PAINT FILM DEFECTS
Causes & Cure

Agenda

- Introduction
- Corrosion Chemistry
- Surface Preparation
- Recommended Painting System at IPCL
- Application
- Inspection & Control

Corrosion

Corrosion is the gradual deterioration of a metal by electrochemical reaction with air and moisture

Corrosion occurs as refined metals attempt to reach their lowest energy state i.e. their oxide state

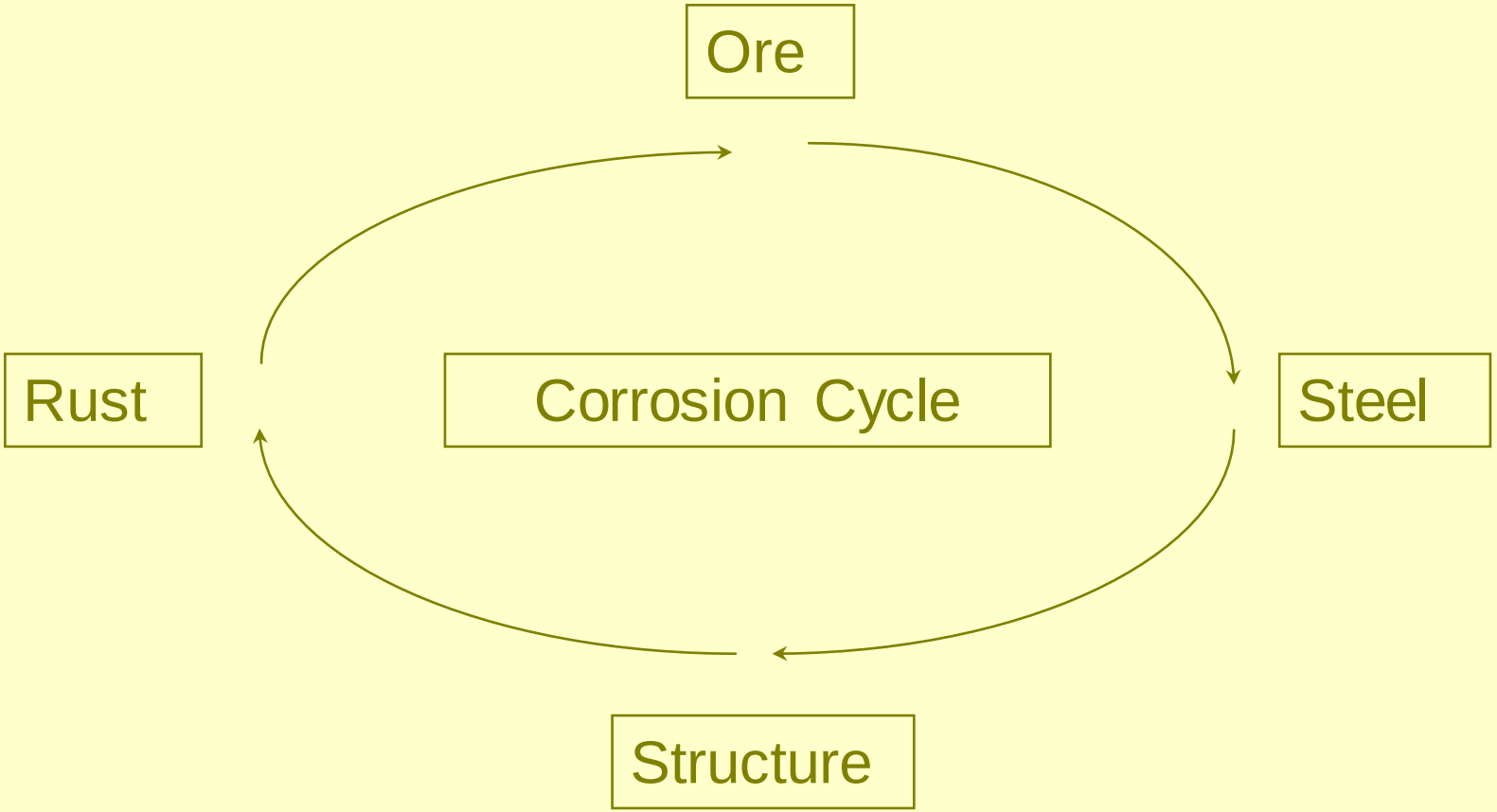
Chemistry

$$Fe + H_20 + 0_2 \longrightarrow Fe_20_3.\ x\ H_20\ (Rust)$$

- A Galvanic process akin to a dry cell battery
- Moisture provides the medium (electrolyte) and air, the oxygen

Compositional difference, differential stress, surface contamination, mill scale form the anode and cathode

Rust to Rust



Surface Protection

Coatings having one or more of the features listed below holds the key

- Barrier : Blocks air, moisture & weathering agents
- Inhibitive : Prevents the ionic path
- Cathodic : Sacrificially corrodes
- Anti-Decay : Prevents fungus, mould, mildew

Coating Composition

- The composition of protective coatings is as follows:

- Pigment :Hiding, Colour, Corrosion prevention
- Resin : The coating backbone
- Additives : Specific property introduction
- Solvent : For application ease

Coating Range

Diverse environments lead to diverse resin usage and as a result coatings are classified based on the principal resin used

Surface Preparation

Is surface preparation really important?

YES!!!

More than 75% of all premature coatings failures are a result of poor or incomplete surface preparation.

Surface Preparation

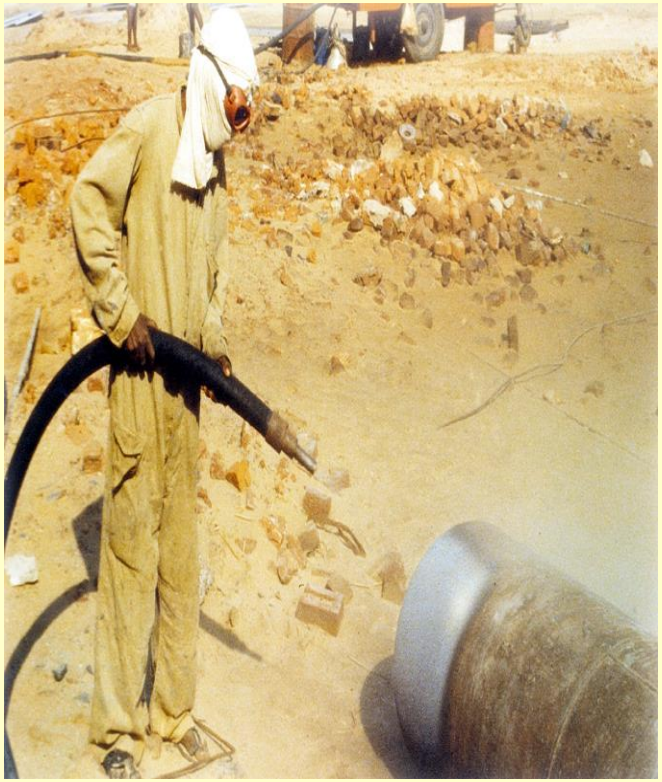
"And what more is that the effective lifetime of a coating applied onto a substrate depends to a large extent on how thoroughly the surface is prepared prior to painting. Sadly, this aspect is quite often neglected"

Surface Preparation

- Surface Preparation can include
  - Removal of oil and grease, soil, salts and other contaminants
  - Removal of rust and mill-scale
  - Creation of anchor Profile

Surface Preparation

- And may involve
  - Chemical / Solvent cleaning
  - Hand and power tools
  - Flame Cleaning
  - Steam Cleaning
  - Water jet cleaning
  - Abrasive Blast Cleaning



