EXPOSITION, SAFETY, CONSERVATION

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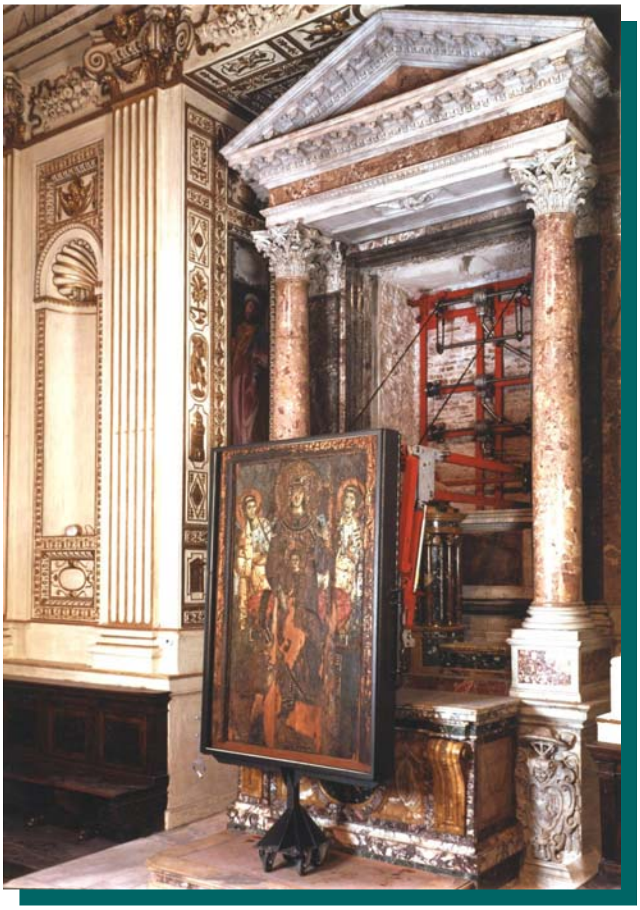
I- Introduction

"The art work, from the monument to the miniature, is made up by a certain number and quantity of matters, that, joined together, and due to an indefinite series of circumstances and specific agents, can be subject to alternations of various kind, that, harmful to the image, matter, or both, determine the restoration work. As a consequence, the possibility to prevent these alternations depends on the physical and chemical characteristics of the materials that the art work is made of".[1]
The restoration work, nonetheless, is fruitless, and therefore it must be frequently repeated if the art work is located in exposition areas or warehouses which do not offer suitable conditions for its protection and preservation.
We can't say: "*now that the art work has been restored, it will live forever*".
The "health" of the art work, of a collection, and of a monumental complex cannot rely only on restoration works, even if radical, spaced out among periods of carelessness, nor can rely on maintenance only, which shall be performed to make the restoration effects more durable.
For a concrete and effective restoration work, we cannot detach from "prevention": a series of interventions that mainly aim to eliminate the causes of deterioration, pointed out through a series of surveys and targeted studies.
For this reason, by joining the "conservation" and "prevention" concepts, the "preventive conservation" concept arises, which is based on all procedures, expedients, and technical solutions that prevent possible causes of objects deterioration, thus guaranteeing and controlling the suitable conditions for preservation.

In other words, this type of conservation can be also defined as "indirect conservation", since it does not directly involves the art work, but it is necessary.

Experience already proved us that it is useful for example, to restore an icon on a board if it is then relocated in the same environment where it was previously exposed and damaged. Prior to relocate it at its place, it is necessary to adjust the temperature and humidity conditions of the environment to the needs of the painting. In addition, another fundamental requirement for the protection of cultural objects is that the works must be moved and handled as less as possible. Basically, they must be stored in spaces specially studied, which facilitate their view to art students and to whom is fond of art, and that allow for an easy access to restorers. [2]

