Investigation and Analysis of Wood Pathologies in Quincha Construction at Hotel Comercio in Lima, Peru; With Recommendations for Its Treatment

Rie Silvana Yamakawa

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Investigation and Analysis of Wood Pathologies in *Quincha* Construction at Hotel Comercio in Lima, Peru; With Recommendations for Its Treatment

**Abstract**
Quincha has been an integral construction system in Peru for over 2,000 years, adapting and evolving along with Peru’s development as a nation throughout history. This traditional construction system proved to be extremely efficient in withstanding seismic activity, while being economic, adaptable, and fast to build. Unfortunately, the tradition of building with quincha in urban areas declined over the 20th century until it was lost. As a result, building with quincha has been all but forgotten in Lima today. Although quincha buildings comprise most of the structures in Lima’s historic centre, their neglect has caused them to deteriorate and often collapse. This has led to an extensive loss in Lima’s cultural heritage, not to mention public safety concerns.

This thesis investigates quincha’s construction technology in an attempt to safeguard Lima’s architectural heritage, to build more sustainable buildings in a hazard-prone environment, and demonstrate that it is in fact, an efficient and reliable construction system when build and maintained properly. This study encompasses archival research, interviews, documentation, laboratory analysis, and pathologies and diagnosis studies. Hotel Comercio, a three-story archetypal example of adobe+quincha construction system, was examined and its conditions were studied in order to investigate the pathologies of wood in quincha and the possible deterioration mechanisms. Wood samples were taken and analyzed macroscopically and microscopically at the Architectural Conservation Laboratory at the University of Pennsylvania. Wood and insect identification were conducted, and recommendations for conservation and treatment of quincha were explored.

**Keywords**
peruvian architecture, wood conservation, wood identification, insect identification, seismic activity

**Disciplines**
Historic Preservation and Conservation

**Comments**
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INVESTIGATION AND ANALYSIS OF WOOD PATHOLOGIES IN QUINCHA CONSTRUCTION AT HOTEL COMERCIO IN LIMA, PERU; WITH RECOMMENDATIONS FOR ITS TREATMENT

Rie Silvana Yamakawa

A THESIS

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To my family and Dan
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# Table of Contents

List of Figures .......................... vii
List of Tables .......................... ix
Glossary and Acronyms ................. x
Contacts ................................ xi

Chapter 1: Introduction

1.1 Identification of the Problem .......................................................... 3
1.2 Methodology .................................................................................. 6
   Site Visits ..................................................................................... 6
   Case Study .................................................................................. 6
   Archival Research and Interviews .................................................. 7
1.3 Delimitations ................................................................................ 8
1.4 Objectives ................................................................................... 9
1.5 Lima and its Context .................................................................. 9
1.6 Historic Background .................................................................. 13

Chapter 2: Adobe + *Quincha* Construction

2.1 Definition .................................................................................... 19
2.2 History and Evolution of *Quincha* ............................................. 20
2.3 Materials .................................................................................... 23
2.4 *Quincha* in the Construction System ......................................... 26
   Foundation and First Floor ...................................................... 27
   *Quincha* .................................................................................. 27
   Planning the Frame ................................................................... 27
   Floor Framing .......................................................................... 26
   Wall Framing ........................................................................... 28
   Finish/Enclosure ...................................................................... 29
   Roof ......................................................................................... 29

Chapter 3: Possible Pathologies of Wood in *Quincha*

3.1 Conditions Glossary .................................................................... 31
   Stains ....................................................................................... 31
   Cracks ...................................................................................... 31
   Fracture .................................................................................... 31
   Detachment .............................................................................. 32
   Perforation .............................................................................. 32
   Cavities / Tunneling (from insects) ......................................... 32
   Voids / Material loss ............................................................... 32
List of Figures

Chapter 1
Figure 1.1 – Lima’s Cathedral and Archbishop’s Palace ................................................. 2
Figure 1.2 – Financial Center of the San Isidro District ................................................. 3
Figure 1.3 – Collapsed are of Hotel Comercio ............................................................... 5
Figure 1.4 – Map of Lima ............................................................................................... 11
Figure 1.5 – Monthly average temperatures and precipitation for Lima .................... 12
Figure 1.6 – Huaca Huallamarca .................................................................................. 13
Figure 1.7 – Map of Lima in 1885 ................................................................................ 16

