2. 2019 VERSION

Guidelines

Condition Assessment and Monitoring of Wall Paintings and Architectural Surfaces

BDA BUNDESDENKMALAMT

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Cover photo
Head detail of Christ, North wall, St. John Chapel in Pürgg (© Stefan Linsinger ZT – GmbH, Salzburg 2011).

2. Version dated 1st January 2019

Guidelines

Condition Assessment and Monitoring of Wall Paintings and Architectural Surfaces

Measuring the surface conductivity on the Romanesque wall paintings in the St. John's Chapel in Pürgg

Foreword

The idea of drawing up **guidelines** for the 'Condition Assessment and Monitoring of Wall Paintings and Architectural Surfaces' basically originated from reviewing and evaluating earlier restoration work. The term monitoring in connection with the conservation of monuments is usually understood as pertaining to unspecific, individual examinations or the taking of diverse measurements. It therefore seemed appropriate to develop apposite definitions and compile various individual methods into a coherent system. This system provides guidelines that should naturally not be rigid but instead be completed according to object and case specific content.

These guidelines are also intended not least to create an instrument with which the inspection of condition can be actively instigated instead of restoration or preservation activity invariably being reactive to some case incident or occurrence of damage. This project therefore aligns itself with the current objectives of preventive conservation and the concepts of care and maintenance. This is why preference has also been given to aiming at broad applicability over and above the latest practicable scientific differentiation.

The guidelines are intended to represent an orientation aid for conservators and to provide curators of monuments, architects and owners with useful information to define the steps expected and with them the costing and the stipulation of the scope of the commission as well.

Special attention was paid to ensure the guidelines are user-friendly, flexible and practical in application. In consequence, their structure is based on *steps* and *blocks*. Depending on the question, the problem posed by the object under investigation, the goals or the financial resources, the blocks from Step I or supplementally from Step II – singularly or all – should be consulted. The requirements described in the blocks are intended to lead to an even clearer basis for interdisciplinary collaboration between conservators and scientists, curators of monuments, architects and owners. Naturally the blocks do not just serve for the performance of monitoring alone but can also be referred to during the planning of conservation and restoration work. Unsurprisingly, they do not include every step relevant to the preparation of a conservation or restoration and, therefore, do not encompass the whole spectrum belonging to a preliminary examination prior to executing measures.

The guidelines in principle, therefore, do not represent rigid instructions for certain examinations on wall paintings and architectural surfaces (e.g. diagnostics). The application of individual methods of examination and measurement described here must as a rule be reassessed and discussed for each and every object by the respective conservators. The guidance sheets attached in the appendix were devised as models. The guidelines lay no claim to completeness or definitiveness and are, therefore, expressly qualified as a numbered version. They will be evaluated at regular intervals and in this context criticism and suggestions will be happily received.

Special thanks are due to Wolfgang Baatz, Bernd Euler-Rolle, Erich Mursch-Radlgruber, Beate Sipek, Katja Sterflinger-Gleixner and Johannes Weber, who have contributed to the development of these guidelines during numerous working sessions since December 2010.

This 2nd edition – 1 January, 2019 of the present document is based on an evaluation of current projects on 'Condition assessment and monitoring on medieval wall paintings' in Austria and the practical experience gained in these projects. The guidelines have proven to be user-friendly due to their flexibility in practical application and their two-fold systematic structure in 'steps' and 'blocks'.

The progressive development of science and technology demands a continuous update. Therefore any suggestions for a further revised edition (of this document) are most welcome and can be sent to the Department for Conservation and Restoration at the Federal Monuments Authority, Austria (arsenal@bda.gv.at).

Markus Santner
Vienna, January 2019

Contents

Introduction

The **aim of the guidelines** is to promote a unified approach to the investigation of condition and the documentation of wall paintings and architectural surfaces with the objective of optimally inspecting condition and ascertaining necessary conservation requirements. These guidelines distinguish between two forms of inspection: condition assessment and monitoring. Both forms follow the same goal in principal, namely

- to recognise and define a need for action, and
- to detect deterioration processes and their causes.

Both forms are closely related and build upon each other; they are thus styled Step I (condition assessment) and Step II (monitoring). In particular cases the same methods may well be employed.

The **conductors** of the condition assessment or monitoring are generally assumed to be conservators, who may be working in conjunction with scientists as the circumstances require. However, any necessary research the object demands is also to be performed by other project partners (owners, departmental staff from the Federal Office for the Protection of Monuments and the dioceses).

The **condition assessment** (Step I) aims at collecting relevant information about an object with regard to the existing stock and condition as an overview. The stock survey aims specifically at the material substance of the surface structure and the technique of execution. Sources of damage and risk are to be investigated in such a way that necessary urgent measures can be recognised and defined. Furthermore, the condition assessment should make it possible to draw comparisons with available earlier findings on the one hand while also allowing for comparative scrutiny in a broadly objective manner at a later point in time on the other. The condition assessment is primarily based on visual investigation and the use of simple handheld devices. In many cases a condition assessment requiring a relatively brief amount of time will be sufficient. For this reason it is defined as an independent step. However, if the significance or complexity of the case demands further inspection or monitoring, the condition assessment will already form the first block for monitoring anyway. In this event, it will potentially need to be extended and intensified.

Should serious defects or deterioration trends be discernible during the assessment, immediate **emergency consolidation** of the wall paintings are to be implemented. Such emergency consolidation measures, however, must only be carried out after a qualified restorative examination of the damage symptoms.

The **report** of the condition survey should be so compiled that the findings of Step I can also be used as a reference for later simple monitoring (followup checks). This way any later changes in the condition can be recognised more easily and accountably assigned. The report at the level of Step I will in many cases be a valid conclusion to the investigation. This will particularly be the case in the framework of systematic assessment programmes.