The exposition of art works, especially if temporary, involves risks to their integrity due to transport, and also decay risks caused by their removal from the micro-environment where they were subject to a specific temperature, and by the exposure in a different environment also characterized by the presence of numerous visitors. When the art work is one of the most famous paintings of board of the History of Art, the great interest that it attracts makes these problems even more relevant.
Due to the great flow of visitors, protection from theft and damages must be guaranteed at the outmost level, without nonetheless neglect the emotions to visitors, from directly coming into contact with the painting: as a consequence, full visibility of the work, and a suitable illumination must be foreseen. [3]



We will describe herein under some applied cases of "preventive conservation" regarding paintings on boards that explain how it is possible to ensure protection of the art work with he help of high technology and in compliance with all the rules of best rendering, by placing the art work in an environment which allows for the most suitable conservation and safety conditions.

<u>II- Replacement of the "Madonna della Clemenza e della Pace" on the Altar (end of VIth century, beginning of VIIth century A.C). Santa Maria in Trastevere, Rome.</u> Picture 1
Research project in collaboration with Istituto Centrale del Restauro (Central Restoration Institute) of Rome.

Conservation state: The work presents some peculiarities, both as regards the physical structure and the conservation state, which make the exposition to the public particularly troublesome.
The antiquity of the execution, dated end of

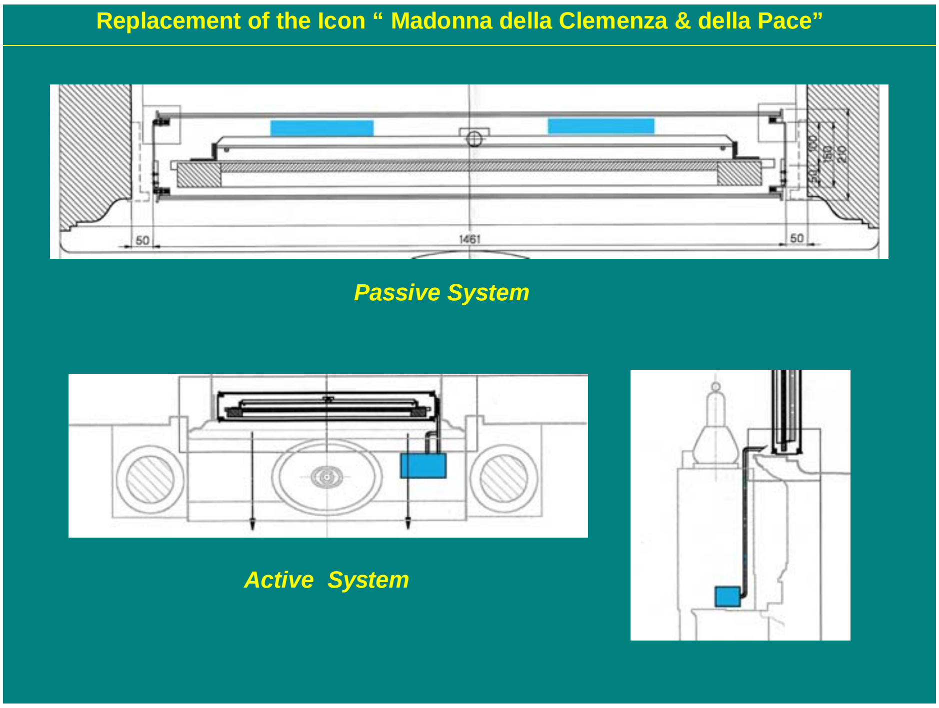
VIth century and beginning of VIIth century, the peculiarities of the support made of cypress wood and linen fabric, and of the encaustic painting technique, and above all its history rich of negative restoration works, among which also a fire, they render it particularly fragile and sensitive to preservation conditions.
To allow the exposition of the work in conditions suitable to its preservation, in the place where it has been located since 1593, the Altemps Chapel in S. Maria in Trastevere Basilica in Rome, it was required its total isolation from the surrounding environment, open to the public and subject to relevant temperature and humidity variations, which cannot obviously guarantee the necessary stability of micro-climatic conditions. [4]

Picture 2

Conservation environmental parameters:
The thermo-hygrometric conditions suggested for painting on wood boards indicated by the various Bodies and conservation experts, are in average between 50% and 60% of relative humidity, mainly focusing on the condition stability rather than its absolute value. The reference value was therefore established to be 60% RH.