Chapter 3
Figure 3.1 – Joist from Hotel Comercio exhibiting white and gray stains .............. 38
Figure 3.2 - Beam from Hotel Comercio with peeling surface and staining .......... 38
Figure 3.3 – Map of Peru showing distribution of Maximum Intensities of Seismic Activities ................................................................. 49

Chapter 4
Figure 4.1 – Pilodyn. Source: InspectApedia ............................................................... 57
Figure 4.2 – Resistograph. Source: IML Wood Decay Detection Instruments ...... 58

Chapter 5
Figure 5.1 – View of Hotel Comercio ........................................................................... 70
Figure 5.2 – Entrance to restaurant and bar El Cordano on Jirón Ancash .......... 71
Figure 5.3 – Interior of El Cordano ............................................................................. 73
Figure 5.4 – Ceramic tiles in Hotel Comercio ............................................................ 75
Figure 5.5 – View of first patio ................................................................................... 76
Figure 5.6 – Plan of Lima, 1685 .................................................................................. 79
Figure 5.7 – Isometric perspective of the city of Lima, 1924 .................................... 79
Figure 5.8 - Bar of El Cordano with Luis and Antonio Cordano on the right .... 80
Figure 5.9 – View of Jirón Carabaya with Palacio de Gobierno to the left, Estación Desamparados at the center, and Hotel Comercio to the right ..................... 84
Figure 5.10 - Hotel Comercio from Estación Desamparados .............................. 85
Figure 5.11 – View of Jirón Ancash from the second floor of Hotel Comercio towards the San Francisco Complex ......................................................... 87
Figure 5.12 - Laboratory tray with wood samples ..................................................... 95
Figure 5.13 - Stored wood samples ................................................................. 95
Figure 5.14 - Sample S1-II-a from Hotel Comercio, longitudinal section,
40x magnification ......................................................................................... 98
Figure 5.15 - Atlantic White-Cedar longitudinal section ................................. 98
Figure 5.16 - Northern White-Cedar longitudinal section ............................. 98
Figure 5.17 - Sample S1-III-a from Hotel Comercio, longitudinal section,
40x magnification ......................................................................................... 99
Figure 5.18 - Douglas-fir longitudinal section ............................................. 99
Figure 5.19 - Sample S3-II-a radial section from Hotel Comercio.
200x magnification ....................................................................................... 99
Figure 5.20 - Douglas-fir spiral thickening in longitudinal tracheids with resin
canals ............................................................................................................. 99
Figure 5.21 - Sample S3-II-b from Hotel Comercio, longitudinal section,
40x magnification ......................................................................................... 101
Figure 5.22 - Peruvian walnut longitudinal section ..................................... 101
Figure 5.23 - Sample S2-I-b from Hotel Comercio, longitudinal section,
40x magnification ......................................................................................... 101
Figure 5.24 - Black walnut longitudinal section .......................................... 101
Figure 5.25 - Sample S2-I-b from Hotel Comercio, tangential section,
40x magnification ......................................................................................... 101
Figure 5.26 - Black walnut tangential section ............................................. 101
List of Tables

Chapter 2
Table 2.1- Characteristics of pre-Hispanic *quincha* and Colonial *quincha* .......... 23

Chapter 3
Table 3.1 - Classification of Peruvian woods according to durability .................. 44
Table 3.2 - Seismic Activity affecting Lima since 1650 until 2007 ......................... 47

Chapter 5
Table 5.1 - Ownership Timeline ........................................................................ 83
Table 5.2 – Wood samples from Hotel Comercio ................................................. 102
Glossary and Acronyms