Monitoring (Step II) is based on the approach of systematically comparing phenomena and measurements which are observed and recorded at more or less regular intervals with references compiled in a baseline survey. This is intended to make processes recognisable which can be interrupted with suitable measures if necessary. The creation of references is an essential part of any monitoring programme. Therefore, objective and reproducible follow-up checks on the references are paramount. Only values are to be measured or phenomena documented that are judged replicable and to be relevant to preservation. Once these references have been determined, they will also be checked upon in the monitoring programme even if there is no immediate suspicion of change. Monitoring should be repeated at certain intervals (≤ 10 years).

Each step of the guidelines consists of **blocks** (work stages) that make up a matrix. It is a gridwork of criteria and parameters that are to be consulted and filled with content depending on the nature of the object. The guidelines' blocks provide an orientation aide that cannot be exhaustive and therefore should not be understand as multiple choice. Varying approaches can result, depending on the nature of the object and the phenomena of its condition. The case may arise that as early as Step I a block from Step II might be used. The blocks also intermesh of course.

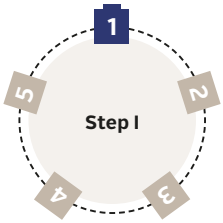
A crucial impetus for the creation of the guidelines was the desire to promote the active conservation care of stock. The intention is also to initiate a systematic programme of surveillance for wall paintings and architectural surfaces in certain regions from defined epochs or in particular categories. It goes without saying that the stages and methods described should also be applied to any conservation and restoration work that has already been planned. Individual blocks will be supplemented with example **guidance sheets** in the appendix.

The guidelines relate to the current status of technology and knowledge. There are a number of high-tech methods available for rare, isolated cases that are not treated in the guidelines. The guidelines must remain developable and are to be updated in each succeeding version. That is why the present document has been designated as the 2nd Version 2019 with the date of compilation. Any reference therefore requires mention of the version number. Sections of text in italics offer explanations, those in normal print make up the work stages.

Step I

Guidelines for the condition assessment

Stock survey (pre-survey)



BLOCK I — 1
Details about the building

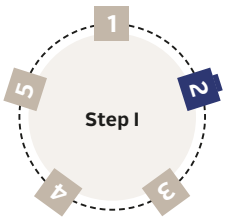
Factors that can be relevant for state of preservation of the wall paintings and architectural surfaces

I—1.1. Location (Building)
situation ▪ free standing ▪ sloping site ▪ summit ▪ depression ▪ surrounding tree population ▪ neighbouring emission source ▪ close heavy traffic etc.

I—1.2. Environment
adequate level connections or falls to drain rainwater ▪ sloping site water ▪ discharge of the downpipe ▪ extent and functionality of drainage system ▪ damp proof floor joints ▪ burden through snowfall ▪ extreme shade ▪ traffic ▪ spray water ▪ deicing salts in winter etc.

I—1.3. Exterior
intactness of the exterior render, the distemper or stone pointing ▪ recognisable damp proofing through the exterior rendering ▪ damp or salt lines and patches ▪ open wall-floor joints ▪ plinth damage (type and extent) ▪ wall cracks ▪ condition of the roof cladding and the roof drainage system ▪ vulnerable areas for damp at the building component connections, roof valleys, verges etc. ▪ functionality of guttering, hoppers and downpipes ▪ plant growth on wall etc.

I—1.4. Interior
condition of interior render and distemper ▪ damp proofing effect of base render or wall coverings ▪ damp or salt lines and patches ▪ damp or salt tide marks and patches ▪ wall cracks ▪ damp proof floor construction ▪ visible moisture damage on the floor covering ▪ weather-tightness of the windows against driving rain ▪ drainage of condensation from window surfaces ▪ single or multiple glazing ▪ possibility of through ventilation ▪ traces of condensation on the vaulting or ceiling, walls and floor ▪ functionality of the ventilation openings in the vaulting ▪ type of heating and visible heating damage ▪ visible microorganism contamination on the vaulting or ceiling, walls and floor etc.



BLOCK I — 2
Details about the wall paintings and the architectural surfaces

I—2.1. Brief research on the object
e.g. Dehio, church guidebooks, document and photographic archives of the local conservation department, conservation reports etc., with indication of sources:
date of origin ▪ author ▪ illustrations ▪ previous condition reports or documentation ▪ previous restorations ▪ oral history etc.

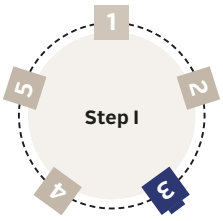
I—2.2. Position of the wall painting or architectural surface
exterior or interior ▪ building element ▪ height from floor level ▪ measurements ▪ cardinal direction and weather exposure where applicable ▪ exposure to direct

sunlight ▪ shelter ▪ connecting building elements behind the bearing wall ▪ nature and thickness of the bearing wall (rubble, ashlar or mixed walling, brick ▪ discernible construction alterations that encroach upon the wall painting such as window openings ▪ mechanical stress etc.

I—2.3. Technique of execution (original / later re-workings)
recognisable render and paint stratification (layer structure, binder, aggregates etc.) ▪ recognisable painting technique (fresco, secco, sgraffito, moulded applications, scarification etc.) ▪ surface structure, roughcast or trowelling traces etc.) ▪ various paint layers or coats (e.g. overpainting), etc.

Condition survey

BLOCK I — 3
Determination of the state of preservation

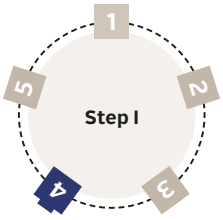


I—3.1. Determination of the state of preservation by visual-empirical criteria (identification of critical areas and recognisable causes of damage) with reference to the various phases of production when applicable:
visibly recognisable damage (cleavage in the form of flakes or scales through bonding loss, loss of stability in the form of sanding through the deterioration of the binder, losses of render or paint layers, erosion, mechanical damage, cracks, salt efflorescence, encrustations, sintering, microorganisms etc.) ▪ soiling ▪ observations related to damage on adjoining surfaces ▪ attempt at evaluation of the progress of damage by comparing the current appearance with an earlier condition.

