Handbook on

CONSERVATION *IN MUSEUMS*

Dr. V. Jeyaraj

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HAND BOOK

ON

CONSERVATION IN MUSEUMS

By
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FOREWORD

'Conservation' is one of the prime functions of Modern Museums. Consequently, museologists, museographers and archivists are in utmost need of guidelines to be adopted in preserving the priceless objects acquired through various modes. The Government Museum, Chennai is gifted with a fully furnished Chemical Conservation Laboratory since 1930. It is one of the best laboratories in India.

The author of this book entitled, "Conservation in Museums", Dr. V. Jeyaraj is the Curator in charge of conservation in the Government Museum, Chennai. He has acquired considerable experience while working in the museum in the twin fields of both 'Curative Conservation' and 'Restorative Conservation'. This book was first published during 1995. As the book has been sold out within a short span of time, it was decided to reprint it this year.

I hope that this reprinting will be useful to scholars, students, professionals and conservation chemists.

CHENNAI-600 008

15-3-2002 AD

(**Dr.R.Kannan**, Ph.D., I.A.S.)

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PREFACE

The Chemical Conservation and Research Laboratory of the Government Museum, Chennai is one of the pioneering conservation laboratories attached to museums in India. This is the first of its kind, which conducted the conservation-training programme in 1974. The first Curator of the Laboratory, Dr. S. Paramasivan through his pioneering research got recognition for his conservation activities. Many followed him in this Laboratory. Messers R. Subramanian, N. Harinarayana, S. Thangavelu are some of them to mention. Even though the museum was conducting such courses, there were no study materials available for the participants of the refresher course. I entered into the museum profession in 1978 without knowing anything about conservation. But the interest created by Dr. S. T. Satyamurti, then Director of Museums was so great. I began to learn from Mr. N. Harinarayana, then Assistant Director of Museums, fundamentals of conservation of museum objects.

I was awarded an UK Visiting Fellowship by the Nehru Trust for the Indian Collections at the Victoria and Albert Museum, New Delhi in 1994. I visited many laboratories in the UK, Paris and Berlin and the various conservation policies were studied by me. Soon after my return from UK, I was concentrating on writing a book on Conservation of Museum Objects. Since most of the participants of the Refresher Course on Care of Museum Objects wanted the study material, it made me to write the book, Handbook on Conservation in Museums and published it in 1995 by the encouragement given by the then Commissioner of Museums, Thiru. M. Ramu, I.A.S.

This book exhausted soon and it was proposed to reprint the book. This publication has come out as a reprint with photographs and some new topics on conservation. I thank the Commissioner of Museums,

Dr. R. Kannan, Ph. D., I. A. S., for including the book for reprinting. I am thankful to the staff of the Laboratory, Messers. J. D. Jagannathan, P. Balachandramurugan, S. Sampath and to my research scholars. I thank Mr. K. Lakshminarayanan, Assistant Director and Dr. C. Maheswaran, Curator for Education for reprinting the book. I thank my wife, S.R. Hepzibai, my son, J. Abraham Durairaj and my daughter, J. Christy Veda for their help in bringing out the reprint. I thank M/S. Smart Fonts for their excellent execution of the book.

I hope this will serve as a source book on Conservation of Museum Objects for those interested in the conservation of museum and related objects.

Chennai - 600 008,
14-3-2002.

(V. Jeyaraj)

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PART - I

GENERAL

INTRODUCTON

A museum was considered as a temple of the muses- *mousein* (Greek) up to 15^{th} Century AD. In the 15^{th} Century museum was considered as a building used for the storage and exhibition of historic and natural objects. According to the ICOM, "Museum is a non-profit making permanent institution in the services of the society and of its development and open to the public, which acquires, conserves, researches, communicates and exhibits for purposes of material evidence of man and his environment". In Venice, for the first time museum was made available for visitors in 1523 AD. In 1625 AD a collection of biological specimens and artefacts by John Tradescant and his son at Lamberth, London was made available for public. In India the first museum was started at Kolkata (Calcutta) in the beginning of this century. The first museum (Government Museum, Chennai) in Tamil Nadu was started in 1851. The museum movement took a shape in the 1950s and now in India over 750 museums are present, which are of various categories like National Museums, Regional Museums, State Museums, District Museums, University Museums, Local Authority Museums, College and School Museums, Private Museums depending upon the agencies which run the museum. Depending upon the activities of the museums, they are classified as Multidisciplinary Museums, Archaeological Museums, Science Museums, Transport Museums, Personalia Museums etc.

Now a days, museums are considered to be Institutions, which preserve the hoary and glorious past through the original materials for posterity besides making the visitors to understand them and enjoy. Most of the earlier day museums were established because of the bequest of rare objects by individuals. Nowadays, State Governments are taking keen interest to establish museums. The Department of Museums, Government of Tamil Nadu is keen in opening museums in the district headquarters in order to make the people of the district to know about their past and the materials of the state besides giving information and enjoyment to the visitors. At present there are 20 museums under the control of department of museums and 16 museums under the department of archaeology. Besides these, there are central government and private museums.

Museums are actively involved in increasing their collections through field collections, gifts and exchanges, purchases, treasure-trove finds, confiscation of objects etc. The major archaeological collections like bronze icons, coins, jewelleries are through the Treasure-trove Act of India, 1878. Acts like Treasure-trove Act of India, 1878, The Antiquities (Export Control) Act 1947 help the museums to preserve the precious antiquities for posterity. The important roles of a museum are collection, preservation, documentation, display, research, publication, outreach, public relation, training etc. Among the various activities of the museums conservation is the most important one.

Museum objects are varied both material-wise and subject-wise. Objects of daily use, utensils and tools, paintings and decorative art, folk art, ethnographic, tribal, cultural and contemporary art, natural history, etc., are not having similar properties. Many of us think that once an object enters the museum, the responsibility of the Curator is over. These objects before their entry to museum attained equilibrium with the surroundings. But, most of the objects try to deteriorate as soon as they reach the museum as the new environmental factors start to interact with the objects.

In fact conservation of cultural property means remedial measures to be taken to eradicate the defects already present in the objects and protecting them from further damage by maintaining certain conditions for their better preservation. To remedy the defects present in an object and to remove the unwanted materials, one has to examine the object, diagnose the defect, documenting its condition and the type of treatment needed and then treat it. The custodians should know therefore the characteristics of the objects, their chemical behaviour and the effects of environment and other causes of deterioration.

In the European countries, most of the museums have classified their collections areawise not materialwise and therefore the head of the collections has to know much about all the materials. The objects are better preserved when custodians, conservators, designers and administrators co-ordinate. In India most of the museums are headed by a Curator who may be a specialist in a particular subject. Very few museums have the conservation facilities with them. Proper house-keeping will help the objects to be in a good environment. If the custodian is aware of the dangers involved and precautionary measures to be taken against them, he can preserve the collections better. He should know the deteriorating factors, the symptoms of deterioration, methods of handling the objects, display techniques, storage principles, packing devices, transportation, safety measures, vandalism, neglect etc., for better maintenance of his collections.

CLASSIFICATION OF OBJECTS

Any object representing culture, art etc., preserved in a museum qualifies itself to be a museum object. They vary from one to the other due to nature, type, property etc. Their vulnerability to damage and their control measures also differ. Depending upon the type of treatment to be given to the objects, they can be classified as follows:

1. Metals
2. Organic objects
3. In- organic objects and
4. Paintings.

Metals

Metals and alloys form a major portion of museum collections. They are bronze icons, bells, vessels, weapons, jewelleries, coins etc. They are affected by corrosion. The corrosion products should be removed and stabilised avoiding further corrosion.

Organic Objects

Materials derived from living organisms are organic objects. Wooden objects like temple cars, doors, *vahanas*, clothes, palm leaves, leather objects etc., are prone to climatic changes. The environment should be stable and the objects should be attended to carefully, as insects also at large easily affect them.

In-Organic Objects

Inorganic materials are very stable. They are complex in nature. Stone pillars, sculptures, inscriptions, terracotta objects glass, ceramics etc., are some of the inorganic materials. They are mostly exposed to the atmosphere and are affected both by rain and weathering takes place. They should be treated and preserved.

Paintings

Whatever may be the medium, type and variety, the paintings are multi-layered and therefore, they require special study and treatment. There are various types of paintings like murals, oil paintings, water colour paintings, panel paintings, glass paintings, miniatures in paper etc.

HISTORY OF CONSERVATION AND CONSERVATION LABORATORIES

Evolution of Conservation

The application of chemistry to study the decay and conservation of antiquities is not new. In the middle of 19^{th} Century Michael Faraday studied the deterioration of easel paintings and others were already applying the method of chemical analysis to determine the composition of objects particularly those made of metal. The first scientist to have been employed in a museum, however, appears to have been Friedrich Rathgen, who headed the laboratory in the Royal Museum in Berlin from 1888 to 1927. Rathgen published his methods in a book, which was subsequently translated into English. Also in the mid 19th Century, the National Museum in Copenhagen, faced, in particular, with he problem of preserving an increasing number of waterlogged wooden objects found in Peat bags, employed its first conservator, V.F. Steffensen, in 1867. In 1896 Gustier Rosenberg, who also left a testament to his career in book form, joined him.

A new laboratory, named after Rathgen, was founded in Berlin in 1975. The First World War, however, can be credited with initiating the scientific conservation of antiquities in the UK, because when the objects of the British Museum, London were unpacked in 1919, after wartime storage in the underground railway tunnels, some of them were found to have noticeably deteriorated. As a result, the Department of Scientific and Industrial Research appointed Dr. Alexander Scott, FRS as a consultant to the British Museum and in 1926 Dr. Harold Plenderleith, M.C. was recruited as a full-time Conservation Scientist. His career is well known, culminating in the establishment of the International Centre for Conservation in Rome.

The positive emergence of conservation as a profession can be said to date from the foundation of the International Institute for the Conservation of Museum Objects (IIC) in 1950 and the appearance soon after in 1952 of the Journal, Studies in Conservation. The role of the conservator is distinct from those of the restorer and the scientist had been emerging during 1930 with a focal point in the Fog Art Museum, Harward University, which published the precursor to Studies in Conservation, Technical Studies in the field of the fine arts (1932-42).

UNESCO, through its Cultural Heritage Division and its publication, had always taken a positive role in conservation and the foundation, under its auspices, of the International Centre for the Study of the Preservation and the Restoration of Cultural Property (ICCROM), in Rome, was a further advance. The Centre was established in 1959 with the aim of advising internationally on conservation problems, co-ordinating conservation activities and establishing standards and training courses.

A significant confirmation of professional progress was the transformation at New York in 1966 of the two committees of the International Council of Museums (ICOM) one curatorial on the care of paintings (1940) and the other mainly scientific (1950) into the ICOM Committee for Conservation.

From the early 1960s onwards, international congresses (and the literature emerging from them) held by IIC, ICOM, ICOMOS and ICCROM not only advanced the subject in its various technical specialisation but also emphasized the cohesion of conservators and their subject as an interdisciplinary profession.

British Museum and Victoria and Albert Museum (all types of objects) in London; Freer Art Gallery (paintings), Getty Conservation Institute in USA, Louvre Museum, Paris, Rathgen Research Institute, Berlin are some of the institutions, which do remarkable work on conservation.

Although the number of conservation scientists in the world has increased significantly in the last 30 years, it is small in relation to the problems faced in trying to conserve the cultural heritage of mankind.

EVOLUTION OF CONSERVATION IN INDIA

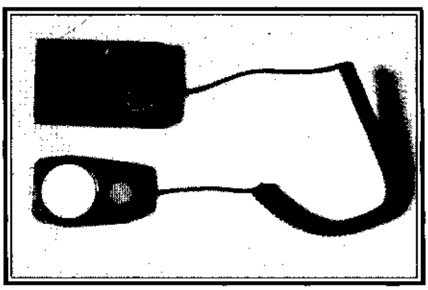
The conservation branch of the Archaeological Survey of India was established in 1917 in Dehradun for the conservation and preservation of archaeological antiquities and momuments. The beginnings of conservation chemistry in India may be stated to date from the time of its inception in 1917. Dr. R.K. Sharma is the Director (Science). Madras Government Museum was the first of its kind to establish a conservation laboratory in 1930 with the appointment of Dr. S. Paramasivan and developed by Mr. N. Harinarayana susbsequently. National Museum, New Delhi, established its conservation laboratory in 1950. Conservation Scientists like Mr.T.R. Gairola, Dr. O.P. Agrawal, Mr. A.S. Bisht have contributed much to the National Museum, New Delhi. Indian Museum, Kolkata and Salar Jung Museum, Hydrabad, concurrently started their respective laboratories in 1960. It is needless to state that in recent years there has been a rapid growth in conservation awareness in India. Under the guidance of International Organisations such as UNESCO and ICOM (International Council of Museums) several museums laboratories and national institutes have been established. Today, there are over 50 museum conservation laboratories instituted all over India. National Research Laboratory for the Conservation of Cultural Property was established in 1979 at New Delhi by Dr. O.P. Agrawal, later it was shifted to Lucknow to cater to the national conservation requirements and to carry out research programmes in the conservation of cultural properties. Dr. Tejsingh heads it. Its branch, the Regional Conservation Laboratory was established at Mysore in 1987. Recently the Indian National Trust for Art and Cultural Heritage (INTACH) has established the Indian Conservation Institute with the efforts of Dr. O.P.T. Agrawal, the retired director of the NRLC. It has its branches at Bangalore, Bhuvaneshwar, New Delhi, Rampur, Trissur. National Museum in New Delhi has started the National Museum Institute in which conservation is one of the departments, which is headed by Dr. I.K. Bhatnagar. The Indian Association for the Study of Conservation of Cultural Property is committed to conservation personnel and profession in the country. The present President is the author and the Secretriat is at National Museum, New Delhi. Mr. S.P. Singh, the Chief Restorer in the National Museum, New Delhi in the present Secretary.

ATMOSPHERIC FACTORS AFFECTING MUSEUM OBJECTS

Conservation refers to the whole subject of the care and treatment of museum objects both movable and immovable. The two aspects of conservation are the control of the environment to minimise the decay of museum objects, and their treatment to arrest decay and to stabilise them where ever possible against further deterioration. Therefore one who is interested in the conservation of museum objects must know the damaging effects of the environment on them such as light, humidity and air pollution, sound and vibration and what to do to minimise their damage.

Light

Light is a form of energy. It can change colours, can bring about deterioration on the surface; where surface is the very essence of exhibits like paintings, drawings, textiles and can bring down the strength of the object. Stone, metal, glass and ceramics are not affected but all organic objects such as cellulosic and proteinaceous are affected. Light is much more potent than heat as far as art objects are concerned. The spectrum of radiation from museum light sources such as daylight, fluorescent and incandescent lamps etc., can be divided into three regions, by wavelength. They are ultraviolet radiation (300-400ηm), light or visible radiation (400-700ηm) and infrared radiation (beyond 700ηm). The light of wavelength up to 500ηm brings about degradation on materials by photochemical reaction. Therefore the light should not directly fall on the objects, but only reflected light from a surface painted with zinc oxide or titanium oxide should be allowed. These chemicals absorb the ultra-violet radiation from the light.



Lux Meter

All textiles are subject to damage by light, as many of the colours used in miniatures, water colours and art on paper, natural history specimens are sensitive. Oil paintings change more with light. The paint medium whether oil, egg, gum or glue is certainly damaged by light.

The colours of the materials absorb both the ultraviolet and the visible radiation and they deteriorate. Day light has the highest proportion of UV radiation and therefore, it must be filtered. Fluorescent lamps have less UV radiation than day light but they need to be filtered. Light from incandescent lamps need not be filtered, as they do not emit UV radiation. The illuminance of light is measured in terms of lux. Digital lux meter is used to measure the intensity of light. Different papers like Rhodamine-B paper, to monitor the visible light and litharge paper, to monitor ultra-violet radiation have been developed. By the change of colour the corresponding intensity of various lights can be inferred. The rate of damage depends on the exposure. The exposure is the simple product of illuminance and time. Therefore in order to reduce damage to objects by light, we have to reduce both intensity and illuminance time. When we want to control the illuminance it is better to have artificial lighting up to 50 lux. In order to avoid glare and have a good look of objects, the light should be partly directional and partly diffused. Fibre optics are nowadays used in the European museums. In the Government Museum, Chennai the oil paintings by Raja Ravi Varma are displayed in the National Art Gallery where they are lit by the fibre optic lighting. This lighting does not produce both heat and UV light.

The problem of day light in museums is not yet solved. There are many ways of reducing exposure in particular circumstance that the most that can be done are as follows:

1. Limited exhibition materials should be brought out from stores.
2. Illumination should be given only during opening hours.
3. Illumination may be provided only while on view.
4. Use of replicas may be thought of.
5. Curtains over desk cases are a best conservation measure, which should be followed.

Heat

A small change in temperature can have several effects. But temperature change is not as important as humidity change except when it, in effect, causes humidity changes by drying.

Storage with low temperature can be of benefit to archival materials and textiles. Excessive radiant heat must be avoided, but there should be no problem at 50 or 200 lux of light. Rise in temperature influences the rate of deterioration by light.

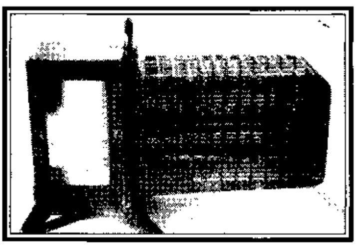
Humidity

The moisture content of air is humidity. Objects originated from plants and animals have water in them. If the moisture is taken away from wood, ivory or bone, they contract and very likely to split and warp. The absorption of moisture makes objects swell and vice-versa. In changing size, they also may change shape or warp. Many museum objects are made of composite materials. The humidity is measured by a scale of relative humidity (R.H.).

$$R.H. = \frac{\text{Amount of water in a given quantity of air at a given temperature}}{\text{Maximum amount of water which the air can hold at that temperature}} \times 100\%$$

There are various instruments to measure the R.H. They are sling or whirling hygrometer or sling psychrometer, hair hygrometer, recording hygrometer, electronic hygrometer etc. Use of a reliable electronic hygrometer with self-checking device or of a wet-and-dry-bulb instrument is essential for calibrating other R.H. recording instruments.

Various classes of museum materials respond to R.H. The different modes of deterioration, which are influenced by R.H., are physical, chemical and biological modes. All moisture absorbent materials, such as wood, bone, ivory, parchment, leather, textiles, basketry and matting, and adhesives swell when the R.H. rises and shrink when it falls, causing warping, dislocation between parts, splitting, breaking of fibres etc., especially at low R.H.



Thermo Hygometer

Most insect pests flourish at higher humidities. Very low humidities would be preventive but impracticable. Insect damage may be discouraged but cannot be prevented by humidity control. Freeze-drying is done at a very low temperature such as -20° - 30° C.

Humidity Control

Air-conditioning is the best way, as it not only controls humidity but also removes dust and gaseous pollutants from the air. One single equipment cannot humidify and dehumidify. Therefore, humidifier or dehumidifier can operate but with a humidistat, which maintains a constant R.H. automatically by switching a heating system on and off.

There are electrically operated humidifiers of atomising and evaporative types and dehumidifiers of desiccant and refrigerant types. For humidification, an evaporative type of humidifier should be chosen because of its convenience. For dehumidification in warm climates, a refrigerative type of dehumidifier and in cold climates a desiccant type should be used.

In the showcases a buffer can be used. A buffer is a moisture-containing solid which, when the R.H. rises, absorbs moisture and gives it out when the R.H. falls. The best buffer is silica gel, not in its dry form, but brought into equilibrium with air of the required R.H. 2 kg silica gel per cubic metre of case volume is suggested for best result.

In the closed cases, a bowl of specified solutions may be kept in which the water will evaporate and gives R.H. depending on the salt. At 20° C magnesium nitrate gives, in practice, about 50% R.H. and sodium bromide about 58% R.H.

High R.H. in museum buildings is due to flood and high monsoon. Floods are rare, but dampness in buildings is the main cause for humidity. Dampness in buildings may originate from roof, foundation, exposed wall, plumbing failure, toilets or drinking water facilities etc. It may also be carried in by visitors. This dampness may be brought to control in the event of no humidity control system by ventilating the outside climate through windows, dry conditioning by electric immersion heaters and fans.

In the event of dry weather bowls of water may be kept at spots. The window *cus-cus* curtains may be moistened to allow cool air inside the galleries.

Air Pollution

Air pollution is one of the serious dangers posed to museum objects. The various means by which air pollution created is, particulate matter, gaseous pollutants, salt sprays, sound and vibration. Air pollution, therefore, is the contribution of various factors.

Particulate Matter

Particulate matter in the atmosphere is due to expulsion of smoke in the factories, due to fuel combustion, vehicular traffic, salt spray from the sea, etc. The normal level of particulate matter in a clear weather is 0.9 to 1.5 microgram per cubic metre. In a highly industrial area of a foggy weather it goes up to 5 microgram per cubic metre. The walls of new concrete buildings give off dust of alkaline in nature inside the buildings.

Removal of Particulates

Particulate matter can be avoided to certain level by well made closed show cases in exhibition rooms and polythene bags in storage, providing screens to windows, foot-mattresses at the entrances, regular vacuum cleaning etc. Removal of particulates involves full ducted air-conditioning so that air passes through the filters. Disposal of water by firing should be avoided in the campus as it creates particulate matter in the campus.

Gaseous Pollutants

Like the particulate, gaseous pollution is caused at large by the burning of fuels in power-station, factories, domestic buildings and automobiles. There are various pollutants in the atmosphere. They are oxides of sulphur, nitrogen and carbon, ozone, hydrogen sulphide etc.

Oxides of Sulphur

When the fuel is burnt sulphur combines with oxygen in the air to form sulphur dioxide. Sulphur dioxide further combines with oxygen to form sulphur trioxide. As soon as this is formed it combines with water to form sulphuric acid. Sulphuric acid is a very strong and corrosive chemical and it cannot be removed by cleaning the air because of its involatility. The chief materials to suffer from sulphur dioxide pollution are calcium carbonate containing materials like marble, limestone, frescoes, cellulosic materials like paper, cotton, linen, proteinanceous materials like silk, leather, parchment and wool, other organic materials, metals etc.

Oxides of Nitrogen

There are various oxides of nitrogen; among them nitrous oxide and nirogen peroxide are harmful to museum objects. But nitrogen oxide has a concern in the museum environment. It is soluble in water and forms a strong acid, nitric acid. It is more dangerous than sulphuric acid.

Carbon dioxide

The oxides of carbon are carbon monoxide and carbon dioxide. Carbon dioxide dissolves in water in the atmosphere to form carbonic acid. Even though this acid is weak, it affects all organic materials.

Ozone

Ozone is a poison found at high concentration in polluted areas. Ozone can enter the museum from three sources; by the natural production in the upper atmosphere, by the effects of sunlight on automobile exhaust gases and from certain kinds of lamp and electrical equipment, which are used inside the museums.

Ozone affects unsaturated organic compounds. Ozone also increases the rate of oxidation of silver and iron and sulphidation of silver and copper. Fading of colour from paintings, textiles, natural history specimens is expedited by ozone.

Salt Sprays

The salts present in dust in the atmospheric air are chlorides, silicates, carbonates, ammonium sulphates etc. The chlorides are the most dangerous contaminant, which affects metals, stone objects, terracotta objects etc. Droplets of seawater are thrown into the air, and they may evaporate to form sodium chloride crystals, which are carried by the wind inland. In fact only coastal museums will be affected most. Research has indicated that a level of up to 5 micrograms per cubic meter of chloride may be found anywhere, even far inland.

Pollution from the Materials of Display and Storage

Even though we are able to eliminate all outside pollutants there is a problem from within the showcases and storage, contributed by the materials used. Some types of rubber, composite board, wood used in the display cases and storage give off organic vapours such as organic acids volatile sulphides and they affect metals especially, lead, silver and photographic materials. The adhesives used give off certain harmful gases. Cellulose nitrate gives off nitrogen oxide vapours, poly vinyl chloride gives off hydrogen chloride. Materials used for display and storage are subjected to Oddy's Test [finding out the increase of weight of a polished copper foil after exposing it to sulphide atmosphere] to find out their suitability for the display and storage purposes in the museum.

Removal of Gaseous Pollutants

It is essential to keep the museum objects out of the contact of the gaseous pollutants. There are two well-known methods for removing the gaseous pollutants in the museum environment. They are (1) water spray methods and (2) activated carbon filter method. In the water spray method air is passed through a water spray in the air-conditioner by which the soluble oxides of nitrogen, sulphur and carbon are absorbed. But ozone is not absorbed by this system.

Activated carbon filters and copper impregnated activated carbon are used to absorb the gaseous pollutants. They have to be replaced periodically. Copper impregnated activated carbon filters are replaced once in 5 years. Disposal of waste materials by firing should be avoided to cut off the oxides.

Sound and Vibration

Sound and vibration affect weak museum objects. Sound affects museum objects and therefore a specification is suggested for maximum allowable background noise from traffic and local machinery in an exhibition or storage area. Vibrations caused by building work, traffic, ventilation equipment and other machinery affect weak museum objects. High frequency sound and vibration should be avoided in the galleries and storage areas. Rubber cushioning may be provided for weak objects on display and storage at the bottom of the legs of the showcases as shock absorbers.

MISHANDLING, NEGLECT AND VANDALISM

Much of wear and tear, as well as accidental damages to museum objects can be significantly reduced by the judicious application of collection care management and adapting certain basic conservation principles. Many damages to the museum objects are attributed to poor handling, lack of training to staff, neglect and vandalism.

Mishandling

Human factors such as poor handling and lack of training to staff to tackle objects result in serious damages to the objects either in the storage, transportation or in museum galleries.

Careless handling of the objects results in soiling, dents, scratches, abrasions, tears etc.

Mishandling

Damage occurs when objects are dropped, objects tear or break when outsize or heavy objects are hand-carried instead of being transported on trolleys. Objects break when they are lifted from points of weakness. Surfaces of objects get damaged when surfaces of objects are dusted or cleaned with coarse or soiled clothes, brushes or vacuum cleaners carelessly.

Neglect

Neglect of museum objects results in various problems. Areas where any type of work on art objects is done must be kept absolutely clean. Very often its is noticed that perspiration and grease of hands stain art objects. The natural oils from hands, deposited on objects, attract dust, which is chemically harmful. It is advisable to wear clean cotton gloves when handling objects of art, or to use a clean cloth between hands and the object. Hands should not touch painted surface, as in the case of miniatures or manuscripts, photographs or slides and negatives.

Vandalism

Vandalism is a deliberate act by which damages are made on the museum objects. Acts of true vandalism are fortunately very few. The visiting public is generally respectful of the works of art on display. The motivation of the deranged individual to damage the objects take place in crowded galleries. The defacement of paintings or sculptures with graffiti by pencils, felt pen, etc., particularly on nudes and female figures have moral and behavioural connotations, which require study by psychoanalyses. Other instances of willful damage can be attributed to political, religious or racial fanaticism.

In the majority of situations the conservation and security precautions in museums are sufficient to prevent accidental damage, negligence and to inhibit the less determined vandal. These measures include physical or psychological barriers, such as floor elevations, ropes and stanchions or the total encasement of the objects in show cases. These barriers will deter many visitors from approaching too close and touching, marking or accidentally scratching the objects. However, mischievous visitors will find ways to outwit the guard. Other means of security protection depends on the guard's perception of deviant behaviour in visitors. Close circuit TV scanning of queues of visitors can often pinpoint strange behavioural patterns and the guard on duty can be alerted to be more watchful of the individual spotted. Another method is to pass the visitors, through airport style security electronic barriers and remove potentially harmful devices.

Whether it is mishandling, neglect or vandalism, it can be reduced to the minimum by the close monitoring of the duties of all the staff and by imparting training to the concerned staff who preserve the museum objects for posterity. It is always adviceable to keep the objects inside show cases to avoid uandalism. Most of the museums and monuments find it difficult to avoid graffiti on objects, walls etc.

BIODETERIORATION

There are various agencies like light, heat, humidity, pollutants, micro-organisms, which have deteriorating effects on the materials of museum objects. Of these agencies, biological agencies like micro-organisms and insects of various kinds are the most devastating. Almost all classes of museum objects such as stone sculptures, metal objects, cellulosic and proteinaceous objects, paintings are damaged by these agencies. Among them organic materials such as textiles, paper, fibrous materials are affected beyond restoration at times by the biological agencies.

Biodeterioration is any undesirable change in the properties of the materials effected by the activities of the living organisms. Tropical climate, temperature between 25°C to 35 °C and relative humidity above 70% favour biodeterioration.

Symptoms of Biodeterioration

The activities of the biological agencies can be noticed only by a close examination of the objects regularly. As soon as some changes are noticed on the objects they should be investigated seriously.

1. Stains and Discolouration

Because of the biological activities stains are formed on the objects. Foxing, a brown spot formation, in paper is due to micro-organisms. Excreta of insects, dead insects create stains on objects. Because of the excreta of insects, the pigments found in the objects get dissolved and discolouration takes place.

2. Erosion

Because of the frequent passage of certain insects erosion occurs on the object. The path of the insects are visible to naked eye even proving the maximum activity of the insects on the object.

3. Disfigurement

Insects eat away portions of the objects and permanent disfigurement is created. E.g. photographs are eaten by silverfish, wooden objects are eaten by termites. Rodents cut books and damage them.

4. Pitting

The surface of objects is pitted and become rough; metals by corrosion; stone by sulphate reducing bacteria and nitrifying bacteria. The surface of art paper becomes rough and looks ugly due to the eating of the surface coating by cockroaches.

5. Tunneling

Insects eat the organic based materials and tunnel through them leaving holes. This can be avoided if the objects are examined every day. This is faster when the humidity is high especially during the rainy days.

6. Fibre Formation

Because of the action of the biological agencies composite materials become fibrous. The binding medium found in the materials are eaten by the organisms and only the fibres present in the materials are present.

7. Powder Formation

Even though the insects are not visible, the powder falling from the objects will reveal their action. When the wood-borer beetles bore wooden objects, the powder formed falls down showing the activity of the biological agencies. This picture is an example, where heaps of powder in formed on a wood inlay work.


Powder Formation

8. Development of Odour

Distinct smell will be emanated when fungal growth is active. The death of rodents, insects, birds etc., will be inferred from the bad smell emanated from the area, where objects are on display or from storage.

9. Changes in Properties

Mechanical and chemical properties are lost in the objects due to biodeterioration. For example, materials become weak and light. They become loose, warp, crack, glossy nature is lost, they look mat etc.

Insects

Organic objects like wooden objects, leather, textiles, books, stuffed biological specimens etc., are worst affected by insects. Insects bore holes into the materials and eat voraciously. The insect menace is high due to high temperature and humidity. Some of the most common insects attacking materials are silverfishes, cockroaches, termites, moths, beetles, book lice and crickets.

1. Silverfish

Both the young ones and adults cause surface damages to paper, eat away glue, paste etc., from books and documents, herbarium specimens, photographic plates, paintings of the Tanjore style as they involve, paper, textile and paste. In order to eradicate them, 5% D.D.T., B.H.C. or pyrethrum in kerosene is sprayed.