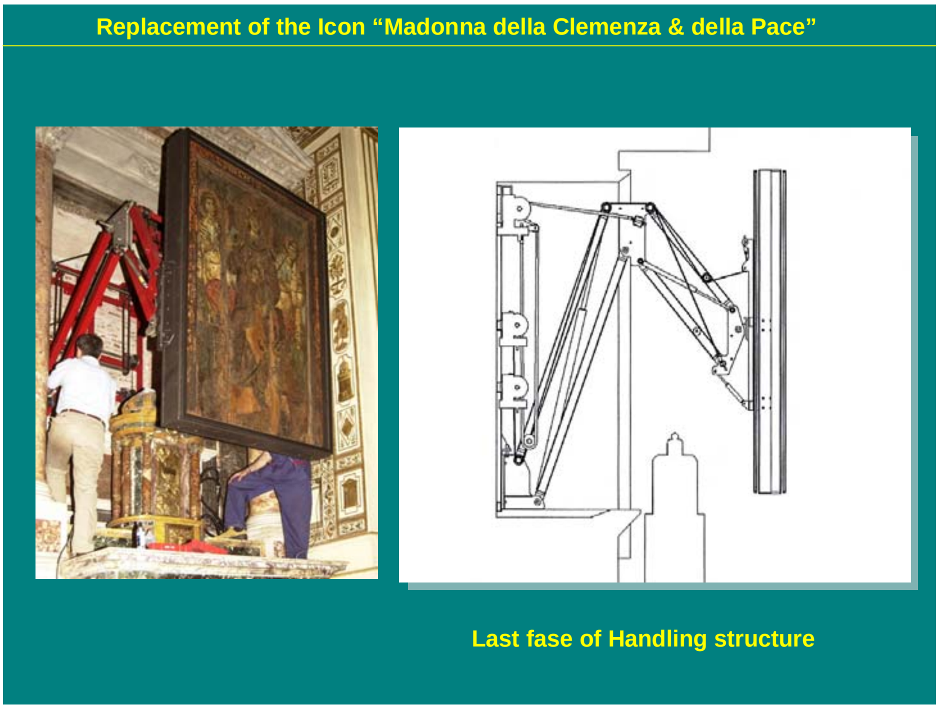
The same sources indicate temperature values between 18ºC and 24ºC, always highlighting the importance of stability rather than that of the absolute value.
The light conditions suggested are generally less or equal to 50 lux, with a maximum value of the ultraviolet component equal to 75μW/lumen and a maximum annual exposition equal to 200,000 lux/h.

The semiactive system of relative humidity control: Picture 3



To obtain the stabilization of the interior micro-climate, it is necessary to reduce the air exchanges between the shrine’s interior and exterior to the minimum, in order to maintain the wanted relative humidity inside the showcase and impede that chemical agents eventually present in the exterior air and able to damage the material, penetrate inside it.
The stabilization of relative humidity, monitored by a sensor, is guaranteed by a hygroscopic tampon material (silica gel) made of silica gel associated to a Peltier-cell device having thermo-electric effect which allows to quickly restore the relative humidity rate to the established values and the gel at the same time.
The system is also foreseen to perform control functions of gas pollutants and micro-dusts through special filtering cartridges. [5]