Surface Preparation: Cleanliness Standards

Cleaning Method	***Swedish Standard***	***ISO Standard***	***SSPC Standards***	***NACE Standards***
Hand Tool	*St 2*	-	*SSPC-SP 2*	
Power Tool	*St 3*	-	*SSPC-SP 3*	
White Metal	*Sa 3*	*Sa 3*	*SSPC-SP 5*	*NACE = 1*
Near White Metal	*Sa 2.5*	*Sa 2.5*	*SSPC-SP 10*	*NACE = 2*
Commercial Blast	*Sa 2*	*Sa 2*	*SSPC-SP 6*	*NACE = 3*
Brush Off Blast	*Sa 1*	*Sa 1*	*SSPC-SP 7*	*NACE = 4*

Rust Grades: Visual presentation
As per ISO 8501 - 010

A

B

C

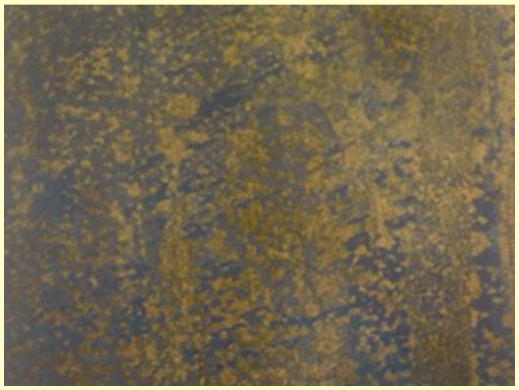
D

Surface Preparation: Cleanliness Standards (Visual)

A Sa 2 1-2

A Sa 3

Surface Preparation: Cleanliness Standards (Visual)



B St 2

B St 3

B Sa 1

B Sa 2

B Sa 2.5

B Sa 3

Surface Preparation: Cleanliness Standards (Visual presentation)

C St 2

C St 3

C Sa 1

C Sa 2

C Sa 2.5

C Sa 3

Surface Preparation: Cleanliness Standards (Visual presentation)

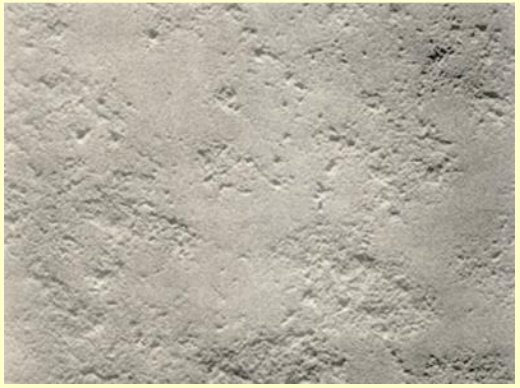
D St 2

D St 3

D Sa 1

D Sa 2

D Sa 2.5



D Sa 3

Application Tools

- Brush Application
  - Versatile, minimal wastage
  - Slow, Labour oriented, brush marks
- Roller Application
  - Suited for broad plain surface
  - Slow, Labour oriented
- Spray Applications
  - Quick, uniform finish
  - High wastage, costly operations

Spray Application

- Air Spray
  - High finish quality
  - High loss, Low build
- Airless Spray
  - Lower loss, High Build
  - Coarse finish

✹ Twin feed airless

- ● Solvent free & high solid products
- ● Mixing of base & hardener at the nozzle tip

Application Considerations

- Contamination (Substrate & Coating)
- Application conditions (Temp & Wind Vel.)
- Humidity (% RH < 85, DP + 3 Deg C)
- Solvent & Thinner as per recommendation
- Fresh water rinsing of salts

Inspection Plan

Coating Material

- Brand, Batch No.& Shelf Life
- Mixing Ratio for 2 Pack products
- Test Certificate / QAP
- Data Sheet
- MSDS
- Thinner, Cleaners & Touch up material
- Storage Conditions
- System Specification

Inspection Plan

Surface Preparation

- Availability of Standard Equipments & Spares
- Blasting Media –contamination
- Surface Contamination
- Cleanliness Standards & Measurement of Surface Profile
- Interval between Cleaning & Painting
- % RH & Surface Temperature
- Trained Operators
- Supervision & Controls

Inspection Plan

Application

- Availability of Standard Equipments & Spares
- Selection of Nozzle & Air Pressure
- Mixing of Paints & Induction Time
- Selection and addition of thinner
- Substrate Temperature & Dew Point
- Substrate Condition
- Coating Intervals & Pot life
- Wet Film Thickness
- Edge Coverage

Inspection Plan

Applied Coating

- Dry Film Thickness
- Film Imperfections (visual)
- Film Discontinuities

HOW COATINGS WORK ?

- **INSULATION OF OF SUBSTRATE FROM EXTERNAL ENVIRONMENT BY PAINT FILM**
  - **LOW PERMEABILTY TO CORRODENTS**
  - **PREVENTION OF RUSTING & CORROSION**

- ***ESSENTIAL PROPERTIES OF COATING***

  -- Strong adhesion with substrate

  -- Excellent wetting on substrate

  -- Low permeability

  -- Cohesive & Adhesive strength to withstand stress

  -- Good mechanical properties and chemical resistance

REASONS FOR COATING FAILURE

- **IMPROPER DESIGN**
  - -- Product formulation & system design
  - -- Selection of improper coating systems
- **POOR SURFACE PREPARATION**
- **APPLICATION RELATED FAILURES**
- **STRESS RELATED FAILURES**
- **ENVIRONMENTAL EFFECTS**
  - – Microbial Growth

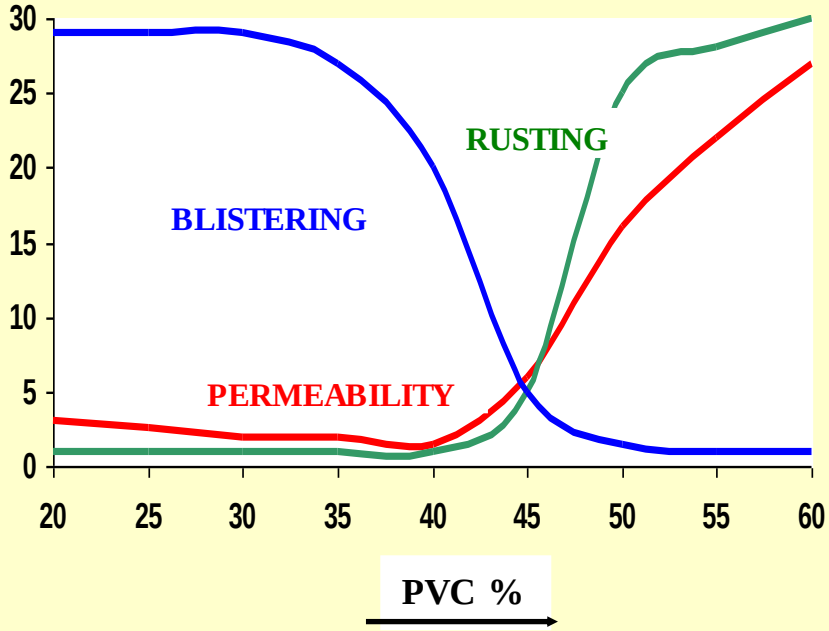
FAULTY DESIGN

PERMEABILITY

- P(pigment) : B(binder) ratio, %PVC,
- Type of pigment
- Cross-link density
- DFT

Properties of coating varies with PVC (Pigment Volume concentration)

$$PVC = \frac{(VOL\ OF\ PIGMENT) * 100}{(VOL\ OF\ PIGMENT + VOL\ OF\ BINDER)}$$



PERMEABILITY

- Influenced by
  - **CPVC- CRTICIAL PIGMENT VOLUME CONCENTRATION (FORMULATION)**
    - ***Permeability increases above CPVC & vice versa***
  - **DRY FILM THICKNESS**
    - ***Permeability reduces as film thickness increases***
  - **CROSS LINK DENSITY**
    - ***Thermoset coatings have high cross-linking & lower permeability***