2. Cockroach

Both the adults and young ones damage wool, leather, paper, herbaria, ethnographic and natural history materials, palm-leaves. 5% D.D.T., Chlordane, B.H.C. or Pyrethrum in kerosene as a spray, sodium fluoride, gypsum (1:1) as poison powder, Baygon Bait are the effective insecticides used for the eradication of cockroaches.

3. Termite

There are two main categories of termites. They are dry-wood termites and subterranean termites. The subterranean termites maintain a link with the earth, whereas the dry-wood termites live in wood. Adults bring about irreparable loss or damage to wooden objects, furniture, showcases, panels, books, textiles, and other cellulosic materials. Structural timbers may be coated with creosote, zinc chloride or sodium fluoride. AsCu (Dichromate - 4 parts, copper sulphate-1 part, arsenic pentoxide-1 part and water 100 parts). Sprays of Dieldrin, Aldrin, Durshban TC, D.D.T., B.H.C., Chlordane eradicate termites. Subterranean termites have the capacity to build the nest without any support to a height of two feet from the floor. Subterranean termites may be eradicated by treating the soil of the affected area by drilling pits and filling them with the solution of insecticides. Fumigation with ethyl bromide or carbon-di-sulphide is good for small wooden artefacts.

4. Book-lice

Adults of book-lice cause surface damages to paper, herbaria, leather, gelatin of photographic plates, Tanjore panel paintings, watercolor paintings etc. Such materials are fumigated with para-di-chloro-benzene to drive off the insects. Naphthalene balls are also used. A spray of 5% D.D.T. in kerosene may be given to the object.

5. Clothes Moth

The active stage of the insect pest, clothes moth is the larval stage. It destroys woolen fabrics, hair, fur, feather, stuffed mammals and birds. Fumigation may be done with 1% penta chlorophenol in alcohol. Arsenical paste (arsenic trioxide, alum, soap) is used in stuffing mammals and borax in case of birds. Fumigation may be done with para-di-chloro-benzene. Naphthalene balls may be used in closed boxes or where the materials are on display or stored.

6. Beetle

The larval stage of the beetles is active in damaging objects. The carpet beetles feed on hair, wool, feather, leather etc. The hide beetle damages leather, stuffed birds, dried fish etc. The wood-boring beetles bore into wooden objects, also book-bindings and palm-leaf manuscripts. The bookworm beetles tunnel into books, palm-leaves etc. Fumigation with methyl bromide, ethyl bromide or carbon-di-sulphide is an effective measure to control the beetles. 5% solution of pentachlorophenol, Pyrethrum, D.D.T. in kerosene may be sprayed.

Insect Trapping in Museums

In pest control treatment in museums, insect trapping is becoming a favourable means of early warning and monitoring of insect pest infestations. Insect traps normally consist of two components. They are an attractant and a killing and retention system. The attractants are food baits, light, coloured surfaces etc.

The insects attracted to the traps are killed and retained until they can be disposed off. Common systems are like electrocution by a high voltage grid, drowning them in the attractant solution, fumigation with a vapour phase insecticide, exhaustion of the insect in a closed container from which it cannot escape, adhesion to a sticky surface, as with fly-paper and sticky traps. Most types of insect traps are not suitable for use in museums because of their damaging effects on objects.

Most traps used in museums are sticky type where the sticky surface forms the base of an open-ended box. In this construction the sticky surface does not get accidentally to objects, visitors or staff and is protected from dust and particles, which would reduce its efficiency. Small triangular prism shaped traps typically with a base size of 2.5 x 3.0 cm using synthetic sticky materials of inert poly butenes will be of much use. Window-traps are nothing but a corrugated plastic with a central sticky well, have been found useful in catching larval forms of some pest insects. Owing to their see-through window over the sticky well, the window traps are valuable in showcases etc., where any catch can be seen without opening the case or disturbing the trap.

General Treatment for Insects

There are two main methods of treatment of museum objects with insecticides. They are:

1. Fumigation and
2. Dusting or application in solution form or fogging.

Fumigation

Fumigation is nothing but keeping the insect infested objects for few hours in an airtight chamber, where volatile fumigants, which are injurious to the insects are kept. Paradichlorobenzene, carbondisulphide, methyl bromide, ethyl bromide, carbon tetrachloride, naphthalene balls, ethoxide are some of the fumigants used in the eradication of insects from the infested museum objects of organic nature especially ethnographic, natural history specimens, documents, textiles, etc. Even if there is no infestation on the objects, the insect prone objects should be fumigated prior to monsoon. The choice of fumigants is very important as some are toxic and some affect certain materials.

Ethylene oxide has an adverse effect on leather, wet paper, paint, varnish, resin etc. Methyl bromide has an adverse effect on rubber, leather, woolen materials, paper, photographs, feathers etc. Fumigants will not have lasting effect on the objects and therefore periodic fumigation should be done.

Even though the application of insecticides in the solution form either by brushing, injecting or spraying is having certain health hazards, it has long effect on the objects. 5% solution of insecticides like D.D.T., B.H.C., D.D.V.P., pentachlorophenol, mercuric chloride are most suitable. Storage, cupboards, drawers, shelves etc., should be treated with the insecticides in the solution form.

Cryptogamic Plants' Growth

Bacteria, fungi, algae, lichen, liverworts and mosses constitute the cryptogamic plants, which affect museum materials. Among these, only fungi generally pose very high threat to museum objects. Bacteria are found to flourish only when the moisture content of the medium is very high. Organic objects like wood, textiles, paper, leather, musical instruments, certain paintings are disfigured and destroyed to a considerable extent on account of mould growth. Moulds, by reason of their ramifying mycelia, which can seek out moisture from a distance and transport it from one point of growth to another, can grow in atmospheres of little more than a 70% relative humidity. Fungi are unable to photo-synthesise their own food and hence damage the materials on which they grow. Usually they are aerobic (need air to grow) but some species are an-aerobic also. Fungal spore is present in the atmosphere all the time, but remain dormant. They become active and start developing as soon as conditions of humidity and temperature favourable for their growth occur.

Damages by the Cryptogamic Plants

Bacteria

There are various species of bacteria. Sulphate reducing bacteria affects iron objects, stone objects and sulphur containing objects. Besides this nitrifying bacteria is also very active.

Fungi

There are various species of fungi like aspergillus species, niger. Paper, cotton, textiles, ethnographic objects, wood, leather, outdoor stone objects, herbaria, stuffed birds and animals etc., are affected. Fungus degrades organic materials like paper, leather, textiles, and also causes stain on them. It disfigures paintings, stone objects and wooden materials and chemical and mechanical properties are changed. Oil paintings, which have rough surface also, found to be affected by fungi at high humidity conditions.

Control Measures

Control of bacterial and fungal growth on museum objects is two fold, viz., preventive and remedial or interventive. Since moisture is the very important requirement for the growth of bacteria and fungi, humidity control is the best preventive measure. Since most of the museums cannot afford to have air-conditioning facilities, proper air circulation and ventilation may be provided. Cleanliness is essential to avoid bacterial and fungal growth. Therefore organic materials should be dusted using a fine brush or vacuum cleaner periodically and very carefully.

Fungal infested objects should be brushed off and fumigated. Thymol is a very good fumigant. 5% thymol in rectified spirit spray will be an effective check to fungal growth. Dried fungicidal paper prepared by treating filter paper with 10% p-chloro-m-cresol solution or 1% phenyl mercuric acetate solution and then keeping it on the paintings will drive away fungi. Panacid is also a good fungicide.

TRADITIONAL CONSERVATION METHODS IN INDIA

The study of the history of various traditional conservation methods in India is much interesting. Parts of plants were used for preserving the cultural heritage, both as insecticides and fungicides.

Metal Icons

Ancient metal icons are images of gods, goddesses and others created by our ancient craftsmen for worship both in temples for common worship and in houses for individual worship. Since metals are prone to deterioration, various preservation treatments were provided by using naturally available materials like oils, flour, ash, sandal powder etc. The various preservation treatments were oil preservation, flour preservation, sandal preservation etc. These were done on a regular basis. This technique is nothing but the present day *poulticing.*

Stone Objects

Stone was used for making sculptures for worship. These stone images were applied with oil as well as milk with an idea of preserving them in the name of *abhisheka.* The oily accretions were removed regularly by tamarind, which is acidic in nature. By this act, the images were protected from all environmental damages. The accretions on stone surfaces are removed by various poulticing methods such as oil preservation, flour preservation, sandal preservation regularly in temples by the application of the paste made out of the above mentioned flour with water and removing them when dried. This was repeated till the accretions were removed. Some times, the stone idols are applied with butter to safeguard the stone surface.

Palm-leaf Manuscripts

Palmleaves were used for writing purposes. In the preparation of the palm-leaf manuscripts itself, preservative methods were adopted. Turmeric powder was used to avoid insects and fungi. They were cleaned and bundled by red silk cloths keeping natural materials like dry *neem* leaves, *vettiver,* pepper, turmeric powder etc. The palm-leaf bundles were normally stored in the lofts of the kitchen. Annually they were cleaned and fumigated on certain festive occasions specially meant for this purpose.

Wood Carvings

Woodcarvings of the temple cars were coated with *mahua* oil to preserve them. They were annually cleaned by applying curd on them followed by flushing with water. The application of oil and curd kept the woodcarvings free from deterioration and drying.

Fumigation

Fumigation is in practice from time immemorial. In temples, fumigation is used to be done to eradicate insects and fungi. In villages, palm-leaf bundles were kept in lofts just above kitchen so that this could be fumigated every day to eradicate the insects and fungi. The bundles were used to be covered with red coloured silk to avoid insects. On *Vijayadasami* Day, the bundles used to be taken out of its place, cleaned, dried under sunshade, applied with turmeric powder and kept again in the loft after bundling them with a red silk cloth. Even today we see the *Moulvis* fumigating every day in shops to eradicate insects from the cash counter etc.


Traditional Fumigation

Environment Treatment

The temple areas and even houses were fumigated with camphor, which drove away insects, bacteria, fungi etc. Moistened *cus-cus* curtains were used to send cool air into the rooms. Trees were grown around buildings to absorb dust. Trees are natural air-conditioners and dust absorbers. Brooming of court-yards was done only after wetting the ground to avoid flying of dust and resettling.

Most of the traditional methods of conservation are practiced even today in temples and villages. They are considered to be the better methods even today, as they do not introduce any new problems. In temples, lights are used to be burnt throughout the day and night in order to avoid insects. Temple deities are used to be clothed with red or yellow cloths to avoid insects.

PREVENTIVE CONSERVATION

"Prevention is better than cure". Therefore, care should be taken to prevent damages to objects. All forms of direct and indirect actions aimed at increasing the life expectancy of (an) undamaged and or damaged element(s) of cultural property is termed as conservation. All forms of direct action aimed at enhancing the message(s) carried out by (an) damaged element(s) of cultural property is termed as restoration. There are three types of work in the museum. They are:

1. Preventive Conservation
2. Curative Conservation
3. Restoration

1. Preventive Conservation

All the collection in a museum are sound, stable and some are damaged. What ever may be the condition of the objects preventive conservation is essential. It warrants only indirect action.

2. Curative Conservation

In a museum about 2% of the collection may be in need of curative conservation. When a unique piece is actively damaged, it needs curative conservation. It is an urgent and vital process to be carried out by a trained conservator / restorer. It warrants direct action.

3. Restoration

About 10% of the objects in the collection of a museum are in a damaged condition. The priority of the treatment is secondary. A trained conservator-restorer may do restoration. Some objects are in need of only conservation. Some objects are only in need of restoration. There are objects, which are in need of conservation and restoration.

Museum Collection

The sources of the cultural property in a museum are varied. The objects may come through exploration, excavation, treasure-trove finds, through purchase, gifts, transfer etc. Once upon a time, the objects were taken care of by their own environment/owners. When they are brought to the museums, which is a new environtment, a very few members of staff manage a large number of objects. The aggression due to nature and human beings is high. In order to control the deterioration of the cultural property,

1. The museum personnel must be aware of the factors of deterioration or dangers.

2. The museum personnel should be competent to handle the problems and
3. The conservators-restorers and the museum staff should be good communicators.

The message from an object should be communicated to the onlookers and also should be protected.

All the Curators of the collections in a museum are not much aware of the damaging factors of the objects. There are very few cases, where objects are miraculously protected without the help of any direct or indirect action. If the curators discuss the problems with the conservators, most of the objects will be better preserved.

In order to increase the life of an object, one must know the life history of the object. The physical integrity of the object is 100% at the time of its creation. The time taken for the object to completely disappear is called the life expectancy. For example an iron object at the time of its making has 100% physical integrity. When it completely corrodes, there is no metal core but the form of the object is maintained. Even though there is deterioration, the life expectancy is increased further.

The history of an object, which comes as a treasure-trove, excavated object, at the time of excavation it is found under a deteriorated condition. By the application of certain acts, the life expectancy may be improved, reduced or will reduce at the rate at which it was deteriorating.

Aggressions of Cultural Property

The aggressions or the deteriorating factors of an object can be natural or man made. They may be by the environment, building and staff. The natural aggressions may be lead to immediate destruction or progressive destruction.

Immediate Destruction

Immediate destruction to the cultural property may be brought about overnight by flood, fire, earthquake etc.

Progressive Destruction

Progressive destruction is also natural one. This is brought about by environmental pollution due to air, dust, moisture, heat, light, micro organisms, wind, salt and intrinsic factors like chemical changes with in the material, physical changes etc.

The man made aggressions are classified as public aggression and professional aggressions.

Public Aggression

The public aggression is mostly due to unawareness. They are such as vandalism, more tourism attraction, theft, war and terrorism, urbanisation, misusing the cultural property.

Professional Aggression

The aggression due to the professional mishandling of the antiquities and cultural objects is called professional aggression. This is due to the lack of awareness, planning, training, security, control and improper execution of curative conservation, restoration, transport, storage, exhibition, support, lighting, handling, maintenance etc.

Strategy for Conservation

For better conservation of the cultural property, a systematic strategy is to be adopted. There are seven steps for the conservation measures to be taken. They are:

1. *Know* the collections
2. *Categorise* and *identify* the aggressors
3. *Avoid* the aggressors
4. *Block* the aggressors
5. *Check* or monitor the aggressors
6. *React* against the aggressors
7. *Communicate.*

Preventive Measures

The Curator in consultation with the conservation scientist or the conservator must determine the degree to which a collection is to be handled and the display area and storage arrangements must be tailored to the demands made upon it.

1. Correct levels of heat and humidity: full air conditioning; improvised micro climate.
2. Well planned storage areas, stacking, furniture etc.
3. Protection from light: correct levels of light; blinds and curtains.
4. Use of conservation technique and materials for housing.
5. Full instructions to the users of collections: that is clean hands, correct handling, allowing no smoking, allowing no pens or inks into places where prints, paintings are preserved.
6. Good surface for viewing: secure light
7. Cleanliness Vacuum cleaning
8. Using facsimiles, replicas, holograms instead of the originals.

GENERAL METHODS OF CONSERVATION

The greatest challenge facing museums is the caring for the collections and at the same time exhibiting and interpreting them for public education and enjoyment. Persons, who handle the objects under their possession, should know conservation methods. There are two types of conservation. They are,

a) Preventive conservation and
b) Interventive conservation.

Preventive Conservation

Prevention is better than cure. If the degradation caused by a poor museum environment can be avoided reducing the need for remedial conservation, the museum objects will be saved for posterity to study and enjoy.

Planning for preventive conservation in a new museum, a museum expansion or renovation involves the proper coordination among museum staff and proper knowledge about conservation so that the needs of the museum collection are met in the brief; and that they continue to be met through the design process in construction, building operation and maintenance.

Preventive conservation involves three broad categories. They are
i) Environmental standards,
ii) Fire, security and safety factors and iii) design specifications.

Environmental Standards

There are four main factors after the conservation of antiquities for which conservation experts have established standards. The role of preventive conservation is to apply the following standards to the specific collections and effectively implement them in museum buildings in order to prevent damages on the museum objects.

Relative humidity	:	50±3% R.H.
Air cleanliness	:	90-95% efficiency in particulate filtration 50 lux for highly sensitive objects. 150-200 lux for medium sensitive objects. 300 lux for low sensitive objects
Temperature	:	21±1°C.

Fire Safety

Fire is a devastating agency, which completely destroys objects such as organic objects and selective in-organic objects. Even metallic objects like lead will also be damaged. Fire safety is an important aspect to be cared for. Fire fighting is separately dealt with in this book.

Design Specification

The display and storage areas should be designed in such a way that lighting, environmental controls, building construction are up to the standards. The design of the building for a museum and the materials used for construction of buildings play an important role in preventive conservation. As far as possible, insect proof materials, like steel, aluminium should be used for structures. All timbers should be properly treated to make it insect proof, especially against termite attack. While constructing the museum building the ground should be treated for insects. The plants and trees touching the buildings should be trimmed to avoid the passage of squirrels into the buildings. All ventilators should be well weld-meshed to avoid pigeons, owls etc. Some museums have installed mechanical and electronic devices to drive off insects, birds etc.

Planning for new buildings for museum is a complex one; but making existing buildings to fit into a museum is more difficult. To reduce the risk of degradation and loss of the collection in a museum over the short and long term, the conservation requirements of the collection need to be met.

The application of the environmental standards and the fire and safety and security measures will go a long way towards preserving the collection for posterity.

Interventive Conservation

Interventive conservation is the conservation intervening the natural and physical decays taking place in the objects. The three important facets of chemical conservation are a) removal of accretion b) stabilising and arresting defects and c) consolidation and protection.

Removal of Accretion

Museum objects are prone to various accretions like corrosion, surface adherents; unless these accretions are removed the objects loose their aesthetic look and the details cannot be legible. These accretions may be removed by physical and chemical means, electrochemical and electrolytic reduction means in the case of metals.

Physical Method

When objects are received at the museums either as treasure-trove, field-collection, excavation, purchase or gift they may have accretions on the surface hiding all the details even giving an ugly look. Accretions like siliceous materials on metallic objects may be removed by means of chisel, knife, vibro-tool etc. Accretions found on ceramics, beads etc., may be removed by brushing and by the application of soap solution etc. Incase of prints, paintings etc., superficial dirt maybe removed by rubbing with an eraser. Soot and biological accretions on stone objects may be removed by erasers, air abrasion, steam cleaning and laser cleaning. Since we do not introduce any chemicals in this method no side effects are noticed.

Chemical Method

The unwanted surface accretions may be removed from the surface of the objects by chemicals by dissolution. When chemicals are used less strong chemicals with low concentrations should be used. In the case of metals the corrosion products may be removed by dissolution. Alkaline Rochelle salt solution removes chlorides and carbonates, citric acid solution removes the oxides from copper-based objects. Formic acid and ammonia remove the black tarnish and white chlorides from silver objects. Lead carbonate from lead objects is removed by acetic acid. Oxalic acid and glycolic acid remove rusts from iron objects.

Solvents like acetone, benzene, rectified spirit etc., remove the oily accretions from stone objects. Brown varnish layer from paintings and other objects are removed by organic solvents such as spirit, alcohols with the help of a restrainer like turpentine very carefully by means of cotton swabs. Oily accretions from painted wooden panels, tribal bamboo objects are cleaned by means of rectified spirit, benzene etc.

Stabilising and Arresting Defects

Various defects such as corrosion on metals, warping in wooden objects, flaking and cohesion in paintings, scale removal on stone objects, twisting in palm-leaves, browning in case of papers and textiles, hardening in leather etc., take place. These defects should be arrested and the objects should be properly stabilised.

Metals

Corrosion in metals is stabilised by chemicals by forming a complex with the corrosion products and is stabilised and thus the corrosion is arrested. Eg. Benzotriazole stabilises the *bronze disease* and arrests it.

Wooden Objects

Warping in wooden objects is removed by a mixture of water and glycerine and kept under weight and then wooden objects are protected by polyvinyl acetate in toluene, which cuts off water entry thereby the warping in the objects is arrested.

Paintings

Flaking in paintings and cohesion in the painted layers are stabilised by means of adhesives and inpainted. Paintings are provided with glass front, without touching the painted surface, and a backing to avoid moisture, dust and insects.

Stone Objects

Stone objects are affected by salt formation in the pores of stones. Absorbed salts are removed by poulticing with paper pulp, sepiolite etc. After the removal of salt, the surface should be protected by adhesives like polyvinyl acetate. Scaling is avoided and stone is stabilised. Paraloid B72 is also used to protect stone objects. Silanes are also used to stabilise stone objects.

Palm Leaves

Because of desiccation, palm-leaf manuscripts become brittle and twisted. Sticking of leaves is removed by moistening with steam and applied with rectified spirit and citronella oil after cleaning. This gives flexibility to them and proper weight over it keeps them straight.

Cellulosic Materials

Cellulosic materials such as paper, textiles, because of acidity gets brown colour. These should be de-acidified and treated with calcium bicarbonate or barium hydroxide in order to arrest further acidification and as a reserve or buffer against acidity.

Leather Objects

Because of desiccation proteinaceous objects get hardened. Any oil applied on it enters into the cells of the proteinaceous materials and flexibility is restored.

Consolidation and Protective Coating

Fragile objects need to be consolidated. Consolidation should be done by adhesives which strengthen the objects. Paraloid B72, polyvinyl acetate, wax, acrylic esters are some of the consolidants. The consolidation may be done either by application, immersion, impregnation or by vacuum impregnation. Protective coating may be done with one of the above consolidants.

The consolidants should be transparent, soluble in a solvent, reversible, should not react with the objects but should physically make bonding with objects.

CONSERVATION ETHICS

Conservation is the means by which the true nature of an object is preserved. The aim of conservation is to control the environment to minimise the decay of objects. In treatment, it is arresting decay and where possible, stabilising objects against further deterioration.

General Obligations of Conservators

One who involves in conservation of museum objects must be aware of his responsibilities to posterity, colleagues, profession and to the public.

1. One must be aware of his responsibility for the museum objects entrusted to his care.
2. It is his responsibility to be knowledgeable of possible risks to objects and must protect objects in their custody, against damage and loss.
3. It is his responsibility to advise those involved in the display, photography, transportation, handling and packing of objects on methods, which minimise risks to objects according to museum environmental policy.
4. It is crucial to maintain records of technical examination, assessment of condition, treatment and any information regarding its original appearance and function.
5. Highest standards of treatment should be followed irrespective of the value, nature or quality of the object.
6. No one is expected to know all aspects of conservation and therefore one should seek the advice of other professionals in the field.
7. By monitoring the handling of objects, their storage and the environment in which they are displayed, the objects can be preserved better at the same time the chemical treatment could be avoided.
8. Full documentation of any treatment carried out should be made and kept as a permanently accessible archive, which will be useful to arrive at future conservation when necessity arises.
9. Materials and techniques used in the treatment of an object should be familiar to him; they must not cause damage to the object or to its original constituents.
10. The selected treatment should be effective as long as possible without incurring repetition.
11. Any residual chemicals remaining after treatment must not impede reversal or prevent further treatment.

12. There is no obligation to remove old repairs unless they result in the deterioration of objects. Old repairs, if ugly, may be removed without damaging the object.
13. Over treatment should be avoided, instead minimum required treatment should be given to preserve its originality and aesthetic beauty.
14. Physical methods should be tried first, if not possible, then chemical methods may be chosen as the residual chemicals damage the object when chemical methods are followed.
15. When we use chemicals one should try neutral solution. One should proceed form the most dilute solution and the least strong methods to more complex solutions and equipments.
16. Drastic methods should **never** be used.

PART II
METALS

FACTORS AFFECTING METALLIC ANTIQUITIES

Metals as materials have more strength and flexibility of manipulation than stone or clay or wooden objects; but when it comes to chemical stability they (except gold and silver) fall far short of the latter. They are susceptible to many factors, which bring about their deterioration, resulting in the formation of deleterious compounds conducive for further deterioration and the ultimate transformation into forms (ores / minerals) in which form(s) they occur in nature. Corrosion is the menace that the Conservator faces with metallic antiquities.

The principle behind this is that when objects are buried for a long time under certain conditions that are reasonably constant, they tend to attain a state of equilibrium with their surroundings. This will constitute the first stage in metallic corrosion. Soon after excavation these materials are once again exposed to yet another entirely new environment upsetting the earliest equilibrium in which they had been conditioned; and owing to such series of changes, most metallic objects are profoundly affected. Metallic objects buried in salty ground are exposed not only to moisture but also to the action of corrosive salts dissolved in the ground water. In short excavated objects exposed to a new environment may cause a new type of corrosion to break out afresh as they once again tend to adapt themselves to the new conditions.

The deteriorating factors affecting metallic antiquities are:
(1) Humidity / Temperature,
(2) Air/ Contaminated air (with pollutants) and
(3) Lack of maintenance.

(1) Humidity / Temperature

Humidity is the measure of moisture content in air / soil. Humidity brings about deleterious effects on metallic antiquities. Under excessive wet conditions, corrosion on metals is encouraged. In damp and hot conditions bacterial and fungal growth facilitate further corrosion.

In Tamil Nadu the climatic condition is unfavourable for the upkeep of the antiquities. Generally, the relative humidity in Chennai is very high, i.e., above 90% during July to January. The humidity is very low down to 27% during the month of June. During May it is comparatively low in the range between 30% to 40%. There is always a difference in the relative humidity and temperature inside and outside the galleries, which are not favourable for the long-term preservation of antiquities. Relative humidity between 45-60% and temperature between 19-21°C is ideal for antiquities under which condition the deterioration will be minimum.

(2) Air / Pollutants

Oxygen, oxides of sulphur, carbon and nitrogen, hydrogen sulphide, brine spray, etc., present in the air adversely affect the metal objects forming oxides, carbonates, sulphates, sulphides, nitrides and other complex corrosion products. The brine (chloride salt) spray present in the atmosphere along sea shores adversely affect metallic antiquities forming the corresponding sulphides.

(3) Lack of Maintenance

Prolonged exposure to an un-optimised temperature, humidity, etc., negligence, mishandling, vandalism, improper package, transportation and direction during transit etc., also affect metallic antiquities to a great extent.

It is always better to inspect both the galleries and storage daily and check the objects, their condition, temperature, R.H. etc. If there is any problem, the Curator may consult the conservator for the tackling the problem in safeguarding the objects preserved in museums.

CONSERVATION CHEMISTRY OF METALLIC OBJECTS

The two main objectives of conservation of metals are,

i) Removal of corrosion products and

ii) Arresting further corrosion.

Removal of Corrosion Products

Deleterious corrosion products on metallic artefacts should be thoroughly removed in order to prevent further corrosion of the artefacts. Removal of corrosion products can be effected either by a) physical, b) chemical, c) electrochemical / electrolytic methods or d) by the combination of one or more of the above methods.

a) Physical Method

Corrosion products along with the siliceous materials can conveniently be removed physically by simple mechanical tools such as pin, scalpel, chisel, hammer, mechanically operated vibro-tool, etc. The areas exposed after the unwanted corrosion products thus removed are given a final rub with fine emery sheet to bring out the inner patina layer to relief adding aesthetic beauty to the objects for certain patina can also act as a protective coat. Mechanical means of removing deposits have the advantage over chemical means in that the former methods do not introduce or leave behind any additional chemicals or products of chemical changes on the metal artefacts. Air abrasion may also be carried out with suitable powders.

Ultrasonic method can be used to remove the extraneous siliceous matter by immersing the objects in a detergent solution contained in an ultrasonic cleaner. Vibro-tool may also be used. However this technique calls for extreme care, for lack of it may damage the finer workmanship of the artefacts. Airbrasive, laser beam can be of use for plain surfaces.

b) Chemical Method

Usually chemicals, which can dissolve or form soluble complex with the corrosion products are used to remove the deleterious materials from the objects. Only mild chemicals and very dilute solutions are used to remove the corrosion products without affecting the metal beneath.

If chlorides are present in bronze antiquities, the antiquities are soaked for few weeks in an aqueous solution of sodium sesquicarbonate (equal proportions of sodium carbonate and bicarbonate), the completeness of removal of the corrosion products is indicated by the carbonate solution acquiring the faintest blue tinge. By this procedure the metal chlorides get converted into oxides and / or to other harmless yet protective corrosive products and thereby the metallic artefacts are protected and preserved.

Buried bronze antiquities coated with a heavy white deposits of calcareous materials such as calcium carbonate and magnesium carbonate are soaked for about a week in 5% aqueous sodium hexa meta phosphate in which the calcareous deposits are soluble.

Bronze diseased bronze or brass or copper objects may be treated with alkaline Rochelle salt solution (15gms of Rochelle salt i.e. sodium potassium tartrate, 5gms of sodium hydroxide and 80ml of distilled water). This removes completely the corrosion products of copper and the oxide layer is exposed. Red copper II oxide is removed by treating with a 10% citric acid solution, but the surface is found to be rough because of pitting of the metal by citric acid.

10% ammonia is used to remove the copper corrosion products as ammonia forms a complex with the copper chloride.

A 5% E.D.T.A. solution is used to remove corrosion products of copper.

The black silver sulphide (Tarnish) and the lavender silver chloride are removed by 10% formic acid and 10% ammonia alternatively. Debased silver objects look like copper as they are covered with corrosion products of copper. They are first treated as if they are copper objects.

Lead objects are treated with 5% acetic acid. This removes the corrosion products of lead.

Iron corrosion products are stabilized by the use of tannic acid based products.

Poulticing with sepiolite may clean wax-coated iron objects.

Chemicals such as 5% phosphoric acid or thioglycolic acid can be used for the immersion treatment of the iron objects. Objects retrieved from the sea / saline soil can be boiled in a 10% solution of sodium hydroxide solution, which removes the chloride arresting further corrosion. But intensive cleaning is required to remove the excess of sodium hydroxide.

Ion-exchange resin treatment is yet another approach to treat especially corroded lead antiquities. The corroded lead object is placed in contact with granules of treated exchange resin (Amberlite IR120) covered with warm distilled water for about 20-30 minutes. Metallic lead is unaffected, but incrustations of lead cations are removed by the Amberlite

IR120. The Amberlite IR120 may be regenerated and used again by treating it with dilute nitric acid.

c) Electrochemical / Electrolytic Reduction

The electrochemical reduction involves the reduction of the corrosion products by nascent hydrogen evolved by the action of 10% sodium hydroxide on zinc granules / powder on the affected spots.

Corrosion (oxidation) of metallic artefacts is usually an electrolytic process. Removal of the oxidative corrosion process can be effected through reductive electrolysis. In 1930, S. Paramasivan adopted this technique in the Government Museum, Chennai for the restoration of large sized South Indian bronze icons and heavily corroded copper plates with inscriptions. This method continues to be popular even to this date by many conservation scientists for the restoration of coins and inscribed plates. But this gives a black colour to bronze icons and therefore this method is advisable only for badly corroded bronze icons to remove the corrosion products easily.