I—3.2. Determination of the state of preservation and relevant factors using simple intruments
percussion measurement ▪ determination of salt ion content on the surface with a moist swab ▪ overview measurement of the distribution of moisture across the walls (e.g. conductivity or capacitance measurement) ▪ intermittent indoor climate measurement etc.

I—3.3. Spot sample taking for laboratory analysis to clarify particularly serious phenomena and to determine further examination methods (e.g. salts, microorganisms)

BLOCK I — 4
Appraisal of the type and urgency of further measures



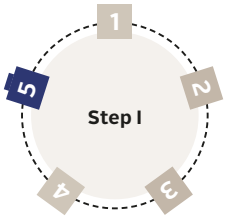
I—4.1. Type of further measures
Definition of a restorative preservation concept (e.g. aim of measures, work steps, methods) ▪ emergency consolidation of the wall paintings ▪ immediate building and/or indoor climatic measures ▪ initiation of a monitoring programme ▪ compilation of a structural or restorative preservation concept etc.

I—4.2. Degree of urgency

Assessment and classification of the urgency of further building or restorative measures ▪ classification of the need for action can be made e.g. by means of a traffic light system:

I: more urgent need for action with an immediate danger of loss of substance (red)
II: more urgent need for action (orange)
III: moderate need for action (yellow)
IV: no need for action (green)

Report



BLOCK I — 5

Formal and material requirements

The written, photographic or graphic documentation should comply with the structure of the foregoing blocks. It encompasses sketches (e.g. pencil contour drawings of water damage) and photographs for the documentation of the spatial distribution of significant zones of damage and condition parameters. The significant patterns of damage should be readily comprehensible through the textual, graphic and pictorial descriptions.

I—5.1. Components

Title page ▪ data sheet ▪ table of contents ▪ task ▪ stock survey ▪ condition survey ▪ concept for treatments ▪ appendix

> The hardcopy of your report should be handed in soft-bound and in A4 format and the electronic version as a single PDF-A file on a data carrier (300 dpi, maximum file size 70 MB for reasons of storage capacity).

I—5.2. Data storage format

Text files: PDF-A, DOC, DOCX ▪ image files: JPEG, TIFF ▪ measurement data: ASCII-text, e.g. TXT, IDX, DAT, CSV ▪ digital plans: DWG (Version 2004), DXF, AI ▪ analog maps: PDF-A (1200 dpi)

I—5.3. Archival quality

Hardcopy on acid-free and archival paper (for standards cf. DIN-ISO 9706) ▪ digital prints: permanent print (laser print) on acid-free, archival paper ▪ data carriers and their cases are to be labelled with permanent markers.

Step II

Guidelines for the monitoring

Criteria governing the decision to perform

The definition of monitoring and its distinction from condition assessment (Step I) is to be found in the introduction to the guidelines.

The decision about whether and to what extent a monitoring programme should be performed on a certain object will in practice depend on various factors. Aside from preservation, financial, logistical and technical criteria, an evaluation determining the necessity for systematic and periodic surveillance is decisive. This is based on the suspected or proven dynamics of the damage. Thus, during the course of a condition assessment, it may well turn out that surveillance through monitoring is necessary and expedient in order to recognise and define the conservation requirements for an object's preservation. In such a case, the extent to which the condition assessment already provides or has provided sufficient references for monitoring should be checked as well as whether extension towards a baseline survey is necessary for monitoring.

Determination of references

References are categorically understood to be comparative in these guidelines. These include both external influential factors that are relevant as causes for deterioration processes (e.g. indoor climate) and intrinsic material changes to the object itself (e.g. salt efflorescence). Insights into the relationships between cause and effect and their periodic comparative inspection are the core of monitoring.

Normally, the whole surface of a wall cannot be recorded within the framework of a monitoring programme. Reference fields (e.g. a defined section of the painting) are therefore defined to facilitate the detection of representative changes in condition.

The definition of reference fields for later monitoring should, of course, also represent the conclusion of conservation and restoration treatment.

1. Selection of reference fields for later follow-up checks

The definition of fields is determined by the criterion of the significance and representativeness of the observed phenomena. A suspected or proven dynamic of deterioration assumes a particular importance through the selection, possibly in connection with other parameters measured (e.g. indoor climate). When selecting the reference field, it should be remembered that later condition checks require equal accessibility.

2. Selection of reference criteria (see Blocks)

Determination of the *parameters* to be checked should take all the *influencing variables* and *factors* into consideration that are relevant to the state of preservation and are to be recorded anew during later follow-up checks (photographable phenomena, measured data from moisture and salt analyses, climate measurements, etc.). The recording methods for these parameters must be precisely adhered to in order to guarantee that measured values and observations can be gathered as far as possible under the same conditions (season, equipment type, etc.).

Criteria for the selection of blocks

The systematics of the blocks is described in the introduction to the guidelines. The criteria of selection and application on the level of monitoring is explained in the following:

An assessment of condition is to be performed in all cases. The extent of research done on previous case history, however, is governed by the principle of outlay against usefulness as well as the historical significance of the object.

When making the decision about which block is to be applied and to what extent and with which precision of technical measurement or spatial exactitude (resolution), the following criteria are to be taken into consideration:

- relevance of the respective block to the goal of the monitoring (examine how far a planned work stage can provide pertinent findings on the obvious or suspected damage processes.

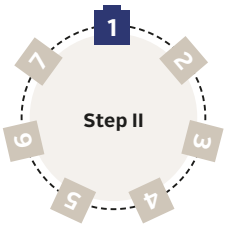
- availability of reference data or information from earlier assessments or the possibility of comparative reports within the framework of future monitoring (information that cannot be compared with earlier or future reference reports does not facilitate the tracking of deterioration processes. However, such information is of importance if it serves to explain the causes of damage or determine the remedial measures to be taken).

