POLITECNICO DI MILANO
Department of Architecture, Built Environment and Construction Engineering
School of Architecture Urban Planning Construction Engineering

THE BUILDING'S MAINTENANCE: SERVICE LIFE PLANNING OF BUILDINGS

- Maintainability requirements
- Maintenance strategies
- Maintenance planning

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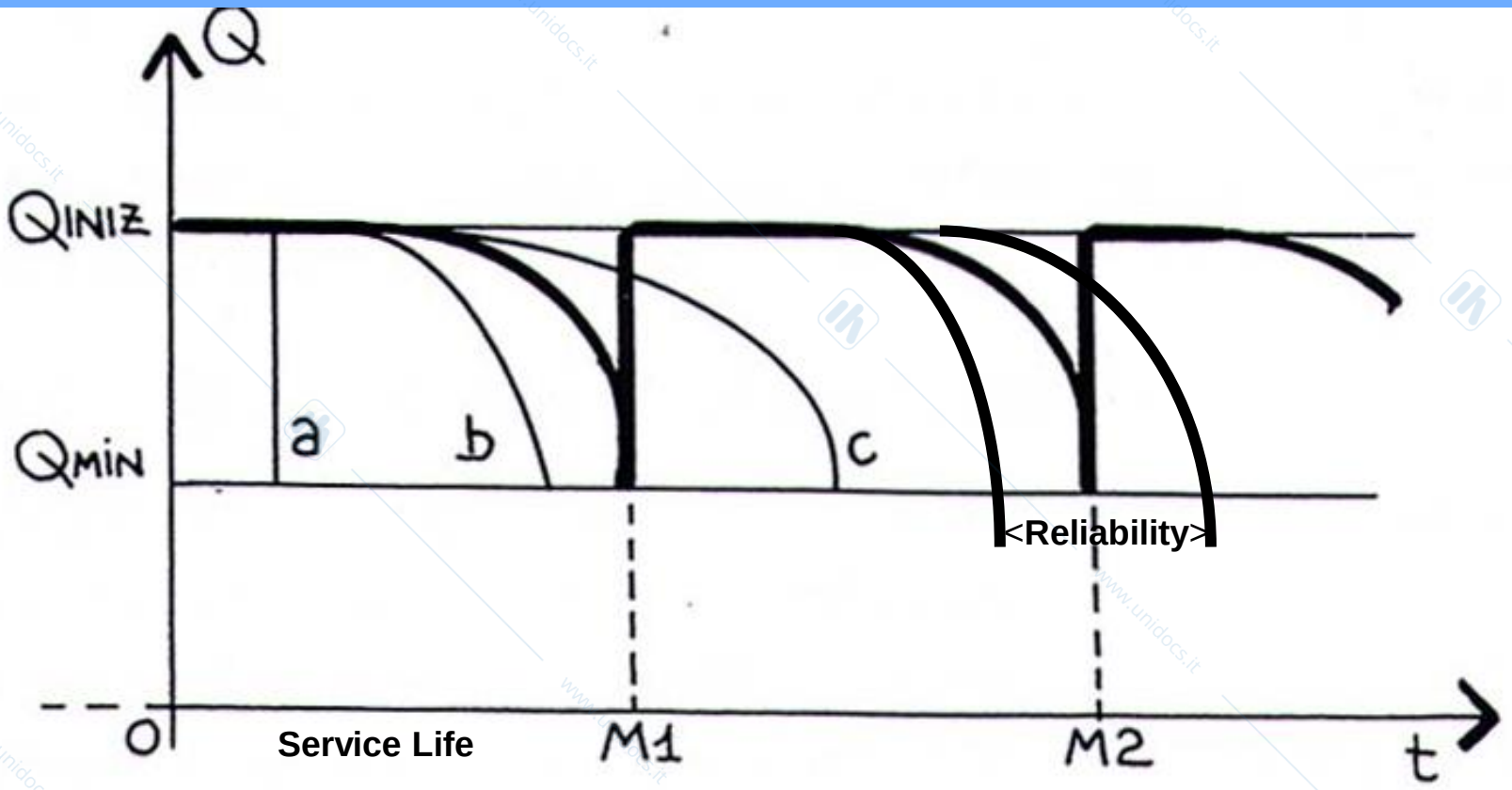
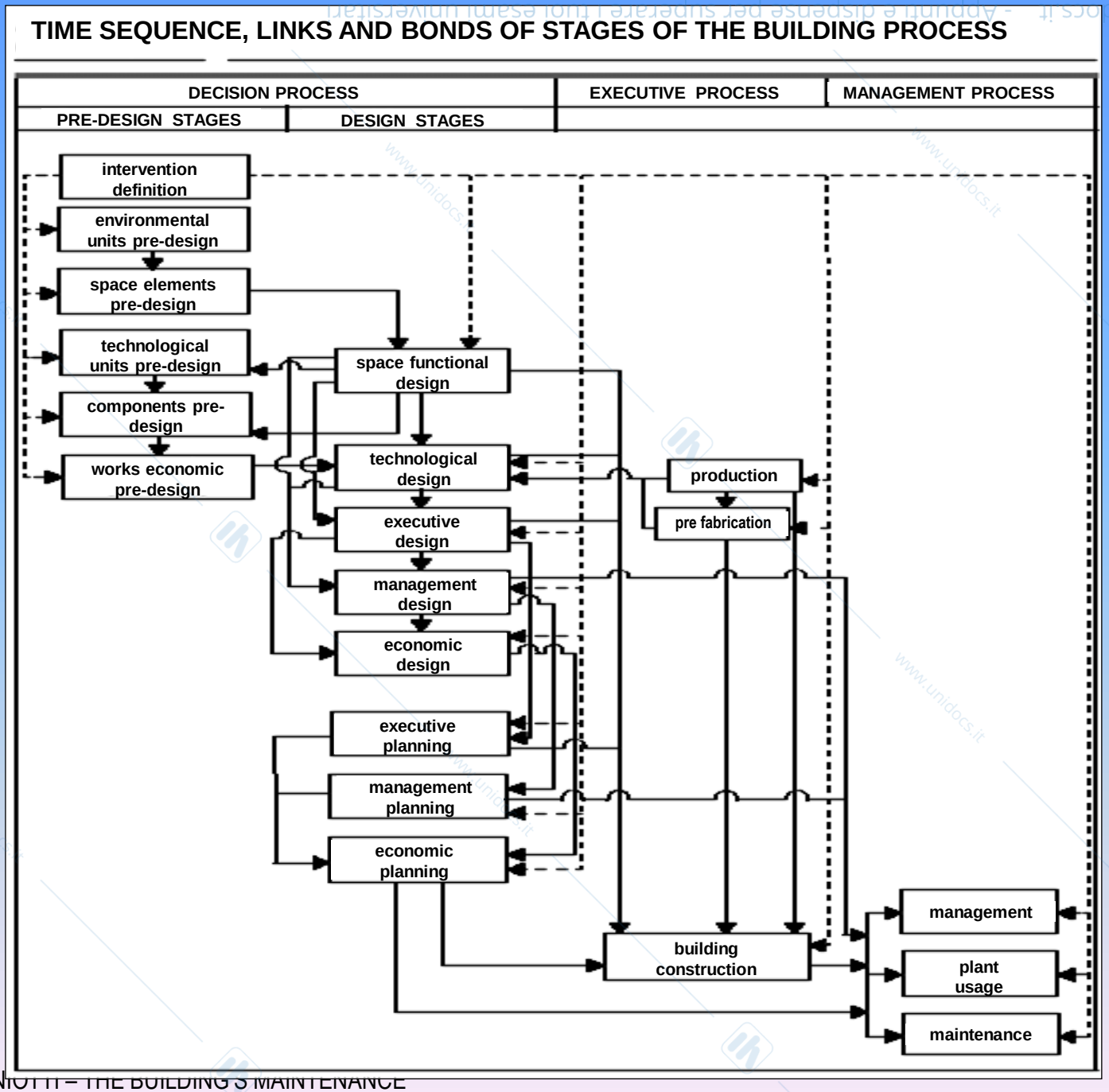
Service Life Planning.
Quality as a function of performance over time.