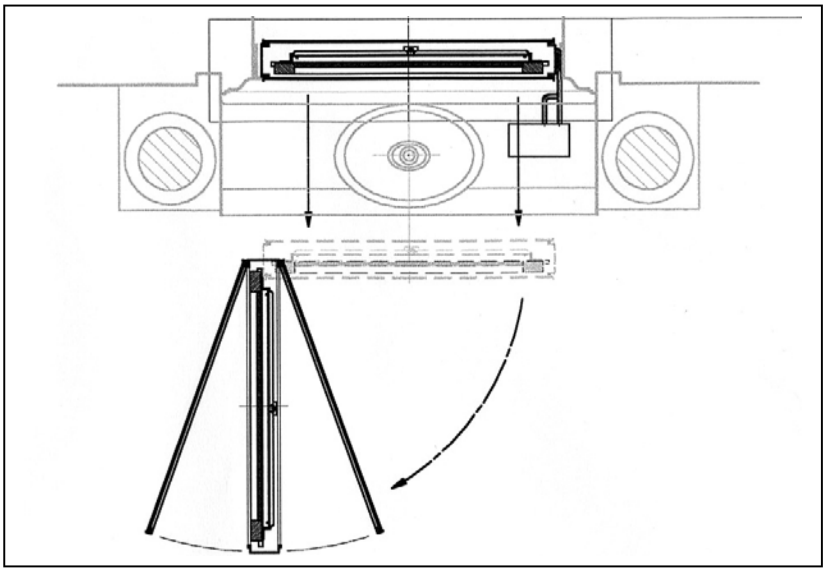
The protection and handling structure: Picture 4



In exposure conditions, the shrine is entirely located in a niche arranged above the Altar, where it was previously positioned.
The choice to relocate the icon in its historical, original position requires limiting the showcase’s overall dimensions, in order to reduce the visual impact, and also due to the reduced front opening of the niche, slightly larger than the work.
Due to the reduced useful dimensions, and to the presence of the tabernacle, which prevents the opening of the showcase, thus maintaining it in a fixed position, it was necessary to foresee the movement of the shrine each time inspection operations, checks of the conservation state, and eventual maintenance and restoration interventions were needed.
To solve this problem, avoiding the manual movement of the shrine and of the icon contained in it, which would have involved unacceptable risks for operators and the exposed work, it was necessary to design a handling mechanism of the shrine, completely retractable and anchored to the church’s wall structure.
The handling system consists of a lattice girder articulated in two pantograph mechanisms, which supports the showcase at its edges.

The movement is controlled by knobs which, through rotation shafts and mechanical reducers, enable the chains and gears system that regulates the mechanical movement of the pantographs.
The mechanisms are assisted by gas springs that also ensure continuous movements, free of vibrations.
Due to the reduced gap between the showcase and the niche's walls, and to the existence of an architectural obstacle to overcome, the movement resulted to be complex and divided in three main phases. Starting from the exposure position, with the shrine located in the niche above the altar, after having removed the gap's closing veils, an extraction movement of the showcase will begin, keeping it strictly parallel to its initial position up until its complete expulsion from the niche.

The second phase of the movement foresees the overcoming of the tabernacle; the showcase is first tilted forward and lifted at the same time (avoiding interferences at the bottom with the top of the tabernacle, and at the top, with the above architectural frame); therefore, once these obstacles are overcome, the showcase is brought back to its vertical position.
The third phase consists in the final movement of depositing the shrine in the space in front of the altar, laying it on a movable support foreseen to improve the operators' safety and reduce the mechanical stress on the structure. In this final position, it is possible to rotate the showcase around a vertical axis located on one of the two frame fittings, after having released it from the other frame fitting, and also open the showcase from both sides and access the work. Picture 5
For safety reasons, all movements have been studied for manual control and enabling; due to the fragility of the operation and architectural structures involved, great care must be taken by the staff, which must be properly trained. [6]



Showcase's technical characteristics: Picture 5

The showcase designed by the Laboratorio Museotecnico for the exposure of the icon, consists of a shrine which contains the work, of sizes only slightly bigger than the work itself, and of reduced depth. The sides of the shrine are in metal sheet and make up the frame supporting the showcase. Both sides of the work can be viewed through the glass surfaces, which can be both opened, and allow to inspect the front and rear of the board without necessarily opening the shrine, thus altering the interior micro-climate.
Due to the icon's dimensions compared to the space available in the niche above the altar, a very linear design has been chosen.
The structure of the shrine includes fittings to the lattice girder, one of which allows rotating the shrine on a vertical axis, and the second allows its release, also to allow movement.