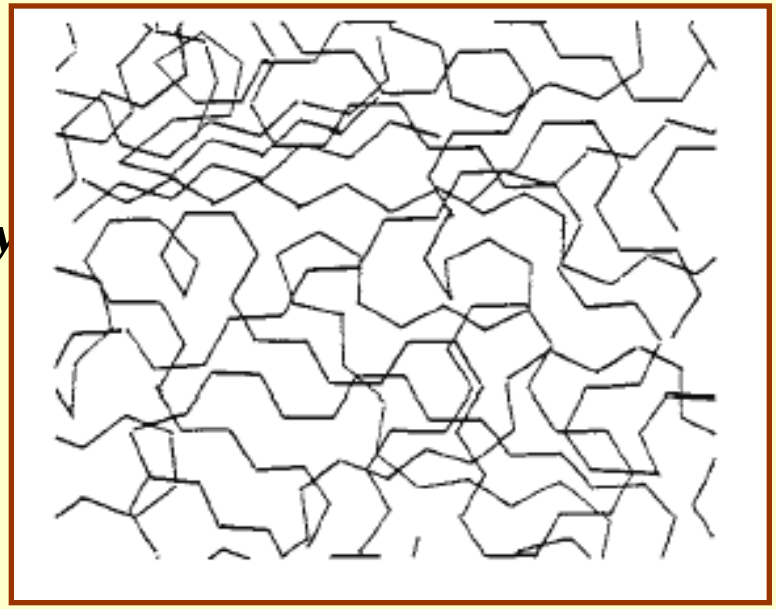
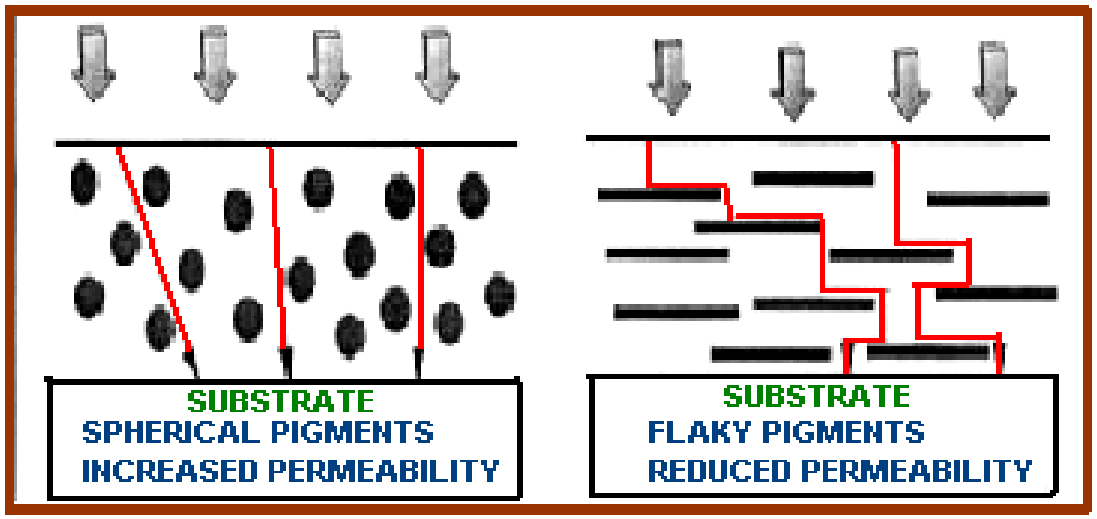


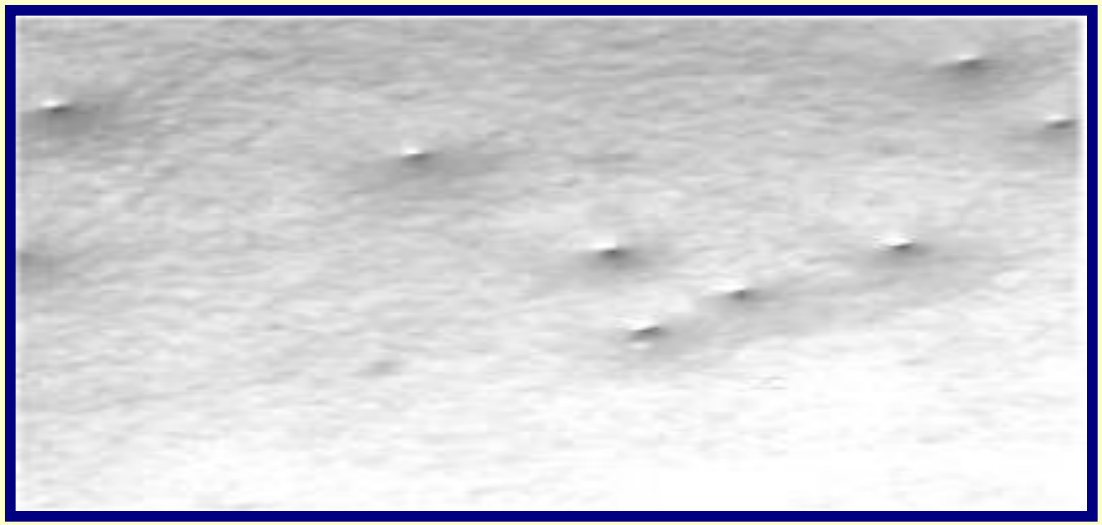
FIG : CROSSLINKED NETWORK POLYMER

PERMEABILITY



PLATY PIGMENTS REDUCE PERMEABILITY

Glass-flake , mica, aluminium flake,



PINHOLES

FILM DEFECTS INCREASE PERMEABILITY

Example- Pinholes increases permeability

FAULTY DESIGN

IMPROPER COATING SELECTION

Alkyd T/C over IZS coating

FAILURE OF WRONGLY SPECIFIED TOP COAT APPLIED OVER INTACT SHOP PRIMER

FAULTY DESIGN

USAGE OF INCOMPATIBLE COATING SYSTEMS

COATING SYSTEM FAILURE DUE TO INCOMPATIBILTY BETWEEN TOP AND BOTTOM COATS

POOR SURFACE PREPARATION

- **75% failures attributed to faulty surface preparation.**
- **Service life of coating system is enhanced by 50-100% between manual vis-à-vis blast cleaned steel.**
- **Coating fails miserably if there is underneath mill scale, rust, soluble salts, oils & greases.**
- **Surface contaminants**
  - ***Impairs wetting***
  - ***Affects adhesion***
  - ***Promotes blisters / rusting***
  - ***Causes delamination***

Adhesion Failure

Adhesion Failure

Causes :

Surface contamination or condensation

Remedies :

-- Ensure that the surface is clean, dry and free from any contamination and that the surface has been suitably prepared.

-- Use the correct coating specification.

ADHESION FAILURES

Bittiness


defects reference guide
back
Bitty surface foreign contamination on surface of film

Bittiness

Causes

The main cause is contamination within or on the surface of the paint film. This can be paint skin, gelled particles, airborne sand and grit or contamination from brushes, rollers etc.

Remedies

Use clean application equipment and clean working environment. Use new, uncontaminated paint. Follow good painting practices.