- dimensions of the object (naturally, observations, measurements, mapping and pictorial documentation relating to the spatial resolution depend on the size of the wall).

- conservation aspects (any impairment of the object during the course of inspection should be avoided or kept within justifiable limits).

The challenge is to determine the situation during a preview in such a way that the selection and scope of the blocks can act as a basis to outline calculations and financing in advance.

Monitoring blocks



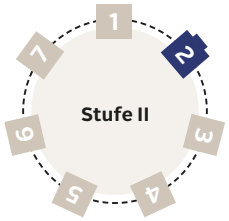
BLOCK II — 1

Adoption of information from the condition survey (Step I)

The condition assessment (Step I) is simultaneously the first block of monitoring (Step II). During the monitoring process the condition assessment (stock and condition assessment) represents the starting point on the level of Step I. The documentation of the condition assessment is the basis for consolidation and expansion.

A consolidation and expansion can also be useful for research on previous case history. Literature, archive material, conservation reports, scientific analyses (laboratory reports etc.), plans, floor plans etc., photographs (prior state, old views), oral reports etc.

Research can be carried out by conservators or, amongst others, curators of monuments. Parish office/municipal office, diocese, authority for the protection of monuments, in some cases diverse archives.



BLOCK II — 2

Damage documentation

The documentation of damage should lead to an extended and more penetrating acquisition of data recording the state of preservation (ensuing from Step I, Block I—3) with the focus on the pattern and dynamics of deterioration.

Should serious defects or deterioration trends be discernible during the assessment, immediate building and/or indoor climatic measures and emergency consolidation of the wall paintings are to be implemented. This emergency consolidation should be carried out alongside further assessment.

II—2.1. Methods of damage appraisal

- initial detections based on visual-empirical criteria (→ see I—3. 1.)
- further visual detection (digital microscope / incidental light / raking light / UV light, etc.)
- detection of colour changes with a colorimeter
- initial detections with simple instruments (→ see I—3.2.)
- quantitative evaluation of the progress of the damage in respect to the appearance, intensity and spatial distribution in comparison to the prior state
- graphic depiction of the spatial distribution of visible and hidden damage (mapping, → see Block II—7.)
- Overview and macro photographs taken under replicable lighting conditions
- periodic measurements of losses to the surface (progressive collection of the material lost and gravimetric evaluation)

- percussion monitoring
- thermal imaging
- other relevant measuring techniques (e.g. active or passive laser methods for the measurement of dimensional changes)

II—2.2. Criteria and parameter for the description of the damage pattern

- appearance of the pattern of damage (e.g. types of destruction / types of salt efflorescence etc.)
- dimensioning (uniform or variable)
- single or extensive occurrence
- intensity (slight / medium / heavy)
- neighbouring damage phenomena if a connection can be established with the described damage pattern
- other observations relevant to the damage

II—2.3. Photographic images for the damage catalogue (→ also see Block II—3.):
The image should, if possible, contain a scale. Indication of coordinates or localisation in a sketch or on a mapping plan or sample plan.

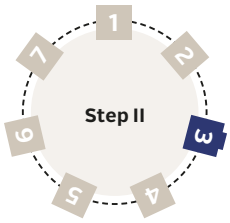
The damage catalogue should depict deterioration patterns that are obviously related or could be related to a recent development in the damage.

The description of the damage serves a replicable evaluation of the object's condition at the time of the survey and has the main aim of gauging changes over the course of later campaigns.

A broadly objective description and documentation of the deterioration phenomena requires the employment of consistent terminology as far as possible. In this context the description and interpretation of phenomena must be clearly differentiated.

A example guidance sheet for a **damage catalogue** is attached in the appendix.

The nomenclature compiled on page 35 is meant to supply support as a kind of manual for the description of the forms of damage through its respective object-related application. The compilation derives mainly from Konrad Zehnder 'Naturwissenschaftliche Untersuchung und Dokumentation des materiellen Zerfalls an Denkmälern', in: Salzschäden an Wandmalereien, Arbeitshefte des Bayerischen Landesamtes für Denkmalpflege Vol. 78, Munich 1986.



BLOCK II — 3
Photographic documentation

The goal of photographic documentation is visibly to record the current condition of the object, any architectural peculiarities as well as the sources of deterioration, etc. A complete view can also serve as a basis for mapping.

The same applies to reference photographs as does to all other forms of reference production: the fields are selected according to the criterion of significant and representative phenomena/suspected or proven dynamics of deterioration/ correlation with other measured parameters (e.g. indoor climate).

Company

Location: .....

Object: .....

Date: .....

Example label

II—3.1. Fundamental requirements for photographic imaging

- Standardised colour scale (e.g. Kodak)
- White balance, e.g. Kodak grey scale
- When possible, a label (detail image) (location / object / photographer / date of execution / scale) or a scale (overall view) should be included in the image.
- The resolution should ensure that the smallest significant phenomenon is readily legible in the photograph. For example, an image of a grain of sand with a diameter of ca. 0.05 mm requires a resolution of 3000 × 4000 pixel in a detail image of 15 × 20 cm, which is equivalent to 12 megapixels. In order to capture a grain of sand measuring 1 mm the detail image with a 12 megapixel camera can be 20 times larger.

II—3.2. Details of photographic images of reference fields for monitoring

- Exposure date
- Section of image (e.g. general view or detail view, macro shot) and their size
- Light source (e.g. flash / photo lamps / cold or daylight lamps / UV / natural daylight)
- Record of the image section after noting the coordinates and or localisation on a sketch or a mapping plan.
- Description of the phenomena in the image section to be observed and given particular attention during the monitoring programme. (e.g. white coating, changes to the flakes, etc.)

