how-chambers-work/cct-chambers-salt-spray-mode-how-it-works/

SHOPLOTS 5 YEARS IN RURAL AREA

Source: BlueScope Inspection, FC24-18

COMPARISON BETWEEN 2 PRODUCTS AFTER 5 YEARS

Source: BlueScope Inspection, FC24-18

BEACH RESORTS
5 YEARS IN SEVERE MARINE INFLUENCE

Source: BlueScope's photos, Lexis Hibiscus, Port Dickson

TRIED AND TESTED IN THE SPECIFIC ENVIRONMENT

Source: BlueScope's photos, Lexis Hibiscus, Port Dickson

AIRPLANE HANGAR

12 YEARS IN URBAN AREA

Source: BlueScope inspection, CS-XPD-03

4 PROJECT SITE CASE STUDIES

STUDIES DONE TO OBSERVE THE COLOUR PERFORMANCE

Source: BlueScope inspection, CS-XPD-03

OF COLOUR PERFORMANCE AFTER 12 YEARS

Source: BlueScope inspection, CS-XPD-03

④ PROJECT SITE CASE STUDIES

BEACHSIDE AQUARIUM

15 YEARS IN SEVERE MARINE WEATHER

Source: BlueScope inspection, CS-ZAL-1

NO SIGN OF SURFACE RUSTS

Source: BlueScope inspection, CS-ZAL-1

STUDY OF THE INTRICATE AREAS

Source: BlueScope inspection, CS-ZAL-1

EFFECT OF ACCUMULATION

EFFECT OF ACCUMULATION

EFFECT OF SCRATCHES ON COATED STEEL

SUMMARY

1. SALT SPRAY TEST (SST)
2. CYCLIC CORROSION TEST (CCT)
3. OUTDOOR WEATHERING TEST
4. CASE STUDIES

Source: BlueScope photo

QUESTION & ANSWER SESSION

Source: BlueScope

BlueScope

steel CONNECT

Colorbond® VERMOE™ Zincalume® TrueCore®

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NS BlueScope Malaysia