Bleaching

Bleaching

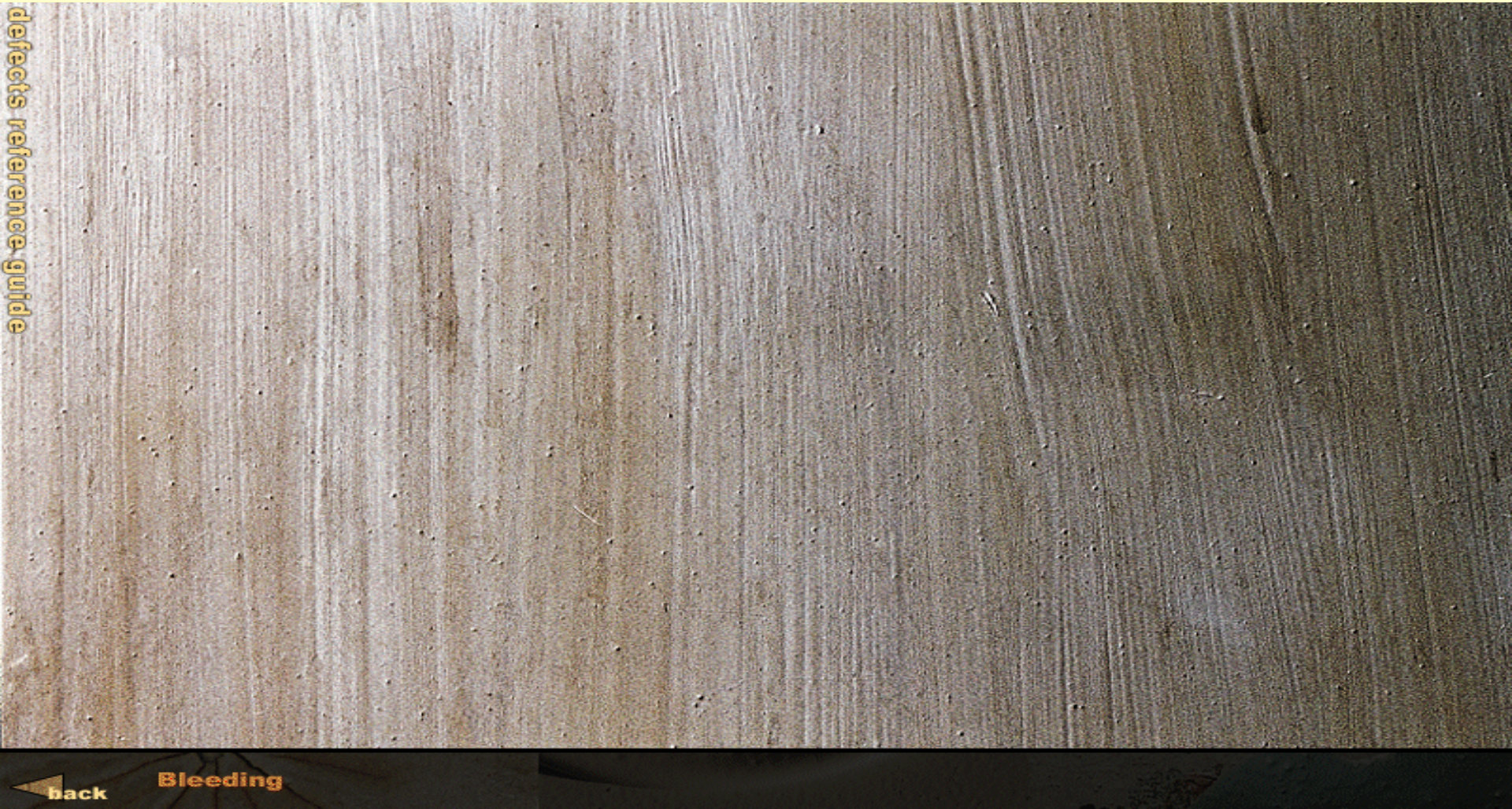
Causes :

Bleaching due to weathering or chemical attack.

Remedies :

Use colour stable pigments or a system which will withstand the chemical environment.

Bleeding



Bleeding

Causes :

'Bleed Through' is generally a full or partial redissolving of the previous coat. Bleeding can happen when strong solvents are used in the topcoats.

Remedies :

Use correct coating specification and materials. Use compatible materials. Use appropriate sealer coat.

Blistering


defects reference guide
back
Blistering virtually intact minute blisters to wood surfaces (moisture)

Blistering

Causes :

Localised loss of adhesion caused by

contamination with grease, oil, salts,

rust, trapped moisture, retained solvent, hydrogen vapour pressure (on coatings used with cathodic protection), etc. Osmotic blistering can also occur in immersed conditions.

Remedies :

Ensure correct surface preparation and application. Apply a suitable coating system.

BLISTERING


BLISTERING


ENTRAPPED SOLVENTS


OSMOTIC BLISTERING
BALLAST TANK


HYDROGEN EVOLUTION
(CATHODIC
PROTECTION)

Brush Marks


defects reference guide
back
Poor opacity incorrect paint grade, brush applied

Brush Marks

Causes :

Viscosity of material may be too high for brush application; Incorrect thinners used in the paint; Inadequate mixing or poor application technique. Two-pack paints may have exceeded application pot-life.

Remedies :

Use brushing grade of paint and apply adequate thickness. Thin paint to brushing viscosity. Use within pot-life

Bubbling

Bubbling

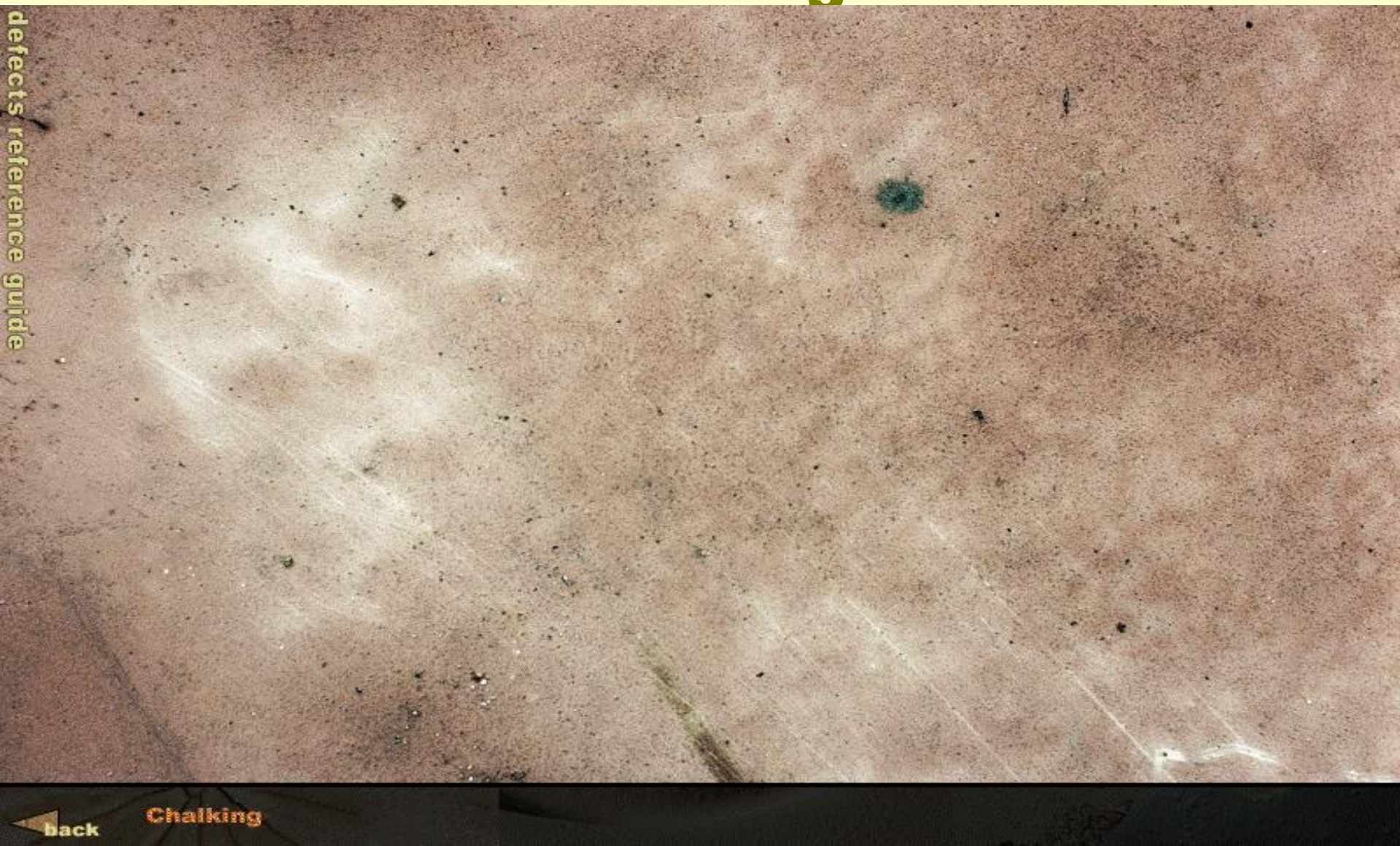
Causes :

Trapped air/solvent within the coating which is not released before the surface dries. Can be found with factory applied coatings where application is by dipping, electrodeposition

Remedies :

Spray application - use airless spray equipment, reduce viscosity with thinners. Use correct mixing equipment to ensure air is not stirred in during mixing. Add defoaming agent to emulsion paints.