Reduction is usually carried out in an electrolytic cell keeping the antiquity as the cathode with two strips of iron gauze suspended on either side of the object or a cylinder of the same material enclosing the object all round, as the anode in a 5% aqueous sodium hydroxide / sodium carbonate / acetic acid or formic acid electrolytic bath. Direct current is passed from a 1-50 volts source and an optimum density (2 amps per square decimeter with respect to cathodic object) for a few to several hours, depending on the thickness of the encrustation. The corrosion products on the metal antiquity are reduced and removed by alternate brushing and washing until the hidden details are exposed with all its intrinsic artistic details

Electrolytic Brushing

In the case of large sized, non-transportable bronze objects (which cannot be easily shifted from the galleries / stores to the laboratory) a localised treatment of a slightly modified electrolytic method is resorted to, with good success. The metal object affected by spot corrosion is kept as the cathode. A steel rod with a sponge head moistened with 10% caustic soda solution is connected to a 12-volt direct current power supply and the electrolyte-impregnated sponge is pressed on the affected spot and the circuit completed. Electrolytic reduction takes place and the spots get reduced to the corresponding metal. The author for local treatment and conservation of bronze icons, iron swords etc., has very successfully used this process. Lead coins may be conserved with graphite anode effectively.

Electrolytic brushing locally cleans the bronze icons, which are affected by *weeping*. Since the holes found at the *weeping* spots are just able to take the finest needle of a syringe, the liquid collected in the holes is first syringed out. When numerous holes are present in the icon, the surface of the affected object is poulticed with moist neutral paper pulp and the same removed when dry. This procedure is repeated till the paper pulp removed gives a negative test for chloride.

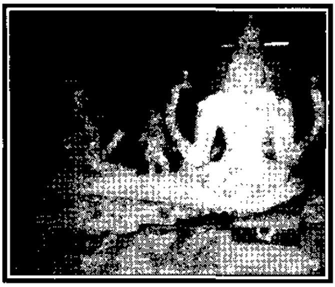
Treatment of slightly corroded iron objects in fairly good condition with solid core of metal is best done by electrolytic reduction. Spot reduction can be effected by electrolytic brushing or by electrolytic reduction.

Intensive Washing

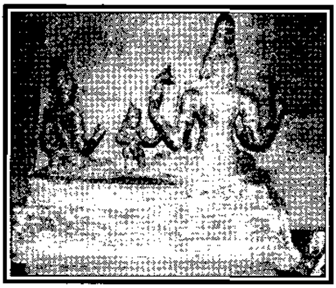
Intensive washing is the last step but definitely not the least in importance in conservation of artefacts. Unless the treated objects are washed completely free from the residual chemical(s) left behind on the objects, they will once again react with metal and the corrosion cycle will be repeated again. Therefore, washing should be intensive and thorough in the final stages especially with methods involving chemical treatment. The last residual salts in the treated objects is best eliminated by prolonged soaking of the objects in distilled water or the process may be speeded up by using hot water. This process may be repeated to ensure complete removal of chemicals.

Consolidation and Protective Coating

Metallic antiquities, which are very fragile and highly mineralised, need to be packed up with wax / resin. This process is called consolidation. Consolidation can be done with 10% wax dissolved in benzene or by vacuum impregnation. A 2-3% polyvinyl acetate in acetone, toluene or acetone-toluene mixture can either be coated on the object or vacuum impregnated. In the case of fragile bronzes, the missing corroded portions after treatment are filled and modeled with resin like fibre glass and resin, M-seal or Paraloid B 72 mixed with suitable colour.



Damaged Pedastal and Corroded Broze Icon



Restored Bronze Icon with Fibreglass-resin

Arresting Corrosion

1. Stabilization of Highly Corroded Objects

In most of the excavated and treasure-trove objects, it is seen that the corrosion has proceeded to an extreme stage where very little metal is left intact. In such cases, objects can best be conserved by stabilising the corrosion products formed.

Spots of *bronze disease* formed over protective layer of patina may be mechanically removed. The pits found are then filled with a fine paste of silver oxide (in alcohol / water). Insoluble silver chloride thus formed seals off the underlying harmful effect of copper (II) chloride arresting further corrosion. Sodium sesquicarbonate (equal amounts of sodium carbonate and bicarbonate) solution dissolves the copper (II) chloride *(bronze disease)* without affecting the copper (II) carbonate (protective patina). Zinc dust in place of silver oxide may be used effectively. Therefore prolonged immersion of the *bronze-disease* affected antiquity in a solution of 10% sodium sesquicarbonate removes the deleterious chlorides and stabilises the carbonate patina formed on copper alloy antiquities. Benzotriazole (B.T.A.) in water or alcohol forms a complex with cupric chloride and oxides. This inhibition procedure can also be adopted to arrest further corrosion. Benzotriazole in water is preferred to Benzotriazole in alcohol in the case of antiquities with thick layer of *bronze disease* as the former slowly but surely penetrates into the core of the metal-the evaporation of water mixture being slow compared to Benzotriazole-alcohol treatment. This is the most effective method for the conservation of copper and bronze archaeological antiquities affected with *bronze-disease.*

One of the methods of preventing *bronze disease* in antiquities is to maintain the antiquity in a dry atmosphere (45-60% R.H.). Under these conditions the spreading of further corrosion is arrested.

Even wood emanates some acid fumes and therefore silver objects displayed inside the cases are affected. Zinc oxide globules are kept in the cases to absorb the hydrogen sulphide vapours thereby tarnishing is averted.

Poulticing is adopted to remove salts from iron objects since iron rusts fastly. Applying water repellent on the surface of the objects may stop the rusting. Besides wax, some consolidants like poly vinyl acetate, Paraloid B 72 or varnishes can be applied on the metal surface to avoid water / moisture reacting with the metal.

METALS / ALLOYS USED IN ANCIENT OBJECTS

There are various metals used in antiquity. The most common metal in antiquity is copper. Alloys of copper such as bronze, brass, bell metal, billon, potin are important. Lead is also one of the metals very commonly used in antiquity. The lead pipes in Pompeii were very common. Many jewelleries are found in museums, which are made out of gold, silver, electrum, white gold, red gold etc. Most of the coins are found in silver, gold, lead, copper, bronze. Most of the antiquities are made out of bronze. The weapons found are in copper, iron etc. The alloys used in antiquities and the approximate composition are given below:

Name of the Metal/Alloy	Constituent Metals	
White gold	Gold 90%	Silver 10%
Red gold	Gold 90%	Copper 10%
Electrum	Silver 70%	Gold 30%
Debased silver	Silver 60-90%	Copper 40-10%
Pewter	Lead 20%	Tin 80%
Coinage bronze	Copper 90%	Tin 10%
Bell metal	Copper 78%	Tin 22%
Billon	Copper	Siver
Potin	Copper,	Tin, Lead, Silver

The following table gives an idea of the physical properties of some of the important coinage metals:

Metals	Gold	Silver	Lead	Copper	Zinc	Tin	Aluminium	Nickel
M.Pt. °C	1063	963	327	1084	419	232	658	1455
Sp.Gr.	19.93	10.1	11.4	8.9	7	7.3	2.6	8.9

COPPER OBJECTS

The earliest recorded use of copper was in Northern Iraq (8500 BC) and then is Asia Minor and Egypt around 7000 BC. The copper objects found on the Sinai Peninsula have been dated to be about 3800 BC. The oldest copper mines known to have been used by the Egyptians are also situated in the Sinai Peninsula. The metal was extracted from ores consisting mainly of green copper carbonate (malachite) and copper silicate (Chrysocolla). Slags found at the afore mentioned sites are of very varied composition, providing evidence that the process of extraction was not always carried out in an uniform way. The deposits in Cyprus were mined as early as 3000 BC. The mines located in Cyprus were the prized possessions of the empires that followed the Egyptians and became the chief source of copper metal for the Roman Empire. The metal was named 'aes cyprium' and subsequently cuprus from which is derived the English word 'Copper' symbolised, Cu.

Recorded reports on the first investigation was made on the findings at the Indus Valley sites, which dates back to 4000-3000 BC. Analysis of ancient Indian copper artefacts excavated at Mohanjodaro and Harappa have been reported and the findings have revealed the type of manufacture and the type of metals and alloys used during that period.

One probable mechanism for the underground corrosion of bronze is described in which, strata of cuprous chloride, cuprous oxide, and basic copper carbonate are found in succession from the metal to the surface. The cuprous chloride is usually present at the interface between metal and cuprous oxide. Cuprous chloride is known to reach in a reversible manner with water to form both cuprous oxide and hy lrochloric acid. The hydrochloric acid is then removed from the system by reaction with metallic copper in the presence of oxygen to regenerate cuprous chloride .

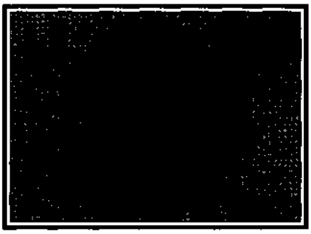
The first of these reactions is caused by the second to proceed in a forward direction with the formation of cuprous oxide, which will be added to the mass of this mineral, which is already present. As a result of the second reaction, cuprous chloride is continuously regenerated ahead of the newly formed cuprous oxide. The copper metal is correspondingly corroded away, with the net result that the layer of chloride moves steadily forward into the metal.

At areas of loose overlying layers of minerals, air and moisture may enter sufficiently rapidly to convert compact cuprous chloride directly to bulky basic cupric chloride, which then breaks out, upon the surface and provides an easy-path for the entrance of yet more oxygen. The loose powder formation can also be referred to as *malignant patina.*

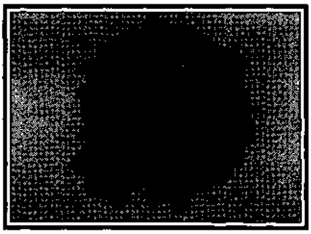
Patina Formation

Under conducive temperature in the presence of atmospheric air copper reacts with oxygen, an oxidant, to form a layer of cuprous oxide, Cu_2O. The object becomes covered with the familiar *brown patina* of bronze, which constitutes a protective layer conforming to the original contours of the object. This copper (I) oxide may subsequently be oxidised to form copper (II) compounds, which are characterised by blue-green colour. Basic copper nitrates, sulphates, carbonates are the end products of the continued combined effects of air, water (moisture), carbondioxide and pollutants like oxides of nitrogen and sulphur on copper and its alloys. Such patina once formed is stable for centuries and is called *edel patina,* which imparts an aesthetic beauty to the artefacts.

Large amounts of same copper coins are kept with coin collectors. Such coins may be kept in coconut oil for a few days and are rubbed, keeping then in catton cloth. This action removes corrosion and loose siliceous materials are removed. The traces of oil keeps the coins corrosion free.



Corroded Copper Coins



Treated Copper Coins

BRONZE ANTIQUITIES

History of Bronze Technology

Bronze technology seems to have preceded iron in human civilization and had emerged in the Near East as early as 3000 B.C. There are historical records of the prevalence of bronze casting technology in India even before 2500 B.C. This is evidenced from the excavated bronze image of the dancing girl from Mohenjodaro, which is currently preserved in the National Museum, New Delhi and the man-like figure found at the confluence of Ganges and Jamuna in North India, which has been dated to be about 1000 BC.

Bronze technology in Tamil Nadu dates back to the 7th Century B.C. evidenced from the bronze objects obtained from excavations at Adichanallur, Tirunelveli District, Tamil Nadu; these objects are today preserved in the Government Museum, Chennai. Recent excavations by the Department of Epigraphy of Tamil University, Thanjavur at Kodumanal, Erode district, Tamil Nadu, have brought to light a semi-precious stone-studded tiger bronze image belonging to circa 2000 B.C. Even though the bronze icon making was in vogue during the Pallava period (close of 3rd to 9th Century A.D.), the Pallavas have left too few of their icons to enable one to evaluate the full potential of the technological achievements prevalent in those periods. In spite of the existence of the bronze technology of the Pandyas (2nd Century B.C. to 17th Century A.D.) the remains of bronze icons of that period are not many. During the reign of the Cholas (9th to 13th Century A.D.), high quality bronze icons have been manufactured. Later, Vijayanagar kings encouraged the art of bronze icon-making in the 15th and 16th Centuries A.D.

The bronze icons in the Government Museum, Chennai, acquired through the Treasure-trove Act of India 1878 are mainly from Thanjavur, Trichirappalli and Pudukkottai districts of Tamil Nadu. Scientific examinations of these objects reveal the traditional solid casting was the technique in vogue. Bronze icon-casting technology by the traditional method is practiced even to this date at Swamimalai in Thanjavur and also in a few other places in Tamil Nadu.

Generally bronze is an alloy of copper (75-80%) and tin (20-25%). Ancient bronze icons are generally considered to be made out of *panchaloha* connoting a five-metal alloy usually a composite alloy of metals-copper, tin, lead, silver and gold in varying proportion. But analysis of South

Indian bronzes reveals that they invariably consist of copper, tin, lead, zinc and iron. Trace quantities of arsenic, antimony, bismuth are also detected in a few of them.

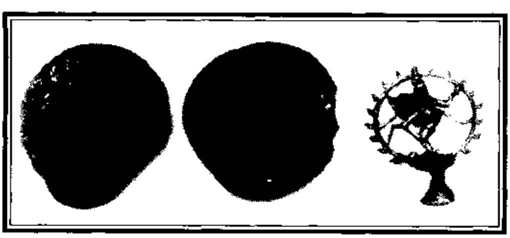
Methods of Bronze-casting

Basically the two popular methods of bronze casting practiced in India are:

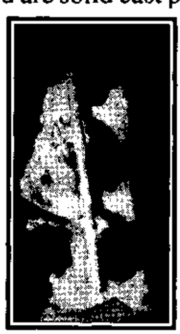
1. Solid casting (*cire-perdue* meaning lost wax process) and
2. Hollow casting.

1. Solid Casting

The solid casting process is otherwise called *cire-perdue*, a French term meaning lost wax. The basic principle of the solid casting is that the image is first fashioned out of wax, then over it are laid in succession sufficiently thick, uniform layers of fine-grained clay (*'puthumann'*) followed by coarse sand with clay. The try mould was used to be buried and the molten alloy was used to pour. The hot molten alloy used to burn the wax and fill up the volume of wax. But now a days, the mould thus prepared is allowed to dry under shade, and then heated to about 80°C to let out the molten wax through openings provided in the clay layer. Finally molten bronze melt is poured into the hollow space thus created in the clay mould kept buried in the soil, taking care to fill every crevice and corner in the mould cast. The mould is allowed to cool and the clay layer is broken to bring out the cast bronze icon. This is then given the finishing touches by the artisan with chisel and hammer to bring out the finer details of the image. The icon is then given a final polish with fine sea-shore sand. By this method, it is possible to cast only one icon at a time. The laborious mould preparations should be repeated for every individual casting of the icon. The famed bronze master-pieces from Tamil Nadu are solid cast pieces.



Modern Solid Casting of Bronze Icon



Bronze Icon along with the Ancient Mould

2. Hollow Casting

Hollow cast Bronze

Since this type of casting of icons has an inner core of clay, it is called hollow casting. They will be comparatively light in weight. In this process, a slightly smaller sized image is made out of clay. Thread like wax is extruded on to the clay mould and wrapped around it. The wrapped wax is flattened out evenly to the contours of the image. Finally the clay model is covered uniformly and completely with a thin layer of wax. Then the intricate details are worked out on the final wax layer. After the wax figure is fashioned to the required form and size, fine clay is applied over it. During the working of the clay mould, holes and inter connections (runners) are suitably provided to facilitate easy flow of the molten alloy in the hollow space around the inner clay core and the escape of hot gases during the pour process. The mould is cooled, and broken up carefully to reveal the image. To get the artistic details required for the image, finishing touches like chiseling, filing, polishing, etc., are effected by the artisans. By this method also only one piece can be made from a mould.

The technique of making a large sized bronze statue is to cast the image in pieces and assemble the separately cast fragments together by welding in the final stage. Several books on ancient technology on metallurgy, detail this art. Work on the 10-foot bronze statue of Duplex of the 18^{th} Century A.D. at Pondicherry, is a classical example of the piece-mould hollow casting. Industrially many pieces can be made from a single mould.

GOLD OBJECTS

Gold is a noble metal. If gold is pure, it does not corrode even if gold objects are found buried under the earth for a long time. Red gold, white gold, *electrum* are some of the important alloys of gold. When such alloyed objects are exposed to corrosive atmosphere the baser metals corrode first and leached out to the surface resulting in the surface enrichment of gold. For example, copper in a gold alloy corrodes first and the corrosion products cover the whole object making it to look like copper. When the corrosion products are removed, gold appears to be bright.

Gold objects, which are in contact with copper also, appear greenish-blue because of the corrosion products of copper. Such objects are treated with alkaline sodium potassium tartrate and the original appearance is regained.

Gold objects, which were buried in lime deposits, were found to be covered with calcareous materials. Such objects are immersed in a 1 % solution of nitric acid, which removes the calcareous materials.

The dirt on gold objects can be easily removed by a mild detergent or soap like *Extran*. Cleaning with an ultrasonic cleaner with a detergent solution cleans the objects for a few minutes in a 2% caustic soda solution. Buried gold objects sometimes appear purplish-red in colour giving an aesthetic look. It is a valuable patina worth preserving but it is easily rubbed off.

Gilded objects need care while treating them. If gold coating is found over copper or bronze, alkaline Rochelle salt treatment is rewarding. But, in general mechanical cleaning with needle etc., is advisable. Gilded gold objects found darkened by soot, dirt etc., may be cleaned with the help of 5% ammonia solution.

Pure gold is very malleable. Therefore, only an experienced conservator should reconstruct crushed objects.

SILVER OBJECTS

Silver is a noble metal. It corrodes when it is buried or exposed to unfavourable environment. The normal corrosion products of silver artefacts identified are black silver sulphide, lavender silver chloride and pale yellow silver bromide. Silver objects form silver sulphide when buried underground for long time. In a museum atmosphere, they rarely change to silver chloride, but often they *tarnish,* indicating the formation of silver sulphide. Buried silver coins sometimes are found to be covered with copper corrosion products which is due to the corrosion products of copper alloyed with silver object or due to the transfer of corrosion products from the copper container in which the silver coins are usually hoarded. Mostly silver coins are found buried in a copper container and the treasure-trove coins are usually received in museums along with the copper containers.

Being a noble metal at ordinary temperature and dry air, silver remains apparently unoxidised. However, at ambient temperature, combination between metal cations and oxygen ions result in the formation of an oxide. If the oxide assumes a similar crystalline structure to that of the metal upon which it is growing, and if it occupies a volume larger than that of the metal destroyed for its formation, it acts protectively. If the silver oxide film is produced in dry conditions at room temperature, it is in fact outstandingly protective. Hydrogen peroxide that is formed promotes the penetration of corrosive agents by introducing irregularities in the oxide structure. Chloride ions easily permeate through the oxide films peptize conglomerates of their molecules and intensify the already existing flaws, leading to the creation of numerous local electrolytic cells in all crevices and abrasions of the silver layer. The exposed copper present in the object acts as an anode and the silver object acts as a cathode to which copper goes into solution forming copper (II) chloride in the chloride environment. Silver then undergoes attack by copper (II) chloride and forms silver chloride. This white silver chloride can be removed by treating with ammonia. The black silver sulphide formed with hydrogen sulphide can be removed by treating the object with 10% formic acid. The object should be washed throughly with distilled water to remove all the residual chemicals inorder to avoid further corrosion.

LEAD OBJECTS

Ancient lead objects excavated from the soil are often covered with white incrustation, which is produced by the chemical action of saline matter in the soil. A wide variety of corrosion products have been identified in lead objects. They are, massicot (PbO), platnerite (PbO_2), cerrucite ($PbCO_3$), hydrocerrucite [$Pb_2(CO_3)Cl_2$], anglesite ($PbSO_4$), galena (PbS), etc.

Leaden objects are normally coated with a thin film of dull grey oxide; this is pure dry air (free from pollutants) acts as a protective patina. However, this film of oxide is contaminated and is discontinuous and non-protective and in course of time, active corrosion breaks out with the formation of basic lead carbonate. This corrosion product is puffy, voluminous and loosely adherent. It is for these reasons that leaden objects often suffer serious disfiguration unless the corrosion is checked in the early stages.

When lead objects are excavated, they are commonly found to be covered with a dull white encrustation, which appears to be stable; it is in such an unsightly condition and often as to be unacceptable as specimens for exhibition that the lead antiquities are received in museums. Improper storage affects lead objects.

Lead objects buried under the soil are mostly found covered with corrosion products. Their removal sometimes results in serious deformation and complete crumbling down of the objects. Such objects in near total state of deterioration should be consolidated rather than conserved, at least to restore back their gross details. However, sound objects may be subjected to conservation methods as detailed earlier to restore back the hidden details.

IRON OBJECTS

Iron objects corrode easily, giving rise to unsightly rust that cause swelling and deformation of the decaying objects. The various corrosion products identified on iron antiquities are oxides, sulphites, phosphates, basic sulphates, carbonates, chlorides, hydroxides, oxychlorides of iron etc. Exposed monuments of iron in the atmosphere are in constant contact with oxygen, pollutants, moisture, heat, etc., and hence they are prone to chemical and physical changes. However, the wonder iron pillars at Dhar and Delhi have withstood the ravages of time due probably to their high purity iron content of 99.8% and 99.72% respectively.

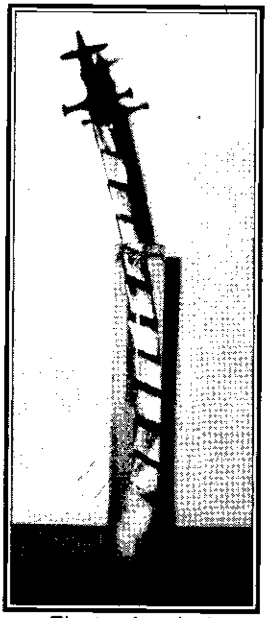
Many iron objects buried under the ground are heavily materialised with only a thin metal core. Chlorides play an important role in the corrosion of iron objects. If the excavated iron objects are partially corroded by the chloride bearing corrosive agents, the chloride must be removed completely, otherwise rapid corrosion will completely mineralise the objects.

Depending upon the stage/state of corrosion, the iron objects can be classified under three categories as:

a. Slightly corroded
b. Extensively corroded but having a thin metal core
c. Grossly corroded and mineralised objects.

Iron objects may be treated as detailed earlier. Mostly excavated iron objects will not have any metal core. Such objects should be cleaned to remove salt and consolidated with poly vinyl acitate, Paraloid B 72 etc.

Slightly corroded iron objects may be treated either electrolytically or electrochemically. If the corrosion is less, then the object may be applied with a paste prepared out of pumice powder and kerosene and rubbed with a coton swab after allowing the rust to be softened by kerosene. Air abrasive may also be tried.



Electrochemical Cleaning of an Iron Sword

MODERN METALS

Artefacts, coins, and medals made of aluminium, zinc, magnesium, nickel etc., and their alloys form a small but significant part of the collections of objects of modern metals.

Zinc

Zinc was known as a distinct metal in India in the 14^{th} Century. But, knowingly or unknowingly zinc is invariably found in all icons, artefacts and antiquities made of copper alloys even before 14^{th} Century.

At high humidity, zinc is corroded to form zinc hydroxide [$Zn(OH)_2$] in the absence of carbon dioxide and basic zinc carbonate [$ZnCO_3$. $Zn(OH)_2$] in the presence of carbon di oxide. In the presence of sulphur-di-oxide it forms zinc sulphate. Zinc corrodes in the presence of oils and plywood used for making showcases.

Aluminium

Aluminium was discovered in 1820. Aluminium is resistant to corrosion due to the formation of a protective film of aluminium oxide (Al_2O_3). It forms chloride and sulphate. Aluminium corrodes in an enclosed environment containing urea – formaldehyde adhesive, in tropical climate.

Magnesium

Magnesium was discovered in 1808. Magnesium corrodes and forms hydroxide, basic magnesium carbonates [$Mg(OH)_2 MgCO_3$] and sulphates. Acids profoundly corrode magnesium and its alloys. Wood emanates gases, which corrode magnesium.

Modern metallsic coins may be cleaned well with the helep of electrolytic restoration.

BIDRIWARE

Bidriware is made out of zinc alloyed with copper, tin and lead. The name *Bidri* was derived from a place in Andhra Pradesh where a special earth was found, which had a chemical effect on this alloy and was used to make objects. The object, after casting and polishing, is engraved with designs to be inlaid with silver or gold wire or plate and thereafter rubbed with earth. This process gives the object a beautiful black colour, leaving the silver or gold wire shining.

The black finish is important to *bidri* objects. This should not be subjected to acidic or alkaline chemicals. If the inlaid silver or gold wire or sheet is separated, it should be fixed in position with adhesives like *poly vinyl acetate.*

The *Bidriware* are normally affected by corrosion and the surface will appear white due to the formation of zinc carbonate lead carbonate. Use of acid should be avoided. It may be cleaned with organic solvents. Puffing may be done with a soft cloth.

PART - III

INORGANIC OBJECTS

STONE OBJECTS

Stone is a postion of rock. Rocks and minerals are in abundant and are consisted with silicate units. The main cations are sodium, calcium, magnesium and aluminium. A linear polymer-like structure of silicate units form the basis of fibrous minerals such as asbestos. A planer structure in which silicate units are linked in two dimensions give rise to soft, slippery minerals, such as talc, mica and soapstone. A three dimensional framework silicate, as in quartz and feldspars, results in an extremely strong solid.

There are various types of rocks such as igneous, metamorphic and sedimentary rocks. Igneous rocks like granite and basalt are those which were formed by the cooling of volcanic lava. Sedimentary rocks like sandstone and limestone were formed by gradual sedimentation of layers of sand and other inert materials brought by rivers streams and deposited at the beds of lakes and ponds. In due course of time these layers got petrified and stone formed. Metamorphic rocks, for example marble, were formed by the metamorphosis of either igneous or sedimentary rocks into a new form on account of pressure or heat or some other geological change.

Granites are the basic materials for carving out sculptures in India especially in south India. They have outstanding hardness and strength. They are mixtures of quartz, potash feldspar and mica, formed under intense pressure and high temperature. They have also been chosen as building materials. Most of the cave temples are cut out of these rocks.

Sandstone was also chosen to cut and shape sculptures. Mathura region has this type of stone sculptures. It is composed of quartz grains.in a matrix of either more quartz, when it is strong, or limestone, when it more easily, because limestone (calcium carbonate) is readily attacked by acidic solutions i.e. even by rain water (pH is 5-6). Most of the regious in Madya Pradesh, Orissa, Rajasthan etc., have limestone rock-cut temples. Lime stone also falls in this group and it is also attacked by acidic solutions and chlorides.

Marble was also used in sculpturing as well as facing monuments like Taj Mahal. Marble is non-siliceous and is nothing but compressed limestone. It takes good polish, as it is less porous. The coloured lines are the impurities present.

Dolomite was also chosen as a stone to carve sculptures and as building materials. It is a double carbonate of calcium and magnesium and its properties are similar to marble and limestone.

Laterite are rocks, which are very porous and easily affected by moisture and percolation of water. Many sculptures made of this rock are also found.

Deterioration of Stone

Excavated stone objects are much affected by crystallisation of salts, which are absorbed with in stone. Since salts are deposited in cavities near the surface, they can impose strains great enough (up to more than 1000 atmospheres) to cause complete disintegration of surface features such as ornamentation.

Outdoor stone objects suffer the damages due to acid rain, which is atmosphere. Leaching away of mobile materials from inside and recrystallisation occurs on the surface as an efflorescent deposit. Further more, substances dissolving in the capillary passages of stone may produce high osmotic potential gradients, which can lead to pressure damage. In urban areas black crusts of carbonaceous materials are often present.

Deterioration also occurs due to the growth of algae, fungi, moss, lichen and other micro-vegetation. After drying they appear black.

Droppings of insects and birds also affect the stone objects and monuments.

Visual Examination

In order to decide on the strategy of conservation, stone objects should be studied and examined very carefully.

Using a magnifier the condition of the stone should be studied. The surface should be watched for the presence of deposits like crust, salts, mould, dirt, pigments, graffiti marks, voids, flaking, powdering etc. The hardness may be tested. The alteration products may be analysed by spot tests and by x-ray diffraction studies. Soluble salts like chlorides, nitrates, sulphates should be removed immediately otherwise they will damage the stone. Pigments, if found, should be preserved as such.

Preservation of Stone Objects

Most of the deteriorations on stone is due to water. Now, the job is to remove the unwanted dirt and salts from the objects, protecting the surface with a water repelling material, and consolidating the crumbling surfaces.

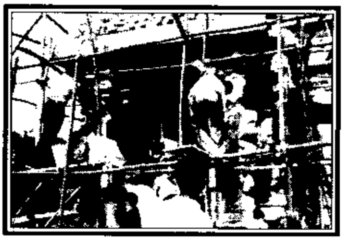
Removal of Dirt

Stone sculptures often accumulate dust, dirt and stains. Loose dust can easily be brushed off. Pure water with detergent like Extran is used to remove the dirt accretions. Stains of grease, oil, wax or paint can be cleaned with suitable organic solvents like toluene, acetone, benzene, trichloroethylene, triethanolamine etc., or their mixtures. If the oily grease is deeply rooted, then the accretions may be removed by applying paper pulp in rectified spirit to the surface of stone where the accretions are found and covered with a polymer sheet to avoid the escape of the solvent and removing the paper pulp after an hour or so. The grease is removed step by step and the real colour of the stone is regained after repeated application of the paper pulp with the suitable solvent. Whenever paints fall on the objects it should be cleaned before drying. Steam cleaning is also done.

Wishab, a type of pencil eraser, may be used to remove the dirt by rubbing against the dirty surface of the stone object.

Removal of Salts

Salts that have migrated into the stone are to be removed along with efflorescent deposits on the surface without causing further damage. Smaller objects may be immersed in salt free water. A *poultice* is applied to remove the salts. Porous materials such as cotton wool, paper pulp or sepiolite (hydrated magnesium silicate) are used as poultices.



Removal of Salt by Poulticing

Removal of Biological Accretions

Deposits of moss or algae not only make them to appear patchy, green or black in colour but also produce pits in the surface of the stone, thereby weakening the structure. A 5-10% solution of ammonium hydroxide is used for removing algae. Cotton pads dipped in the solution and kept on the affected area for about 15 minutes, brushing and washing will remove the growth. The carbonaceous accretions are removed either by air-abrasion or by laser treatment. Laser cleaning in safer.

Characteristic of Consolidants on Stone Objects

The choice of a good consolidant is very important. The consolidant must penetrate the stone thoroughly and not simply sit on the surface to obviate removal by abrasion. The protective layer or the consolidant should breathe, i.e. allow water vapour to escape. It should be reversible, so that anything applied to the stone can subsequently be removed and a different treat ment used, if found to be more suitable. The consolidant should not alter the appearance of the object on which applied.

Acrylic resins like perspex, polyesters, epoxy resins like, polyvinyl acetate, polyvinyl chloride, Araldite, Paraloid B72 are some consolidants which are in use. Organosilanes are largely used in the consolidation of stone objects. Tri methoxy methyl silane and triethoxy methyl silane are very commonly used of which the later is preferred as the former is more volatile and leaves off methanol, which is poisonous. Perfluoropolyethers are composed of carbon, oxygen and fluorine and are extremely stable to light, heat and chemical agents, permeable to gas, transparent and colourless and are insoluble in water and common solvents, although able to be dissolved.