The opening system is of simple rotation on the glass surfaces' hinges, anchored to the frames made of metal bar. Closing mechanisms are anchored on the same frames, with safety locks. Closing of the doors involves compressing the gaskets.

The choice of building materials was coherent with the conservation objectives: these have characteristics suitable to the construction of air-tight structures and are compatible with the conversation needs of the exposed objects. (It is more appropriate to speak of "compatible" materials rather than "inert" materials: a compatible material may not be totally inert, but the substances that it releases do not jeopardize the object present). For the construction of the showcase, metal frames have been used with air-tight welded joints, layered safety crystals with anti-vandalism performances, elastomer gaskets carefully chosen and applied, glues and sealers, selected based on their chemical composition, needed along all joints, in order to ensure air-tightness. The materials used are iron and aluminium sections, properly studied and manufactured, and press-formed, welded steel sheets, varnished with epoxy powders at 200ºC, mainly not polluting and inert, due to the high temperature to which it is subject.
To realize the air tightness, gaskets are used that work in compression, mounted along all joints that could leak air: the materials used for the gaskets are elastomers and synthetic fibres which do not release toxic substances.
For the glass surfaces, it was used extra-clear glass that, for its particular chemical composition with low iron content, is free of any chromatic shade. The light transmission coefficient and the colours performance are higher that those of the crystal sheets commonly used which, even if considered free of colour, always present a light green shade that could interfere with the perception of the works' colours.

Safety performances:
Protection of the exposed works from thefts and vandalism is guaranteed by a safety layered glass, chosen based on safety considerations, and on the showcase's dimensions.
The metallic structure and the complexity of the handling and closing system, also protect the work from thefts.

III – The new safety showcase of the "Gioconda" by Leonardo da Vinci (dated 1504)
Research project in collaboration with the Energy Department of Milan Polytechnic, directed by Prof. Cesare Maria Joppolo.[7]
Picture 6

The main needs consisted in guaranteeing the proper conservation of the board and also the maximum safety levels against thefts, vandalism, and terrorism.

Conservation state: The painting's support is a thin poplar board of convex form, extremely reactive to environmental changes. Due to temperature and humidity changes, worsened by the constant increase of visitors (six millions a year), the wood panel was gradually bending, with the risk for the painting film to detach.

An Italian team got in charge of the restoration work and made it “smile again”.
The Italian team is the research group in the preventive Conservation field and is in charge of the Exposition in the Museum called “Laboratorio Museotecnico Goppion”, with more than 50 years of experience.

It is easily inferred that the conservation aspects of the board were the major concerns for restorers and the showcase’s manufacturers.
The requests of restorers, as regards the climate control of the exposition space which is about 1.5 cubic metres, were therefore extremely demanding:

1) Highly air-tight showcase: the peremptory “option dix jours”, a complete exchange every 10 days.
2) Safe and effective stability of relative humidity.
3) Absence of (chemical, parcel, biological) pollutants inside the exposition space.

To these requests, the following solutions were given:

- A steel structure on three sides, closed at the front by an armour-glass sheet, inside of which an environment with constant temperature (20º) and humidity (52%) values must be guaranteed. The opening of its three by two and half-metre door, and the handling of the weight of more than six hundred kilograms are possible with no effort from the operators.
- An anchoring system of the board, studied to quickly remove the board in case of fire or other emergencies by the operators, once the locks have been released
- An air-tight mechanical system, made up of a complex compressors and levers system that pulls the door together with special gaskets, with air exchange every twelve days, instead of ten. Indeed, the proper functioning of the entire circuit is based on the assumption that the air exchanges between the interior and exterior of the showcase are extremely reduced.
- A double customized and miniaturized climatic control system, which in addition to maintain the relative humidity constant inside the showcase that encloses the precious board, also protects it from bacteriological pollution.
- Everything is located on a shelf in front of the board. The system is built so as to self-adjust, without the need for external interventions: behind the painting, there are indeed some sensors that constantly measure the environmental

conditions, air temperatures and humidity: the data is sent to the exterior and collected by an electronic regulator which automatically manages the system, the alarm signals, and the communication between the two parallel systems.