Chalking



Chalking

Causes :

Disintegration of the paint binder on exposure to weathering and/or UV light.

Remedies :

Apply a topcoat with high resistance to chalking, such as a polyurethane of acrylic.

Checking


defects reference guide
back
Checking exposing underlining coats

Checking

Causes :

Typically a formulation and/or a specification problem. As with cracking, stresses are developed which cause the surface of the paint film to become brittle and crack. Limited paint flexibility.

Remedies :

Use a correctly formulated coating system

Cheesiness

Cheesiness

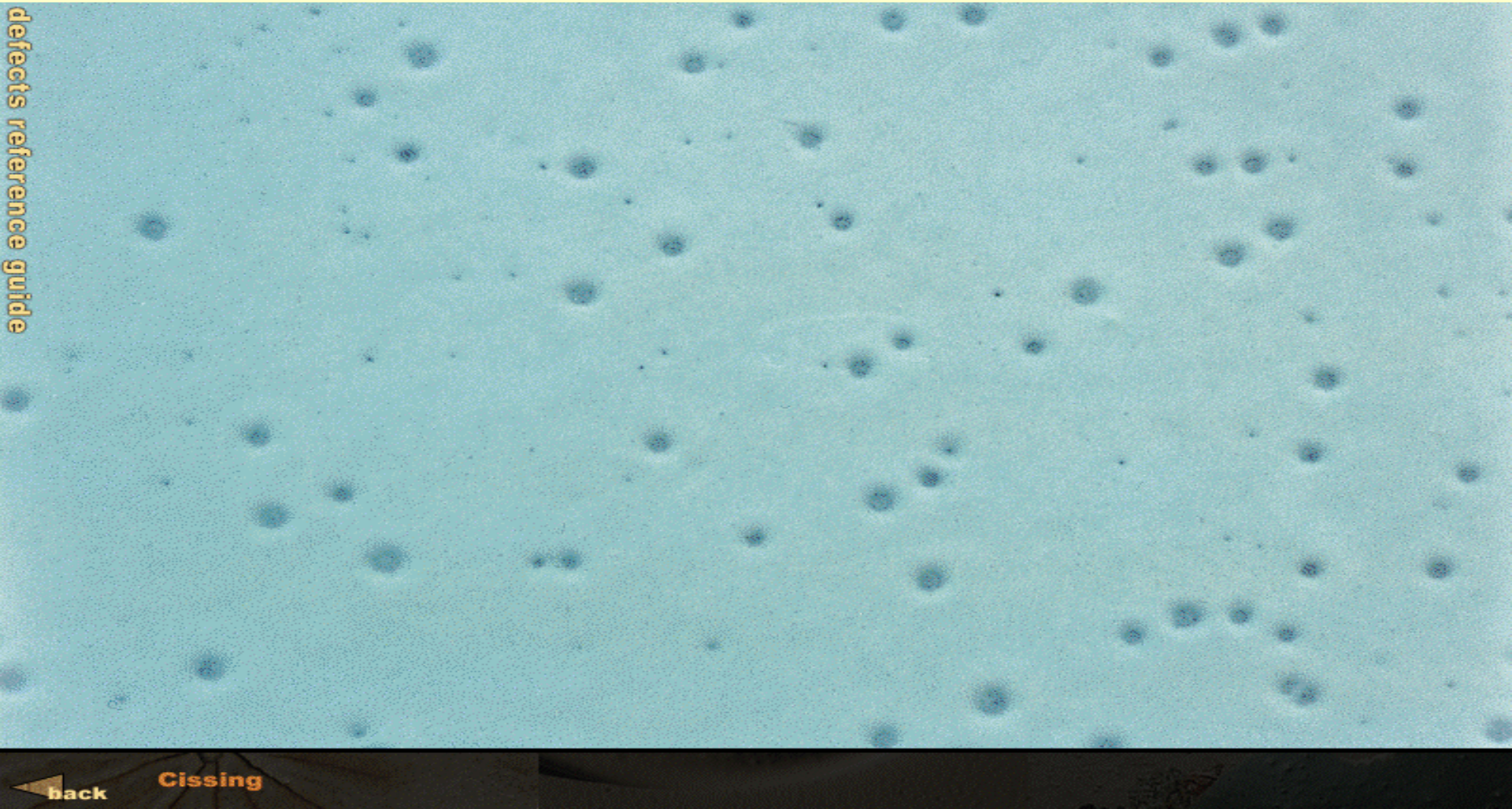
Causes :

Wrong mixing ratio for two-pack paints. Too low a drying/curing temperature. Excessive solvent retained within the coating.

Remedies :

Ensure adequate mixing of two-pack paints. Only use the recommended amount of thinners. Apply and cure the coating under controlled environmental conditions.

Cissing



Cissing

Causes :

Surface contamination by either moisture or foreign matter such as oil, grease, silicone etc. Also known to happen when incorrect solvent blends have been used.

Remedies :

Ensure surface is clean and free from grease, oil and foreign contaminates prior to application of coating.

Cracking

Cracking

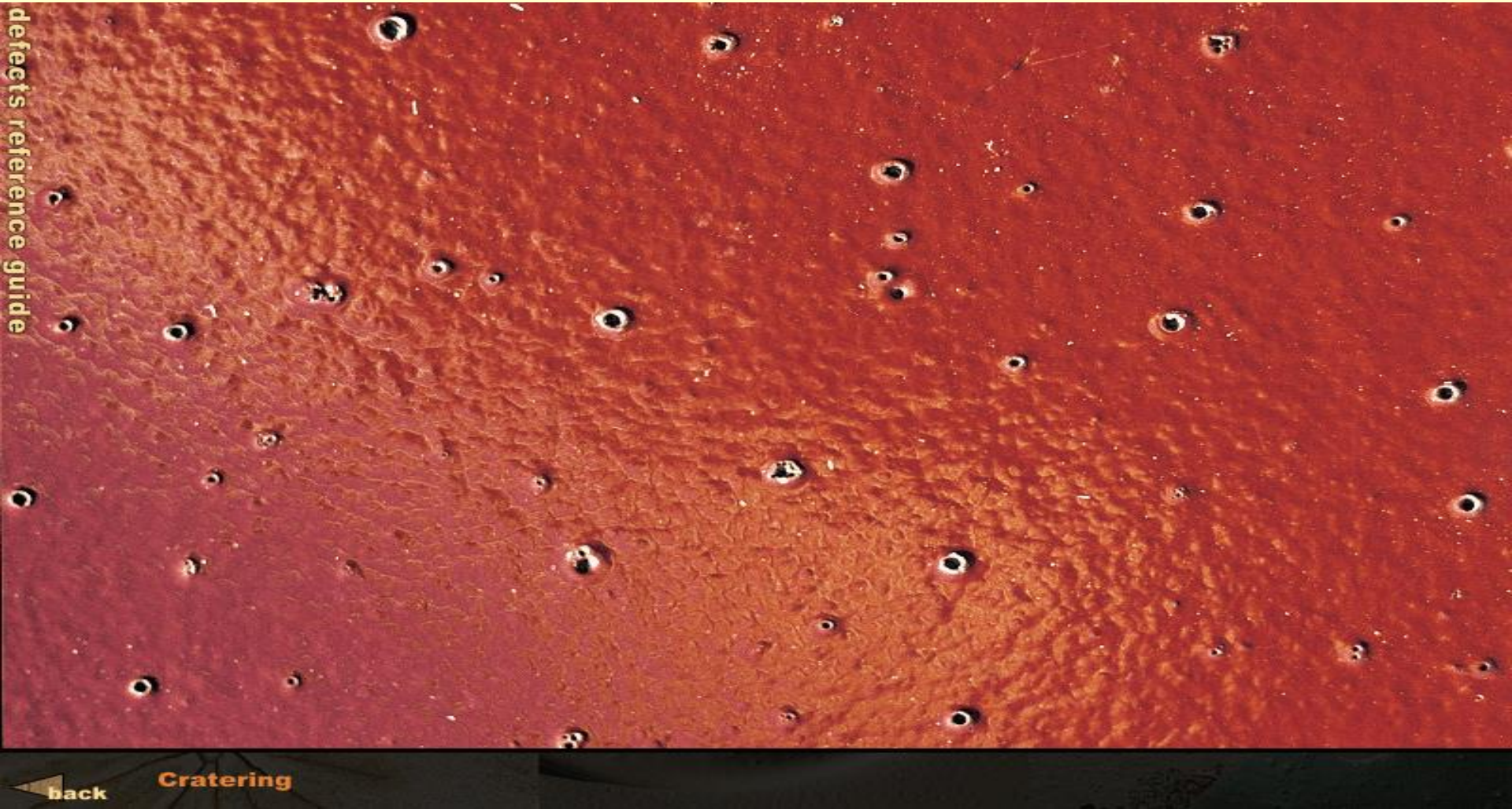
Causes :