II—3.3. Specific requirements for photographic images of reference fields for monitoring

In order to facilitate the comparison of pictorial information relating to reference fields during monitoring the following should be given due consideration: even illumination (raking light is generally not very suitable) (sufficient depth of focus / low distortion, etc.). These qualities and criteria must be documented so they may be repeated as closely as possible during monitoring at a later point in time. Implementation is highly demanding and is possibly only guaranteed with professional support.

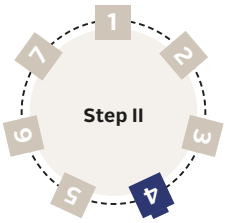
II—3.4. Requirements for photographic documentation

The individual photographs with details of the photo number either on a CD or DVD or USB Stick must be attached to the report. The individual reference fields must be reproduced in the report. The photographic prints must be printed out on acid-free archival paper in the defined quality.

An example guidance sheet for **photographic documentation** is attached in the appendix.

BLOCK II — 4

Moisture measurement



For the implementation and extent of moisture measurement in accordance with all pertinent interests relating to preservation refer to the introduction to the blocks on monitoring.

II—4.1. Requirements of baseline measurements

During an initial survey and sporadic routine follow-up checks, spot measurements are to be performed on vertical and horizontal profiles, especially in the skirting or plinth area.

The following measurement parameters are to be recorded:

- object
- localisation/building element
- date of measurement
- compiler
- type of equipment and method of measurement (conductivity / capacitance measurement)
- if possible, the current climate values (RH, temp)

II—4.2. Requirements for further measurements

Should the object exhibit a critical condition or there be exceptional circumstances such as the initiation of planned long-term monitoring or the run-up to renovation work, measurements should be taken in a grid pattern at the very least in the zones usually effected or obviously suffering from dampness (especially in the plinth area and that immediately above it) if not over the whole surface.

- Determination of the size of the grid in regard to the size of the object (as a rule of thumb the grid should measure at least 1/10 of the longest side and no more than 0.5 meters high).
- Depending on the distribution of the measurements in the grid and the grid size, it is preferable that several measurements are taken in each field and the average value recorded as the valid measurement in the documentation.

- Different materials and surface structures can lead to distinct variations in measurement. This should be taken into consideration during the positioning of the grid and the determination of the number of measurements conducted.

Methods for the direct measurement of moisture

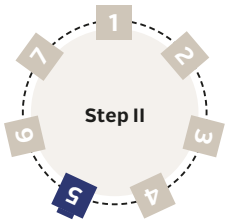
The actual moisture content can be determined gravimetrically (e.g. employing the Darr method, usually in a laboratory) or the CM measurements.

II—4.3. Measurement records

The measured values should be written down along with coordinate details as well as in a plan or sketch or recorded in a photograph. The allocation of the values to specific damage phenomena and/or samples should be recorded either in written or photographic form. In purely graphic representations of the values, it makes sense to plot the results in categories (e.g. division into low – medium – high values with a key).

Several measurements are to be conducted in zones where deterioration is obviously active and where a connection between moisture and salts in presumed to exist.

The replicability of measurement in respect to the recorded measurement parameters, the position of the measuring points and the connection to the damage phenomena are also of particular importance here.



BLOCK II — 5
Climate measurement

For the implementation and extent of climate measurement in accordance with all pertinent interests relating to preservation refer to the introduction to the blocks on monitoring.

Important parameters for climate measurements:
air temperature, surface temperature, relative humidity, absolute humidity, air exchange, flow, sorption, changes in air humidity

II—5.1. Information on the reasons for climate measurement and details about the indoor space and its use

It is important to note that additional information about the indoor space provides important leads for the interpretation of climate data and must therefore be recorded and researched as far as possible (e.g. height, volume, heating system, heating method, efficiency of ventilation, ventilation systems, air-conditioning (yes/no), use of space, visitor frequency).

The guidance sheet for climate measurement relates solely to continuous measurement, i.e. measurements recording climate history over a certain period of time. The period of measurement will vary depending on the issues and the deterioration problem.

Usually long-term measurement at 60 minute intervals for at least a one year cycle is expedient and necessary. The measurements are often seen as a routine contribution to the assessment of the general situation without any particular indication but they can also be related to any concrete suspicions regarding certain damage phenomena. These considerations should be noted in the guidance sheet for climate measurement.

In reasoned cases, the measurements can provide sufficient information over a one day cycle.

In cases where measurements are conducted for one day and relate to the use of the space, the intervals between measurements are usually shorter, e.g. 10 minutes is recommended.

II—5.2. Requirements for continuous climate measurement

- The primary measurement parameters are temperature and relative humidity. Depending on the requirements and feasibility, surface temperature, internal wall temperature, luminous intensity and CO_2 content of the interior atmosphere might also be measured.
- Measurement over a one-year cycle should be the goal.
- Calibration of individual sensors through comparative readings (over a period of no less than one day) is necessary once a year for the correction of several devices.
- Any variance beyond the scope of accuracy specific to the device must be followed by the adjustment of data and a record in the documentation. The device must be replaced.
- Devices for climate measurement must be programmed to Central European Time (CET) / standard time, Summer Time is not used.

Climate measurement outdoors:
Outdoor climate measurement is an important factor for the interpretation of indoor values. Data from meteorological stations (e.g. ZAMG *www.zamg.ac.at*, hydrographic service) may be used if it has been gathered from a site with comparable climatic conditions in the proximity. These measurements have the advantage of providing data on rainfall.

II—5.3. Climate measurements outdoors

The following points should be observed when independently taking exterior measurements:

- Not all measuring devices or sensors are suitable for exterior measurements.
- Temperature and moisture sensors must be shielded against direct sunlight and rain (e.g. following the principles of a Stevenson screen) or installed in a protected location (e.g. in a tree).
- Installation should not be too close to the object (≥ 2 m distance) otherwise warmth from the building will influence the measurements.