Picture 7

The climatic control system was developed in collaboration with the Energy Department of Milan Polytechnic, directed by Prof. Cesare Maria Joppolo, and tested at the Laboratorio di Condizionamento dell'Aria e di Refrigerazione (Refrigeration and Air Conditioning Laboratory) of the same Polytechnic.

"For humidity control, passive and active systems have been combined for the first time in the museum. The former uses hygroscopic materials of mineral origin as silica gel that, thanks to their chemical-physical characteristics stabilize the relative humidity conditions in confined environments. In practice, they have a buffer effect: they capture and cede humidity according to the humidity content present in the air", explains Mr. Cesare Maria Joppolo. It is the most renowned system nowadays in the most famous European museums, as the British Museum, also for the conservation of electronic and optical devices. "Unfortunately the silica gel's salts gradually exhaust their absorbing/humidifying power, and this impedes to keep constant values in the long run".

The active system instead is made up by a group of devices that regulates the relative humidity, so as to keep it constant on programmed values, by exploiting the air heating/cooling mechanism, which is also at the base of residential systems: air cooling causes vapour formation, therefore the steam turns into liquid and decreases the humidity in the air; vice versa, in order to humidify the air, water is heated until it evaporates. In various museums – only a few in Italy and Greece – a general conditioning system of the environment is present, while it is rare the localized treatment around the single art work. “Each painting has different needs, according to the board, or fabric, and the materials from which it is composed”, explains the professor. And this is the real step forward of the system studied for the Monna Lisa. Once the common compression cooling and absorption cycles have been disregarded – due to sizes, noise levels, regulation aspects, and problems linked to possible leaks of the cooling fluid – the most suitable method is the one that uses thermo-electric effects, in particular the Peltier effect. “Created for electronic and space applications, Peltier cell produces heat and cold through the passage of electric current in a proper semi-conductor material, with no vibrations or relevant temperature and humidity changes”.

The “mixed” system combines the action of the active system, which stores the liquid steam (produced by the dehumidification process) and evaporates it when it is necessary to humidify the showcase’s air, with a suitable hygroscopic buffer material, typical of passive systems. To this, it is also added a ventilation network which allows the proper air diffusion in the showcase, and its circulation in the system’s components.

The climatic control system is shown in the image. First of all two parallel systems were realized, one of which is in stand-by as back-up system, in case the other one fails. The “Gioconda is sick” call was aiming at infallible safety levels. Picture 8

It was then decided to apply small fans so as to optimise air flows inside the showcase, not relying upon the simple inertial and convection movements. Some sensors have been placed behind the board and in various points of the showcase that send the collected data to an exterior processor that manages the system in its whole.

Picture 8

The mixed stabilization system was applied by Goppion in various occasions, to an extent such to obtain a patent in 2000. In the specific case of the Gioconda's showcase, it saw the association of absolute anti-particles filters, of the fans for optimal air recirculation and the management of the system by an exterior processor. The advantages of the system are mainly the following:

- It reduces oscillations around the programmed set-point (52% in case of the Gioconda), typical of on-off systems.
- It maintains the relative humidity value in case of failure of the active air conditioning system, due to lack or improper device maintenance, thanks to the "quick intervention" of the buffer material.
- It maintains the relative humidity value in case of technical failure (due for example to short circuit) of the active air conditioning system.
- It is equipped with an alarm system that activates at critical times (exterior climatic variations, unforeseen and excessive flow of visitors, etc.) or inefficiency.