ASTM: American Cosiety for Testing and Materials
caña brava: type of cane
Carrizo: type of cane
cabildo: municipality during the Viceroyalty
Casa Militar del Presidente de la República
Casonas
Contrapunta: diagonal bracing
Enramado/solera: sill plate
Estación Desamparados: Desamparados Train Station
GCI: Getty Conservation Institute
Huascas: leather ropes or strings used to tie wood poles and cane reed
Jirón: street
Lime: Found in limestone formations or shell mounds, naturally occurring lime is calcium carbonate. When heated, it becomes calcium oxide. After water has been added, it becomes calcium hydroxide. This calcium hydroxide reacts with carbon dioxide in the air to recreate the original calcium carbonate.
Palacio de Gobierno: Presidential Palace
Plaza de Armas: Lima's main square
Plaza de San Francisco: Church of Saint Francis' square
Punta: horizontal wood blocking
Quechua: Amerindian language spoken in primarily in the Andes of South America
Quincha: traditional construction system of Peru
Segunda Región de Defensa Civil
Tornapunta: diagonal bracing
SENCICO (Servicio Nacional de Capacitación para la Industria de la Construcción): National Training Service for the Construction Industry
Solar: a fourth of a block shaped in a perfect square. Given for free to important people such as Conquistadors, and later sold by the Cabildo.
INC (Instituto Nacional de Cultura): Peruvian National Institute of Culture
ININVI (Instituto Nacional de Investigacion y Normalizacion de la Vivienda): National Institute for Housing Research and Standardization
PUCP (Pontificia Universidad Católica del Perú): Pontifical Catholic University of Peru
UNALM (Universidad Nacional Agraria de la Molina): National Agrarian University of La Molina
UNI (Universidad Nacional de Ingeniería): Peruvian National University of Engineering
UNMSM (Universidad Nacional Mayor de San Marcos): University of San Marcos
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xii
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Lima, named “City of the Kings” by Spanish conquistador Francisco Pizarro, was founded in 1535 on the valley of the Rímac River. Lima is a growing modern city that has had maintained the richness of its historic center, declared by UNESCO as a World Heritage Site in 1988. The architecture is a reminder of the city’s past as a land populated by Amerindian groups since 2200 BCE, as the center of the Viceroyalty of Peru from where the Spanish ruled South America, and as the capital of the Republic of Peru after its independence from Spain in 1821.

The historic centre of Lima has a rich and diverse urban fabric. Its architecture is characterized by a mix of styles, descending from eclectic architectural roots in Spain, France, Italy, and the Middle East. Colonial architecture was influenced by Baroque, Churrigueresque, Mudejar and Andalusian architecture; brought by the Spaniards. The influences of these styles on both public and residential buildings are apparent, but as Lima grew, it developed its own architecture with unique elements and spatial distributions according to the needs of the population (Fig. 1.1). Following Peru’s independence from Spain, the architectural styles gradually shifted to Neoclassical and Art Nouveau. In the 20th century, Modern architecture and industrial materials arrived in Peru, as in most of
the rest of the world, making building construction more efficient, and also allowing for taller buildings, which satisfied the needs of a growing capitalist country. The adoption of Modern architecture was a symbol for progress, and gradually it became the predominant architectural style; thus, the humble construction techniques from the past were lost and forgotten (Fig. 1.2).

Fig. 1.1 – Lima’s Cathedral and Archbishop’s Palace. Source: Amy Allcock.
1.1 IDENTIFICATION OF THE PROBLEM

Lima's high concentration of historic monuments built during the Spanish presence until the beginning of the Republican era, are “typical examples of Hispano-American baroque. Also, historic nucleus recalls Lima at the peak of development of the Spanish Kingdom of Peru.”¹ Furthermore, ICOMOS considered its historic center as an “excellent witness to the architecture and urban development of a Spanish colonial town of great political, economic and cultural

importance in Latin America.”

The neglect of historic buildings in Lima in the past, both by the government and their owners, has led not only to a loss of the city’s cultural heritage, but has caused major safety concerns for their occupants, as well. Since there is no governmental or commercial interest in these buildings, and a lack of interest in protecting the low-income residents who occupy them, many are neglected to the point of total deterioration, often times to the point of collapse (Fig. 1.3).

The alarming amount of historic fabric lost and the concern for public safety, led individuals as well as institutions to study *quincha* in the last decades. The history and evolution of *quincha* has been explored, but no methodology has been elaborated for the conservation of *quincha* buildings. The performance of *quincha* buildings against earthquakes and methods to test the condition of the elements and materials, need to be explored in order for implementation to occur.