II—5.4. Climate measurement indoors

- When selecting measuring points, a representative measurement for the average indoor climate must be provided. In doing so, due consideration should be given to the height of measurement (vertical distribution of temperature), exposure to light from windows or lighting as well as air currents caused by drafts and openings. Additional measuring points might be necessary and make sense in individual cases, and they will be sited according to the issue in question.
- Whilst bearing the above considerations in mind, the measuring point for indoor climate should be as close to the object being examined as possible.

II—5.5. Measurement of surface temperature

- When measuring surface temperature, the rear of the sensor should be shielded against radiated warmth.
- Special sensors with direct contact to the surface should be used for taking measurements. In principle, the use of non-contact infra-red thermometers is possible but it should be remembered that an exact comparison with the room temperature, e.g. in calculating any drop below the dew point temperature, will only be conditionally possible due to the various measuring principles. As incidents of condensation are primarily caused by developments in the indoor climate, which is itself subject to diurnal and seasonal fluctuations, continual long-term measurement of both values (room and surface temperature) remains the goal.

II—5.6. Representation of the results

- Data is to be submitted in numerical form (Ascii file).
- The record must include the object, the device identification (pursuant to the guidance sheet on climate measurement) and the measuring period, e.g. Gurk_Vestibule_1_31.01.08-31.01.09 (location_object_device identification_measuring period)
- All measurements must be related to a date and time.
- Annual overviews of values (usually temperature and RH) should be represented as time series with a date abscissa (=climate curve in the usual form)
- A maximum of one year per diagram
- The results are to be submitted digital (pdf, tiff or jpeg) and printed form.

II—5.7. Requirements of climate data for monitoring

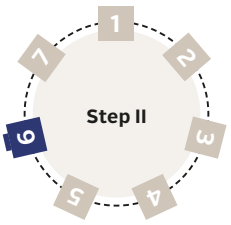
The following qualities and criteria are to be observed and must be documented in order to facilitate comparable measurement during the course of monitoring:

- general details about the object
- measuring point / position (indoors/outdoors)
- measuring period
- measuring device
- measured variables (RH, temp., surface temp.)
- measuring intervals (max. 60 mins)
- compiler
- representation: diagram, scatter diagram, table (digital or as a printout)
- table of devices: details of the type of device, position, measured variables, measuring intervals, measuring period, particularities (see guidance sheet on climate measurement)

A monitoring programme not only records data but ensures that the quality of the data is constant. The manner in which the data has been collected must be readily understood. However, this does not include an interpretation of the measured data.

An example guidance sheet for **climate measurement** is attached in the appendix.

BLOCK II — 6
Sample collection



The collection of samples is justifiable only in connection with a specific problem arising from a phenomenon or process of deterioration and laboratory analysis will potentially offer a solution. It should also be noted that every sample collected only provides a selectively isolated condition assessment. For this reason, it is particularly important to ensure that the choice of sampling site and sample size reflects a certain wall section or specific form of deterioration representatively.

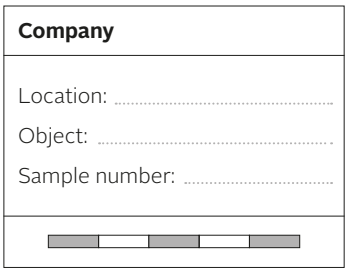
II—6.1. Labelling of samples

- Sample number:

The samples should inscribed with a readily comprehensible identifier (letter or numeral). (e.g. letters or numerals referring to an object + year + consecutive numbering)

- Components of the label:

The sampling site should be documented photographically with a label. Components of the label could be: object, object part, wall or vault surface, grid/coordinates, date, scale.



Example label

II—6.2. Characterisation of the sampling site and issue

Relevant observations about the sampling site, its environs, possible influences etc. should be noted in a short description. Formulation of the issue to be clarified through analysis is crucial (e.g. layer structure, composition of rendering, paint layer structure, pigments, water content, salt crystallisation, quantitative salt content, microorganisms, etc.). Samples are only meaningful in connection with an issue. Telling photographs of the sampling site and its immediate environs are an additional aid. The scale can be applied to or drawn on the label; to illustrate the size of the sample it is wise to photograph the label with a scale. A plan for the recording of sampling sites when a large number of samples are taken is also helpful.

Type of sample/sample collection (technique/method)

A considered choice of sampling site and sample type tailored to the main issue and analytics is decisive for the representativeness of the informative value of the analysis. Furthermore, certain examinations require minimum amounts of sample material and in some circumstances a certain sample consistency. For most cases there are the following types of sampling:

- scrape sample (pigments, salts, microorganisms, etc.)
- peace sample (render, paint layer, layer sequence, salt crystals)
- drill core or shavings (quantitative salt ion and possibly moisture distribution at depth)
- compress (broad, non-destructive information about the type and amount of extractable salt ions; details about date, compress material, amount of water for production, duration of extraction, surfaces, etc.)
- adhesive strips

II—6.3. Render and mortar samples

Samples of render originating from areas with all layers cohesive and intact are generally preferable (arriccio and intonaco). The size of the sample depends on the size of the granules and its homogeneity. The size of the piece should be at least three to five times that of the largest granule. All the characteristic values cannot be determined in a sample taken from detached fragments.

II—6.4. Paint layer samples

Samples of the paint layer with at least the interface to the layer beneath it are generally preferable. (minimum diameter ≥ 2mm). For pigment analysis a scraped sample from the paint layer may be sufficient.

II—6.5. Salt samples

Salt analysis is differentiated into the qualitative identification of the crystals (e.g. scrape and chip samples) and the quantitative determination of the salt content (e.g. chip or drill samples from various depths or compress samples). The samples should be kept in airtight containers. Crystals should additionally be protected against mechanical damage and storage should be at approximately the same temperature as when the sample was taken (e.g. refrigerator).