M1, M2: maintenance work
a, b: accidental pathological failures

TIME SEQUENCE, LINKS AND BONDS OF STAGES OF THE BUILDING PROCESS



Technological quality aspects

Technological quality aspects	reference technological requirements
Q_c= characteristic technological quality performance quality at time 0, out of system and context	behaviour technological requirements specific for a class of technical elements
Q_u= useful technological quality product aptitude to maintain initial characteristic technological performance levels Q_c	Durability: reliability, service life
Q_m= maintenance technological quality product aptitude to obtain specific levels of maintenance	controllability, aptitude to cleaning, reparability, aptitude to substitution; parameters: availability, mean time of reparation
Q_o= operative technological quality product aptitude to obtain specific levels of economy and operability in the construction phase	economy of product, economy of necessary machinery economy of necessary workmanship economy of necessary controls economy of production

METHODOLOGY FOR BUILDINGS COMPONENTS SERVICE LIFE EVALUATION

1. The methodology for buildings components experimental reference service life measurement
2. Methods to evaluate estimated service life in design conditions
   - FACTORIAL METHOD
   - ENGINEERING METHODS
   - STATISTICAL METHODS

The evaluation of building component's reliability propensity

The building component's reliability propensity is evaluated through four aspects:

Functional reliability.

Balance degree in the distribution of the analytical functions in the functional elements of the component estimating through the observation of the functional model of the component. It's an index of the stress to which the component will be subjected in its practice phase.

Executive reliability.

Degree of foreseeable conformity of the component execution at the intentions of the project. It's an index of the foreseeable precision in the installation of the component.

Inherent reliability.

Degree of evenness of dimensional changes between the functional elements of the component throughout its performance in comparison with the stress context. It's an index of functional integrity of the component in its practice phase.

Critical reliability.

Degree of chemical-physical compatibility which characterizes the different materials making up the functional elements of a component. It's an index of structural integrity of the component.

FAILURE

The end of the entity's capacity to develop the requested function

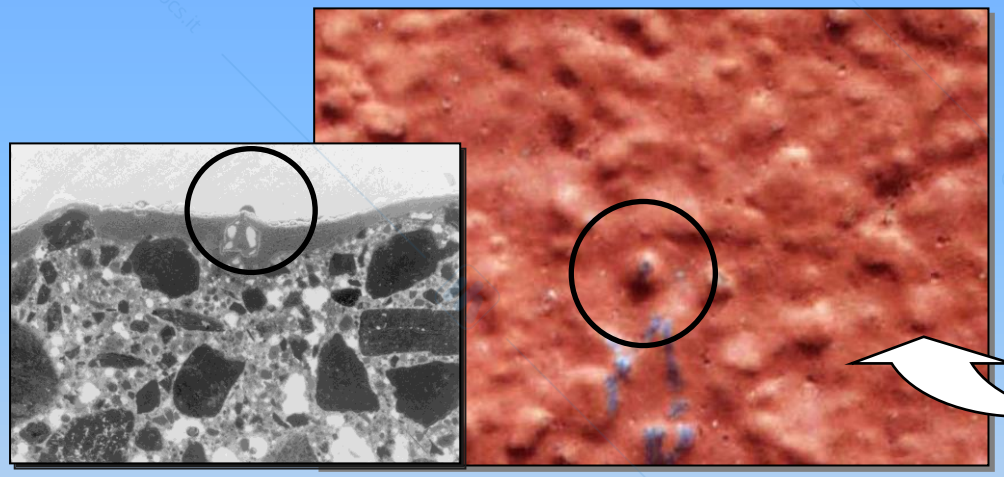
(ref.: EN 13306.2003. Maintenance. Terminology.)

- **Durability failure** is the one which is produced by the usual degradation phenomena given by the agents' action and linked to reaching of the foreseeable service life end.
- **Pathological failure** is the failure produced by defects caused by **mistakes of design, execution or management** and it comes before the foreseeable service life end.