Cracking is generally a stress related failure and can be attributed to surface movement, ageing, absorption and desorption of moisture and general lack of flexibility of the coating. The thicker the paint film the greater the possibility it will cracks.

Remedies :

Use correct coating systems, application techniques and dry film thicknesses. Alternatively, use a more flexible coating system.

Cratering



Cratering

Causes :

Trapped air bubbles which have burst to leave small craters as the coating dries. The coating has insufficient time to flow into a uniform film.

Remedies :

Improve spray technique to avoid air entrainment. Add thinners as recommended by the paint supplier.

Delamination

Delamination

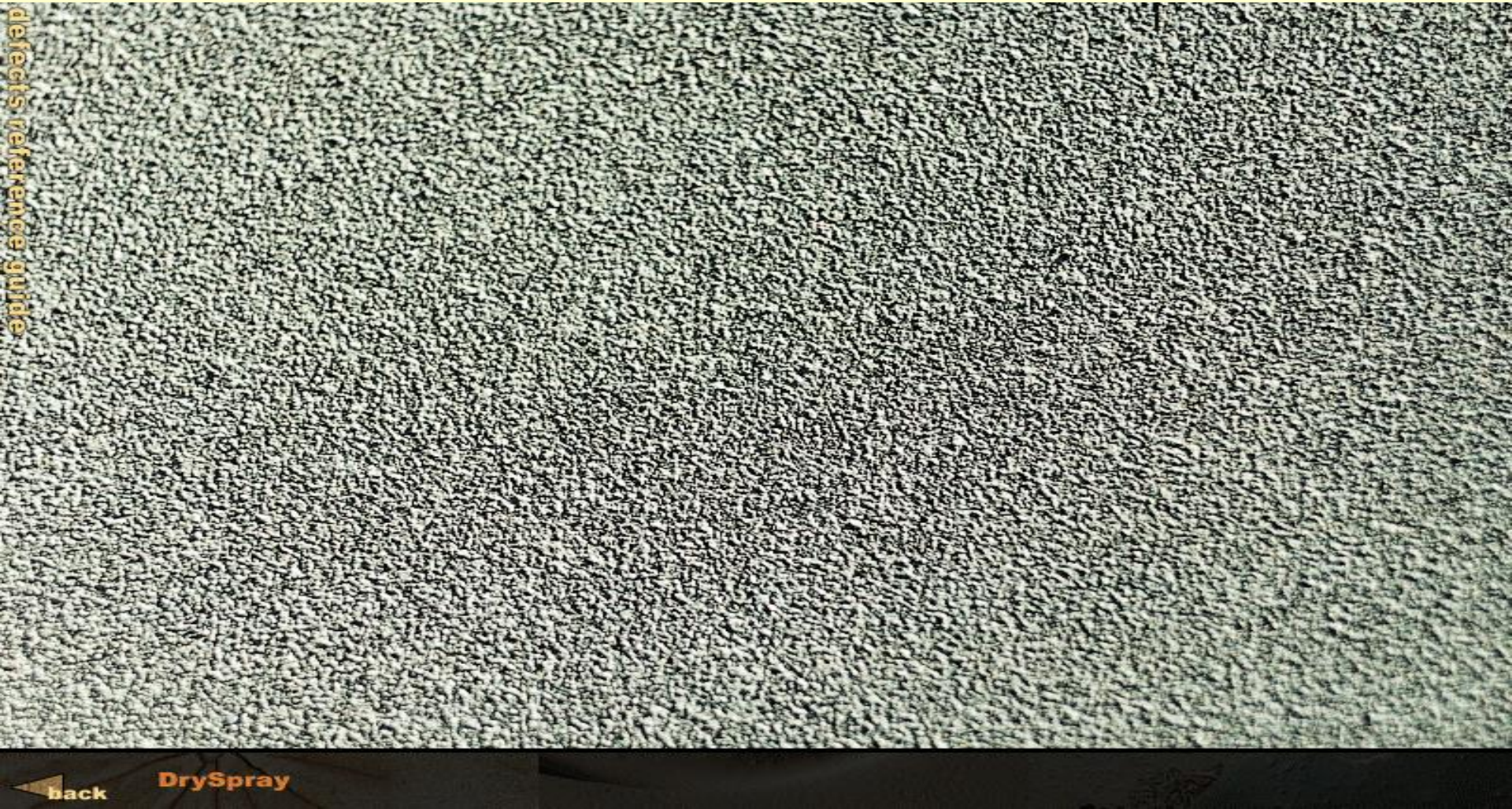
Causes :

Provided compatible paint materials have been used, delamination defects are generally related to poor surface preparation and application defects, such as contamination between coats; exceeding overcoat times; application to a glossy surface.

Remedies :

no contamination between paint coats, closely follow intercoat times, lightly abrade and clean glossy surfaces between coats.