\footnote{Ibid.}
Fig. 1.3 – Collapsed area of Hotel Comercio. Source: author.
1.2 Methodology

The study began as a result of my interest in Peruvian architecture and its associated cultural heritage, combined with conversations with Claudia Cancino from the GCI (Getty Conservation Institute). The need for research for the conservation of buildings constructed with quincha was evident, and I became inspired by the work of institutions such as the GCI and the PUPC (Pontifical Catholic University of Peru), to contribute to the study of this unique construction technique and its conservation.

Site Visits

It soon became apparent that a visit to Peru would be required, since very little information about quincha could be found in the U.S. Two site visits were performed. Three weeks were spent in Peru during the Winter of 2011. The time was employed conducting interviews, visiting archives and libraries, exploring buildings constructed with quincha, performing photographic documentation, and collecting samples from Hotel Comercio (case study explained below). The second site visit was on October of 2012 and was focused on extracting wood samples from various areas of Hotel Comercio.

Case Study

The Hotel Comercio was chosen as a case study due to its location, historical significance, condition, ownership, and access. The hotel is located in Lima’s historic centre as a testament of Lima’s beginnings and its evolution. Its construction, the adobe+quincha system, is typical of Colonial and early Republican architecture in
Lima; a construction system that struggles to survive. The hotel is currently owned by the Ministry of Culture, which has been very enthusiastic about the conservation of these type of construction, and facilitated the site visits. Visual examination throughout the building was performed, and conditions were recorded with photographs, field notes, sketches and measurements. Additionally, samples were collected to be further examined in the U.S.

**Archival Research and Interviews**

Documents concerning the Hotel El Comercio were found at the archives of the Ministry of Culture’s Bureau of Historical Research. Documentation of the building such as historical photographs, memorandums, technical reports, condition reports, notarized letters, and newspaper articles were gathered. In the same archive, documents of the restoration of two other well known adobe+quincha houses in Lima, Casa Osambela and Palacio Torre Tagle, were gathered as well.

Furthermore, an interview with engineer Rafael Torres from SENCICO (the National Training Service for the Construction Industry) was extremely helpful since he directed me to their library in where publications, some out of print, regarding historic quincha and modern quincha were found.

Publications about Peruvian native woods commonly used in construction was found during a visit to the Department of Forestry of UNALM (National Agrarian University of La Molina). Additionally, an interview with engineer Manuel Chavesta Custodio, whose specialty is anatomy and identification of wood and wood technology, was conducted.
Other libraries such as the Ministry of Culture’s library and the National Library were also visited in order to find any publications referring to *quincha*, construction in Peru, or Peruvian Architecture.

### 1.3 Delimitations

The adobe+*quincha* construction is a system, and as such it has problems that are unique to this type of construction due to the compatibility (or incompatibility) of the superimposition of one (*quincha*) over the other one (adobe). However, the scope of this thesis would not address the conservation of adobe. It was decided that the study would focus on *quincha* and would only address the adobe as it relates to the *quincha*. This decision was based on several factors. For one, both consist of very different materials and techniques of construction and because of time constraints, it would be very difficult to address the analysis and conservation of both. Another reason is that there are very few studies analyzing the condition of wood in *quincha* and its conservation, focusing on *quincha* was determined to be the more pressing issue to study.

The Hotel Comercio is partially occupied on the first floor; therefore, these areas could not be inspected during the site visits. Moreover, the observations made are limited to the areas of the building that were already exposed.

Recommendations on this thesis are based on the observation and analysis of the Hotel Comercio in hopes that they will be applicable to other buildings constructed with the same system.
1.4 Objectives

- Survey – gather data
- Study *quincha* as a construction system
- Analyze modes of failure – identify decay process – pathologies
- Research available testing methods for diagnosis
- Research NDT for material testing
- Document and assess current conditions of case study
- Research wood properties and types of wood used in the coast of Peru
- Recommendations

1.5 Lima and its Context

Peru is a country in South America, bordered by Ecuador and Colombia on the north, Brazil on the west, Bolivia on the southeast, Chile on the south, and the Pacific Ocean on the west. Peru has two official languages: Spanish, which was introduced by the Spanish conquistadors in the 16th century, and *Quechua*, which is an Amerindian language and official language of the Inca Empire. The country is divided into three contrasting topographical regions: the coast (*costa*), the highlands (*sierra*), and the eastern rain forests (*selva*).