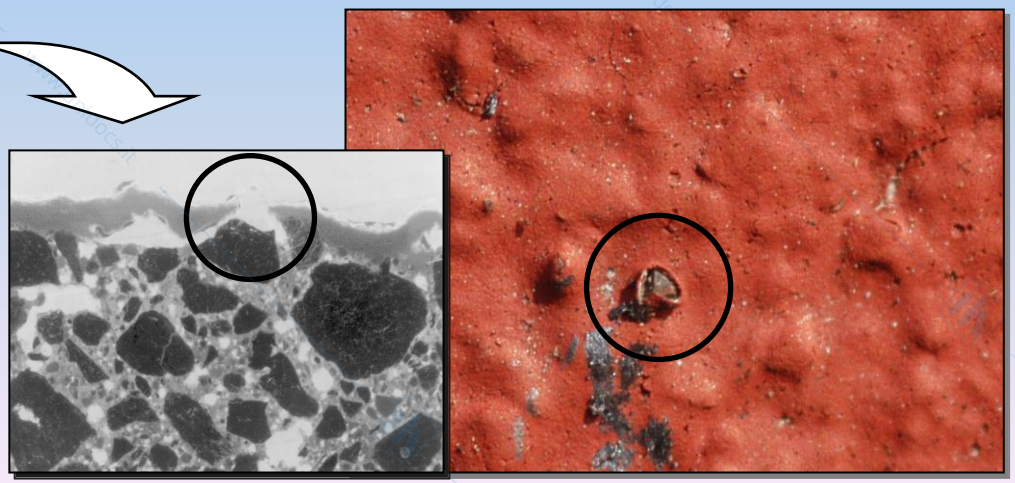
Degradation : progressive decay of the physical integrity (alteration) and/or of the performance efficiency (performance decay) of a building component.

- **Durability Degradation** is the one which is produced by the usual degradation phenomena given by the agents' action and linked to reaching of the foreseeable service life end.
- **Pathological Degradation** is the one produced by defects caused by mistakes of design, execution or management and it comes before the foreseeable service life end.

COMPARISON BETWEEN LABORATORY AND OUTDOOR AGING DEGRADATIONS



Comparison between VH lab samples (**75 cycles**) and VH45 after **2 years** of natural aging**:** begins the blistering



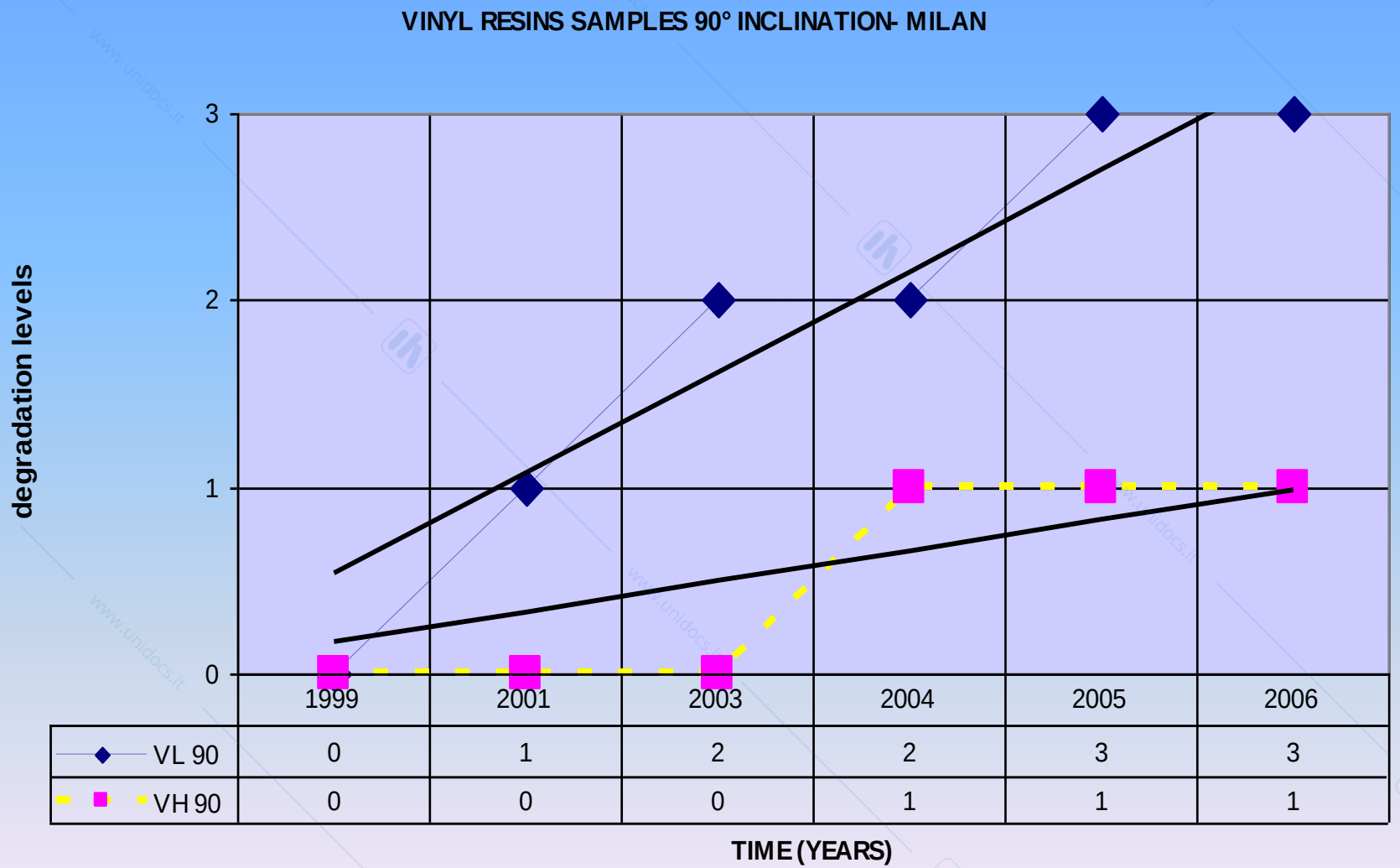
Comparison between VH lab samples (**150 cycles**) and VH45 after **4 years** of natural aging: cracks and detachments of the protective film appear