- Description of the salts prior to sample collection (phenomenological: whisker, pustules, crusts, coats, etc. / exact position of the salt crystals: on surface / reverse of flakes)
- If possible, details of the surface moisture in the immediate vicinity (capacitance meter/conductivity meter)
- If possible, details of the temperature/air humidity at the time of sample collection
- Other relevant observations

II—6.6. Microbiological samples

Microbiological samples serve to answer the following questions:

- is there any biogenic infestation?
- is the infestation having a detrimental effect on the condition and preservation of the object?
- is the infestation recent and active?
- what type of microorganism is involved?
- is the infestation only on the surface or is it also deep in the material?
- are measures to remove and/or exterminate the infestation necessary?
- what measures are suitable for the removal or elimination of the infestation?
- how can a new microbiological infestation be avoided after cleaning?

It should be noted that microbiological sample material as a rule must be sufficient for two examinations:

- samples for the analysis of the microbial colony (for concentration and cultivation and/or DNA extraction) and
- samples for analysis under a light microscope and/or a scanning electron microscope to determine the depth of colonisation.

Basic requirements for microbiological samples are:

- Sterile sample collection: the samples are collected with a sterile scalpel or needle. Samples must never be touched with the fingers. Samples on the floor (e.g. fallen flakes) are not suitable.
- Size of the sample: the sample should have a surface area of several mm^2; optimally it should be no smaller than 3 × 3 mm. The depth of the sample depends on the depth/number of the paint layers. The sample should include all of the paint layers and the substrate.
- The samples are placed in sterile containers (e.g. 1.5 ml Eppendorf tubes). If no sterile container is available, an unsterile container can be cleaned thoroughly with 70% ethanol.
- Samples should be sent to a microbiological laboratory for examination as quickly as possible. If storage is unavoidable, conditions should be dark and cool (4°C – no freezing). Storage under warm conditions or in direct sunlight is to be absolutely avoided.
- Very fresh samples are recommended for scanning electron microscope analysis as the cells of the microorganisms dry out and shrink during prolonged storage. Low vacuum or cryo scanning electron microscopy are suitable for the depiction microorganisms.

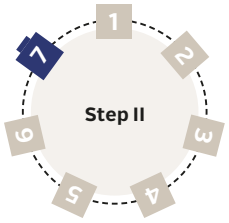
II—6.7. Additional samples

Any additional collection of samples or sample amounts for further analytical procedures should be discussed with the laboratory concerned beforehand.

Possible analytical procedures on samples:

- polarised, reflected, transmitted and UV light microscopy (render, paint layer, salt crystals)
- instrumental ion analysis, e.g. ion chromatography (drill samples, quantitative salt analyses)
- scanning electron microscopy (SEM/EDX) on micro-sections (render, paint layer and pigment analyses; salt distribution of low solubility)
- FTIR (e.g. plastic additives)
- Sorption isotherm (equilibrium moisture content: render samples, drill samples, salt efflorescences)
- (in individual cases): x-ray diffraction (XRD) (precise phase analysis: salt crystals)
- taste, colour

An example guidance sheet for **sample collection** is attached in the appendix.



BLOCK II — 7
Mapping

For the implementation and extent of mapping in accordance with all pertinent interests relating to preservation refer to the introduction to the blocks on monitoring.

Mapping is employed when

- the distribution of phenomena cannot otherwise be sufficiently recorded or traced
- pertinent findings are made apparent or suspected deterioration processes can only be illustrated through the depiction of the phenomena's spatial distribution
- comparable checks within a future monitoring programme can be expected to take place.

Mapping (stock and condition mapping) is usually a fundamental component of monitoring and augments any written documentation. Mapping should make the localisation and distribution of existing stock, damage and/or measurements readily legible. Any treatments performed on the object should also be included.

Execution is based on an on-site measurement, a mapping photograph, a drawn plan or even a dewarped photograph. The description of any damage should already include the mapping symbols. Every sheet must have a header and a key.

Categories of condition and damage mapping:

- distribution of moisture (see the block on moisture measurement)
- distribution of salt ion concentration on the surface according to salt testing strips
- distribution of pH values on the surface according to pH testing strips
- salt efflorescence classified according to the significant characteristics of the phenomena
- biogenic infestation
- appearance of deterioration classified according to the significant characteristics of the phenomena
- distribution of cavities according to percussion
- areas of cracking
- Emergency and consolidation measures

Guidance sheets (appendix)

Guidance sheet for damage documentation (damage catalogue)

Building:

Localisation/
Building element:

Compiler:

Compilation period:

Image No.:

Damage phenomenon:

Mapped phenomenon: yes no

Mapping symbol:

Description of the form of damage/cause:

Appearance or localisation on building/quantification of damage if possible:

Image No.:

Image localisation:

Image(s):

Guidance sheet for photographic images of reference surfaces

Building:

Localisation/
Building element:

Compiler:

Compilation period:

Sheet No.:

Image number	Image section / coordinates	Details about noteworthy phenomena	Light source	Exposure date

Guidance sheet for climate measurement

Building:

Localisation/
Building element:

Compiler:

Compilation period:

Sheet No.:

Reasons for climate measurement and information about the space and details of its use

If possible details relating to any connection between the deterioration processes and the indoor climate.

Reasons for the positioning of the individual devices

Equipment type and device identification	Measurement location	Anomaly relating to the choice of location (e.g. proximity to door, window niche, elevational gradient)	Measured variables (RH, temp, surface temp)	Intervals	Period

Guidance sheet for laboratory analyses

Handover date:

Object:

Street/No.:

Post code/Town:

Client

Company/institution:

Address:

Tel:

Email:

Sample

Name:

Date:

Commissioner/invoice address (if different to that of the client)

Name:

Address:

Tel.:

Email:

Number of samples deposited:

Guidance sheet for laboratory analyses (sheet 2)

Building:

Localisation/Building element:

Sample number:

Temperature (°C): Relative humidity (% RH):

The climatic conditions during the collection of samples plays a role with samples of salt, microorganisms.