Restoration of Stone Objects

Restoration is often necessary for reasons of safety of the object and is carried out using modern materials in manner sympathetic to the existing structure, but not necessarily identical with it. Doweling can be done in the case of broken objects by joining the pieces by means of stainless steel headless rods, called *dowel* and adhesives. One of the main causes of moisture formation in stone buildings and objects, which are directly in touch with the ground, is the rise of water from the ground to the body of the object through the capillary pores present in the stone. Hence stone objects should never be displayed by embedding parts of them in the ground or in brick or cement pedestals. Stone sculptures can be placed on brick or cement pedestals only when a moisture barrier, like a plastic sheet, is inserted in the pedestal, just above the ground.

Broken & Restored Stone Sculpture

General Care

Stone materials should never be whitewashed, painted. Salt should never be sprinkled. The soot deposits due to burning of lamps etc., should be cleaned by solvents like benzene, spirit, acetone. Oil accretions by touching should also be removed as mentioned earlier.

CERAMICS

Early man started using the naturally available materials for his daily use. Clay was certainly among man's earliest discoveries of natural materials adaptable to his needs. Ceramics is the general term for an object made out of clay like pottery, porcelain and earthenware. Ceramic materials were in vogue in the sites of ancient culture throughout the world. The red and black wares, polished wares, megalithic potteries and the modern glazed wares are familiar to India.

Constitution and Types of Ceramics

Ceramics has its principal raw material clay whose ingredients are alumina and silica, with varying quantities of other minerals such as illite, chlorite or mica. The composition varies from clay to clay. When clay is fired dehydration, oxidation and vitrification take place. Ceramic objects differ according to the kind of clay used and the heat applied in firing. The various types of ceramics are earthenware, terracotta, stoneware, porcelain. Clay forms may be decorated in a wide variety of ways glazed or unglazed. Fired clay is durable. Kiln firing temperature can vary from 650°C for terracotta to 1400°C for porcelain. Some pottery is poorly fired and this results in a very low quality, fragile ceramic as not all of the clay minerals have been irreversibly altered. The shape of ceramic utensils and decorative objects can be achieved by using a number of methods such as hand modeling, coil building, ring building, slab forming, giggering, jollying, slip casting and, most commonly, throwing or wheel turning. Following forming, the object may be decorated and fired.

Deterioration of Ceramics

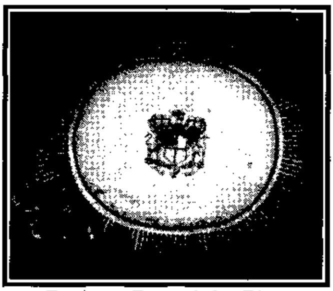
Most of the ceramic objects are excavated and are saturated with both insoluble and soluble salts of the soil, if they are unglazed or broken. Unbaked clay objects are very fragile and are easily affected by water. Even high humidity will make it to disintegrate. Unbaked clay objects are vulnerable to shock and disintegration occurs when the object inherits severe vibration or shock. Baked clay objects are also vulnerable to shock and severe vibration. Rough unfired clay objects as well as weathered baked clay objects are easily accumulated with dust, which becomes dirt with moisture and is difficult to remove the dirt. Ceramic objects very easily get stained. This may be effected because of the iron nails and their rusting. Labeling with adhesive labels also make stain on the objects. Since clay objects are fragile, they are vulnerable to abrasion and scratches. Objects may be broken by being dropped or knocked over. Manufacturing defects may occur due to some techniques, which have an inherent instability. Applied decoration such as gold leaf or unfired pigments might be poorly fixed. Previous restoration using faulty methods or poor materials also result in damage to the objects.

Conservation of Ceramics

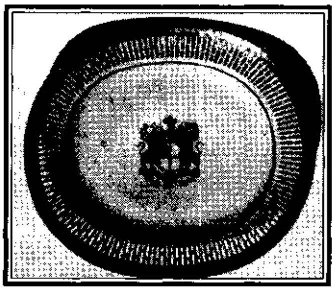
Since unbaked clay objects are prone to the damages due to water, moisture, shock, vibration etc., care should be taken to conserve them. Such objects should be impregnated with a consolidative resin like polyvinyl acetate. Larger objects may be impregnated by means of brushing and small objects may be vacuum impregnated. Unbaked clay objects may be hardened by baking it. Clay objects if once baked then they may be washed to remove the salts present in them. The excavated baked objects may be soaked in running water and the salts present are leached out by this process. Any stain found on them may be removed by using solvents like acetone, benzene etc., after they are dried. In order to remove the dirt 1% *Extran* in water may be used and brushed well with a soft brush. Encrustation on the ceramics may be softened by moistened pads. Fine scalpels may be used to take off the softened encrustation.

Mending of Ceramics

Most of the excavated ceramics are found broken and portions are not found. The broken pieces have to be mended. It requires great patience. It is always better to number the pieces and put them together. The broken edges should be cleaned with a soft brush and then with rectified spirit or other suitable solvents. The adhesive, normally the acrylic resin, should be applied at the broken edges and joined. The joints should be filled with filler like acrylic resin and matched with acrylic colours.



Broken Procelain Plate



Mended Procelain Plate

Storage

For most of the ceramic objects the relative humidity and temperature levels are not critical but these two factors should never be allowed to fluctuate drastically. In case the objects have soluble salts then the relative humidity should be around 50±5% and the temperature around 19°±2°C. If the ceramic is painted with light sensitive pigments, the light level should not be above 150 lux.

STUCCO OBJECTS

Stucco objects are constructed out of fired brick and lime mortar. They have the quality of both fired brick and lime mortar. These objects are normally found in middle aged temples and they are found white washed and details would have been almost lost. Some of the stucco figures are found painted and are brilliant.

Deterioration and Their Causes

Various causes of decay found in the secco figures are cracking, flaking, salt action, powdering, physical damage etc. These can be avoided when the objects are free from moisture, abrasion, etc. The stucco figures found in the towers (*gopuras*) are normally found painted. But due to age, they turn black as they are exposed to the open air where moss, lichen etc. react with the stucco during the monsoon.

Control and Conservation Measures

Stucco figures are not many in museums. But the damages found on the stucco figures should be set right. The soluble salts may be removed by poulticing. The loose broken pieces and ends may be fixed to the main object by means of a 10 –15 % solution of poly vinyl acetate dissolved in toluene. The black accretion may be clean with the help of dilute ammonia.

GLASS AND GLAZES

The use of glass dates back to 3000 B.C. Mesopotamians, probably, were the first user of glass. Ancient glasses were found to have either magnesium or aluminium. Those glasses, which contained aluminium, are much durable than the other. Pottery and mud bricks were also glazed to make them impermeable to water. The glazes used were similar in composition to glass artefacts although often made opaque to cover defects on the surface of the substrate. For similar reasons metals were sometimes coated with coloured enamels, which were also glossy in nature.

Liquid glass is cooled below the melting point too rapidly to crystallise. Glass is a supercooled liquid. Glass is made by heating silica (silicon dioxide), soda (sodium carbonate) and lime (calcium oxide). In a typical sodalime glass (75% sand, 15% soda and 10% lime), soda lowers the melting point of silicon dioxide from 1710°C to 700-500°C and the lime stabilises the glass by making it insoluble in water. Potash glass and lead glass are stronger varieties of glass. The characteristic properties of glass are its transparency, hardness and rigidity at ordinary temperatures obtained with a capacity for plastic working at elevated temperatures.

Coloured Glasses

Small amounts, usually less than 0.5% by mass of metallic oxides import colour to glass. Eg. Ferrous oxide - blue, ferric oxide-yellow, both iron oxides-green, copper-red, cadmium - orange, chromium - orange, titanium - yellow, nickel - yellow, blue, cobalt - blue, violet, iron - blue yellow, green, amber, manganese - violet, pink, black.

Defects in Glass

Glass is preserved well in a dry climate. Devitrification may taken place due to the growth of seed crystals into larger in course of time. The glass may lose its transparency and become cloudy or crizzled, which is commonly called as *glass disease.* When moisture is in prolonged contact with glass the cations such as sodium, potassium and calcium are leached out and replaced by hydrogen and a layer of alkali metal hydroxides such as sodium, potassium and calcium hydroxides are formed at the surface of the glass. They are very hygroscopic and absorb more water. If left untreated at a pH above seven the silicate network breaks down and the glass may become so badly crizzled that small flakes break off when the glass is handled. Acid rain containing dissolved oxides of sulphur and nitrogen contributes deterioration resulting in sulphates and nitrates.

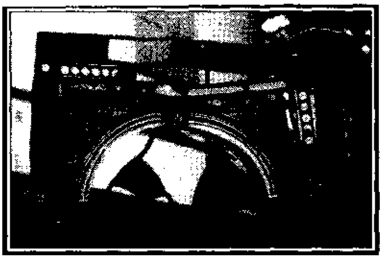
Conservation of Glass

The deterioration of glass can be stopped by avoiding contact of water with glass. The soluble alkali salts are washed with water, dried with rectified spirit, acetone or ether and stored in low humidity cases keeping silica gel. Broken glass vessels are repaired by using cellulose nitrate adhesives like *Durafix*, which does not shrink or undergo discolouration.

In the restoration of glass i.e. infilling the missing parts thermoplastic, methacrylate resins such as perspex are often used. The most successful results are with certain acrylic and polyester resins, as they are transparent, do not yellow, appear similar to glass and can be tinted simulating the stained glasses.

Stained Glass

Glass is a silicate. The overall stability of the glass depends on what elements are added and the precise quantities used. It is at the initial melting stage that colour is introduced. This usually takes the form of various metal oxides, which are either dissolved into the glass or applied on top of a clear sheet of glass. When we talk of the stained glass, we have to see the glass, surface decoration, lead and the cement used to fix them with the lead cames.



Damaged Stained Glass

Deterioration in Stained Glass

There is both physical and chemical deterioration in stained glass. The deterioration of stained glass is similar to that of glass.

Physical Deterioration

The physical damages include such factors as strong winds, hardened cement, bad fixing, faulty design of the structure, loss of paint due to bad fixing, vandalism, etc.

Chemical Deterioration

The chemical deterioration is due to the condensation of water on glass. If water is allowed to remain on the surface of glass for a prolonged period, it attacks the glass by releasing the alkali metal ions forming the hydroxides. By this, the glass will become weaker in its structure and more likely to crack and deteriorate.

Conservation Treatment

A detergent in deionised water removes surface dirt. No water is left behind on the surface. In order to remove the cement used in the stained glass, the cement portion is soaked in a detergent solution. The accretions are removed by air abrasion by sodium bicarbonate. The mended portions are cleaned with acetone. The corroded lead cames are replaced with new ones.

Storage

Since glass is fragile, it is essential that good storage facilities should be used. Stable glass can be stored and displayed at normal ambient museum conditions. For weeping glass, the RH must be maintained at 45 ± 2% with a temperature of 19° ± 2°C. Glass which is liable to crizzle should be stored at about 55% R.H. and 19° ± 2°C.

PART - IV
ORGANIC OBJECTS

WOODEN OBJECTS

Wood is a part of a tree and is an organic object. Wood can be obtained from monocot plants (palm trees) and from dicot plants (branched trees). There are two parts in all these timbers. They are heartwood and sapwood. The heartwood (strong) contains organic constituents like *lignin*, which make the wood insect proof. The sapwood (soft) is easily prone to insects.

Wooden Objects in Museums

The use of wood by man is from the earliest times. Wood was used for making agricultural implements, transports, household articles, hunting weapons, houses etc. Museums possess objects like woodcarvings, wood with decorated surfaces (lacquer, oil, paint and water-based colours), wood with inlays (veneers, shell, seeds and beads set in gum or resin), handcrafted objects, household articles, parts of houses, folk and tribal objects with leather, skin or hide coverings or with fibre ornamentation. Some of the objects are complex in nature.

Deterioration in Wooden Objects

Wood, even though hard and durable, is an organic material. It is very vulnerable to various causes of deterioration both of natural and man-made.

Wood is fibrous and cellular. A seasoned wood is said to have its water content in equilibrium with the atmosphere. When the wood is kept in a very dry atmosphere because of its quick drying, cracks are developed. Because of the change in relative humidity wooden objects swell or warp. In moist condition, wooden objects are easily affected by insects such as beetles, wood borers. The powder-post beetles make their entries into wood and give out fine powders. This damages the whole wooden object without anybody's knowledge. Among the insects the most damaging one is termite or white ant, which destroys the objects overnight. If wooden objects are kept in a damp condition for a long time, they may develop fungal growth, which weakens the surface. A really dangerous type of fungal attack on wood is called dry rot. Excavated wooded objects should be kept in moist condition wrapped with wet gunny bags, otherwise they may disintegrate. Woodcarvings from temple car appear to have covered with hardened oily accretions disfiguring the details of the carvings. This was due to the application of protective coating of oil applied to preserve the sculptures at the time of festivals. Repeated coatings of oils and leaving the temple cars along the streets allowing dust to accumulate the woodcarvings appear disfigured with caked up oil. In order to protect the wood carvings, the surface of the carvings sometimes are painted. It is not correct. It actually mars the beauty of the carvings and in due course the details get lost.

Mishandling and vandalism also affect wooden objects very much. Faulty handling, display and storage and neglect create havoc in the protection of wooden objects. Man-made and natural calamities also play very great role in the destruction of wooden objects. In such cases rescuing the affected objects becomes very difficult. Fire is the very dangerous calamity in most of the cases.

Conservation Measures

Wooden objects should be segregated from the soil and walls in order to avoid the contact of termites. The showcases and the area of the display as well as storage areas should be treated for insects and pests with Aldrin, Chloropyriphos, Durshban TC etc. But it is always better to use non-toxic pest control methods to treat the wooden objects. This is the common practice in the western countries now a days. Intense light and the UV content of light causes bleaching of wooden surface and structural deterioration. The light levels falling on the wooden objects should be within 200 lux or less and the light falling should be filtered to reduce the UV level to less than 75 micro watts per lumen.

Wide variations of climate cause disastrous effect on wooden objects. Microclimate inside the cases may be maintained by air-conditioning the galleries. Specific areas may have different R.H. because of want of air circulation. It may be better to provide fans to circulate air. The ideal relative humidity is 45-60 %. If air-conditioning is not possible, those cases, which need absorption of moisture, silica gel may be provided to remove the excess of moisture in side, the showcases. Both humidifiers and dehumidifiers may be installed in case if the objects are in the very advanced state of deterioration. This controls insect and fungal growth besides distortion of wooden objects.

Insect attacked wooden objects may be fumigated with a mixture of carbon disulphide and carbon tetra chloride (1:4) in a closed chamber. This kills the powder-post beetles. Then the holes are filled with wooden putty mixed with an insecticide like D.D.T. The growth of fungus is eradicated by the application of 1% orthophenyl phenol in rectified spirit.

In the fumigation of wooden artefacts, methyl bromide is preferred for the following reasons:

It kills eggs, larvae, pupae and adults of insects.
It is non-inflammable and non-explosive.
It is easy to apply and does not stain the objects.
It is economical to use and leaves non-toxic residues.
It has a high degree of penetration and no residual odour.
It is chemically stable and can be stored in steel cylinders for an indefinite period.
Its low boiling point permits rapid vapourisation.

Water logged wooden objects may be brought to the laboratory by keeping them in water or wrapped with wet gunny bags. They may be conserved by *freeze-drying* in which the water in the wood in frozen and is removed by vacuum sublimation by the *polyethylene glycol method.* Wood is placed in a solution of polyethylene glycol, which slowly replaces the water inside the wood.

Warping of wood may be set right by application of water and oil at the concave side and keeping lightweight on the other side with proper padding. After required flat surface in regained the sides are coated with resins like poly vinyl acetate to avoid further water absorption.

Accretions on the wooden objects may be removed by the use of solvents and softening agents. If accumulated dirt only is found on unpainted wooden objects, they may be removed by using *Extran* in rectified spirit. The excess Extran used is removed by rectified spirit. If dirt is accumulated on painted wooden objects care should be taken to remove the dirt. Benzene, rectified spirit etc., may be used by means of cotton swabs and the dirt may be removed area by area.

In the case of oily caked up accretions, the conservation treatment is difficult. In such cases the accretions may be softened by the use of organic solvents like acetone, rectified spirit, benzene. Care should be taken to avoid fire while handling, as these chemicals are inflammable. In such cases, a hot solution of 5% sodium carbonate is conveniently used to soften the hard material. Brushing with toothbrush and removing the material using blunt scalpels will clean the wooden objects. Thorough washing with pure water is done to remove the sodium carbonate used, if necessary. The wooden object should be dried under shade. When dried, the insect holes and cracks are filled with putty made out of same wood, if not possible similar wood and insecticide like D.D.T. A 2% solution of "AsCu" (a combination of arsenic and copper compounds) in water may be applied as an insecticide as well as fungicide.

Galleries should be vacuum cleaned to avoid resettling of the dust. Dust on wooden objects should be brushed off using soft brushes regularly. Since wooden objects are delicate in nature, great care should be taken in handling and storing them. The wooden objects may be wrapped in polythene bags in the storage to avoid dust. They may be stacked in padded wooden racks. The storage area where the wooden objects are stored, insecticides like B.H.C, D.D.T. may be sprinkled. Fogging with D.D.V.P. may be done to drive off insects.

Wood-carving with Dried Oily Acreations

Wood-carving after onservation

Protective Coating

When the surface is cleaned for the accumulated dust and dirt, the surface is cleaned and it should be protected from further accretions. Varnish may be applied to give a glossy look when there is no painted surface. If painted surface is available, a 2 % solution of polyvinyl acetate in toluene may be applied as a protective coating.

PAPER BASED OBJECTS

Among the materials used for writing, the oldest records are stone and baked clay (6000 B.C.). Papyrus was widely used in Egypt from 3000 B.C. to about 900 A.D. Leather, parchment, vellum, silk, ivory, bone, wood, paper, palm-leaf, metal, stone etc., are some other writing materials. Papyrus and paper, even though prone to decay, were widely used as writing materials.

Papyrus

Papyrus - a type of sedge - was used to manufacture papyrus. (Greek, Papyros=the paper reed). Rolls of paper have survived for thousands of years in the dry atmosphere of Egypt.

Deterioration of Papyrus and its Remedy

Brittleness is the major defect due to loss of water. The normalcy will be regained by moistening. Biological damages can be stopped by treating them with fungicides and insecticides.

Paper

The word paper is derived from papyrus. The method of manufacture of paper is entirely different from that of papyrus. The plant fibres were used for the manufacture of paper in the earlier days. Until 20th Century linen and cotton rags were used. But nowadays, wood pulp is mostly used for this purpose. The credit of inventing paper goes to the Chinese. Even though the use of paper was known for so many centuries, at about second Century A.D. only it was used for writing purposes. Cellulose is the chemical compound present in paper. Cellulose in paper is a condensation polymer.

Deterioration in Paper

The two factors responsible for the deterioration of paper are,

1) Intrinsic factors and 2) Environmental factors.

Intrinsic Factors

Acidity is the major deteriorating factor in paper. The essential cause of acidity is the existence of hydrogen ions. The hydrogen ion concentration is represented as pH. The pH value ranges from 0 to 14. If the pH is less than 7 it is acidic and it is alkaline, if the pH is above 7.

The acidity in paper is due to the formation of acid within the molecules. The 'alum' used in paper is hydrolysed and this increases the acidity. The lignin present in the paper increases the acidity. The residue of the chemicals used during the manufacture of paper increases the acidity. The cellulose decomposes and increases the acidity.

Environmental Factors

The various environmental factors responsible for deterioration are moisture, dust, oxides of nitrogen, sulphur and carbon, biological agents etc., besides mishandling, faulty storage and vandalism.

Moisture

Either the increase of acidity, increase of volume or sticking of art papers is due to the excess of moisture. The moisture content is measured by means of relative humidity (R.H.). When the relative humidity is more than 60% it adds water to paper, which encourages various deterioration to follow. The ideal condition is to maintain the R.H. at 55 to 60%.

Suspended Particulate Matter

Suspended particulate matter in the atmosphere settles on the paper and helps to disintegrate at moist condition. The suspended particulate matter is very high in industrial area and in Chennai it goes above 1300 micrograms per cubic metre at certain areas. It is very high in Delhi.

Oxides of Sulphur and Nitrogen

In cities like Chennai city the oxides of sulphur, carbon and nitrogen are very high due to industries and automobiles. These oxides dissolve in moist air and increase the acidity of the atmosphere, which increases in turn the acidity of paper.

Biodeterioration

The moisture in paper encourages mould and fungal growth and insect attack. Common insects are silver fish, booksmoth, beetle, bookworm etc. Foxing is the formation of small brown spots, which are due to biological activity as well as due to iron impurity in the paper. Paper becomes brown due to acidity and becomes brittle.

De-acidification of Paper

De-acidification is the removal of acidity from paper. This can be effected by dry methods as well as wet methods.

Dry De-acidification

The paper materials are de-acidified by keeping them in an ammoniacal atmosphere in a closed cabinet. The acid is neutralised by ammonia, which is basic in nature. Mass de-acidification is done by fumigating the room or gallery or stack room with diethyl zinc.

Wet De-acidification

If the paper has permanent inks wet de-acidification can be effected. Otherwise the writings will be lost. Anyhow, the wet de-acidification may be done with the help of methanol, ethanol, diethylether etc.

By Hydroxide

A saturated lime water de-acidifies the paper material and then reacts with carbon dioxide, forming calcium carbonate, which acts as a reserve to neuralise any subsequent acidity. If the use of water is to be avoided, sometimes a saturated solution of barium hydroxide is also used as it dissolves in methanol.

By Bicarbonate

Magnesium bicarbonate is also used to neutralise the acid and the magnesium carbonate thus formed is used as the reserve against acidity.

Cleaning and Bleaching of Paper

Stains formed on paper may be removed by the use of non-abrasive erasers, soaking in water to remove or reduce staining and by the use of organic solvents like toluene, hexane, methanol, ethanol, pyridine, chloroform, trichloroethane, acetone etc. The pigment should be tested before the use of the above solvents. The chlorine dioxide evolved by the action of formaldehyde on sodium chlorite is a mild bleaching agent in water medium. Chloramine-T in alcohol is also used. Chlorates and hypochlorites are powerful bleaches. Therefore they should be used in a very low concentration. Hydrogen peroxide is also used. In case, water is to be avoided, hydrogen peroxide in diethyl ether must be used.

Inks and Adhesives

In the earlier times soot mixed with vegetable gum was used as black ink. Later iron gall inks were used. Nowadays chemical inks are used. Therefore, it is always safer to test the ink for the fastness before any conservation work is started.

In order to remove the old pastes used in binding etc., enzymes are used to separate the sheets, if rebinding is required. In the present day, carboxy-methyl-cellulose, wheat flour paste, maida flour paste etc., are used along with little (0.1%) fungicide like paranitrophenol and insecticide like mercuric chloride and copper sulphate. 1% formaldehyde is also used in the preparation of the paste as fungicide.

Repair of Paper Materials

If the paper is very fragile, it can be strengthened by lamination. This can be effected by a laminator with the help of cellulose acetate foil and tissue paper under heat or by hand lamination with cellulose acetate foil and tissue paper using acetone to convert acetate foil as a paste in cold condition. Chiffon lamination is also effected by the use of chiffon and maida or wheat flour paste. All these repairs are reversible. If any method is ineffective, the lamination can be reversed at a later date.

Insect Attacked and Restored Print

Care of Paper Materials

A suitable storage condition of constant temperature of about 20°c and a relative humidity of 55-60% in pollution free atmosphere. A proper storage of paper manuscripts should be made. The manuscripts, books etc., should be kept perpendicular to the shelves and cleaned periodically by vacuum cleaner. It should be ensured that proper ventilation and air circulation is made, if air conditioning is not done. While handling, if the books or manuscripts are very fragile, a proper book rest should be provided. Paper materials should be periodically fumigated with the help of thymol or paradichlorobenzene to eradicate the fungal and mould growth.

Papier- mâché

Well-pounded water soaked paper is in the form of pulp and is called papier-mâché. It is being used traditionally to make boxes, baskets, decorative objects. Quite often they are prepared hollow. These objects are mostly found decorated in colours or paints and are varnished or lacquered.

Damages to Papier-mâché

Since the main constituent of papier-mâché is paper, it is affected by high relative humidity and highly prone to fungal growth. Insects also damage these types of objects.

Conservation Measures

Since papier-mâché is similar to paper the treatment is also similar to paper based materials. These objects are very weak and fragile. Therefore, they should be handled carefully.

PALMLEAF MANUSCRIPTS

In the tropical countries like India, China palm trees are in vogue and the palm leaves were used as writing materials. Styluses were used to inscribe on palm leaves. Museums, temples, libraries etc., are in possession of palm-leaf manuscripts, which consist of *stalapuranas*, accounts, *Ramayana, Mahabharatha,* local history, medicine etc., which should be preserved.

Preparation of Palm-leaf Manuscripts

The tender palm leaves of 4 to 5 weeks old are cut into required size and dried under shade or buried under marshy water. On the contrary, they are boiled in steam or in turmeric solution. Such seasoned palmleaves are inscribed by stylus. Since the inscribed letters are having the colour of the leaf the inscribed portions were either applied with the essence of *Kadukkai* (Terminalia chebula) or green leaves of *Kovakkai plant* (Coccinea grandis). The letters after sometime appear black, making it legible to read. The palm-leaf manuscripts range from 4 cm to 85 cm in length and up to a bundle thickness of 50 cms. Sometimes the palm-leaves are found to have paintings. The edges of bundles are gold gilded.

Deterioration of Palm-leaf Manuscripts

Palm-leaf manuscripts are organic in nature and therefore they are affected by high humidity, microorganisms, insects, dust, heat, mishandling, vandalism and ill maintenance. When certain insects attack them, they bore holes from one edge to the other making a tunnel and hence the leaves are stuck together. The edges are accumulated with dust and they attract fungal attack. Normally the palm-leaf manuscripts were preserved in the lofts of the kitchen. They are accumulated with soot and smoke. Silver fish etc., eat away the surface and letters are lost.

Traditional Preservation

The palm-leaf manuscript bundles were dusted, cleaned with turmeric powder and bundled by cloth keeping neem (Azadirachta Indica) dry leaves or *cus-cus,* called *vettiver* (Vetriveria zizanoides). Sometimes powdered pepper (Piper nigrum), *pattai* (Cinnamomum zeylanicum), cloves (Caryophyllus aromaticus) etc., are mixed and kept in between the bundles in a cloth sachet. These are used to drive away the insects and microorganisms.

Conservation of Palmleaves

The stuck palmleaves of the bundles are baked in a steam vessel. Steam percolates and moistens the clayey materials and the leaves are easily separated. The leaves are cleaned with brush followed by rectified spirit. Then a 5% solution of citronella oil or lemon grass oil or olive oil in rectified spirit or the extract prepared out of fresh palmleaves in rectified spirit is applied and allowed to dry in shade. The oil used restores flexibility to the palm-leaf as the cells in the leaves absorb oil. If the palm-leaf is distorted, 1:1 rectified spirit-water mixture is applied and pressed between oilpaper and kept under weight. When dried it is found flat. Then 5% oil in spirit is applied and dried. This act not only gives flexibility but also provides insecticidal and fungicidal property to the palm-leaf manuscripts.

Restoration of Palm-leaf Manuscripts

The broken palm-leaf manuscripts should be restored. The restoration can be done in many ways. Because of the cleaning process or natural means the letters become illegible. Therefore, the inscribed portions should be rubbed with *kadukkai* essence, *kovai plant leaves* or lampblack in oil. Then the mending is done. The torn portions are cut to the required size keeping similar uninscribed leaf underneath with a knife. The affected portions are now pasted at the edges with the cut leaves using a 10% solution of poly vinyl acetate in acetone. At times lamination by chiffon using maida flour paste is done. Lamination by cellulose acetate foil and acetone is also is done but the edges are trimmed so that the leaves may breathe. Joining of the torn portions or breakage may be repaired by using polyvinyl acetate in toluene or Paraloid B 72.

General Care

Since the palmleaves are easily stained, they may be displayed by keeping them under polythene bag or cover. By this way dust is also avoided. The display as well as storage areas should be kept clean and treated with insecticides and fungicides. Fogging with D.D.V.P. will be effective as it penetrates through the leaves and drive away the insects and fungi.

The palmleaves are tied keeping two planks of teakwood on both sides, which is slightly wider than the leaves so as to give a protection from distortion and physical damage. The bundles are stacked in such a way that they stand on the support of the planks. This avoids dust to be accumulated at the edges of the leaves. Since high humidity bulges the bundle and attracts insects and microorganisms the galleries and storage areas may be air-conditioned. Otherwise they may be kept inside showcases and silica gel may be kept inside them to absorb excess of moisture.

TEXTILES

There are references for the use of leaves and leather as dress materials. Barks of certain trees were also used to make clothes. When man learnt to spin and weave, the fibres and fabrics came into existence. The term 'fibres' covers untreated leaves, grasses and reeds, split cane, raffia and flax, as well as threads spun, twisted or plaited from any of these, plus asbestos, coconut husk, human and animal hair and the more familiar fibres – cotton, silk, linen, wool and modern synthetics. Fabrics can be made from any of these fibres by weaving, when they are known as textiles, or by non-woven process such as knitting, lace-making, netting or felting. Felting may sometimes also denote bark-cloth. The invention of dyes made man to make colored fabrics. Designing of the textiles took importance when man wanted to have aesthetic beauty.

Types of Textiles

Textiles are made out of natural and man made fibres. Fibres from plants, animals and insects, like cotton, flax, hemp, jute, wool, silk are natural fibres. Nylon, polyesters, terylene etc., are made out of synthetic materials and are man-made. Museums possess all types of fabrics and textiles viz. Barks, leaves and costumes ranging from a simple cotton saree to ornately decorated costumes of silk or wool. Care of textiles of natural fibres is of importance and of concern to the museum Curators and private collectors.

Causes of Deterioration

Biological Agents

Microorganisms like fungi, moulds grow on textiles made of cotton, flax, hemp, jute, wool etc. Fungi not only weaken the fibres but also leave stains, which are difficult to remove. Insects play havoc in the case of textiles. Termites destroy all types of textiles when suitable damp condition prevails. Wool-moths attack woolen materials. Certain beetles like the dermested beetles damage wool and silk.

Mishandling and Vandalism

Improper display and storages cause greater damages to the textiles. Neglect and ill maintenance also matter much. Vandalism is yet another serious factor, which damages our museum textiles.

Conservation Measures

Acidity in textiles make them to change the colour and weakens the fibres. Acidity of the textiles is found out by pH papers. From the colour change, we can find out the pH and say whether the textile is acidic (pH: up to 7) or alkaline (pH: over 7). If the textile is plain without any colour, it may be de-acidified by fumigation with ammonia in a closed chamber. In case of fast coloured fabrics, the acidity may be removed by keeping the textile in between chiffon cloths on a glass support and washing with 1% *Extran* in distilled water. It should be thoroughly washed in water to remove acidity as well as the soap completely.

Stain may be removed by ringing method. The stained side is padded with cotton and from the other side a solvent like acetone is applied which loosens the stain and is absorbed by the cotton pad. In European countries wet methods of treatment are abandoned.