CLASSIFICATION of DEGRADATION LEVELS EXTERNAL WALLS PAINTINGS AND FINISHINGS SAMPLES EXPOSED TO OUTDOOR NATURAL AGEING

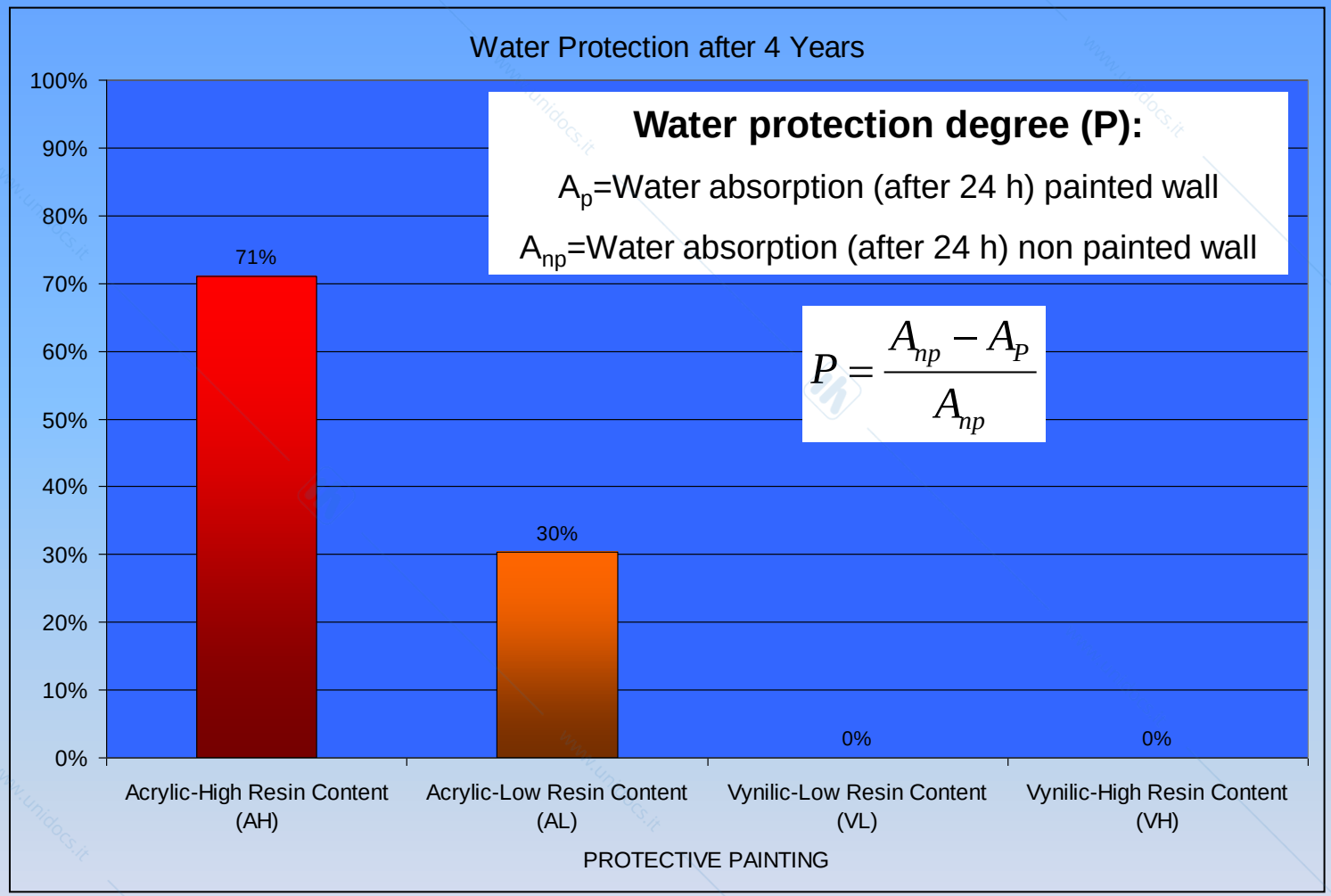
- ✓ DL0: No relevant degradation
- ✓ DL1: Localized degradations (cracks, blisters, etc.)
- ✓ DL2: Close net of micro-cracks
- ✓ DL3: Diffuse presence of broken blisters, lacerated bumps, detachments and surface salt crystallization