Position/description of the place taken/sample:

Question posed:

Photo/sketch:

Nomenclature for forms of damage

1. FREQUENT FORMS OF DAMAGE

1.1 General forms of damage (not material specific)

- mechanical damage
- cracks (static cracks, shrinkage or hair cracks, etc.)
- decompaction of composite materials and / or in individual materials (cavities ...)
- deformations (blisters, differences of level, etc.)
- discoloration, patches (damp stains, tidelines, etc.)
- hardening/embrittlement
- encrustations, deposits (soiling, dust, organisms, products of chemical reactions, etc.
- salt efflorescences

1.2. Forms of damage to rendering and walling

- damage derived from technique (free lime, cracks, shrinkage, etc.)
- structural forms of damage (crumbling, scaling, sanding, peeling, pitting, cavities, etc.)
- other phenomena (lacunae, etc.)

1.3. Forms of damage to painting and coatings

- damage deriving from technique (cracks, shrinkage, etc.)
- cohesion damage (flaking, curling, blistering or cupping, cleavage, etc.)
- structural forms of damage (decompaction, chalking, powdering, swelling, shrinkage, thinned paint layer, pitting, abrasion, etc.)
- other phenomena (lacunae, pigment changes, etc.)

1.4. Forms of damage deriving from latter additions

- rendering and walling (stabilising elements, new render, scratches, damage from uncovering, overpainting, graffiti, restorations, etc.)
- painting and coatings (damage from removal of overpainting, scratches, graffiti, fly spots, restorations, etc.)
- chemical degradation of the binder, pigments

2. TYPES OF DECOMPOSITION

2.1. Chemical processes

- chemical dissolution
- chemical conversion (through hydrolysis, oxidation, etc.)

2.2. Mechanical processes

Changes in volume, deformations through

- hygric expansion/contraction
- thermal expansion/contraction
- chemical processes

Cracks, decompaction through

- frost
- crystallisation (and hydration) of salts
- chemical processes (e.g. rust bursting)
- plants, organism activity
- vibrations

3. SALT EFFLORESCENCES

Salt efflorescences often occur in different manifestations depending on the seasonal climatic cycle and these are significant to any understanding of the mechanism, cause and potential of damage. As far as it is possible, allocation to the following categories should be decided upon. For a more detailed description of the categories see *http://193.175.110.91/saltwiki/index.php/Deterioration_Patterns_Wallpaintings*. The following terms and descriptions have been adopted in the main from the webpage cited above.

- **Whiskers:** a few µm thick to 1 cm long, columnar and often curved crystals.
- **Feathery-fluffy efflorescence:** very loose, fluffy or cotton-like efflorescence, usually consisting of bent whiskers.
- **Acicular crystals-bristly efflorescence:** loose coating of needle-like to columnar whiskers standing more or less perpendicular to the, 0.1 to several millimetres long. Often only clearly visible in raking light.
- **Powdery efflorescence:** white, floury, dense or loose to fluffy coating.
- **Salt haze:** a thin, cohesive, well-attached semi-transparent coating where single crystals cannot be discerned even under low magnification.
- **Salt pustules:** loose to compact heaps of salt crystals up to 1 mm in diameter.
- **Salt crust:** compact, sometimes solid salt aggregates attached to the surface with planar cohesion and very variable thicknesses (a few µm to mm).
- **White loose salt crust (sugary crust):** consists of aggregates that are visible to the naked eye or under low magnification as glass-clear crystals.
- **Satin crust:** flat, shiny salt crusts. Thick shiny crusts of gypsum are formed only by repeated recrystallization of crystals over longer periods of time.
- **Framboidal or botroidal crusts:** crusts of white, spherical aggregates – its surface resembles that of a raspberry or blackberry or even a cauliflower. Botroidal crusts occur preferentially along small defects (e.g. cracks) on an otherwise relatively dense plaster surface. They also can form as separate units on dense stones.
- **Fibrous crust:** crust composed of densely packed whiskers, perpendicular to the substrate. They usually develop on moist substrates.

4. BIOGENETIC INFESTATION (MICROORGANISMS)

- **Bacteria:** bacteria are microscopically small organisms that are not visible on the object with the naked eye. In some cases infestation by a certain bacteria can be identified through a particular discoloration. 'Pink' is an indication of halophile bacteria; white, powdery coatings can indicate the presence of actinomycetes/streptomycetes (they are easily mistaken for mould mycelia); green coatings indicate cyanobacteria (phototrophic bacteria that often occur with algae) and orange discolorations (carotene) often occur in connection with bacteria producing oxalic acid. Bacteria damage objects with acids, mucilage, colour excretion and the degradation of binders.
- **Moulds:** moulds create powdery, in part granular or velvety coatings on surfaces. These can be uncoloured (white, hyaline) or exhibit a grey, green, brown, red-brown or black hue. Fungal hypha penetrate several mm into wall paintings. Moulds damage objects with acids, colour excretion, mechanically and through the degradation of binders.
- **Algae:** algae are microscopically small one or two celled phototrophic organisms. They occur in places where there is a lot of moisture. They are usually green in colour but there are also green algae that appear red (trentepholia) or brown (diatomes). Algae create thick films on surfaces and damage objects with acids and the production of thick mucilage.
- **Lichens** are usually crust-like organisms growing on surfaces that consist of either a fungus or an alga. Lichens normally grow outdoors. They damage the surface by encrustation, production of acids and mechanical penetration.
- **Mosses** are plants and produce small, soft pillows on a surface. They penetrate the substrate with rhizomes. They require a high level of moisture. They damage the object by mechanical dislodgement through the rhizomes.

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Notes

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