There are several methods of strengthening textiles. This can be done either by mounting, lamination or by impregnation. Mounting of weakened textiles is done on strong backing cloth by means of needle and thread or by velcro. Lamination by chiffon is also done by stitching. Impregnation can be done by methylmethacrylate. Freeze-drying may be done once a year to avoid all biological activities at -20° C. The movement of insects in the galleries or storage areas are identified by the use of various insect traps, which are cardboard devices with sticky materials, to catch insects.

Mending of Textiles

If the textiles are found torn, they need mending. The darning may be done by fixing the textile in a frame. While darning is done, the thread of the same size as that of the original textile is used. In European countries the fibres for darning are dyed by the conservator with the use of the similar type of dye used in the original textile.

General Care

All fabrics should be carefully examined at the time of accessioning to identify fibre type and fabrication technique and to note the presence of any colouring material or attached decorations. The condition report also should be made and they should be inspected once a month.

Since all kinds of textiles are extremely susceptible to light, care should be taken in the following lines: in the displayed area the intensity of illumination should be kept low, which may range from 50-100 lux. Ultra violet absorption filers may be used in the light sources. Natural light has ultraviolet radiation and so natural light should never be allowed in the galleries as well as storage areas but only artificial source of light, that too indirect light, should be used. Now a days, fibre optic lighting is preferred as they do not emit heat, ultra violet light etc.

High relative humidity favours always fungal growth as well as insect attack. Therefore, it is always good to control moisture by air-conditioning the galleries and the RH should be maintained at 45 – 60 %. In order to avoid fungal growth in the textiles, they may be periodically fumigated with thymol. Naphthalene balls may be kept in the display cases. Fumigation with D.D.V.P. may be done periodically both in the galleries as well as storage areas.

Since insects damage the textiles, insecticides and germicides should be applied both in the galleries and storage areas. Termicides like Durshban TC, Aldrin and insecticides like D.D.T., B.H.C. may be used.

Since dust creates a lot of problems, dust filters may be fixed in the air-conditioners. Regular vacuum cleaning should be done both in the galleries and storage areas. The textiles are covered by polythene covers over acid-free tissue paper and stored.

Because of the various shapes and sizes of the costumes, it is difficult to have a proper storage. One method is to store them in cabinets and hang them on padded hangers, with polythene sheets or bags to cover them. Contrarily, they are stored flat with pads or sheets of tissue paper inserted in the folds. To store costumes in a flat position, wooden drawers in cupboards are useful.

Regular inspection is to be made to find out the defects, if any. Periodical application of insecticides, fungicides and termicides and a good maintenance to keep all the textiles in good condition. Pre-monsoon application of biocides in the galleries and storage areas considerably avoids fungal and mould growths.

RUBBER OBJECTS

Museums nowadays collect objects of all types. In European countries, present day objects are collected and displayed. Ethnographic museums or multidisciplinary museums collect objects of rubber. Rubber is present in the form of natural rubber bands, coloured balloons, rubber tubing, tyres, inner tubes, etc.,

Constituents of Rubber

Natural rubber is prepared out of the latex from rubber tree. Rubber is largely composed of unsaturated polymers like poly isoprene, polyputadiene, polystyrene, co-butadiene.

Causes of Deterioration

Since rubber is an unsaturated chemical compound, it is susceptible to oxidation. When rubber is oxidised the product may be softened or hardened. Attack by ozone causes embrittlement and subsequent cracking of the rubber objects. Prolonged, uncontrolled oxidation and attack by ozone results in disintegration of rubber and serious damage to objects.

Conservation Measures

There are several measures, which can be tried to protect rubber from its degradation. There are both physical and chemical methods.

Physical methods involve introducing a barrier between rubber and atmosphere i.e. giving a coating on the rubber or sealing the object in a bag, which is oxygen proof. Coating of chemicals or resins will alter the appearance of the rubber object.

Chemical method include keeping an oxygen free environment to rubber by keeping the rubber in a nitrogen atmosphere and the oxygen present may be absorbed by keeping *Ageless,* which is nothing but finely divided active iron, which forms iron oxides and hydroxides on absorption of oxygen. The materials which are considered to have suitable properties are poly vinylidene chloride film. Cryovac BDF 200 film. The physical condition of the rubber objects may be monitored periodically by photography in order to see the change.

BOTANICAL SPECIMENS

Collection of Plants

The botanical specimens are necessary as a whole for the study of the various parts in a museum. Therefore when collection of botanical specimens is made it should be noted that the plant should be collected with roots, flowers, fruits etc. The common and general equipment for collection of plant specimens are the vasculum (a tin box) and the portfolio (wooden frames with blotting paper).

Botanical specimens as a whole can be classified as follows:

1. Thallophytes (bacteria, algae, fungi, lichens)
2. Bryophytes (liverworts and mosses)
3. Pteridophytes (clubmass, horsetails, ferns)
4. Gymnosperms (trees with exposed ovules and pollen grains)
5. Angiosperms (monocotyledon)
6. Botanical specimens may be prepared as models and pictures.

Botanical specimens may be preserved both by wet preservation and dry preservation.

Thallophytes are preserved with the help of about 4% formalin mixed with the water in which they grow. Fungi are poisoned with a saturated solution of alcohol with mercuric chloride and allowed to dry. Lichens are poisoned with a 1.25% solution of mercuric chloride in alcohol.

Bryophytes are preserved as dry preserved specimens with the help of 1. 25% solution of mercuric chloride in alcohol.

Pteridophytes are preserved by treating them with copper acetate and glacial acetic acid.

Gymnosperms are preserved with the help of a saturated solution of mercuric chloride in alcohol.

Angiosperms are preserved by different ways depending upon the type of the plants etc.

Herbarium is prepared by displaying both the sides of the leaves and flowers in the drier. First few days the sheets of paper should be changed daily then on alternative days. The specimen sheets should be fully documented for study purposes.

LEATHER OBJECTS

Leather is nothing but cured skin, which is dehaired, defatted, made non-putrescent and impervious to water. Skin is composed of three main layers.

1. Epidermis – outer layer
2. Corium or dermis – middle layer from which the leather is made
3. Subcutaneous layer – the third layer.

Skin is a net work of protein fibres chiefly collagen. Tanning is a method of processing skin to produce leather. To convert a skin to leather it is usual to remove both the layers above and below the corium, which is then subjected to various treatments such as dehairing by liming, pickling, tanning, splitting, dying, puffing etc.

Deterioration of Leather

Leather is an organic material. High humidity, low humidity and temperature affect very much leather objects. High humidity encourages moulds growth and other biological activities. Low humidity dehydrates the leather objects there by leather gets hardened and embrittled. Dust and pollutants like sulphur dioxide make leather to receive acidity there by leather objects become brittle. Daylight and high levels of artificial light affect leather adversely. They can cause fading and colour change and accelerate deterioration.

Conservation Measures

The environment should be controlled where the leather objects are displayed or stored. In the storage the leather objects should be kept covered by acid free tissue paper to avoid dust and sulphur dioxide. Three-dimensional objects should be displayed or stored with their shapes supported. Metal pins or staples should never be used to fix leather objects to a mount.

Leather objects should be fumigated with thymol or para dichloro benzene to avoid the biological activity in the objects. Hardened leather objects may be made flexible by the application of 2% castor oil in rectified spirit. Fungal affected leather objects are fumigated and cleaned with a vacuum cleaner and treated with 0.1 para nitro phenol in rectified spirit. Light intensity should be low in the gallery.

FEATHER OBJECTS

Feather forms art objects on their own rarely. They become part of an object such as head-dress, crown etc. They are almost always secured to some kind of substrates, such as netting, basketry or hide and the method of attachment of the feathers may be sticking, tying, etc. Protein - 'keratin' - is the main constituent in feather. It is similar to that of hair but with a rather different molecular structure. Feathers are not flexible as hair but will break, if folded or stretched.

Causes of Deterioration

Feather is inherently quite stable, but gradually they become brittle over a period of years. They become brittle below 40% R.H. and mould develops over 65% R.H. The bright yellow and red colours in the feathers fade at higher levels of light. Feathers are susceptible to dust, which settles and become trapped. The dirt soils the appearance and provides an additional food source for insects and moulds. Insects attack feathers at larval stage, which feed on keratin.

Treatment of Feather Work

The dirt may be removed by brushing with soft brush using rectified spirit. The eggs of the insects may be removed by brushing. The feather work is fumigated with D.D.V.P. (Vapona). New acquisitions should be fumigated with paradichlorobenzene before they are added to the collection. It is better to maintain the R.H. between 45 and 60% and temperature between 20 to 22°C. In the case of coloured feathers, they should not be exposed above 100 lux. Dust should be avoided either by filtration or keeping the objects in showcases. Infested objects should be isolated and fumigated. Careful handling is important as feathers can be easily bent or broken, or the vanes disrupted. In handling such objects both the hands should be used. Folding should be avoided. Feather work should be stored in dark and cool areas with protection against dust. Open storage should be avoided. Handling objects while inspection should be avoided. Objects should be displayed within cases having light up to 100 lux.

Storage

Feather objects should be stored in dark, cool environment, with protection against dust. They should be stored individually not heaped. Three-dimensional objects should be well padded and supported to retain their shape. Open display of the feather objects is not advisable because of the dangers of moth, dust and physical damage, if they are touched by the members of the public.

BONE AND IVORY OBJECTS

Bone and ivory were early raw materials for carving out artifacts. Bone was used to make fish-hooks, arrow heads, tools, implements etc. Ivory was used to carve, etch, stain, paint, gild, inlay with metals and with precious and semiprecious stones. It is also used to inlay on wood and for veneering.

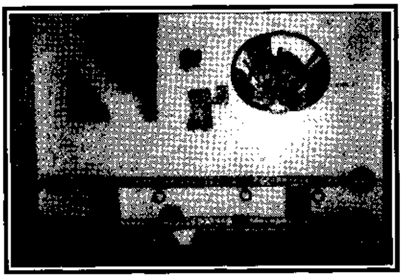
Composition of Bone

Bones are hollow and the cavity contains marrow. Objects made of bone and ivory and indistinguishable by mere sight. The main inorganic constituents are calcium phosphate associated with carbonate and the organic constituent is *ossein.* Bone has cellular structure.

Excavated Bones of Capricon at Veppur, Vellore Dt.

Composition of Ivory

The term ivory describes the teeth or tusks of a number of animals such as elephant, boar, narwhale, walrus, hippopotamus and spern whale. Ivory is much heavier than bone and has a finer grain. Chemically ivory is related to bone. It is composed mainly of calcium phosphate that is associated with some calcium carbonate and fluoride with magnesium. The organic component of ivory is mainly collagen. Ivory has a hard and dense tissue known as dentine, which results in striations. The striations may be seen radiating from the centre of the tusk.



Ivory Objects
Courtesy, Meenakshi Amman Temple, Madurai

Deterioration in Bone and Ivory

Bone and ivory are *anisotropic* having directional properties and for this reason they are easily warped upon exposure to heat and damp. They are decomposed by the prolonged action of water due to hydrolysis of the ossein. Acids disintegrate them. Ultra violet radiation from daylight and fluorescent tubes and high levels of visible light will bleach the surface of ivory and polymerise its natural oil.

Being porous and of light coloured, they are easily stained. They tend to become brittle with age and they lose their natural colour when exposed to sunlight. When buried in the ground for prolonged periods of time, they are disintegrated either by salt encrustation or by water. With the onset of fossilisation, the organic content gradually disappears and the remaining calcareous matter becomes associated with silica in the form of quartz and with mineral salts derived from the ground. Old bone and ivory often have a yellow colour and this is accepted as a form of *natural patination, which* may help to enhance the appearance.

Conservation of Bone and Ivory Objects

There are various methods of conservation of bone and ivory objects. Depending upon the type of defects the treatment varies.

Removing Surface Dirt

Accumulated dirt, soot and grease obscure the beauty of the objects of bone and ivory. If the condition of the bone or ivory object is fairly good, a 1% solution of *Extran* in water is brushed on the surface and the dirt is removed with cotton swabs. Prolonged contact with water should be avoided. When fragility is observed the procedure is adopted with *Extran* in rectified spirit.

Removing Soluble Salts

Excavated bone and ivory objects are found to contain absorbed salts, which tend to crystallise out effecting disintegration, if they were buried in salty ground. The removal of salts from bone and ivory objects is extremely difficult. The soluble salts should be dissolved out by water. Bur, prolonged immersion or washing will damage the structure and it may warp. The soluble salt encrusted objects are immersed in distilled water for 5 seconds and is repeated a number of times with fresh distilled water. Then, two washings in 95% alcohol is made. Finally the object is immersed for one minute, and dried in air.

Removing Insoluble Salts

Removal of incrustations of calcium carbonate or calcium sulphate from bone and ivory objects are a professional conservator's job. A small area of about 1 square centimeter is taken and brushed with a 1% solution of hydrochloric acid for a few seconds and the reacted material is removed immediately by a blotting paper. This is repeated. The incrustation is removed by means of pin or scalpel without making any scratch or abrasion. In order to remove the traces of acid the object is washed in several changes of distilled water for a few seconds at a time and then dried by alcohol and finally with ether. If only calcium sulphate is present, it should be removed by mechanical means even by vibro-tool very carefully provided the object is strong enough. Otherwise it may be left as such

Strengthening

When bone or ivory object is weak, it may be strengthened by impregnating it with a 5% solution of polyvinyl acetate in toluene. This may be done 3 or 4 times to do a justification. Fragile objects may be vacuum impregnated. During excavation, a water emulsion of poly vinyl acetate (P.V.A.) or polymethacrylate may be used to strengthen wet and soft bone or ivory objects before removal of the object. Bone and ivory objects may be given a protective coating of 2% P.V.A. in toluene.

Restoration of Bone and Ivory Objects

In the restoration of bone and ivory objects suitable adhesives, which will not be affected by humidity, are used. Nitro cellulose based adhesive is good for restoration. Water-soluble adhesives should never be used.

General Care

Since bone and ivory objects are porous and are easily scratched, stained etc., they should be wrapped in a clean soft acid-free tissue paper and kept on padded shelves or in padded boxes. They should not be kept along with other objects, which will cause stains. Metal pins should be isolated from bone and ivory objects.

Very badly affected objects should be kept in showcases, which are provided with silica gel to control relative humidity by absorbing moisture.

ETHNOGRAPHIC MATERIALS

Ethnology is the science of the races of mankind. Ethnography is the scientific description of the races of mankind. The materials used by them are called ethnographic materials. Ritual objects of all kinds secular objects, tools, machines, equipments connected with trade, domestic utensils, ornaments and jewelleries, clothes, musical instruments, weapons etc., are some of the types of objects of mankind. Museums normally collect and preserve those objects belonging to the tribes. Metals, especially iron and copper alloys, but also gold, silver, lead and aluminium, glass and stone beads, wood, fibres, grass, skin, animal fibres, bone, teeth, clay, ceramics, textiles, feather, latex are some of the types of materials of the ethnographic collections.

Damages Caused

Climatic variations affect materials of organic nature and paintings. Insects are the main enemies. They are wood-borers, white ants, cockroaches, etc. Cockroach is a great destroyer of subtle patinas, paintwork, feather decoration, textiles and dessicated skin like preserved bodies, mummies etc. Rodents cause damage to ethnographic materials. Lizards, geckos damage the materials by their droppings. There are a great number of fungi both wet and dry of the flowering and the filament type, which cause extensive and fundamental damage to the ethnographic materials. There are many surface moulds, which constantly recur, especially during the wet seasons. These destroy protein elements in patina and will grow well on any film of moisture or finger marks left on metals, and there is even a distinct mould, which constantly recur, especially during the wet seasons. These destroy protein elements in patina and will grow well on any film of moisture or finger marks left on metals, and there is even a distinct mould, which attacks glass. The acids produced by mould metabolism permanently etch the surfaces.

Conservation Measures

In this book the conservation measures are dealt with by the materials used to make the museum objects rather than the type of object. But, a general method of conserving the ethnographic materials is dealt with in this heading.

Mechanical Cleaning

Airbrasive method of cleaning is one of the physical methods of cleaning. The airbrasive process employs a system of grit spraying, which is so refined and controlled that it may be used to clean ethnographic materials disfigured by corrosion products, mud, dusts and other types of loose, non-greasy dirt, which might have been accumulated during use, improper storage or during exhibition where the objects were not protected by show-cases. Good conditioned basketry specimens may be cleaned with dolomite airbrasive cleaning. Greasy basketry specimens may be cleaned with a solvent such as acetone, alcohol etc., and dried. A great deal of beadwork occurs in conjunction with other materials such as leather and cloth. Sometimes it occurs with metal or basketry. Dolomite or glass-bead powder abrasive cleaning may be done. Copper and brass objects may be cleaned with dolomite abrasive cleaning. If the corrosion is merely a thin layer of tarnish or silver, glass bead airbrasive will do. Iron objects can be best cleaned with dolomite airbrasive cleaning. Metallic embroidery - silver, gold or silver with a gold wash may be cleaned with glass-bead airbrasive cleaning, which removes the tarnish quickly and leaves a satin finish.

Chemical Treatment

Ethnographic objects are mostly organic and are prone to all types of deterioration. Due to usage they are adherent with oily or greasy coat. All such materials when added to the museum collection, they should be fumigated for the eradication of insects and fungi with para-dichloro-benzene and thymol. Wooden objects may be fumigated with methyl bromide. Textiles are fumigated with para-dichloro-benzene or naphthalene. The crease or oily ethnographic material may be cleaned with solvents such as acetone, benzene, toluene, rectified spirit etc., and dried if the colour is fast. Since ethnographic objects are complex materials the type of material in the object may be treated according to the type. It is always better to give protective coating to metals attached to the objects. The weakened wooden portions may be consolidated by injecting with 10% Paraloid B 72 in xylene. The ethnographic specimens may be sprayed with ortho nitro-phenol in spirit to prevent mould growth.

Mummies

Mummy is derived from a Persian word '*mummia*', meaning' bitumen'. As the dead bodies in Egypt, in later periods, were treated with bitumen like molten resin the preserved bodies were called mummies. Mummification of human bodies was the practice adopted in ancient Egypt for the disposal of dead bodies. Human body consists of a large amount of water to the extent of 75 %. If this water can be dried out artificially or otherwise, the body can be made to preserve almost indefinitely. This is the basic principle of mummification. Desiccating the body with the help of dehydrating chemicals like calcium hydroxide, common salt or natron found in Egypt in abundance was commonly practiced. The body was dried with natron and wrapped in linen bandages and a plaster case to give it a human form. Sometimes, it was painted also. This bandaged body was placed in a wooden coffin or sarcophagus, which was quite often elaborately decorated and painted.

Mummies
Courtesy : British Museum, London

Causes of Deterioration

Higher humidity affects the surface by mould growth. Very dry conditions between 40 to 50 % relative humidity and 18 to 20°C temperature make the mummies to become brittle. The linen wrapping in some parts of the mummy are lost and portions of the body get exposed, due to vandalism and mishandling. There is a mummy displayed in the Government Museum and Picture Gallary, Baroda, which is found damaged by the visiting public.

Conservation Measures

Water or water based solutions should never be used for the cleaning of dirt on mummies. Only organic solvents like acetone, spirit, tetrachloroethylene, xylene are used. 0.5% solution of ortho phenyl phenol in spirit is sprayed to avoid insect attack. The lost linen portions may be repaired with fresh linen strips and molten resin.

ZOOLOGICAL SPECIMENS

Preservation of zoological specimens requires a special care and attention. At the death of the animals or birds the decay starts. It is essential to take necessary steps to preserve the animal body immediately after the death. It is essential that while preserving the specimens for the study purposes one should remember that the colour, form and the general appearance of the living animal or bird should be found in the preserved bodies. Zoological specimens generally preserved in a museum are such as the skeletons, parts of the living animals, eggs, nests, etc.

Methods of Preservation

There are many methods of preservation of zoological specimens. They are the following:

1. Wet Preservation 2. Dry Preservation and
3. Advanced Methods of Preservation such as

   a. Plastic infiltration b. Plastic embedding and c. Freeze drying

Wet Preservation

In the wet preservation liquid chemicals such as formalin, rectified spirit etc., are used. Formaldehyde is available as 40% solution, formalin, in the market. For the wet preservation, it should be diluted to 4% and is neutralised with 10 grams of borax to every litre of the solution. 90% alcohol is used to preserve certain specimens. For preserving sponges '90% alcohol should be used. Jellyfishes may be preserved by 4% solution of formalin.

Dry Preservation

Insects, birds, and mammals can be preserved as dry preserved specimens. In this method the perishable parts such as the flesh and muscles in the body should be removed. The skin portions should be preserved with the help of chemicals so that the skin is flexible and not eaten by insects. The body is given a false body with jute or similar materials and is kept in the right position so that they look like the original specimen.

Preservation of Mammals

Preservation of mammals involves skinning, tanning and mounting. The skin is removed by cutting open the belly and the skin is peeled down over the hip. The hip joints and leg muscles are cut from the pelvis. The tail skin is peeled back on the tail. Then the forelegs are cut at the shoulder joints and skinning is continued down over the head. The skull is separated from the neck at its base keeping it attached to the skin at the snout. Brain and eyeballs are scooped out from the skull. Arsenic paste (Arsenic oxide, alum and soap) is applied over the limb bones and to the skull. Fine powdered alum is rubbed over the inner surface of the skin. The inner surface is also rubbed with stone to remove the tissues and flesh and fatty oil is applied. The arsenical paste is applied over the inner surface of the skin and also on the limb bones and the skull. It is poisonous and therefore it should be handled very carefully. Mounting is done after the false body is prepared and the preserved skin is fixed to the artificial body and stitches are made. Artificial eyeballs are fixed and suitably painted. The science of preserving the animal specimens is called *Taxidermy*. Taxidermy was coined from two Greek words, Taxis meaning arrangement and Derma meaning skin. This is nothing but the skin art.

Advanced Methods of Preservation

Plastic Infiltration

After preserving the animal, resin is injected into the body to preserve the internal organs. Then the specimen is mounted on a glass plate and immersed in the resin for about 24 hours. Then the mount with the animal is taken out and allowed to dry. After thoroughly dried, the animal is separated from the mount. Fishes and reptiles may be preserved by this method.

Plastic Embedding

In this method plastic resin is used to mould the specimen. The liquid resin is taken in a glass cell and the specimen is kept inside and the catalyst and the accelerator are added. It solidified and the specimen is preserved inside the resin. By this method some insects, fishes and reptiles may be preserved.

Freeze-drying

In the methods of preservation, it is very simple and important method followed in the advanced countries. After keeping the animal in the required position, liquid nitrogen used to fix the specimen in position. This makes the specimen is devoid of moisture. Then the specimen is placed inside the freezing chamber in which low pressure and temperature down to –25° to -45° C is maintained. In this method the moisture is completely removed. Artificial glass eyes of appropriate size and colour are fixed inside the eye sockets replacing the natural eyes.

PART - V
PAINTINGS

PAINTINGS ON CANVAS

India is well known for the traditional paintings such as larger paintings on wall, leather, canvas etc. There are paintings executed by artists of Persian and Indian schools and developed over the centuries. The canvas paintings were introduced by the Europeans in India. Especially British artists excelled in this form of art and we have thousands of British paintings on canvas in India.

Composition of Paintings on Canvas

Paintings have a complex multilayered structure whatever may be their forms. They are support, ground, paint and varnish. In the case of paintings on canvas, the canvas support for paintings is a strong cloth made from unbleached hemp, flax or other coarse yarn. The canvas was coated, or primed, with an inert white powder like chalk, gesso, zinc oxide, titanium oxide in a glue medium, to form a uniform layer or ground. Modern canvases are brought ready-primed with zinc white and linseed oil. The paint layer overlay the ground and consisted of an aggregate of finely ground pigment particles suspended in a binding medium i.e. either oil colour or watercolour. The usual finish was to apply a coat of varnish, to give an enhanced gloss and to protect the painting from light, dust and other environmental factors.

Pigments and Dyes

From antiquity right up to the late nineteenth Century, artists' pigments were almost exclusively inorganic materials-either natural minerals (or synthetic substances resembling them) or else residue from the careful calcination of organic matter such as bone and ivory. The pigments are invariably insoluble in a binding medium and therefore they are used as suspensions.

Dyes used from ancient times to the late nineteenth Century were obtained from plants and animals. Modern dyes and pigments are essentially organic compounds rather than in-organic. Dyes are generally soluble in water and bound to the textile. The natural dyes have not been widely used in painting, because of their tendency to fade and lack of intensity of colour. The madder and indigo are of plant origin and they are fast colours.

Some of the ancient pigments are (white) chalk, gypsum, kaolin, lead white, bone white; (black) lampblack, pyrolusite; (yellow) ochres, siennas, orpiment; (red) hematite, vermilion, madder red, red lead, realgar; (green) malachite, chrysocolla, verdigris; (blue) azurite, ultramarine.

Deterioration of Paintings

The deterioration of paintings may be a result of deterioration of any one or more of the constituent layers viz. support, ground, pigment and varnish.

Deterioration of the Canvas

Deterioration of the canvas is due to the oxidation of the cellulose fibres. There is always a danger of the growth of micro-organisms like fungi, moulds etc., in humid conditions. Silver-fish, cockroaches, beetles, and termites are some of the insects that damage paintings. Climatic variations have a profound effect on the condition of the paintings.

Deterioration of Paint

Paint slowly deteriorates, and may eventually be destroyed by the combined action of atmospheric oxygen and photo oxidation.

Cleavage of paint layer from the ground due to climatic variations causes flaking of paint because the paint is unable to adapt to the change. Atmospheric pollution like sulphurdioxide, hydrogen sulphide, dust particles are very harmful for paintings. For example, white lead becomes black, lead sulphide, by the action of hydrogen sulphide. In situation of high stress cracks develop in the paint layer. Verdigris eats away the canvas.

The Varnish Layer

There are two kinds of varnishes. One is *spirit varnish* -after loss of solvent by evaporation. It gives varnish film, which is brittle, not very durable and changes its colour due to aging. The other varnish is *oil varnish.* The drying of the varnish film is due to polymerisation of the terpenoid constituents. This may be accompanied by oxidation from atmospheric oxygen. Minute cracks on the varnish layer are called *craquelures.*

Conservation of Paintings

Weak canvas may be strengthened by relining. The old canvas is backed with a new canvas of similar weave count, the two being cleaned and joined together by an adhesive which is reversible in nature. In Indian condition wax-resin adhesives used which not only strengthen the canvas but also give flexibility to the old canvas. During relining, front facing is done with tissue paper and reversible paste like *maida*-flour paste for protecting the damaged paint layer and is removed by moistening and scraping it with nail. Spirit varnish when become dark is easily removed by dissolving by solvents like alcohol, benzene. If needed, restrainers, like turpentine may be used. Oil varnishes require special methods, depending on the composition of the varnish and its age. Solvent mixtures are used to remove the varnish layer. Black lead white portions may be cleaned with hydrogen peroxide. After the cleaning of the surface, the loss of pigment is restored by inpainting using acrylic paints. In order to protect the surface, picture varnish or polyvinyl acetate in polycyclohexanone is sprayed. INTACH, New Delhi uses Pedicryl for cold relining with xylene. Now a days hot relining is not done.

Care of Paintings on Canvas

When the paintings are affected by biological agents, they may be fumigated with a vapour type insecticide or fungicide, most commonly by thyme or paradichlorobenzene. Since prolonged fumigation softens the oil, fumigation should be limited for a shorter duration.

Since light is very damaging to paintings, daylight should be avoided. Fluorescent tubes with filters can be used. Indirect lights will be better. Since incandescent bulbs give off heat powerful direct focus lights should be avoided. It should be seen that the light level is less than 100 lux, where paintings are exhibited. Fibre Optic lighting and Dichroic halogen lighting are adviceable.

Since climatic variations affect the paintings, air-conditioning of the paintings gallery is ideal. Otherwise, the paintings may be displayed in a gallery where humidity is controlled.

Atmospheric pollution like dust, sulphur-dioxide, hydrogen sulphide is harmful to paintings. In the absence of air-conditioning and air filtration, the only practical method of protecting paintings from atmospheric pollution is to exhibit them in glassed frames. While providing glass, there should be little space between the glass and the painted surface to avoid the condensed water, which may affect the painted surface.

Oil paintings on canvas should be kept stretched and framed and the canvas should be tightened with wedges and keys. The paintings should be held in their frames by mural plates screwed to the frame with brass screws.

Oil paintings on canvas if needed to be rolled, the painted surface should be kept outside while rolling.

In storage, the painted surfaces should never be allowed to come in contact with one another or with anything hard. Storage binds with spacers that allow the paintings to be kept in a vertical position without touching one another are advisable. Paintings may be suspended with hooks on the parallel vertical grill frames. The frames are fairly near each other and are fitted with sliding frames that slide along the rails in the ceiling and the floor, so that each frame can be slid out for inspection of the picture suspended on the grill.

If the paintings are unglassed, they should be covered when kept in the storage. If the paintings are not glazed in the galleries, railings should be provided to avoid vandalism. The paintings should be suspended slightly inclined in order to avoid dust.

A padded, rolling trolley should be used for the transport of very large or heavy paintings to avoid mishandling. When transported even to a short distance the painting should not face the sun. Too much flashlight should be avoided. Focus lamps for photographing, film shooting or videographing should be avoided.

In the galleries where paintings are displayed or in storage sweeping should never be done. Vacuum cleaning should be done. If dust is found on the surface of paintings, fine hairbrush should be used to dust them off.

Oil Painting Before and After Restoration

DRAWINGS, PRINTS AND PAINTINGS ON PAPER

Paintings are graphic designs on any support with pigments. Many materials like rock, wall, wood, bark etc were used as supports for executing paintings. Sketches, drawings were made on supports like cloth, wood etc. After the invention of printing press, prints were made available. After the invention of paper, paper was used as a support for paintings, drawings and prints. Paper boards were also used for these purposes.

Deterioration to Paper Paintings

Moisture, heat, light, dust, insects are the various deteriorating agencies other than mishandling, faulty display, storage and neglect. Wrong choice of pigments also makes the paintings, drawings and prints to deteriorate. Keeping them in proper environment keeps the objects in good condition.

Conservation of Paper Art Work

White paper or paper-board is changed to brown because of acidity present in the paper and atmosphere. Because of age, the surface gets accumulated dust, which obscures the look of the prints or paintings. They easily get stained. The stains are removed by fine eraser. Acidity from paper is removed by applying barium hydroxide (saturated solution) at the back of the print, very carefully. Vapour phase bleaching may be done in case moisture removes the pigments. When mending is required, the inconspicuous corners of the paper print are taken and filled in the missing areas. Fragile paper works are chiffon laminated with *maida* flour paste added with insecticide and fungicide (0.1% ortho nitrophenol) at the backside. The excess paste is very carefully squeezed out by a squeeze roller. When slightly dried under shade it is kept between blotting papers at the back and oil paper in the front and weight is placed over it. After it gets dried or after one day, it is taken out.

Care of Paper Art Works

Paintings or prints on paper-boards may be damaged, when they are bent or folded. Physical handling quite often makes them to deteriorate. Therefore, paintings on paper is mounted between hinged mats of good acid-free mount-board with a window cut top mat for allowing the painting to be seen while holding it securely in place. The window cut mount is pasted with a tissue paper to avoid dust from falling on the paintings, print or drawing.

To protect the painted surface from abrasion and scratches, the paintings should be kept between soft tissue papers and lifted by the corners so that hands do not come in contact with the painted surface.