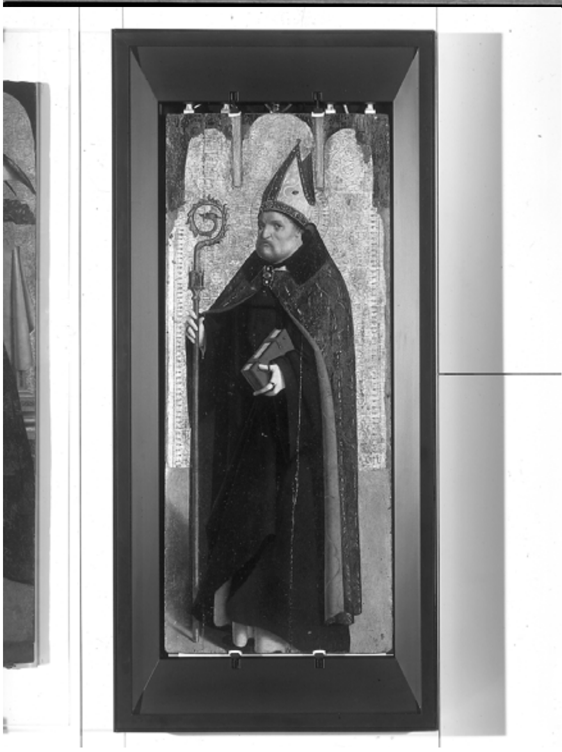
In conclusion, for pollutants control, the circuit is equipped with class H13 absolute filters, of high efficiency, able to also stop very thin particles (less than a micron) and the biological pollutants that can penetrate in the shrine, through infiltration during the regular functioning, and when the shrine is opened. They are filters similar to those installed in some operating theatres or in white rooms where medicines are produced, but more precise and silent: also in this case indeed, the experts of the Polytechnic employed the high technology of aerospacial applications, by using a highly effective filter and an extremely low air passage resistance, therefore by moving air without the need for big fans, with minimum noise and air movement, which would damage the board.

The system, prior to being applied to the showcase, was tested in the Laboratory with measurements of quality type (research for break-even points, humidity and pollutants infiltrations/exfiltrations, visualization of air movements, presence/absence of stagnation areas) and of quantity type (air humidity and temperature, decay time and number of exchanges per unit time, number of particles).
All these checks allowed to perfection the whole system on time, both from a mechanical (gaskets compression and airtight level) and climatic viewpoint (effectiveness of the interior air recirculation and its treatment).

IV- Exposition and transport of the San Benedetto by Antonello di Messina (dated 1470):

Civiche raccolte d'Arte. Castello Sforzesco di Milano.