Dry Spray



Dry Spray

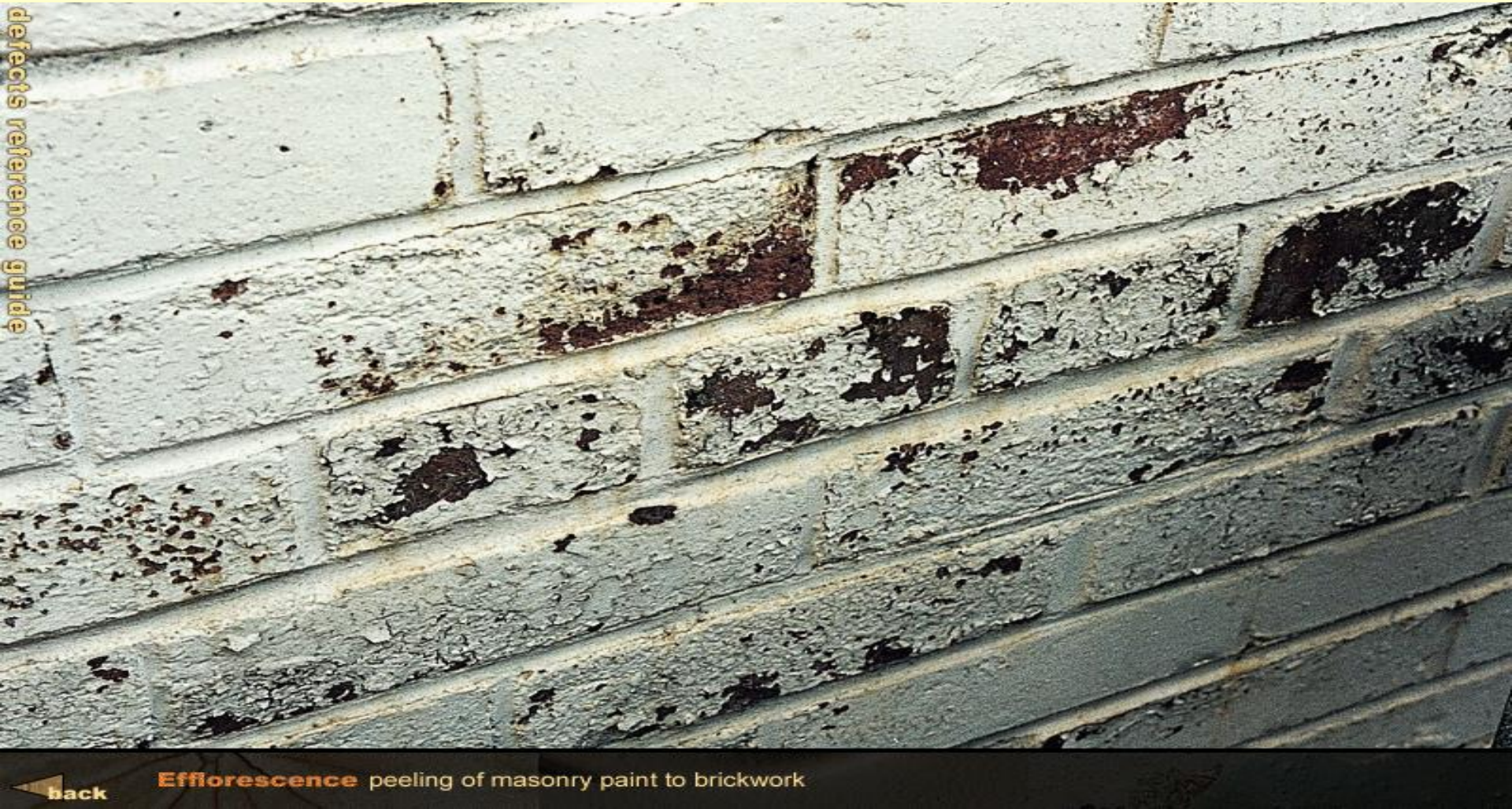
Causes :

Incorrect spray application i.e. gun distance. Also associated with fast drying products and too high an application temperature.

Remedies :

Use correct coating application equipment and techniques. Use a slower drying solvent or solvent blend. Follow recommended application procedures.

Efflorescence



Efflorescence

Causes :

Soluble salts within the substrate. Moisture brings the salts to the surface of the substrate resulting in coating adhesion failure.

Remedies :

Ensure surface is moisture free, clean and suitable for application of the coating system. Remove or eliminate the source of moisture

Holidays


defects reference guide
back
Pinholes pinholes in final coat exposing penultimate coat

Holidays

Causes :

Poor application techniques. Lack of quality control.

Remedies :

Use correct application techniques. Apply good painting practices. Use inspection.

Mud Cracking

Mud Cracking

Causes :

Generally over application of heavily pigmented primers such as inorganic zinc silicates or water based coatings, although can occur with other over thick systems.

Remedies :

Only apply the recommended coating thickness. Use recommended application techniques with suitably formulated products.

Orange Peel

Orange Peel

Causes :

Failure of the paint film to flow out. Usually caused by poor application techniques or by incorrect solvent blend

Remedies :

Use correct application techniques with suitably formulated products

Rippled Coating

Rippled Coating

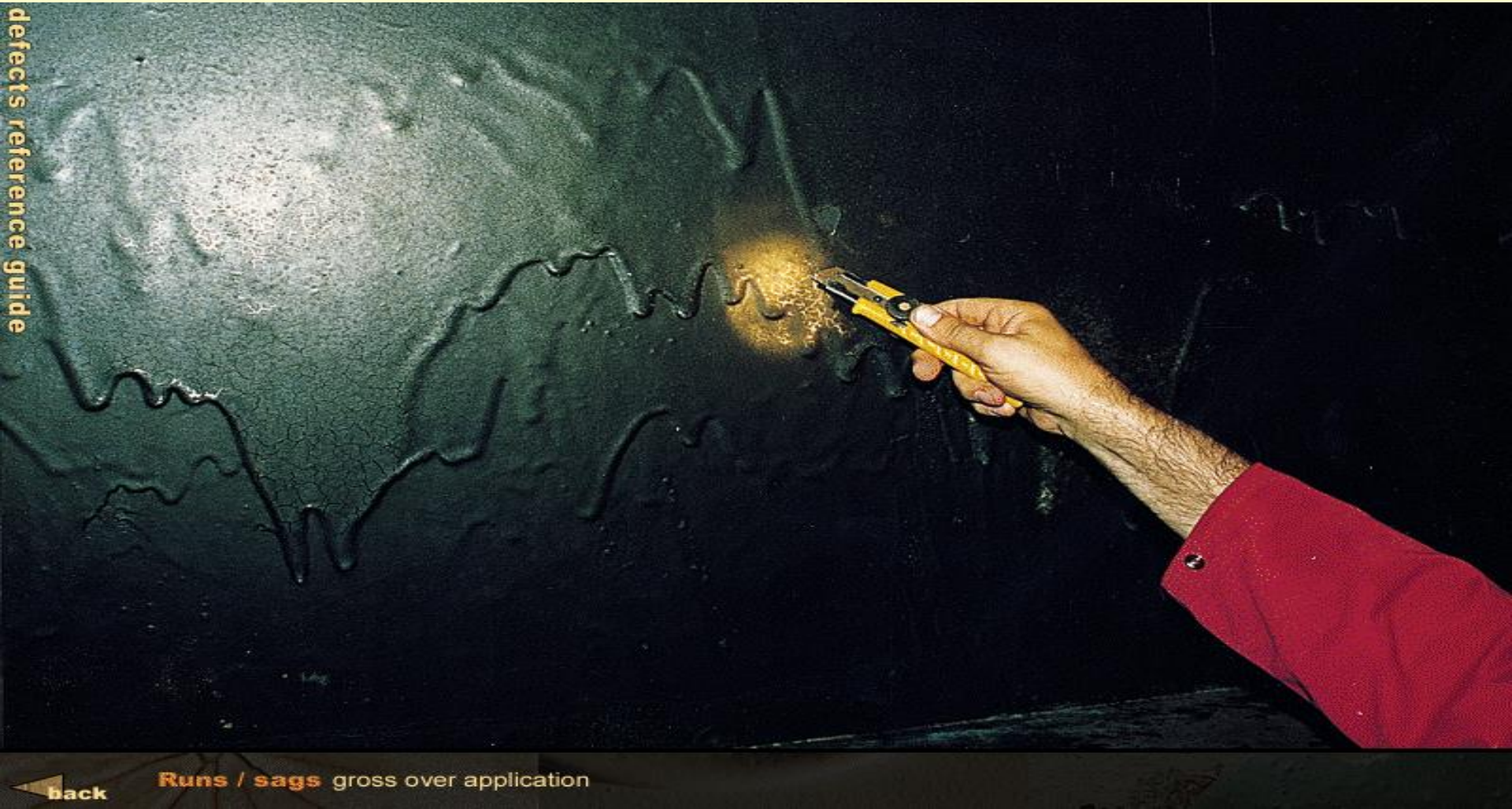
Causes :

Strong wind blowing across the surface of wet paint causes it to ripple. Where this is on the underside, the ripples can hang down in the form of small stalactites

Remedies :

Do not apply paint under unfavourable conditions.

Sagging


defects reference guide
back
Runs / sags gross over application

Sagging

Causes :

Over application of paint, excessive thinners, wrong (lack) of curing agent or just poor workmanship. Could, in extreme circumstances, be a formulation problem.

Remedies :

Use correct application techniques with suitably formulated products.