For storage of mounted paper paintings, prints etc., solander boxes are used. Prints, paintings and drawings are protected by providing glass fronts. Glass should never touch the painted surface. Therefore acid free board or all mat strip may be placed all around in between the paintings and frame. For the safety of the back of the painting, a stiff acid-free hard-board or hand made board may be used.

When displayed, a low intensity of light to the maximum of 50 lux is used. If the gallery or storage is air-conditioned throughout the day, the longevity is improved.

THANJAVUR PAINTINGS

The Thanjavur paintings are in the gilded and gemset techniques and are sacred icons of the Hindu deities. The *iconic* style is therefore not an isolated phenomenon but is spread throughout the southern India and was practiced for about 200 years, approximately 1700-1900 A.D.

Paintings Technique

A sheet of cardboard is coated with tamarind seed paste (white of the seed with gum) to a jack tree wooden base, which is single or joined one. One or two cloths are pasted to the card board. A lime paste is coated, which is called *sudhai* and smoothened. Details are drawn and the positions where gemstones are to be set are marked. *Sukkan* (unboiled limestone ground with glue) is applied and the surrounding is raised with sukkan. Over the relief areas gold paper is cut into strips and pasted with tamarind seed paste. The gold work on Thanjavur painting is of two distinct varities. Gold gilding is either with pure gold leaf or with gold paper.

Damages in Thanjavur Painting

Since the Thanjavur paintings are composite in nature, the problems are also multiple. Since the wooden planks are joined, they give way due to age and cracking is noticed on the paint as well as the textile and cardboard support. The gold paper is lost due to insect attack. The space between the textile and plank are affected by insects and the cardboard is badly damaged. Loss of gemstones and cut glasses, which are used for ornamentation, are noticed. At times it is noticed that the paint applied on white gemstones are also lost due to abrasion. Loss of pigment is noticed. Wrinkling of the surface due to cleavage of support layers, water stain and fading of paints are noticed.

Conservation Treatment

Main Support

The main support of the painting is fine cloth when there is some loose adhesion, tamarind seed paste is used to fix the textile with the accessory support.

Accessory Support

The fine cloth is normally pasted on a card-board which is in turn pasted to jack tree plank, which may be a sheer single plank or two planks joined together and reinforced by two or three reapers. The planks are set right and the cracks, if any, are filled with wooden putty.

Loss of Stones, Pigments, Gold Gilding etc.

The missing stones from the paintings are replaced by new stones and fixed in place using tamarind paste. The gold paper strips are cut and pasted wherever there are loss of gold leaf. If there is any loss of pigment, the places are infilled with lime paste and matched with water colours. The blue background is redone with blue powder ground with gum. If the gilded areas are found to be dark, the areas are cleaned with cotton swabs dipped in rectified spirit, acetone, toluene etc.

Frame

Thanjavur paintings have a broad and light wooden frame. The bottom frame is sometimes broader than the other three sides. The plaster ornaments are repaired, if lost. The frames are cleaned, with fine emery and sprayed with a gild prepared out of gold gild powder and resin in thinner. It gives a good look.

Glass Front

Thanjavur paintings are generally provided with glass fronts or with frames with provision for glass front. If there is no glass front, a 3mm glass front is provided with a spacer in between the painted surface and glass.

Backing

Most of the paintings do not have any backing. The wooden plank is exposed to humidity and dust. The planks are applied with insecticide, the holes, if any, re filled with the insecticide like D.D.T. and wax and coated with varnish to avoid water absorption at the back. The gap between the plank and frame is pasted with a cloth to avoid the entry of dust and insects. If necessary, plywood backing may be given.

General Care of Thanjavur Paintings

Thanjavur paintings should be periodically examined for their condition. Application of spray of insecticides may be given at the backing. It is better to fumigate the paintings in paradichlorobenzene to drive off any insect trapped inside the frame work.

Thanjavur Painting Before and After Restoration

KALAMKARI PAINTINGS

Kalamkari, literally means-done by pen (Pen work). The art of painting on cloth with dyes is found in Gujarat, Andhra Pradesh and Tamil Nadu. The technique is a painstaking process using natural - vegetable and mineral dyes. Though Masulipatam work is also referred to as *kalamkari*, it is strictly not pen work, for the outlines and main features of all the designs are printed with hand carved blocks, which are used repeatedly for years. The *Kalamkari* paintings of *Kalahasti* are painted temple hangings while the Masulipatam block-printed fabrics have little religious association.

Technique

Cloth is nothing but cellulosic material obtained from plant and woven into required size. The technique of *Kalamkari* painting is painstaking. A cloth is applied with a mordant-a substance, which combines chemically with dyestuff to form an insoluble material, which clings firmly to the fibres of the cloth. This gives a printed canvas-like surface. A pointed pen draws the contours and a round pen fills in the colours. Strictly, only this kind of work qualifies as *kalamkari* painting. The pigments are both vegetable and mineral dyes.

Damage

Paintings on cloth are affected by insects, pests and micro-organisms like fungi, beetles etc. Fading, staining, loss of materials and mechanical damages are common. Natural pollutants in the atmosphere cause acidity in paintings leading to browning and finally to brittleness of the thread. Cloth being a good water absorbent, absorbs the acid dissolved in the atmosphere and becomes acidic.

Conservation

Fumigation is first carried out. Acidity is then removed with the help of ammonia fumes. Small tears are mended by different methods of darning using threads weaker than the cloth. Holes are mended with strip / spot lining with fabric. The fabric has to be of similar count as that of the original painting and dyed using natural colours. In some cases when the painting is in an extremely weak and fragile condition, darning is not advisable. A concentrated solution of 20-25% poly vinyl acetate in acetone or Paraloid B 72 is used as an adhesive to carry out spot / strip / total relining.

PAINTINGS ON GLASS

Painting on glass is normally called as painting on reverse glass. The technique of painting on glass was popular art in Europe before the 18th Century A.D. The motif has usually been to imitate the effect of stained glass windows. It is learnt that in Canton the Jesuit Priests taught this art to the artists and artisans. The glass manufacturing countries in Central Europe produced inexpensive glass, which began to be used as a base for painting. China learnt this art from Europe, which later spread to India. It is learnt that Chinese artists were invited to the court of Tipu Sultan and the paintings produced by them are now in the Jagmohan Palace Art Gallery, Mysore. It first spread to Central India and then to Thanjavur. Portraiture and religious themes were common.

Technique

Glass is a super cooled liquid. It is a silicate of alkali metals like sodium, potassium and lead. Painting on glass necessitates a different procedure than painting on solid opaque surfaces. The picture, which is generally coloured in *tempera*, is started first with the brush outlines and necessary details, which when finished, appears uppermost. Then, the larger areas of opaque colour are brushed in. Shading is used for drapery, face and body to achieve fullness. Gold leaf, small sequins and other shining particles are used to imitate jewellery. Some times portions of the picture are mirrored with mercury. In some places metal foil or gold paper is fixed behind the picture and the portions of the picture left bare are seen as gold. The picture is then mounted with its unpainted side foremost so that it is seen through the glass. Paintings on glass were also executed in oils, though these are less common.

Damages

The glass is the support and so if it breaks the painting is lost. Moisture cause flaking of the glass. Flaking of paint, loss of pigment due to insect attack and humidity is common. Pigments fade due to age and alkaline nature, glass disease (i.e. opacity occurs), gold, gild paper etc. detach due to loss of adhesion

Conservation

Breakage of glass results in loss of painting and can be only partially mended with the help of an adhesive like poly vinyl acetate or Paraloid B 72 in acetone. Missing portions are replaced with acrylic sheets of the same thickness and painted over using *tempera* colours. A broken and restored glass painting should be mounted between two sheets of glass. Gum tape should be used to seal the edges in order to prevent entry of dust and moisture. In case the pigments are lost, the whole work is redone on a glass and kept below the painting and frame.

Backing

The back of a glass painting should be well protected. A proper backing of either chemically treated plywood, wooden or aluminium sheet protects the painting from dust, moisture, fungi and insects.

Storage and display of glass paintings are critical due to the extremely fragile nature of the paintings. Scratches should be avoided while storing. Paintings should not touch each other.

Glass Painting
Before and After Restoration

PAINTINGS ON MICA

Mica was used as a support for paintings. The art of painting on mica was prevalent in North India and later spread to the south. Mica paintings are rather small in size due to the fact that only small sheets of this material were available. Mica is transparent mineral composed of complex mixtures of potassium silicates. The variety of mica used most frequently by the Indian artists is *muscovite* $(H_2KAl_3SiO_4)_3$, which is found widely through out South India. Mica is formed between strata of granite and the transparency of the material is a result of the heat and pressure created between the layers of rock during formation. Mica consists of many interlocking platelets, resulting in a laminar structure, which can be split easily into thin sheets.

Technique

Mica is a mineral found in the form of small sheets, these sheets are thin, but extremely smooth. Little or no preparation of the mica was carried out prior to the application of paint. Watercolours were not used on mica because of its non-porous properties. Hence tempera paints were used. The pigments used were mixed with varying quantities of binding medium and thickly applied with a brush. Loud, opaque colours were used on the transparent ground. Some times paint was brushed on both the front and the back surfaces of the mica sheet to increase the opacity and give a more three dimensional appearance to the painting. The subject of paintings catered to the British's taste for the exotic and consisted of depictions of festivals, nature, illustrations of various occupations, etc. The paintings were not fine or sophisticated works but exist as small souvenirs for tourists. The Government Museum, Chennai has many of them.

Deterioration of Paintings on Mica

Mica presents many problems as a support for painting due to the smooth surface as this provides very little key for the paint to adhere to. Weakness occurs in such a way that the binding detaches between the mica and cardboard to which the painting is pasted. The boards may get more acidity and get brown colour and the colour may be transferred to the mica. Careless handling or the action of humidity may make the mica to crack. Loss of paint is possible. Distortion of the mica sheets may cause detachment of the water colour paint from the smooth surface of mica. The differences between the paint layers may cause peeling and paint loss. Mica being soft in nature, scratches due to abrasions is common. Insect attack results in the loss of pigment. Mica is fragile and heavy shocks result in breakage.

Conservation of Paintings on Mica

Fumigation is to be carried out for insect, fungal attack etc. Dirt, stain, grease etc., can be cleaned with a solution of 1% Extran in rectified spirit. Water should be avoided, as tempera paintings are water-soluble. Loss of pigment is a result of cleavage between the pigment and the mica support. This can be rectified by injecting a 2% solution of Paraloid B 72, poly vinyl acetate in acetone in the cleaved areas and by using a weight press. Consolidants are 5% Paraloid B 72 (ethyl methacrylate / methyl methacrylate co polymer in acetone), 2% Isinglass (fish glue in water to which a little of industrial spirit is added). Mounting can be done by encapsulation using *Melinex*[R].

Storage of mica paintings is very crucial, as mica is fragile, soft and smooth. It is advisable to provide an interleaf between painting and the glass front. Soft felt cloth can be used to wrap the paintings during storage.

PAINTINGS ON IVORY

Miniature paintings were done on ivory. Ivory was once a fashionable and inexpensive base for the painting of miniatures. This art was practised by the British and was introduced in North India around 1785 A. D. Portraits, religious myths and nature were the common themes. Playing cards used by the royal personalities were also painted on ivory. Government Museum, Chennai has a good collection of ivory paintings and ivory objects.

Technique

Ivory is the tusk of elephant or walrus etc. Ivory is mostly dentine. Thin slices of the tusk, seasoned or pressed to keep it from warping was polished, smoothened and then used as a support for painting. Due to the smooth surface of the support repeated strokes were necessary to execute the painting. The pores in the ivory absorb the water colour pigments. Soft and fine squirrel hairbrushes were used for painting. The technique employed watercolours applied with the aid of a magnifying glass in a laborious network of stripped dots and crosshatched strokes. The completed picture was glazed with a solution of gum Arabic and glycerine to bring out the colour and provide a binding protection.

Deterioration of Ivory Paintings

Ivory consists of an organic matter, named *ossein*, besides calcium phosphate associated with carbonate and fluoride and magnesium. Ivory is anisotropic and has directional properties. Relative humidity, heat, atmospheric pollutants easily affect ivory paintings. Warping and decomposition are the result of prolonged action of water on *ossein*. Atmospheric acids and the porous nature lead to easy staining, deterioration and brittleness. Sunlight affects the natural colour of ivory and of the pigment. Insect attack lead to loss of pigment.

ROCK PAINTINGS

India is rich in natural, cultural, artistic and archaeological treasures. The art of rock painting dates back to the Mesolithic period (10000-3000 B.C.). India is considered to be one of the richest centres of rock art in the world. India has over 1500 sites with nearly 2500 painted rock shelters located in different parts of India. Tamil Nadu has many sites of rock art with more than 500 rock arts. Scholars in various places in India have discovered many new sites. In India, States like Madhya Pradesh, Tamil Nadu have many pre-historic rock art shelters. The first discovery of rock art in India by John Cockburn and Archibald Carlyle goes back to 1887 AD. This rock art of India has posed complicated problems of preservation. In order to elucidate the causes of deterioration of this rock art, the techniques and materials used have been studied by carrying out a detailed examination of several typical sites and intensive laboratory investigations of representative samples of rocks and pigments.

Technique

Rock art are located in those regions of the Indian sub-continent, which abound in sandstone, quartzite and granite. Rock paintings on limestone have not come to the notice. The paintings are painted on vertical or near vertical rock faces or on the under surface of projecting or over hanging rocks. The painting technique is often the wet colour technique. The colours used for rock drawings were white with yellow, hematite red in various tones or black. The paintings do not have any base other than the rock. In fact no attempt was made to dress the rock, which was neither plastered nor primed before painting. The pigments have gone straight on the rock surface.

The in-organic natural pigments (earth colours) have been used in liquid form. The earth colours were the residual products of weathering of the rock. They are either red ochre or hematite. The examination of the white pigment has not proved lime or gypsum. But it is found to be white clay. Due to the long period of the painting's survival it can be presumed that water was the medium used for the pigments and it is probable that the slow action of water on the siliceous rock resulted in the formation of colloidal silica and the latter produced an imperceptible layer on the pigments, thereby fixing them firmly to the rock, and rendering them immune to the solvent action of water.

Damages

Because of geographical location and easy accessibility, quite a large number of rock art sites in India are under constant danger of being wiped out for ever, due to increasing human activity and changing environmental conditions. At such sites one may see people attempting to scribble over the rock surface and thereby defacing the rock art. The most important causes of deterioration, which have determined by the study of the three elements of the paintings are the following:

1. Weathering of rocks resulting in splitting, flaking or spalling.
2. Formation of salt on the painted surfaces.
3. Due to the seepage of water formation of microbiological growth and thereby the damage.
4. Formation of mud-nests and thereby the degradation.
5. Erosion by flowing of water and sand blasting by winds.
6. Fading of pigments due to isolation and loss of colours due to leaching by rainwater.
7. Accretion of dust, dirt, cobwebs and soot.

Conservation

The following steps may be taken to preserve rock art:

1. General cleaning and removal of dust and dirt.
2. Removal of microbial growths.
3. Consolidation and application of surface coating.

Whenever any conservation work is to be under taken, it is advisable to document the paintings properly. Photography of different types, videography, line drawing etc., may be done to document the rock art. Cleaning may be done with solvents such as toluene, methanol, acetone, ethoxy ethanol, diethyl ether, ethyl methyl ketone, petroleum spirit, ethylene glycol etc. The sooty accretions may be eliminated by using triethanolalmine-ethyl alcohol mixture in the ratio 1:20. Microbiological growth such as algae, lichen etc., may be eliminated by using aqueous or alcoholic ammonia. If there are any stains, they may be removed with the help of hydrogen peroxide. The weakened painting may be consolidated with the help of 5% solution of poly vinyl acetate in acetone or toluene.

WALL PAINTINGS

Paintings are associated with religious activities mostly throughout the world. Some of the temples in Tamil Nadu are blessed with paintings on walls. Both organic and inorganic pigments were used. Knowledge about their technique of execution, decay and maintenance will help those concerned to preserve them for posterity.

Painting Technique

The paintings which are executed on wall (i.e. *muir*) are called *mural paintings.* The wall can be the surface of a cave or building by stone, mortar, mud, brick structure. Over the selected surface a thin layer of paintings using vegetables dyes, lamp black or white kaolin might be created as in the early cave paintings. Such primitive paintings are executed by the application of an aqueous solution of the pigment /dye over the selected surface, preferably porous to permit the dye to percolate in. Later on, it was developed such that the solution was either added with animal glue or vegetable gum to give a solution of workable consistency. This glue or gum gave the dye a certain adhesive quality specially required when the wall or plaster was prepared in advance to accept the paint and a binding medium was required to bring about a true bonding. When the painter used the wet paste to create a painting and used the nature of the lime wash to create a natural colour without an organic binder, the painter is said to have created true *fresco* (buono), when he chooses to work on a dry plaster to express his creativity and requires a binding element in his paint to adhere to the plaster, he creates a fresco. Belonging to this last group of painting with a binder on a dry plaster are the South Indian paintings and these have been termed the tempera.

Deterioration and Their Causes

Flaking of paint layer, lifting up of the paint layer in the form of cups, blistering, separation, scroll formation, fading of paint layers, abrasion, physical damage by mishandling and vandalism are the various deterioration on wall paintings. There are various causes for the deterioration of wall paintings. They are variations in the humidity and temperature, deposition of particulate matter such as dust, soot, smoke, tarry and greasy matter due to burning of lamps, camphor etc., reaction with atmospheric pollutants such as oxides of carbon, sulphur and nitrogen, biological growth and droppings of birds and bats, insect nests, seepage and leakage of water, salt action, cracks in the building etc.

Disintegration of the binding medium, pigments etc., physical and chemical changes in them, expansion and contraction in various layers etc., are the causes within the paintings. Faulty restoration techniques in the past are also play a very important role in the deterioration of wall paintings. Industrialisation and urbanisation in the locality where paintings are located also have contributed a lot in their deterioration.

Cleaning of Wall Paintings

The accumulated dust should be brushed off using a soft squirrel hair or sable hairbrush. The accretions, if any, may be removed by gentle abrasion. The salts formed on the painting may be removed by scrapping or application of wet filter paper with adequate quantity of suitable solvents. Mechanical means or suitable quantity of mild acids should remove the patches of white washings very carefully. The biological growth such as fungal growth should be removed mechanically and then gently brushed with a soft brush. If necessary suitable solvents may be used. Grease, smoke, soot etc., are removed by using 10-20% aqueous ammonia or 10-20% butylamine in water. When blistering, cohesion, cupping, cracking are noticed experts should be consulted to set right things. Normally some adhesives, which will not react with the pigments and reversible, are used to bind the separated painted portions with the wall. The ceiling should be properly repaired to avoid leakage and seepage before the conservation and restoration of the wall paintings are undertaken. When conservation work is in progress fire in the locality and short-circuiting should be avoided.

Care of Wall Paintings

Wall paintings should never be disturbed. Birds like pigeons, bats should be avoided. Squirrels, rats should be avoided by proper monitoring means. If possible the painted walls may be screened to avoid long exposure to light. During renovation of temples, various conservation experts may be consulted, as such works need consultation with experts such as conservators, architects, engineers.

If the wall paintings are found detached from stone or brick walls they may be transferred on panels by the conservation experts and preserved for posterity. National Museum, New Delhi has in its collection of many transplanted murals from Central India.

Stanchions and ropes, physical barriers, glass fronts, weld or wiremesh may be provided to avoid human touch of the paintings.

PHOTOGRAPHS

The art of photography came into existence in the 19^{th} Century. Museums preserve photographs, negatives, slides, cassettes etc. Therefore, the information regarding the preservation and care of photographic materials are mush useful to the curators or collectors of such materials.

History of Photographic Materials

In order to take measures to preserve photographs-positive, negative or slide - one must have a knowledge how a photograph will behave. Photographic processes are of three groups viz. silver based, iron based and chromium based. Out of these, the silver-based photographs are the famous ones. Paper was used as support, which could not give sharp images. Glass negative was used in 1847. Glass supports are nowadays replaced by celluloid, cellulose nitrate or cellulose acetate or even latest by polyester film.

Deterioration of Photographs

Photograph is a very complex material, having several components like support, binding medium and photosensitive image forming chemical which ma react in different ways to various factors of deterioration. The common deterioration noticed in photographs are yellowing, stains, separation of emulsion, fungal attack, insect attack, scratches, finger prints, folds etc. Photographs fixed on moist walls have been affected by fungi.

Conservation of Photographs

In the case of glass negatives, due to age the emulsion becomes brittle, cracks and falls off at slightest shock or touch. Since gelatin is easily prone to damage by water, the negatives or photographs should never be touched on the face, but should be held at the edges.

Photographs or negatives should never be kept together as they stick to each other in a humid condition and it is very difficult to separate them without damage. If the humidity is very low, the gelatin portion starts cracking.

Micro-organisms like fungi affect the photographs at humid environment. Silver fish eats the gelatin as well as paper. It is an irreparable loss.

While framing photographs the glass should never touch the photograph but spacer should be provided between the glass and the photograph.

In case of accidental water soaking, the photograph should be dried without any blotting paper. The surfaces should be cleaned with a soft brush. The photographs are kept inside oil covers and stacked in a cabinet, which is kept in an air-conditioned room. Colour film, being very colour fugitive, it needs low temperature for preservation. The safest storage environment for all photographic materials, whether colour or black and white, is a temperature as low as possible, preferably below freezing, and a R.H. of around 30%.

Damaged Photograph

Restored Photograph

PART - VI

CONSERVATION AND RELATED WORKS

DOCUMENTATION IN CONSERVATION

Documentation is one of the important aspects of conservation. Classifying the books in a conservation laboratory and documenting them, documenting slides, photographic negatives, cassettes, floppy discs, condition reports, conservation reports, classifying the objects on their suitability for exhibition, loan etc., come under documentation in conservation.

Classification of Conservation Books

Classification of books is the basic need of a library. There is no museum without a library. Books are very important for a museum Curator or Conservator for reference as he has to learn the latest techniques of conservation etc. If they are classified and documented properly, it will be of much help to the users. Most of the large museums have a central library to cater the needs of the staff, trainees and researchers. Besides the central library, conservation departmental libraries are also available in order to have immediate access to the staff. It is better to classify the conservation books for their easy location. The conservation books may be broadly classified in various ways. The following is one of the methods: I. Bibliography II. Sources of literature, III. Museology, IV. History of conservation, V. Climatology etc. are the main divisions. Then, each main division may be subdivided and another number is given as follows: III Museology, III.A General Museology, III.B. Architecture of Museums III.C. Museum Organisation, etc. Catalogue cards may be prepared and arranged in the index cabinets. Now a days the library books are electronically documented through a computer, which is very easy to retrive the information on the available books.

Documenting Non-book Materials

Besides conventional documents there are micro-copies, film slides, movie films, photographic negatives, video cassettes, floppy discs, zip floppies, compact discs (CDs), digital versatile discs (DVDs), DATs, optical disks etc., available, which are documented properly enabling easy retrieval and educating the trainees or researchers.

i) Photographic Negatives

Photography is also a very important aspect in conservation. It gives the real picture of the object before and after conservation treatment. Some museums resort into six types of photography viz. black and white, colour, slide, x-ray, ultra-violet and infrared. The negatives are put in covers, which contain particulars like name of the object, accession number, department from which the object was received, number of the negative before treatment and after treatment, reference to publication etc. They are kept in order in closed cabinets either subject-wise or material-wise. Similarly slides are also documented, accessioned and arranged in grooved cabinets. Nowadays photographs are disgitised and stored in CDs.

ii) Video-Cassettes

The various conservation treatments are recorded in videocassettes and they are also documented subject-wise, which may be used by the trainees or scholars who study the subject of conservation.

Documentation of Conservation Work

The collection departments initiate the conservation work, when the museum objects are catalogued, sent for temporary exhibition or when they are sent on loan. Besides these, the affected objects, which are displayed or stored in the storage areas, are also sent for conservation treatment. Certain museums arrange for quarterly inspection of the galleries and storage with the collection Curators and Conservators. When an object is affected, a request for conservation treatment is sent to the conservation department mentioning the name of the object, its location, the date on which the object is to be returned after conservation etc. The Conservator checks the condition of the object and suggests the proposed conservation treatment and is got approved by the head of the collection department. Then the object is received for treatment. In some museums, the Curators of the collection department sent the objects for conservation and the type of treatment required is discussed with the conservator. The object is examined very well even with the help of microscopes and is recorded in the conservation card. Name of the object, previous treatment, if any, reference about its publication, all types of photographic references, date of receipt, date of starting the conservation work, duration of treatment, chemicals used, method, name of the Conservator, etc., are included.

The opinion of the Conservator whether it is eligible for display, loan etc., is entered. The condition of the object after treatment is detailed. The date of completion of the work as well as return is mentioned. This information will be much useful when the object goes for exhibition, loan or comes for conservation treatment again.

Condition Report

There are preliminary condition reports prepared by Conservators to establish whether on object or work of art is fit for exhibition and if possible the kind of treatment required to make it safe to travel.

An essential feature of the preliminary condition report form is its conciseness. The ticking of the squares, or encircling of words, makes the inspection go quickly.

A second type of report form is that used for recording the condition either when an object leaves an institution for an exhibition, or on arrival at the museum where the exhibition takes place. The documentation also includes such vital information as the packing systems used and the mode of travel. The documentation information included should be useful to the head of the collections or registrar for insurance claim apart from obvious record purposes. The condition report is also seen by Conservators of the borrowing institution and if any defect is noticed, it its mentioned in the report. This report goes along with the loaned objects. Besides these, registers are maintained in the conservation laboratory for documentation work. Nowadays all details are kept in the computers, which can be stored in various forms.

Computer Documentation

Most of the European museums now switched over from manual card documentation into computer documentation. It is an easy retrieval system, which can be reformed both by the collections department staff and conservation staff if their computer is linked with the master one. Many museums in India too have gone for the computer documentation.

CONSERVATION IN EXCAVATION

Archaeological excavation is a slow, systematic and planned digging to study the nature and contents of the occupied layers in the reverse order in which they were laid down during the natural burial. "The things the excavator finds are not his own property, to treat as he pleases, or neglect as he chooses. They are a direct legacy from the past to the present age, he but the privileged intermediary through whose hands they come; and if, by carelessness, slackness or ignorance, he lessens the sum of knowledge that might have been obtained from them, he knows himself to be guilty of an archaeological crime of the first magnitude. Destruction of evidence is so painfully easy, and yet so hopelessly irreparable" (H. Carter and A.C. Mace). Even though excavation and related techniques have developed well, the standards of conservation related to excavation have not developed to the same extent. The reason is the excavations at times are carried out in the absence of a Conservator or Chemist in the site. Excavation and conservation should be considered together for getting maximum information from the objects and for their preservation for posterity. The archaeological conservation starts from the planning of excavation, the actual removal of objects from the site — till the objects reach the museum after excavation. In the case of excavation, the conservation techniques have to be applied at the site itself to the excavated objects during and immediately after their exposure to the atmosphere. This is called the *field archaeological conservation*, which is distinct from laboratory archaeological conservation. When an excavation is to be planned both excavation aims and conservation needs are to be satisfied.

The conservation aspects of an excavation involve three stages. They are :

1) Conservation before excavation 2) Conservation during excavation and 3) Conservation after excavation.

1. Conservation before Excavation

Preventive conservation of the site may be studied in advance. The date on local environmental variables such as temperature and relative humidity of the excavation site, extent of shade, the predominant wind direction and its frequency, soil characteristics, water table etc., will be useful to choose the time for excavation besides giving an ecological interpretation of the site.

2. Conservation during Excavation

The buried objects over the years attain equilibrium with their surroundings. When they are exposed by excavation, they are subjected to sudden change in their environment such as temperature and relative humidity and in their access to light and atmospheric factors. The aim of the excavator must be to minimise the environmental shock to the excavated objects during their exposure packing and transport to the site store. A temporary roof over the trenches is good to control the ambient environment.

3. Conservation after Excavation

For a successful conservation of excavated objects at the site good communication among excavators, site custodians and conservators or archaeological chemists is important. The various aspects of conservation are investigative cleaning, stabilisation, consolidation, protection, safe storage and guarding of the excavated objects. The conservation measures will be either preventive or remedial or interventive

First Aid to Objects

As the equilibrium of the buried objects is abruptly disturbed because of their exposure to the atmosphere, the decay or corrosion or disintegration process starts. Organic materials deteriorate faster than the inorganic objects. Even though the objects are retrieved from the same place their treatment may differ from object to object.

Metals

The metallic objects after lifting from the excavated site have to be conserved. Silver and gold objects can not be identified when they have impurities like copper. They may appear greenish in colour due to corrosion of copper. Silver objects either may appear black or red. They should be packed in well-padded boxes. Gold objects may be cleaned by dilute nitric acid. Gold gilded objects will loose the gild if they are cleaned. Thick layers of corrosion should not be removed. Excavated iron objects should be dried under shade and they should not be kept in wet condition. Silica gel will be of use when packed in plastic bags. Excavated lead objects will be covered with greyish-white corrosion products. Acid free tissue paper should be used to pack them.

Organic Objects

Excavated organic objects very easily disintegrate. Bone and ivory objects should be dried slowly and thoroughly. After removing loose siliceous materials from bone objects, they should be immersed in 15% acetic acid for about 10-15 minutes. Then it is coated with 10% polystyrene in toluene or Paraloid B 72 and continued the treatment in acetic acid and washed in water till it is cleaned. Ivory is sensitive to water and so it should be wrapped as in found condition in damp acid-free tissue and polythene sheets. Shells are found in good condition and so they are washed in water. Normally leather does not survive. It is more common for leather to be found in a waterlogged condition. Such leather should be packed wet in polythene covers. Freeze-drying can be done. Dry leather should never be moistened or flattened but should be wrapped in acid-free tissue. It should be flattened only by the application of leather dressing chemicals. Wood is found either in dry or waterlogged conditions. Extremely dry wooden objects may be consolidated by Paraloid B 72 or poly vinyl acetate in toluene or acetone. Waterlogged wood would be packed in polythene covers and sealed with fungicides like Panacid. Wood which needs to be dated should never be contaminated with fungicide or consolidant. Dry textiles should be packed carefully in acid-free tissue. Waterlogged textiles should be sealed in polythene bag with water mixed with fungicides like 0.01% Panacid.

Inorganic Objects

Mostly excavated stone objects are found in good condition. They are washed with water using soft brush. The salts are removed by poulticing with paper pulp. Dry glass should not be moistened. Alcohol or water may soften the hard lumps. Avoiding water is good. It should be packed and padded with acid-free tissue paper and should not be allowed to shake or move. Wet glasses should be kept wet and packed in poly-ether foam containing a fungicide like 0.01% panacid. Baked clay objects may be washed but care should be taken to remove the dirt by wooden knife. Insoluble salts, adherent to the potteries, may be removed by the use of weak acids followed by thorough washing in water. If the pottery is found to contain soluble salts, it should not be allowed to dry but should be packed using poly-ether foam moistened with fungicide like ortho phenyl phenol, Panacid and packed in polythene covers. Unpacked dry clay objects should never be washed in water. The hard encrustation may be removed by adding drops of alcohol and brushing with the help of a soft brush. Glazed potteries should be cleaned with brush. Damp objects should be backed wet adding fungicides like ortho phenyl phenol, Panacid.