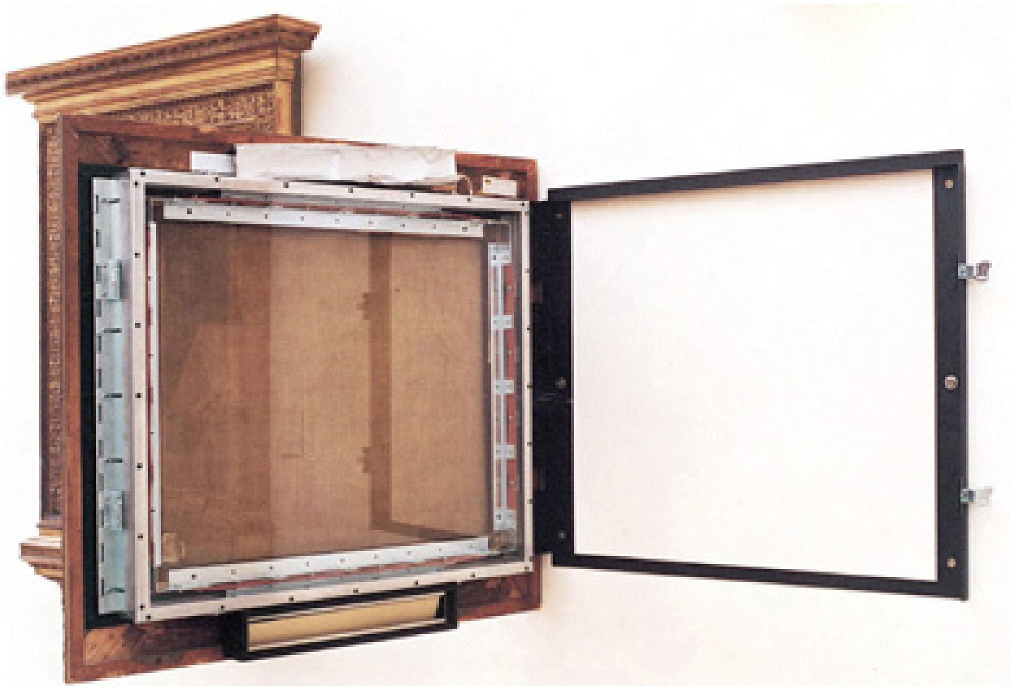
Picture 9 -10



Conservation State: oil painting in good conditions, poplar wood support deformed and fragile, with relevant cracks.
A support frame was prepared so that the board would not be subject to mechanical stresses, due to the anchoring method and also to its own weight. Suitable anti-vibration and shock-proof systems have been placed, and a controlled micro-climate shrine was built with hygroscopic buffer material, equipped with relative humidity and shock sensors able to detect and store data, connected to an exterior processor for sensors programming and data analysis. In conclusion, a transport module has been created.[8]

V- The protective showcase of the "Compianto sul Cristo Morto" by Andrea Mantegna (dated 1500):
Pinacoteca di Brera, Milan

Picture 11



Picture12

It is a shrine, located behind the frame, which only encloses the painting on fabric (as for this case) or board, and that, by rotating it on proper hinges, allows to inspect the rear of the painting without opening the shrine. A case that has obtained an international patent, due its originality in its whole and in some details as the elastic supports of the painting to damp any minimal vibration, [9]

VI- The stable and itinerant protective showcase for the exposition of the "Dama con L'ermellino" by Leonardo da Vinci (dated 1490):
Cszartosky Museum. Krakow

Picture 13

Leonardo's painting, stored at the Czartoryski Museum in Krakow, was the protagonist of an Italian "tournee" that saw it exposed at the Palazzo del Quirinale in Rome, at the premises of the Presidency of the Italian Republic, Palazzo Pitti in Florence, and the Pinacoteca di Brera in Milan.
For its exposition, an air-tight shrine was designed and built, introduced in a self-supporting steel wall

with perimetral protection balustrade; extra-clear anti-vandalism crystals which are anti-reflex treated, equipped with sensors and alarm unit. The shrine is also provided with passive relative humidity control and filtering of polluting gases. [10]

VII – The protective showcase of the "Pala del Castelfranco" by Giorgione (dated 1500):
Venice, Gallerie dell'Accademia

Picture 14

Lightness and effectiveness can be the subtitle of this showcase. An imperceptible shell inside of which a complex system of moduled size optical fibres highlights the brightness of the board whose conservation is guaranteed by the Peltier Cells relative humidity stabilization system. [11]

Legends for pictures:

1. Relocation on the "Madonna della Clemenza e della Pace" Altar (end of VIth century, beginning of VIIth century a.c.). Santa Maria in Trastevere, Rome.
2. After the restoration.
3. Relative humidity control semi-active system.
4. The protection and handling structure.
5. Rotation opening system with two doors for the conservation control.
6. The new protective showcase of the "Gioconda" by Leonardo da Vinci (dated 1504), Louvre Museum, Paris.
7. The shelf that houses the double climatic and the bacteriological pollution control systems.

8. A closed circuit against exterior aggressions.
9-10 Exposition and transport of the Benedetto by Antonello da Messina (dated 1470)
11. The protective shrine of the "Compianto sul Cristo Morto" by Andrea Mantegna (dated 1500)
12. Opening system with two doors for the conservation control.
13. The stable and itinerant protective shrine for the exposition of the "Dama con L'Ermellino" by Leonardo da Vinci (dated 1490);
14. The protective shrine of the "Pala del Castelfranco" by Giorgione (dated 1500): Venice. Gallerie dell'Accademia.

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[10] Esposizione temporanea della *Dama con l'ermellino. Annals of the Laboratorio Museotecnico III.* p.p.193-200

[11] From the archives of the Laboratorio Museotecnico Goppion