Rust Spotting

Rust Spotting

Causes :

Low film thickness, voids and holidays, also defects in the steel i.e. laminations. Too high a surface profile may cause penetration of peaks through a paint film and cause rust spotting. May also occur from metallic contamination of a coated surface by grinding dust etc.

Remedies :

Apply an adequate primer coat. Ensure coating system adequately covers the surface profile. Use a thicker coating system or a lower blast profile. Protection coating from contamination with grinding dust etc.

Settling

Settling

Causes :

Old stock, heavily pigmented paint, wrong formulation or contamination of product. Can be a problem with zinc rich primers

Remedies :

Use products within shelf life. Use adequate mixing procedures. Keep paint mixed or recirculated during spray application

Solvent Popping

Solvent Popping

Causes :

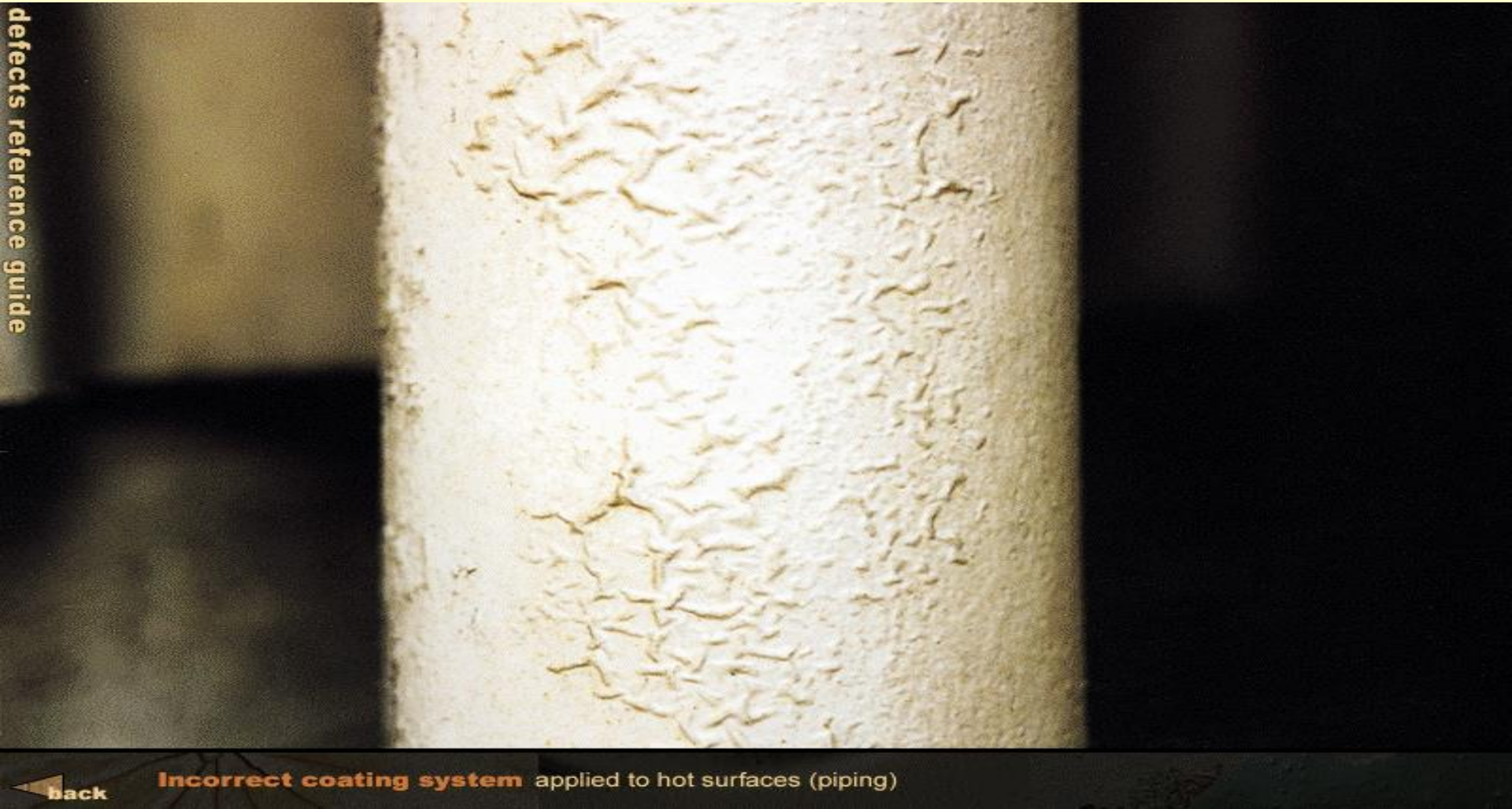
Incorrect solvent blends, porous surfaces and wrong environmental conditions

Remedies :

-- User correct coating specifications and materials. Correct application techniques and environmental conditions.

-- Repair lightly abrade and clean the surface and apply undercoat/topcoat.

Wrinkling


defects reference guide
back
Incorrect coating system applied to hot surfaces (piping)

Wrinkling

Causes :

Usually due to the initial formation of a surface skin with solvent based paints. Also swelling of the coating from solvent attack. Can arise from overcoating before the previous coat has adequately hardened.

Remedies :

Use correct coating specification and materials.
Adequate mixing, application and curing of materials.
Follow the paint suppliers recommended overcoating times

Zinc Carbonates

Zinc Carbonates

Causes :

White rust or carbonates on the surface of galvanising prior to application of the paint coating. Corrosion of zinc under the paint surface. Can be similar to rash rusting but white in colour.

Remedies :

Seal zinc coating from the environment and application of an appropriate protective coating system.

CORROSION

Possible Causes	Maintenance Correction
Salt contamination	Check and if still present, wash with fresh water
Pinholes, porous film or damages	Feather off edges of damages
Mill scale or remnants of rust	Abrade or blast clean mill scaled or rusty areas
Grit inclusions	Remove by chipping or abrading

CORROSION

Contd

Possible Causes	Maintenance Correction
Pittings	Investigate the cause. Pittings should be grinded and filled. It is impossible to coat pittings totally by spray application and sometimes even not by brush
Too low dry film thickness	Upgrade DFT of maintenance system
Aggressive chemicals / solvents	Stop splash and spillage or change paint system

DETACHMENT

Possible Causes	Maintenance Correction
Intercoat contamination within latest applied system or over coating times too long	Check and remove defective paint
Incompatibility of paint coats within latest applied system or with old system eg exudation	• Check specification. • Change paint system.
Attack by aggressive solvents to old system (swelling)	• Change paint system. • Remove all paint

DETACHMENT

Contd

Possible Causes	**Maintenance Correction**
Internal stresses leading to detachment from bare steel. Too thick coat or quick temperature change see also cause blisters	• Check DFT of total system. • Remove all paint
Detachment from bare steel initiated by cracks and moisture	• Check the extend of under creep. • Remove defective paint.

BLISTERS

Possible Causes	Maintenance Correction
Soluble salts present under or in between the paint coats	Check and if still present wash with fresh water
Cathodic over protection	Adjust CP and / or change paint system
Contamination or grease present under or between coats	Thorough degreasing before painting
Trapped moisture due to painting over damp substrate	Application on dry substrate

BLISTERS

Contd

Possible Causes	Maintenance Correction
Permeation with chemicals, solvents and water (condensation)	Take preventive measures or change paint system
Solvent trap in case of thick film application	Allow thorough drying in between coats
Too short overcoating time or application at too low temperature	The conditions during maintenance should be improved

CHECKING -CRACKING

Possible Causes	Maintenance Correction
Hard coating on top of a soft coating. (checking) Sometimes caused by a too short overcoating interval or by the application of a too high film thickness	• Check if still soft material is present underneath. • Abrade checked paint completely. • Adjust paint system.
Hard coating on top of a soft old coating (cracking)	• Check if still soft material is present underneath. • Abrade cracked paint completely. • Adjust paint system.

THANK YOU