Anyhow, conservation at the excavation site is a first aid. The laboratory treatment is necessary for the upkeep of the objects, in the museums as mentioned in the earlier chapters.

EXHIBITIONS AND CONSERVATION MEASURES

Museum exists to preserve the art objects in its collection through proper exhibitions to understand and enjoy them. In the exhibition galleries certain guidelines should be practiced in order to keep the objects in a better state for posterity. In order to take care of exhibited museum objects, one must know about the supporting materials used in display and the environmental factors.

Guidelines for Supporting Materials

The following guidelines may be understood to choose the supporting materials and their proper usage:

1. Framed two-dimensional objects like paintings, prints etc., must be suspended or fixed to walls or display panels with proper supports like nylon threads or mural plates.
2. Three-dimensional objects like bronze sculptures, stone sculptures etc., should be displayed on pedestals detached from the ground, properly secured or within showcases having proper support. The supporting materials used to secure the objects should neither mask, soil nor chemically react upon contact.
3. Pins and supporting wires should be standard stainless steel and covered with nylon or polyethylene tubing. Nylon filament is also good, provided it does not cut into or stain the object and is strong enough.
4. While stapling, staples should never be used in contact with objects, but should be covered over with insulating materials.
5. When mounts are used, it is better to use perspex, plexiglass etc.
6. Textiles, costumes etc., should be supported with padded hangers.
7. Showcase for museum objects should be constructed using non-reactive materials, adhesives and coatings, so as not to cause deterioration or discolouration during long-term exposure. Raw plywood surfaces are to be avoided because of possible formaldehydeemissions. Non corrosive materials will safeguard the objects displayed.

Environmental Guidelines in Exhibition

The following guidelines should be followed to safeguard the objects on display or in storage:

1. The exhibition area must be environmentally controlled and free from all construction, decoration or related activity. Freshly painted areas should be allowed to dry for at least two days under active air circulation. There should be at least a minimum time gap of two months between plastering of walls and exhibition to avoid moisture.

2. The exhibition must have limited and controlled access with provision for daytime security by trained persons and at other times is furnished with intrusion, smoke and fire detectors and related security measures.

3. Works of art and other objects should not be exposed to sunlight, heating, too much cooling or placed close to lamps.

4. Floor cleaners and cleaning operations should not be hazardous through splashing, chemical exposures, or mechanical damage.

5. In case of renovation, repair or painting the exhibition galleries, the objects should be well covered with ploythene sheets and reinforced with wooden structures all around.

6. Thermo hygrometers should be placed in sensitive locations above the floor level to record relative humidity and temperature throughout to take control measures of decay.

7. The light level for light-sensitive objects should be in between 50 and 100 lux, that too, for a limited exposure.

8. Photography, movie and video work should be controlled, as too much light affects works of art.

9. It is better to limit on the maximum number of persons permitted at any one time in the gallery depending on the exhibition space and the capacity of the air-conditioning system.

10. In order to restrict vandalism in the exihibited area, stanchions with ropes may be provided. The security staff may be instructed to act vigilantly.

11. Researchers and visitors who take notes may be asked to use only pencils, which will avoid marking on objects either by forgetfully or accidentally.

There may be some more problems to be tackled by the Curators or persons in-charge of collections depending upon the need.

STORAGE AND CONSERVATION GUIDELINES

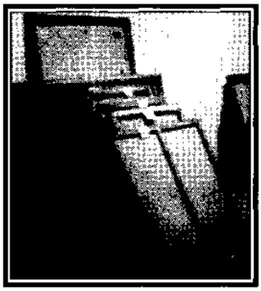
There is a natural tendency to relax conservation vigilance when the museum objects are out of sight in storage or in vaults. The basic principle of storage is to keep the objects in a physically secured environment and yet to permit ready access for inspection before their removal to the galleries, storage or other locations.

Storage Devices

There are various storage devices and they are expected to meet the physical and environmental criteria intended for preserving the museum objects against damages.

Stacking

Paintings and flat framed works, prints, photographs etc., may be placed on pads and stacked vertically using cardboard as separators. In-group stacking, it is necessary to ensure that the pads are skid-proof, that the angle of stacking is average, and that the largest objects are kept first. Three-dimensional objects like sculptures, large objects should be placed on pallets to permit easy handling and lifting.



Stacking of Paintings

Shelving

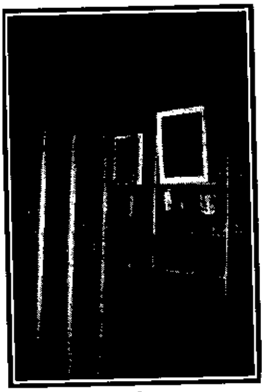
Shelves may be constructed either by wood or preferably by metal free storage of two-dimensional or three-dimensional objects. Vertical slots may be designed for flat items and bays set up for objects. Boxes of different sizes may be made and objects kept wrapped with acid-free tissue paper inside. This method will utilise all the spaces available in the shelves, when there is only a limited space. The Archaeology Section of the Government of Museum, Chennai has got a new storage for brozen icons.

Drawers and Cabinets

Drawers are used for flat works of art on paper, card-board and textiles, maps and similar items, and also, when appropriately designed, for small objects. Interleaves of acid-free tissue papers are used. Drawers for coins are with slots in them. Cabinets are also used for two-dimensional and three-dimensional objects.

Sliding Screens

Sliding screens are very common for paintings and flat works and occasionally for decorative art, or arts, which can be suspected by appropriate hooks. Such system is economical of floor space and are efficient for examination and retrieval purposes. Aluminium screens are now installed to store paintings in Government Museum, Chennai.



Sliding Screens

Compaction Devices

Compaction device is fairly recent in the museum world and answers in the requirements for more storage and less space. Compaction equipment is intended for permanent storage primarily. The compaction units are either electrically or manually operated. The manual type of compaction equipment is probably more useful for museum storage, as it is less likely to go wrong. In this type normally textiles are preserved. The Salar Jung Museum, Hyderabad has recently installed a compaction device for the storage of museum objects.

Vaults

Vaults and security storage areas are used for extremely valuable objects, e.g. gold and silver coins, precious stones or other treasures like silver, gold and diamond jewelleries. The Anthropology and Numismatic Sections of the Govenrment Museum, Chennai have vaults for the storage of valuables.

Conservation Guidelines

1. Storage areas should be maintained clean and the waste and condemned furniture should not be stacked in the storage.
2. Regular vacuum cleaning should be done to get rid off dust.
3. If open storage is maintained, the objects should be covered by polyethlene sheets or bags.
4. In order to avoid wastage of space in the storage as well as to avoid dust, slotted angle shelves should be arranged with different sized boxes containing objects to fit in the space available.
5. The R.H. and temperature should be maintained at the optimum level and it should be monitored regularly.

6. Light sensitive objects should always be kept closed by screens.
7. When scholars are allowed to study the reserve collection pencil only should be allowed for writing. Otherwise there is a likelihood of objects being stained by ink.
8. Biocides should be used regularly to drive off insects and microorganisms. Before the advent of monsoon organic objects should be fumigated with thymol in other to avoid the growth of fungi and fogged with D.D.V.P. to avoid insect attack.
9. Smoking should never be allowed inside the storage area as it involves fire risk.
10. Open fire should never be used even in the form of lamps.
11. When objects are removed from higher shelves ladders should be used with care.
12. Objects should never be kept near windows.
13. Proper pallets should be placed under heavy objects in order to facilitate lifting or handling them.
14. No object should be directly placed on the floor.
15. Lead coins should not be stored in wooden cabinets, but on plastic trays, as volatile acids emanated from wood affect lead coins.
16. It is better not to have the conservation laboratory attached to the storage. Victoria and Albert Museum, London, has a conservation studio in the storage itself.

LOANING AND INSURANCE

When some national or international great exhibitions are conducted, museum objects are received on loan basis. Loan agreement is made between the lending and borrowing institutions. The memorandum of understanding (MoU) of loaning sets out the conditions, duration of loan and insurance coverage for the specified number of works of art or museum objects and for a definite period. In the loan agreement the lender and the borrower agree on the security, conservation and all other technical conditions for the entire period of the loan on 'nail to nail' or 'wall to wall' basis. When specifications are made on the conservation and security of the loaned objects in the agreement, these are implemented by the borrowing and the institutions where the exhibition is held.

The loan agreement will have the following particulars.

1. Exhibition title, description of the borrowing and lending institutional and date of agreement.
2. Ownership and details of the owner of the objects.
3. Complete description of the objects including materials used, artist/ craftsman, provenance, accession number etc.
4. Dimensions and weight of the object including its photograph or shape.

Condition Report

Technical conditions of loaning of museum objects are laid by the lending institutions and the borrowing institution agrees to it. Condition reports are prepared by the lending institution or the reports are prepared jointly by both the institutions. Borrowing institution has to prepare condition report when there is any change in the appearance of the object and send it to the lending institution. Borrowing institution will have to maintain the environmental control. Conditions to photography are laid, as too much light will affect works of art. All care should be taken by the borrower in the exhibition and storage areas. Both the institutions agree that the assessed value is only for insurance purposes and the liability of the borrowing institution will be limited to the insured value only. The borrower should do the packing, transportation and insurance at their cost. The agreement is signed by both the institutions along with witnesses.

The loaned museum objects will be accompanied by couriers who are the defacto ambassadors of the lending authorities and as such are often empowered to make spot decisions, when emergency arises. The couriers are normally curators, registrars, managers, who have enough knowledge of shipping, transportation and conservation of museum objects. The condition reports, associated photographs, environmental records, charts etc., are filled in properly so that they can be readily accessed in the event of subsequent insurance claims etc., when such damage or loss occurs.

Insurance

Insuring museum objects sent on loan are very important. Insurance is made on 'nail to nail' or 'wall to wall' basis. This means the overall protection of the loaned objects from the time they leave the lending institution till they reach the lending institution back safely, within the prescribed time limit. There are a lot of scopes for damage or loss to occur to the objects in transit, at airports, docks, storage areas, exhibition areas or upon arrival and despatch at each venue of the exhibition.

Expert and Evaluation Committee

This committee is either constituted by the Government or the managing body of the lending institution to assess the insurance value in the event of loss or damage of the object to be sent for exhibition outside the museum. This committee will have six to seven members. viz. head of the lending institution, two or three experts, two or three conservators, a representative from the Government. Basing on the age, rarity, value etc., of the objects they may be categorised as

A: rare-cannot be loaned

B: can be loaned after the approval of the committee followed by the order of the Government or the management body.

List of objects to be sent along with photographs and catalogued data such as photograph, size, weight, description, materials value etc., is given to the Expert and Evaluation Committee members. The committee will decide the insurance value of the objects and the total insurance value will be arrived at.

Insurance Coverage

Insurance coverage rates are called for from various insurance companies. The lowest rate is accepted and the same is paid after the approval of the Committee as well as the Government or management body of the lending institution.

Loss or Damage to the Loaned Objects

In the event of damage or loss the borrowing institution intimates the case to the lending institution and insurance company. The extent of damage on receipt of the object will be assessed by the committee and the same should be intimated to the insurance company for settlement after seeking orders from the Government or management body of the lending institution as the case may be. In case there is a loss of the loaned objects the full-insured value will be received from the insurance company.

Thus conservation plays a very important role in the loaning and insurance of objects. But insurance does not save the object but compensates only monetarily.

PACKING OF MUSEUM OBJECTS

The primary aim of packing of museum, objects are to protect them physically and environmentally at all stages through, to the place of exhibition in relation to the type of transportation. The packing system should not involve complicated procedures in packing or unpacking. The materials of packaging, packing systems and guidelines in packing are essential to take care of the museum objects for posterity.

Packaging Materials

Natural materials such as wood are used in packing to avoid cost as well as environmental changes as wood is buffering the environmental changes. Packing containers are made out of wood, plywood, fibre board, block board, steel etc. Traditionally cushioning materials such as cloth, straw, gunny bags were used. All of them absorb moisture and transfer it to the objects resulting in decay. In recent years, a variety of foamed plastic materials in the form of balls, peanuts, spaghetti, derived from polyethylene foam, polystyrene foam and polyurethane foam are used in surround packing or float packing. Rubber, polythene air bubbles also are used. For wrapping the museum objects acid-free tissue paper, corrugated cardboard, polyethylene wrapper, polyethylene cellular film air in sealed bubbles, polyethylene cellular film, open cells in film etc., are used. For binding, pressure tapes are used.

Packing Systems

Depending upon the type of museum objects, (two dimensional or three-dimensional) condition, size, type of transit, weight, distance, duration etc., the packing system has to be chosen. There are many systems and techniques of packing either expensive or moderate. Depending upon the museum's budget the packing also can be chosen. When the packing is done by contractors the specifications should be given and the whole operation should be supervised by a conservation personnel.

Single Packing

Single packing is very simple and is meant for short distance travel and personalised transport of objects like paintings, prints, drawings, photographs etc., are wrapped with tissue paper or kraft paper, and surrounded with additional soft paper padding materials and kept in a slightly larger container made out of wood, plywood or hard board which is provided with a handle to carry.

Multiple Packing

The packing system in which more similar flat works arranged in layers separated by rigid panels with the free space at the perimeter and edges which are stuffed with cushion shreds is called multiple packing. On the contrary instead of rigid panels interleaving the objects may be replaced by corner pads and the slack face all around are filled with cushioning materials.

Horizontal Tray Packing

Accommodating flat museum objects in individual adjustable tray designed with shock absorbers at the corners which are in turn grooved to the inner walls of the packing case is the horizontal tray system of packing.

Vertical Tray Packing

Panels fixed with flat objects are slid vertically, which can slide out and in along the grooves made at two opposite inner walls of the packing cases is vertical tray packing. The vertical panels may have holes or slots for fixing the objects to it.

Track System of Packing

In the place of vertical sliding panels, a system of tracks can be installed in side the packing cases in order to pack the framed works by sliding along the tracks. In this system also we can accommodate framed paintings, works on paper, photographs etc. Proper shock absorbing materials between the tracks and inner walls of the packing case will avoid the transfer of shocks to the packed museum objects.

Horizontal Slide-out Tray Packing

In this type of packing the slide-out panels are like trays to which the objects are attached. The objects should be held by cushioned fixtures having winged nuts.

Float Packing

The surround packing of three-dimensional objects in a packing case with stuffing materials is called float packing. In this packing heavy objects like bronze sculptures, marble sculptures etc., should be wrapped with tissue paper and then stuffing materials like polyethylene, polyurethane balls etc., are filled in the empty space of the packing case. The packing materials should be clean, dry and free from any deleterious chemicals. The inner wall of the packing case may be lined with polystyrene slabs. It is better to cushion the bottom of the case where bronze is kept with a shock-absorbing layer of 1 cm thick rubber sheet.

Compartment Packing

Compartment packing is similar to the float packing but a number of small objects are packed in different compartments within the same packing case. The case should be sturdy, designed for carrying the weight.

Template Packing

It is a packing for complex shaped three dimensional objects by fitting the objects in padded form or templates, which conform to selected contours of the objects. The objects are wrapped with soft tissue paper and the contact edges of the template with the materials are also provided with soft materials to avoid abrasion and the object is fixed in position. Small sculptures or heavy objects can be packed in a compartmentalised box employing similar template holding devices for each items as required.

Rigid Foam Template Packing

In this type of packing, the object is packed within a packing case in a rigid foam plastic like expanded polystyrene, polyurethane or polyethylene, which is trimmed, shaped or scooped out or cut to fit around the contours of the object. In this case also the object is wrapped with tissue paper and polyethylene film.

Double Case Packing

In this packing a packed case is placed inside another case and the interspace between two cases is filled with cushioning materials to avoid shocks and vibrations.

Conservation Measures

1. Air-tight packing cases will avoid change of R.H. and therefore mould growth is avoided.
2. Before packing all the interior wood, filling materials should be fumigated with a fungicide, like thymol.
3. The organic objects and paintings should be treated for the eradication of insects and fungi with suitable insecticides.
4. The packing case should be marked with the directional marks at which it should be positioned.
5. In case of complicated packing system, the procedure of unpacking should be instructed in the case.
6. Screw eyes, wires form the frames of the objects should be removed from all two-dimensional objects while packing.
7. Lids of cases should be bolted or screwed down. Nailing should not be allowed.

TRANSPORTATION OF MUSEUM OBJECTS

Transportation of objects is a part of museologial activities and conservation measures while transportation will avoid possible damages. There are many opportunities for damage to occur while the museum objects are transported internally within the museum premises or externally for longer distances including shipping or flight. Damages may result to museum objects from any of the following:

i. Carelessness and improper handling
ii. Improper packing
iii. Inadequate holding devices and transporting equipment.
iv. Over crowded storage
v. A narrow passage ways etc.

No longer can museum objects be hand-carried from one location to another but must be transported on trolleys or carts properly padded to avoid abrasion. Preparation of the museum objects ready for the transportation and handling the objects are the two importance conservation aspects in the transportation. If proper care is taken, the objects will escape the possible dangers.

Paintings

For safety in handling, paintings should be lifted or carried by both the lower and upper edges of the frame, with the painting side facing the person, as what can be seen is better protected. For larger paintings on the floor, it should sit on soft pads to protect the lower frame and its corners. Large sized paintings should be transported on a special padded trolley. On no account, face of paintings should face the sun.

Works on Paper

The works on paper are of two types. One is fine art on paper, e.g. water colours, pastels, drawings, engravings, etchings, lithographs, oil paintings on paper supports and the other is archival collection. E.g. manuscripts, rare books, prints, posters, maps, documents, photographs, film, video and audio-tapes, etc.

In the care and proper handling of works on paper, emphasis is placed on very careful and clean manipulation, isolation from dust, humidity and temperature control and minimising their exposure to the harmful components of light. The artwork should be hinged to a board having a front window-cut-mount covered with acid-free tissue paper. It is better not to bend while transporting. They may be kept in special boxes to avoid folds and bends.

Sculptures

Tall objects with narrow base should never be transported on a trolley in a standing position. It must lie flat, otherwise it may fall down and serious damage will occur. When we keep it flat proper padding should be given, otherwise it may be abraded. Weak parts should be fixed in position with proper padding to avoid shock.

Ceramics, Glass Etc.

Ceramics, glass and other fragile objects should invariably be protected by wrapping in soft tissue paper or cloth in several layers. Such objects while transporting from one place to the other should always be placed on a trolley, it should be padded to protect the objects from shocks during transportation. Cushioned padding should be given when packed for longer distances.

Ethnographic Collections

Garments, textiles, feather works, puppets, masks etc., have to be well supported avoiding folding and compressing and distributing the weights as much as possible. Special boxes may accommodate more garments keeping tissue paper in between. Large textiles and carpets should be rolled (not folded). The rolling should be on large diameter tubes using acid-free tissue paper over the structure and also as interleaving. It is important that the edge of the textile is more than 3 cm interior from the edge of the roller tube. Small sections of textiles, e.g., ancient fragments, can be sandwiched between pieces of acrylic plastic with sealed edges.

SAMPLING AND ANALYSIS

The notoriety of the analytical chemists as destructive scientists has been the maxim through the past centuries. Substances given for analysis would never return back whole. But this notoriety is now a phenomenon of the past because, now there exists a large number of modern instrumental techniques at the behest of an Archaeological or Conservation Chemist with which he can analyse materials with an insufficient amount of the sample or sometimes with no damage to the material or object at all. The earliest demand for chemical analysis is made in the field of metals. Archimedes (287-212 BC) was perhaps the world's first non-destructive analyst as far as the historical records go. Only since the middle of the 19^{th} Century, non-destructive analysis has come to be practiced mainly by the impact of physics on chemistry through the incursion of instrumentation.

The sophistication of these instruments have evolved to such a degree that the analytical factors such as precision, sensitivity, selectivity and non-destructivity have taken a leap in the 19^{th} Century, especially with the coming of the age of electronics.

When a series of objects are to be analysed, there are certain questions, which must be asked before one decides upon the method of analysis to be used. Before choosing a particular sampling technique it is imperative to consider whether the analysis is intended to involve only the surface, body, or the whole of the object, then resort to sampling accordingly.

From the angle of a curator, conservator or conservation scientist the term sample cannotes its broadest sense, the fragment under examination, whether it is detached or not, from the antiquity. The method of sampling should not disfigure the antiquity as it is likely to spoil the aesthetic beauty and hence it's antique value. A very simple method of sampling of homogeneous materials especially metallic objects without causing visible damages consists in rubbing with a roughened quartz rod across the specimens to be analysed and dissolving the rubbed out sample in suitable solvents. Alternatively, apply a drop of concentrated nitric acid by means of a capillary tube on the spot area of the specimen to be analysed, leave it for a minute, suck the solution thus formed by a capillary tube and analyse drop of the solution by the technique adopted by H. Weisz. Electrographic sampling has been successfully adopted by a number of chemists without causing visible damage to the metallic antiquities. It is being followed in the Government Museum, Chennai.

Non-destructive Sampling

Non-destructive sampling is the best sampling as we want to preserve the past artefacts for posterity. In case of metals, electrographic sampling of metal antiquities was independently developed by Glazunov and Fritz. It consists in anodically dissolving a minute amount of the test specimen on to a piece of quantitative filter paper soaked in a suitable electrolyte. When a direct current is passed, an infinitesimal amount of the anode surface gets dissolved and the ions are imbibed on the electrolyte soaked paper. The sample thus transferred is subjected to micro chemical analysis or by the Weisz ring-oven technique. Pigments are analysed by photographic methods (IR & UV) and analytical tools.

Destructive Sampling

In general for chemical, instrumental or metallographic studies samples are usually collected by filing, cutting, core cutting, drilling etc. Whatever may be the method of sampling, the sampling should not disfigure the object. The sampling should be done only at inconspicuous corners. If sample is drilled or core cut from a metal object, the hole is filled with wax to avoid the moisture and air to be trapped inside. It is always better to keep sample falling down from objects and documented properly, which can be analysed later.

Chemical Analysis

Semi-micro techniques are used in the qualitative identification of elements. Microanalysis by Weisz ring-oven technique is adopted for the qualitative identification of elements present in the various parts of the metallic antiquities as well as inorganic dyes or pigments. When macro samples are available classical macro method of chemical analysis such as gravimetry is resorted to in determining the composition of the major elements in the antiquities. By specific gravity measurements, the composition of small objects can be derived. But nowadays mostly instrumental analyses for elemental detection are conducted.

All Glass Ring-Oven

The improved two piece, all glass Weisz Ring-Oven consists of a round-bottomed cylinder, 45 mm diameter and 70 mm long. The upper face is ground and it has in the centre a well, 22 mm diameter and 25 mm deep. A tall, side-tube serves as an air condenser, while the short one opposite is for pouring the heating liquid in and out. The ground surface in the centre is covered with a cylindrical 70 x 25 mm platinum foil or plate having in the centre a hole of 22 mm diameter welded smoothly to another platinum foil or plate, is rolled and slipped into the well of the furnace, such that the upper ring made by the roll is flush with the flat circular platinum foil. The filter paper circle imbibed with the sample is placed over the platinum foil and is pressed down by a circular glass plate with a 22 mm hole in the centre. The ring-oven is heated with acetone and the sample is eluted by 0.1 M hydrochloric acid and the sample is concentrated in the form of a ring. The qualitative detection of several metallic ions is carried out on a single ring cut into several sectors and identifying the individual ions in the mixture of several ions by applying specific, sensitive spot test reagents.

Chromatographic Methods

Paints, pigments, dyes etc., may be separated and analysed by Weisz ring-oven technique. Besides this, the pigments may be separated by chromatographic method.

Instrumental Methods of Analysis

One of the most important factors to have an insight into the composition and behaviour of materials is the instrumental techniques. Most of these methods are based on interactions between some form of electromagnetic radiations - ultraviolet, infra-red and x-radiation, for example the atoms and molecules present in artefacts, together with any products of corrosion or incrustation, x-ray diffraction method is the interaction with outer electrons, x-ray fluorescence method is the interaction with inner electrons and the neutron activation method is the interaction with the atomic nuclei.

Non-destructive Methods

If the tests on a museum object is non-destructive, the complete integrity of the object is then preserved. If the object is small and is able to withstand very high vacuum, it may be subjected to the non-destructive methods like X-Ray Fluorescence Analysis, Electron Probe Microanalysis, Neutron Activation Analysis, Raman Spectroscopy, Laser Induced Breakdown Spectoscopy, X-Ray Fluorescense Spectroscopy. In these methods, only the outer surface of the object can be investigated.

Destructive Methods

If a small sample of the object is available atomic absorption spectroscopy, metallography, mass spectroscopy, x-ray diffraction, scanning electron spectroscopy, auger electron spectroscopy, Mossbauer effect spectroscopy, photo acoustic spectroscopy, infra-red spectroscopy, electron spectroscopy for chemical analysis, Raman Spectrascopy, Laser Induced

Breakdown Spectrascopy, x-ray Fluorescence Spectroscopy etc., may be utilised depending upon the requirement.

Analytical Tools Used for Museum Objects

Technique	Form of Energy	Application
Atomic Absoption Spectroscopy (AAS)	Light, Visible, Ultraviolet and infra-red	Elemental composition of materials.
Auger Electron Spectroscopy (AES)	Electrons	Surface analysis of solids.
Electron Probe Micro Analysis (EPMA)	Electrons	Elemental composition on the surface
Infra-Red Spectroscopy	Light, Visible, U.V. and I.R.	Identifying resins, varnishes pigments.
Mossbauer Effect Spectroscopy (MES)	Gamma Radiation	Study of corrosion, pigments and ceramics.
Metallography	Light, Visible, U.V. and I.R.	To study phases in alloys and corrosion of metals.
Mass Spectroscopy (MS)	Ions	Ayalysis of isotopes for provenance studies.
Neutron Activation Analysis (NAA)	Neutrons	Analysing inorganic surface.
Optical Microscopy (OM)	Light, Visible, U.V. and I.R.	Identifying fibres, pigments and studying corrosion
Photo Acoustic Spectroscopy	Light, Visible, U.V. and I.R.	Pigment identification on ceremaics.
Scanning Electron Microscopy (SEM)	Electrons	Structure and surface
X-Radiation	X-rays	Internal structure of wood, stone etc.,
X-Ray Diffraction	X-rays	Metals, pigments, ceramics identification
X-Ray Fluorescence (XR)	X-rays	Element composition of solids.
Raman Spectroscopy	Light	Identifying pigments

Laser Induced Breakdown Spectroscopy	Laser	Identifying pigments

Guidelines for Analysis

1. Loose samples may always be preserved for analysis.
2. Non-destructive sampling or non-destructive analysis should be preferred.
3. While taking samples on destructive basis, we should restrict to minimum that too from inconspicuous spots.
4. When samples are taken by mechanical means, the strength of the object should be kept in mind. E.g. when drilling for samples, the hole should be blocked by wax as soon as sampling is over.
5. In the case of lead, while taking sample heat should not be produced, as the heat changes the phase of lead.
6. Vibro methods should be avoided in the case of fragile objects.
7. When chemicals are used to take samples, care should be taken to remove all the chemicals used for the purpose.
8. The documentation must have a reference about the locality on the object from which the sample is taken.
9. When two or three pieces are joined together analysis should be made with the three pieces. E.g. In case of the bronze icons the main image and the pedestal may have different compositions.
10. Sample collected should be kept in airtight containers to avoid the contamination.

FAKING AND AUTHENTICATION

Introduction

Faking of antiquities is very common now a days and it has to be checked. Unless one knows the method of faking and authenticating the antiquities, it is very difficult to safeguard the antiquities in one's possession. Fakes are genuine works, which have been altered in character or added to, for the purpose of enhancing the value. Forgeries are copies of works of art or craft made for fraudulent purposes. Reproductions are copies made for honest purposes, which may subsequently be used by others for dishonest purposes, which may subsequently be used by others for dishonest reasons. Replicas are contemporary reproductions.Faking of art objects has increased in the last decade in India. There were famous forgeries like the Piltdown forgery during the current century, which rocked the art and archaeological world. Since then, many instances have come to light and are well known all over the world and India is no exception. On recent days, we have come across the faking and forgeries in respect of paintings, ivories, coins and even stone objects. Scientific study has become more imperative in the field of art objects. Anyhow, scientific study takes more time for which the objects have to be subjected to detailed technical study.

Reproducing the masterpieces was an accepted fact and was widely practised for centuries by student artists to polish up their techniques in Europe. In India also it was the same. Lately a large number of instances have come to light where these simple craftsmen were being exploited by the people in the art trade to produce fakes and forgeries almost in all types of art works. The art works of recent origin were very cleverly camouflaged to look old and vice versa, which gave smuggling of art works a great boost and the illicit trade is rampant today.

Faker and Scientist

However clever the faker or the forger; however skilful in going into details for producing an art piece that would conform to its conferred antiquity, the fact remains that in some material detail, he slips up and his deception stands uncovered on thorough investigation. The criteria for recognition of authentic objects are fairly well established. Detection of forgery depends on the evidence of presence of discrepancy, if any, in the artefact. If the object so doubted is subjected to intensive scientific analysis for precise identification of the materials and techniques employed in it. The data so obtained has to be compared to the data bank already compiled on the type of objects in question and thus the possible presence of forger's hand emerges.

Authentication of Artefacts

There are many well-established methods of authentication. They are iconographic features in the case of sculptures, bronze icons etc. The style is another criteria for authentication of the artefacts. The various paintings can be categorised through the features exhibited by the paintings of the various types. Materials used are also one of the criteria as the materials are characteristic of the provenance and date. The technique employed is yet another criterion. For example, before the invention of the potter's wheel the method of pottery was hand made. From the type of degradation also one can understand the type of the object and its authenticity. For example, the green patina is an authentic mark for earlier bronze icons. At present the usual practice of authentication of objects, which are purchased for museums and galleries are based on stylistic, artistic considerations, which is described by the members of the Art Purchase Committee who are mostly Museum / Gallery Directors or Curators. It is not definite whether the objects purchased or objects returned from outside exhibitions are the originals or the faked ones.

Methods of Authentication

The methods of authentication are subjective and aesthetic and objective and scientific. Radiology is one of the fundamental non-destructive methods of investigation and examination of works of art such as paintings, paper materials, wooden objects, metal objects, ceramics etc. It has been used in the past and is used in the present in the detection of forgeries of the original works. When x-rays are allowed to fall on an x-ray film through the object to be examined, a shadowgraph is formed on film depending upon the structure of the object. The latent image is developed, like photographic film to obtain the image of the inner structure of the object called radiograph. In the case of painting, the radiograph registers its various parts from the support up to the surface coating. The radiography of bronze icons, coins, weapons etc., will give a radiograph showing the voids and discrepancies inside the metallographic structure. This information is used to conserve and to identify the paintings. Radiography could help in characterisation of these art works in order to finger print them for legal purposes.

Finger printing of art objects and antiquities of all materials could be done if some documentation technique could be used such as Macrophotography, Infrared Photography, Radiography. Analysis of elements through classical as well as sophisticated instrumental methods will reveal the composition of the bronze icons. These records should be kept as secret. Other wise the culprits will use these data and faked objects will be produced in plenty.