SAMPLE	45°	90°
AH	DL1	DL0
AL	DL1	DL1
VH	DL1	DL1
VL	DL3	DL2

Analisis of degradation levels during time



Performance evaluation of Water Protection Degree 4 years outdoor aging



Vynilic Paint: Reference Service Life = 4 years

MAINTAINABILITY REQUIREMENTS:

Maintainability : ability of a component or construction to be retained in a state in which it can perform its required functions or to be restored to such a state when a failure (fault) occurs

- **Checking requirement**: the technological subsystem and their components, in particular when they belong to an equipment or they have to be directly used by the consumers, must be easily checked and inspected to prevent damages and to make easier the necessary maintenance operations.
- **Cleanness requirement:** the components constituting the technological subsystems must be maintained in good cleanness conditions, through the management staff operation of the building, without special staff intervention.
- **Repairing requirement:** the components must allow the repairing of damaged or broken parts , within the ordinary maintenance and service life planning. The repairing operations can request disassembly or reassembly, and also the special staff intervention.
- **Replacement requirement:** the components must be easily replaced to increase the whole durability of the subsystems, within the extraordinary maintenance and the end of the foreseen service life. The replacement operations which need disassembly and reassembly don't have to cause any damages to the components and buildings

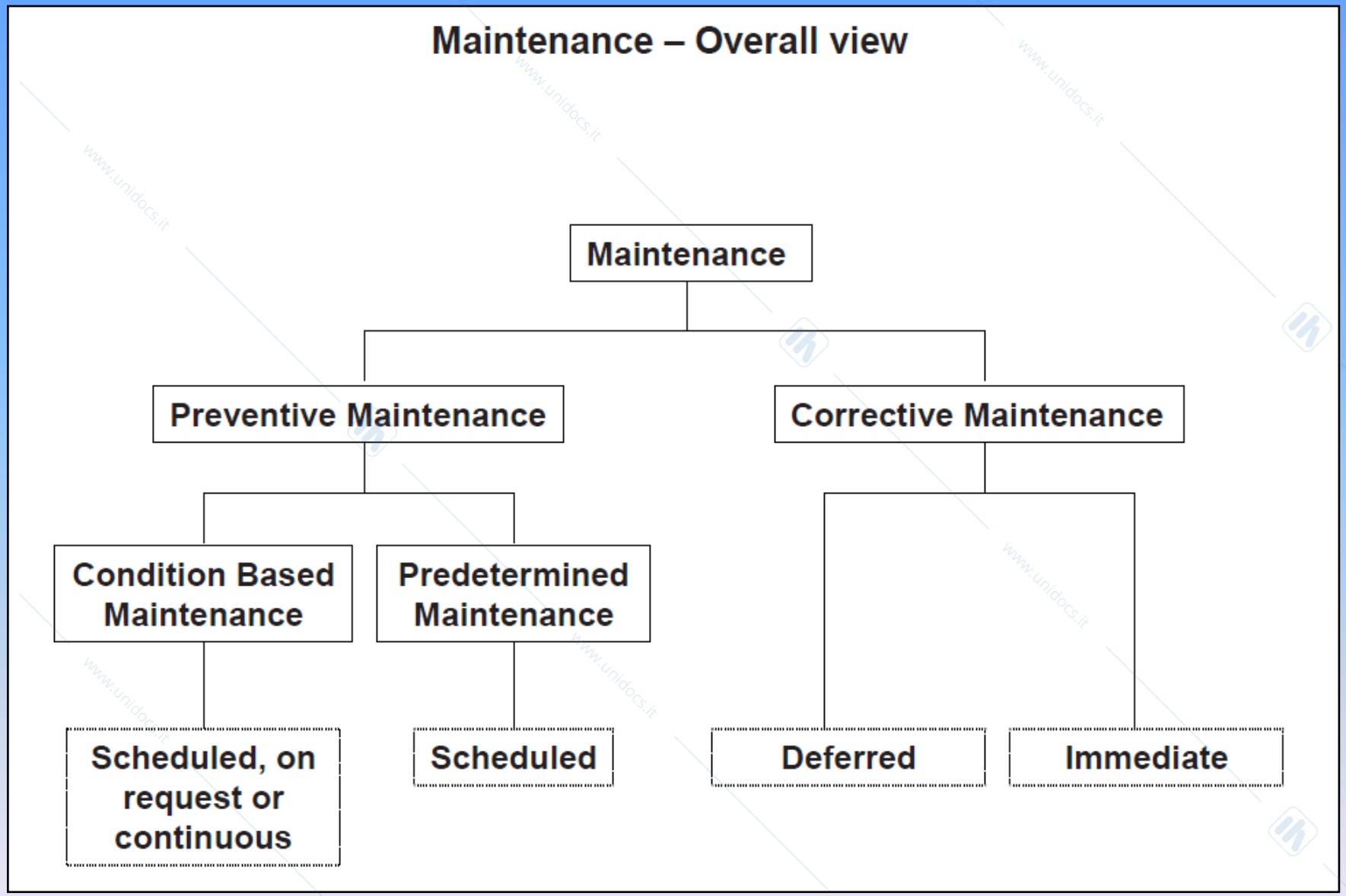
PARAMETERS FOR THE MAINTAINABILITY EVALUATION