DATING OF ANTIQUITIES

Usually, events are dated by relating them to other known and already established events in history and archaeology. Most of the antiquities are dated through the inscriptions available on them or through the associated finds in an excavation. Based on the iconography also the objects are dated. Corroboration of date from the composition also paves a way for dating the antiquities. Whatever may be the method of dating, date of antiquities is very essential to get the fullest information through them.

There are various methods of dating of antiquities. Here, a few methods of dating of antiquities are explained.

Stratigraphy

Stratigraphy is used in relative dating. The archaeologist observes the successive layers in the site and then establishes the chronology of different levels of layers relative to each other. But even in properly observed and recorded stratigraphic levels, there is often doubt and the question arises: Are all the artefacts and human remains found in the same level contemporary? Is it possible that there could have been later intrusions that have become difficult to distinguish? These questions baffle one who is interested in the stratigraphic dating. The amount of fluorine in bones has been very helpful in cases where there are doubts as above due to contamination. If bones in the same geological or archaeological level have markedly different fluorine content, then it is clear that there must be interference.

Dendrochronological Dating

Dendrochronology may be defined as the study of the chronological sequence of annual growth rings in trees. Basic to a tree-ring chronology is the fact that each consecutive annual growth ring is assigned to the calendar year in which it was formed. The outermost ring corresponds to the year of cutting the tree. When the quality of cross dating has been established and modern chronology developed for a given area, it is possible to date tree-ring material either wood or charcoal, from earliest periods.

Effectiveness of dendrochronology as a dating method depends on having

1. Suitable sample of non-complacent wood. Normally 100+rings are needed unless there is a particularly distinctive pattern.

2. A master chronology for that species in that region.

A dender date will give an extremely accurate result for individual rings, giving a data accurate to a particular season of a particular year.

Radiocarbon- ^{14}C Dating

^{14}C are formed continuously in the upper atmosphere by the action of cosmic rays on ^{14}N. This ^{14}C is rapidly oxidised to $^{14}CO_2$ and mixed into the carbondioxide, including ^{14}C, absorbed into plants via photosynthesis. From plants it is passed through the food chain to the entire biosphere. It is also absorbed into the oceans, but more slowly, and with less rapid mixing.

Three forms (isotopes) of carbon occur in nature, ^{12}C, ^{13}C and ^{14}C. Of these ^{12}C and ^{13}C are stable, but ^{14}C is radioactive. This means that it decays spontaneously at a measurable date, defined by the half-life, the time taken for half of any amount to decay away. This is a constant specific to each radioactive isotope. This method is based on the principle that Carbon-14 decays by 1% every 83 years, which means that in 5730 years it will be half. The outer limit is 40,110 years beyond which it is not possible to date using this method

Since ^{14}C is continually being formed and decaying only a certain amount will be in the atmosphere at any one time. While a plant or animal is alive it will constantly replenish content of ^{14}C via the food chain and remain in equilibrium within the atmospheric amount.

Once it dies, ^{14}C lost by decay will no longer be replaced and the amount trapped in its tissues will decline.

Since it is possible to measure the amount of ^{14}C content is also known calculating the elapsed time since death is mathematically simple.

By this method bone, ivory, antler, wood, charcoal, textile, grain, plant materials can be dated. The actual weight needed depends on the age of the sample, the exact carbon content and the precision required. It ranges from 2 gms to 50 gms.

Carbon containing contamination affects the date. Objects, which are consolidated with organic consolidants, are not suitable. All radio carbon results are quoted with error terms, usually in the range from50 to100 years.

Thermoluminescence (TL)

Thermoluminescence (TL) is a property of crystalline materials, which have been exposed to ionising radiation. When such materials are heated they emit both the incandescence normally associated with heat and a small amount of additional light is related to the amount of radiation to which the material has been exposed since it was last heated and hence to the elapsed time.

This method of dating was first developed for use with pottery, but has now been extended to other substances. In pottery, TL builds up in the quart and feldspar crystals, which occur naturally in clay. These receive ionising radiation, most from the alpha, beta and gamma emissions from the decay of uranium, thorium and potassium found throughout the soil and in the pottery itself. As this radiation travels through the crystals it releases free electrons. Some of these become trapped in defects in the crystal lattice. Depending on the nature of the defects these electrons can remain trapped over geological time, thus 'zeroing' the time clock. Subsequent exposure to radiation will result in a slow build up of TL with the amount depending on the elapsed time, the radiation dose from the surroundings and the sensitivity of the material. If both dose rate and sensitivity can be measured or estimated and the amount of TL present determined it should be possible to calculate the time since the last firing. In art historical terms TL is most often used as an authentication technique on pottery.

To produce precise TL dates require an accurate assessment of the natural radiation do to which the sample has been exposed. In an archaeological context this is determined by in situ measurements with a gamma spectrometer or by burying a small, radiation sensitive, capsule for a known length of time. For authenticity work on pottery, where the burial environment is not known, these levels have to be estimated and the result is correspondingly less precise.

Thermoluminescence dating can be applied to pottery, burnt flint, volcanic materials, baked clay, kilns, hearths, core materials in metal work, etc.

Sample size varies very much with material and circumstances, but between 50 and 100 mg are needed for an authenticity test.

The ultimate precision will depend on the characteristics of the materials and the precision with which the environmental dose rate can be determined, but results are normally quoted +5% to 10% or around +25% for authenticities.

Lead-210 Dating

Lead-210 dating is useful to study geological materials within 100 years. *Palaeo- magnetic* dating is based on the measurement of the earth's magnetic field over time. The magnetisation acquired by rocks or fossils is studied. The approximate duration period that can be studied is 10,000 to 100,000 years.

Potassium-Argon Dating

Potassium-Argon dating has made it possible to establish that the earliest remains of man and his artefacts. In East Africa, dates go back at least 2,000,000 years, and probably further. The principle is that of the isotopes of potassium with mass number 40, 88% decays to stable calcium with mass number 40 and 11.2% to argon with mass number 40. This decay is a measure of time passed. Argon will be trapped if the mineral is at a low temperature. It is applied to rocks or minerals. Similarly, decay of U^{235}, U^{238} (Uranium) and Th^{232} (Thorium) are measured for radioactive decay and dating.

Aminoacid Dating

Aminoacid dating is used to date organisms after their death based on the ratio of alteration of amino-acids of the Leavo structure in to the Dextro structure (D/L ratio). D/L values are a measure of the age.

Pollen Analysis

Pollen analysis is done since pollen is indestructible for millions of years. It is destroyed only by aerobic and alkaline conditions. For many areas, long and short pollen profiles are available. This can be used to measure climatic and vegetation changes. The Birbal Sahani Institute of Palaeo Botany, Lucknow carries on this work of preparing profiles. The changes in climate as deduced from other disciplines can be triangulated with this data.

REQUIREMENTS FOR A CONSERVATION LABORATORY IN A SMALL MUSEUM

Conservation is inevitable for a museum whether small or big. Depending upon the size of the museum the conservation laboratory may be designed. There is no museum in the European countries without a conservation laboratory. The strength of the conservation staff is also in commensurate with the number of objects in the collection of the museum. The requirements of a small conservation laboratory is detailed here under.

Staff

Trained staff is very essential for the conservation laboratory. With out staff no conservation work can be carried out. In some of the European museums, the conservation work is entrusted to the private restorers or conservators and the conservators of the museum supervise the work. Either a museum should have at least one person for tackling the conservation problems or one of the staff should be trained and should be entrusted with the conservation work along with his routine work.

Area of the Laboratory

In the beginning for a small museum one room will be sufficient to carry out the conservation work. It will be better to have at least two rooms of size 10 x 10 feet for this purpose. Some of the museums have a conservation laboratory in the storage too. E.g. Victoria and Albert Museum, London.

Facilities Required

Facilities like furniture, equipment, chemicals, tools, etc., are required to take up the conservation work. It is essential to have at least the important chemicals and tools to carry out the work.

1. Furniture

Furniture for the staff such as workbench, cupboards, chair, shelves, water tap, sink, with electrical installation is essential. Depending upon the number of staff the same can be increased.

2. Equipment

Vacuum cleaner is one of the important equipment in any museum to undertake preventive conservation. A distilled water plant or a deionister is much needed, as distilled water is essential for the cleaning of the objects in case needed. Air drier is required for drying. Environmental monitoring equipment like thermometer, hair hygrometer, light meter, UV meter etc are essential for the environmental monitoring.

3. Tools

Simple tools like scalpel, chisel, hammer, knives, saw, nylon brushes, metal brushes, hair brushes, glass plates, trays, weighing balance, screw gauge, Vernier callipers, measuring cylinders, bottles of different sizes, beakers, test tubes, burners, lamps, stands, tongs, pliers, metal cutters, buckets, mugs, water tubs, gloves, polythene sheets, gas masks, supporting materials for conservation work etc. are essential.

4. Chemicals

Now a days preventive conservation is given importance in which chemicals are not in use effectively. Use of many chemicals is avoided. Chemicals such as fumigants, insecticides, pesticides, desiccants, consolidants, reversible adhesives, solvents to take up cleaning work, detergents like Extran, acids and alkalis are mostly needed.

a. Fumigants

Chemicals, which give out fumes, are called fumigants. Thymol, para dichloro benzene, naphthalene are some of the essential fumigants a conservation laboratory must have for fumigation purposes.

b. Insecticides

Chemicals, which kill the insects, are insecticides. The common insecticides are benzene hexa chloride, D.D.T., mercuric chloride, arsenic trioxide, etc.

c. Pesticides

Pesticides are chemicals, which either kill or drive away the pests. The periodical pest control will drive away the pests from the museums. Chloropyriphos is a common pesticide, which is used in museums. It has come out in the name of *Durshban* TC. This is both sprayed as well as injected into the wall and ground.

d. Desiccants

Desiccants are chemicals, which absorb moisture from the environment. Calcium chloride, silica gel etc., are some of the desiccants used in the museums. Among them silica gel is very commonly and freely used in the museums. Silica gel absorbs moisture from the environment and avoids accompanying defects. Silica gel without moisture appears blue and it appears pink when absorbs moisture. This can be rejuvinated.

e. Consolidants

Consolidants are chemicals, which are used to consolidate the fragile museum objects. Consolidants are normally soluble in a solvent and will not react with the object but consolidate the object. Poly vinyl acetate, methyl methacrylate, silanes, Paraloid B72 are some of the consolidants.

f. Adhesives

Adhesives play a very important role in the conservation of museum objects. Adhesives used for conservation of museum objects should be reversible at the same time they should not react with the objects and should not stain them. There are so many natural adhesives such as ising glue, gum Arabic, wax and various resins. There are also synthetic glues, which are reversible in nature. Some of such synthetic adhesives are Paraloid B72, Movilith, Pedicryl etc.

g. Solvents

Solvents are very essential in the conservation work. There are various types of solvents. Common solvents used in the conservation laboratory are acetone, toluene, rectified spirit, diacetone alcohol etc.

h. Detergents

Detergents are soaps, which are neutral in action and they are used for cleaning the objects in a museum. *Lissapol, Teepol, Extran* are some of the detergents used for cleaning museum objects. Glass cleaning detergents are also available in the market for cleaning the showcase glasses. Paper pulp, Fullers' earth, *sepiolite* etc., are required for the removal of salt from terracotta and stone objects.

i. Other Chemicals

Other than the above category of chemicals, some special chemicals are also required in a conservation laboratory. The commonly used other chemicals are ammonia, turpentine, formaldehyde, Rochelle salt, sodium hydroxide, sodium carbonate, acetic acid, formic acid, nitric acid, sulphuric acid, hydrochloric acid, zinc dust, hydrogen peroxide etc.

All these chemicals, equipment, tools, apparatus etc., can be purchased from any chemical and scientific company.

DISASTER MANAGEMENT PLAN FOR MUSEUMS

A Disaster Management Plan is a document containing information on the Standard Operating Procedure to be adopted in an emergency. By its comprehensive nature, it saves the time used in thinking in emergencies. With training drills it ensures quick response of the people involved. It does not respond to emergencies – it is people who do that. It ensures that staff is familiar with the plan and their roles in it, and that they have the resources, training, and authority to undertake their duties and responsibilities. This information has to be made up-to-date and the Plan practiced regularly. Emergency preparedness does not stop once a written Disaster Management Plan is completed.

Disaster Response Team

Disaster Response Team should be organised in the institution. It should have the Co-ordinator, Conservator, Civil Engineer, Electrical Engineer, Fire Officer, Revenue Officer, Police Officer, Health Officer etc. They should be given specified duties and meet regularly to review the situation in the institution.

Duties of the Disaster Response Team

The duties of the Disaster Response Team are multifarious. They are

- Declaring emergencies and implement the Emergency Plan
- Implementing evacuation procedures
- Contacting emergency services (fire, police, ambulance) and utilities
- Establishing a command post, chain-of-command and reporting procedures
- Accessing and stabilise the environment
- Assessing emergency services, supplies and equipment
- Obtaining emergency services, supplies and equipment
- Ensuring the safety of staff and volunteers at all times during emergency
- Arranging for off-site storage and work facilities
- Arranging the transfer of collections to a safe site
- Recording the movement of collections
- Contacting, deploying and supervising museum staff

- Implementing and supervising salvage procedures of collections
- Contacting, training and supervising volunteers
- Documenting all aspects of the response / recovery procedures
- Signing purchase orders
- Meet with the press
- Preparing post-emergency reports.

Emergency Plan

I. Authority Statement

When there is a disaster, the head of the institution authorises its staff, employees and volunteers to meet the emergency. The head of the institution's Disaster Response Team is vested with the authority to declare a state of emergency and to use appropriately whatever resources are necessary.

II. Policy Statement

During a disaster, the museum declares its priorities to be

1. Protection of life
2. Protection, recovery and stabilisation of the collection of records.

For achieving this alone, it authorises the bypassing of normal procedures.

III. General Instructions

1. Wherever necessary, visible emergency exit signs must be posted clearly.
2. On hearing an alarm or information from the staff all persons shall evacuate the museum buildings.
3. Copies of the Emergency Plan should be available readily for the Disaster Response Team.
4. The Disaster Response Team has authority in all practical matters for the duration of the emergency.

Appendices

There should be details of information as required below to take swift action during any disaster.

1. Complete staff list with addresses and phone numbers
2. Emergency Response Team call-out list with phone numbers (Check weekly).

3. Public emergency services phone numbers (Check annually).
4. Phone and fax numbers, e-mail IDs of other sources of emergency support and appropriate Public Works Authorities (Check annually).
5. Phone and fax numbers, e-mail IDs and addresses of local suppliers of equipment, materials, freezing services, ambulance, accommodation and services that might be required (Check annually).
6. Building information, with plans showing location of water, electrical, gas and compressed air circuits and all switches and cut-offs (Update annually).
7. Lists of emergency equipment and materials held in stock with quantities and location (Check stock and update monthly).
8. Lists and locations of fire fighting equipment and first aid supplies (Check monthly and update monthly)
9. Location of safe copies of Collections' Records and Disaster Plan.
10. Distribution of Disaster Plan and Appendices: I, II & III to all staff; III points 1 and 2 in every room; Appendices 2 and 3 beside every telephone.

Signature of Head of Institution & Date

Conclusion

A checklist is a must to assess the condition of the damage occurred to the property. A Conservator may be summoned to advice, if necessary. There are many conservation procedures to rescue the affected manuscripts and art objects. Curators, Archivists, Librarians and the Curators, Collection Managers, Keepers, Caretakers etc., concerned may contact the suitable persons for the conservation of affected objects after the recovery of the objects are made.

Emergency Contact List

State Emergency Services	Name	Phone Number
Fire Service	Fire	101
Police		Patrol 100
Police	Traffic	103
Ambulance	Ambulance	102
Hospital	Medical Office	
Tahsildar	Revenue	
Electricity Services		
Corporation or Municipality or Town *Panchayat*		
Metropolitan and Water Supply and Sewage Board	Head Office Complaint Cell	
Public Works Department	Assistant Engineer (Civil)	
	Assistant Engineer (Electrical)	
Regional Meteorological Centre	Area Cyclone Warning Centre	
Insurance Company		
Police	Technical Services & Finger Print Bureau	
Diffusion Squad		
Pest Control		
Transport Department		
Secretariat	Secretary of the Concerned Department	
Head of the Institution		
Officials of the Museum		

FIRE FIGHTING IN MUSEUMS

Conservators are recognised as the deciding voice where environment standards are concerned. They also have an important contribution to the prevention of fire, security and safety factors. An emergency plan is only a document containing information. It does not respond to, and recover from emergencies. It is people who respond to any disaster. It is the duty of the Disaster Response Team to ensure that staff are familiar with the plan and their places in it and that they have the resources, training and authority to undertake their duties and responsibilities. The information on this should be updated and practiced regularly. The emergency preparedness does not stop once a written plan is completed. The updating should be regular and training should be provided in the management of any disaster, especially fire management

Fire

Fire is one of the devastating agencies in museums and similar institutions, where organic materials such as manuscripts, textiles, art objects, natural history specimens are present. One must take all precautionary measures to contain fire thereby avoiding fire. There are three types of fire. They are

1. Class A fire (Fire on ordinary combustible materials like paper, wood, textiles
2. Class B fire (Fire on inflammable materials like oil, volatile chemicals, etc.
3. Class C fire (Fire on electrical installation)

The fire fighting equiments also varies with the type of fire. One must know the elements of disaster preparedness to avert fire, to safeguard the objects during fire and the salvaging activities after fire. The various elements of disaster preparedness are

1. Before a disaster
2. During a disaster and
3. After a disaster

Fire Safety

Fire is one of the major devastating agencies, which completely destroys objects such as organic objects and in-organic objects with in a short time. Even metallic objects like lead, tin also will be damaged due to fire. Fire safety is an important aspect to be cared for. In addition to meeting the environmental standards, the institutions like museums, archives, libraries should meet fire safety standards for the protection of the artefacts.

Causes of Fire

Fire in a museum can occur due to various factors. They are:

1. Electrical and mechanical factors
2. Chemical factors and
3. Human factors.

Electrical and Mechanical Factors

Electrical installation, electrical fittings, defective air-coolers, air conditioners, exhaust fans etc., are the main reasons for the break out of fire in museums. The cause for most of the fire in museums in the past is the failure of the air-conditioners. In order to overcome this problem substandard materials should never be used and the wiring should be renewed from time to time. Heavy loading of the wire should be avoided. In any case the electrical power loading should never be increased with out the knowledge of the electrical experts. There are instances where halogen lamps used in theatres have caused fire. The very high temperature produced by the arch lamp is responsible for the fire.

Chemical Factors

Museums have conservation laboratories or other biological sections where chemicals are used for the conservation of preservation work. Some times while painting of the galleries is done, paints and other inflammable chemicals are used. The negligence in their use causes fire in the gallery. Even at times the gas used in the canteen also result in fire in the museum.

Fire Safety Systems

There are various fire safety systems available. They are Electronic Automatic Fire Detection and Alarm System, Gas Based Automatic Fire Detection and Extinguishing Systems (CO_2 / FM 200 / NAFS III / INERGEN Flooding System), Automatic Sprinkler System (Wet Pipe-a wet pipe system is one in which water is constantly maintained within the sprinkler piping. when a sprinkler activates this, water is immediately discharged onto the fire, Dry Pipe-a dry pipe sprinkler system is one in which pipes are filled with pressurised air or nitrogen, rather than water and Pre-action-this type employs the basic concept of a dry pipe system in that water is not normally contained within the pipes, the water is held by a pre-action valve), Medium Velocity Water Spray System, High Velocity Water Spray System, Low and High Expansion Foam System, Fire Hydrant System (Both Wet Riser System and Down Comer System), water mist, one of the promising technologies involves the use of fine water droplets, known as micromist. Micromist systems discharge limited water quantities at very high release pressure of approximately 1,000 psi. This produces droplets of less than 20 microns diameter, resulting in exceptionally high efficiency cooling and fire control with significantly little water.

Halon 1301 (CF_3Br) fire suppression systems found quite wide application in parts of libraries, record storage facilities, museums and the like. Due to its high atmospheric ozone depletion potential, Halon 1301 is no longer available for fire protection purposes. Available alternatives include NAFS-III (a blend of hydrochlorofluorocarbons), FM-2000 (heptafluoropropane, CF_3CHFCF_3) and the inert gas system, INERGEN. INERGEN may well serve as an environmentally acceptable alternative to Halon 1301 for critical parts of library facilities.

INERGEN (derived from the words "INERT" and "NITROGEN") is a mixture of nitrogen, argon and carbon dioxide. The specific gravity of INERGEN is 1.05, which is similar to air and there fore human beings could safely remain in the room during trial operation or during accidental release of INERGEN. Of course one should leave the room when fire is involved-not because of the extinguishing agent, but because of the toxic gases released by the fire.

Automatic sprinkler systems (wet, dry or pre-action) represent the preferred protection for libraries and, in the present state of development, are virtually failure proofs. Fire detection and alarm facilities are the next choice and, again the current technology provides very easily warning (and summoning of the fire brigade) with much improved resistance to false alarms.

Clean agent systems, including the new breathable artefacts and documents and suitable for many parts of library installations. The fire protection technology is available-all we need is more dialogue between library / museum administrators and fire protection engineers.

Training the Staff

Training is the process of changing a given behaviour up to a desired behaviour. Training is important because of the following reasons:

❖ Trained manpower is not easily available in the market.

- Training condenses the experiences that others have gained over several years.
- Training removes the anxiety of workers as to whether they can do the job successfully by giving self-confidence.
- Training helps the institution to have a well-coordinated team.
- Training helps to equip a person to do the job in the shortest possible time.

A balanced training programme develops in person knowledge, skills and attitude.

Effective training programmes for those who work in museums are fundamental in ensuring that our museums are equipped to face the challenges of them. Since every one has a role in the success or failure in the disaster management of a museum, training is essential. Training should not apply just to junior staff. Junior staff must be given long detailed training so that they will pick up the subject very well from the beginning. A short-term training should be given to the experienced staff members at regular intervals so that the modern trends will be taken care off. Many directors and senior staff urgently need to acquire improving management and financial staff and it should be just a one-off, but should combine any necessary through out an individual's active career. Computer knowledge is a must now a days.

In-service Training

Museums in the European countries provide training to the staff in the form of Induction Course when they join the museum either as full-fledged staff or as an intern. They are provided with the information on various aspects of museology including fire fighting. This avoids any embarrassment in case there is fire. Fire fighting training provides strength to an individual in the event of a fire enabling him to face the situation boldly. Appropriate specialist bodies should give the training; making available appropriate publications may cover others quite adequately. It is essential for the staff to receive proper training in the provisions and implications of the appropriate legislation, and such training is now often available through local authority personnel departments. For the developments of the staff some of the specialist courses will be of much use. Induction course for security staff will help every new member to know the geography of the building, patrol patterns, emergency fire, theft and bomb procedures, fire fighting and legal issues relevant to his work. A written manual should be provided for all the security staff, covering all basic aspect of their work. Specific training on fire fighting and first aid is usually organised by local authority personnel departments. Volunteers and temporary staff should not exceed the number of the permanent staff and they should be trained in their work. Training like every thing else should be designed to meet a genuine need.

Case Study 1

On 21st December 2000, there was a fire in the famous Museum Theatre of the Government Museum, Chennai around 8.00 PM. The fire was put out within 25 seconds by the museum staff with the help of the newly installed fire extinguishers and all the wooden structures and furniture were saved.

Live Fire Fighting in the Museum Theatre, Government Museum, Chennai

A city school was conducting their cultural programme in the Museum Theatre. Some halogen lamps had been kept near the folded front screen of the stage. The lamp stand leaned over the screen and the velvet cloth came in contact with the white light of the lamp and the cloth got fire. It was immediately noticed by the staff of the Theatre and they jumped into action with the dry powder and carbon dioxide-water fire extinguishers. The parents of the school children rushed to the stage to take care of their children. Some pulled down the screen. Immediately, the Conservation Scientist (the author) was informed. He rushed to the spot. Even though there was a telephone connection, it did not have the '0' dialling facility. More over the telephone was not functioning. It so happened that one of the parents had a cell telephone and the Fire Brigade was informed. Before the number of the cell was given the connection of the fire brigade telephone automatically disconnected. Once again the information was given and the place of occurrence of fire, phone number, etc., were given. The Commissioner of Museums was informed and he rushed to the spot. The press was informed. Since the fire was put up, the Fire Brigade came little late. The Fire Brigade was asked to examine the theatre and they pulled down the things, which were affected by fire. They ascertained that there was no remnant of fire and the theatre was well cordoned by the watch and ward.

It was so happened that the Government had sanctioned Rs. 1,50,000 towards the purchase of fire extinguishers to strengthen the fire fighting with modern fire extinguishers. Training was provided in the operation of all types of fire fighting equipment to all the categories of staff of the museum and allied departments on 8th and 15th of December 2000 i.e. just a week's time before the occurrence of the fire. The Museums Department provided the training with the help of the Fire Brigade and the Company, which supplied the equipment. The fire-fighting drill was performed in the museum campus and the public also participated in it as the information had been publicised through newspapers. Disciplinary action was initiated against those staff, who did not turn up for the training before the occurrence of fire. The companies who offered their tenders were asked to demonstrate their fire fighting equipment before the committee for finalising the orders. All those connected with the purchase were present for the demonstration. It is also noteworthy that in 1998 also fire-fighting demonstration was provided to the staff.

When all the staff involved in the fire fighting on that day were enquired about their experience, they said that the training given to them was fresh in their minds and immediately they could rush to take a fire extinguisher and operate it successfully. If they had not been given training, they could not have used the fire extinguishers during the incident. The training gave them confidence to use the equipment. Those involved in the fire fighting were given certificates for their meritorious service along with a cash award of Rs. 100/-.

Case Study 2

There appeared smoke in the curtain of the auditorium of the National Museum of Natural History due to the use of halogen lamp in the auditorium. It was noticed by the delegates who were present in the conference during February 2002 and the fire was avoided immediately by switching off the light.

CONSERVATION OF MONUMENTS

In India ancient monuments are made of 3 types known as *Nagara*, *Dravida* and *Vesara* with special reference to temples. They were made with various media like stone, wood, brick, stone-cum-brick, etc. Each temple / monument faces different type of problems due to various reasons like age, temperature, vegetations as well as human vandalism, natural calamities and environmental pollution.

If a monument is to be conserved there are many aspects are to be taken into consideration to carry out a proper conservation. The conservator should know the inherent problem of that particular structure in question as well as the problems created by other agencies. Unless these vital aspects are understood the conservator cannot achieve his goal. The monument, which is going to be conserved, should be well documented. Materials used in the original construction, their availability and the knowledge about the percentage of each and every material in the original materials. If a monument is partially collapsed or hanging precariously, the conservator should make proper drawings with scale so that the portion, which is to be reconstructed, will be the same in all the respects after conservation

While conserving the monuments, the following aspects are to be taken care of:

a) Removal of cryptogamic plant growth and other vegetation.

b) Scooping out of dead mortar through the joints or voids followed by filling, pointing etc.

c) Where there is no evidence of the actual shape, size etc., of parts of the monuments, they should be given rough packing.

d) While dismantling the structure the conservator should number the parts very carefully and arrange them in order.

e) The materials used in conservation should be reversible, should not react with the existing materials etc.

f) Any measures taken to strengthen the monument cannot be earthquake proof, but it can resist earthquake.

For doing the conservation, the conservator should have the knowledge of art and architecture, ancient literature on architecture, well versed with modern technique of construction of buildings, capable of using modern materials, tools etc.

PART VII

MISCELLANEOUS

GLOSSARY

Ageless

It is a combination of iron fillings and potassium chloride. Ageless eye looks violet in colour and it changes its colour to pink when oxygen is removed to the level of 0.5% of oxygen.

Airbrasive

The airbrasive unit consists of a metal cabinet containing a vibrator chamber, which holds about 450 gms of an abrasive powder and a rubber hose, which carries air to the chamber from either a carbon dioxide cylinder or an air compressor. Another hose delivers the mixture of air and the abrasive to a small nozzle at the end of a hand piece. The air pressure used is between 2.8 and 5.6 kg/cm^2 depending on the nature of the object. Abrasive powders, which may be used are silicon carbide, aluminium oxide, calcium magnesium carbonate (dolomite), sodium carbonate, glass beads of size 50 microns etc. The abrasive dust and detached corrosion or adherent particles are taken up by vacuum into a dust collector box. The abrasive used is therefore not reusable.

Bleaching

Bleaching is a chemical process in which the dark colours developed due to age or staining may be removed by the use of bleaching chemicals like hydrogen peroxide, chlorine dioxide, chloramine-T etc.

Blistering

When there is an isolated cohesion between the adjacent strata of a painting, the paint layer becomes loose on the surface and it is called blistering.

Bloom

Bloom is the dull bluish-white appearance that develops in a transparent film of a painting and leads to cloudiness. It forms on the varnish layer.

Cleavage

Cleavage is the cohesion between the adjacent strata of a painting.

Condensation

When air containing some water vapour is cooled, a stage is reached when the water vapour is changed to liquid. This phenomenon of change from vapour to liquid is known as condensation.

Doweling

Doweling is a technique of joining broken pieces of wood, metal, stone, etc., together by the use of a headless metallic pin or peg and an adhesive.

Ethoxide

Ethoxide is a mixture of 10% ethylene oxide and 90% carbon dioxide.

Flaking

Loss of paint from the surface of a painting in the form of small particles or flakes.

Fumigation

Fumigation is a process by which an object is exposed to the gaseous chemicals in order to eradicate biological growth on it. The chemical can be a solid, liquid or gas. The effectiveness of the fumigation increases when done under vacuum. This process is called vacuum fumigation.

Hygroscopic Material

Hygroscopic material is one, which has a tendency to absorb moisture.

Impregnation

Impregnation is a process by which a brittle or fragile object is filled with a consolidant like wax, poly vinyl acetate etc., in order to strengthen it. The impregnation will be effective, if it is done under vacuum.

Litmus paper

Litmus paper is a strip of paper dipped in a litmus solution and dried. The blue litmus paper when moistened and kept in any acidic material, it turns to pink. The red one changes to blue when comes into contact with an alkaline material.

Lux

Lux is a measure of intensity of illumination from the source or from the surface of objects.

Oddy's Test

Finding out the increase of weight of a polished copper foil after exposing it to sulphide atmosphere.

Parchment

Parchment is made from the tough, white corium or inner layer of animal skin by a process that relaxes and flattens the capillaries so that they are unable to reabsorb moisture. It is not subjected to chemical deterioration and has proved to be extraordinarily durable as a material for fine writing.

pH paper

pH is in a way the scale of measurement of acidity. When the pH is seven, the substance is neutral. It is acidic, if it is less than seven and alkaline when it is above seven. The strip of paper changes its colour and the change in colour is compared with a colour chart and the pH is found out.

Relining

Relining is a method which can be used for saving a painting that is threatened by the failure of its support.

Restrainer

Restrainer is a chemical, which is used to control the dissolution activity of a solvent in the case of cleaning of the varnish layer of paintings.

Saturated Air

The air is said to be saturated when the air can no longer absorb any more of water vapour.

Seasoning of Wood

Seasoning of wood is nothing but the controlled drying of wood to avoid warping etc.

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