- **Repair Mean Time** (TMDR): is the mean statistical value of the repair times distribution for the possible damages that the technical solution can meet during its service life.
- **Availability** (D): the component probability to perform its required functions within a time period during which the maintenance action is done in conformity with the foreseen procedures and the resources (maintenance plan).

$$D = \frac{TMBF}{TMBF + TMDR}$$

- **Mean Time of Good Functioning** (TMBF) equal to the Service Life

Maintenance – Overall view



The MANAGEMENT PLANNING can be executed with the following strategies, on the basis of durability and reliability data of the components and of the critical failures:

- Emergency maintenance: not programmed maintenance carried on after an unforeseeable failure, usually owing to a project or executive pathology.
- Maintenance after failure: programmed maintenance executed after a not critical foreseeable failure.
- Preventive maintenance , predetermined maintenance: planned maintenance executed at steady age or at steady time spaces (ex. painting) , fixed upon the knowledge of durability data (ex: man. Equipment parts) for critical failures (Es: waterproofing of the roof)
- Preventive maintenance, condition based: planned maintenance executed after the achievement of a limit condition, estimated with inspections based on diagnostic cards, with frequency which is due to the reliability, for critical failures (ex: structural parts)
- Opportunity maintenance: maintenance executed in advance compared with the maintenance planner because of a profitable moment, on the occasion of the maintenance operations about some building parts.

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