Peru lies near the boundary of the Nazca and South American Tectonic Plates, which is a seismically active area. One of the countries’ most devastating quakes on record occurred in May 1970 when a 7.9 magnitude earthquake killed 66,000 people.
Peru’s capital and largest city, Lima, is located at an altitude of 107 meters above sea level, with geographical coordinates of 12° 3’ south and 77° 2’ 60” west. Lima is located in Peru’s Central Coast, and bounded by the Rímac, Chillón and Lurín rivers (Fig. 1.4).

Although Peru’s seaboard is situated well within the tropical zone, Lima does not display an equatorial climate; average temperatures range from 21 °C (70 °F) in January to 10 °C (50 °F) in June (Fig. 1.5).

Lima has received the bulk of rural migrants, and by the mid-1990s the metropolitan area of Lima supported nearly one-third of the total national population. The total number of migrants living in Peru in 2000 was 46,000. In 2004, remittances were $1.3 billion, 5% of GDP. In 2005, the net migration rate was an estimated -1.0 migrants per 1,000 populations. The government views the migration levels as satisfactory.
Fig. 1.4 – Map of Lima. Source: AgainErick
Fig. 1.5 – Monthly Average Temperatures and Precipitation for Lima, Peru. Source: The Weather Channel.
1.6 Historic Background

The area that is presently Lima had been occupied by Amerindian groups such as El Paraíso (2500-1800 BC), Chavín culture (900 BC-200 AD), Lima culture (100-650 AD), Wari Empire (600-1100AD), Chancay and Ichma polity (1110-1440 AD) and the Inca empire (1440 AD). These groups left a great number of complexes, which included irrigation systems, agricultural terraces, and temples (Fig.1.6).

Spanish conquistadors arrived to South America, and after numerous confrontations with the natives, Inca Atahualpa and his army were defeated in 1532. Leader of the Conquistadors, Francisco Pizarro founds Lima as his capital in 1535. Pizarro chose Lima because of its proximity to the Pacific Ocean, its mild weather, and the abundance of water, which made it suitable for agriculture. In 1537,
Spanish emperor Charles V confirms the founding of the city, granting a coat of arms for it.

In 1542, Lima was designated capital of the Viceroyalty of South America, and the site for the *Real Audiencia* in 1543. This meant that all Spanish South America would be ruled from Lima, making it grow in prestige and power. Callao, the Spanish main port and Peru’s largest and most important port until today, played an important role in the economic prosperity of Lima. All trade from the Viceroyalty was required to go through Callao to later go through the Isthmus of Panama and make its way to Seville, Spain. This made the rest of the viceroyalty dependent on Lima’s administrative matters since all wealth of the colony from the silver mines had to go through Lima, as well as all imported goods from abroad.

Following the establishment of a Roman Catholic diocese in 1541, Lima became an important religious center. Many religious orders settled building magnificent monasteries still standing today, such as the convents of San Francisco, Santo Domingo and San Agustín.

Lima played an important role in the history of the development of the continent. The UNMSM (University of San Marcos), the first institution for higher education in the Americas, was established in Lima in 1551. It is the oldest continuously functioning university in the Americas. Furthermore, a print shop opened in 1581; this was the second print shop in the Americas and first print shop in South America.

By 1687, Lima continued to expand and its population grew to around
80,000. However, the Viceroyalty’s decline was inevitable. Two powerful earthquakes destroyed most of Lima leading to epidemics and food shortages. Another earthquake in 1746 severely damaged Lima and destroyed Callao. The city went through a massive rebuilding campaign, which deplored the Viceroyalty’s resources. Additionally, the silver and gold treasures going in and out of Callao made the port susceptible to pirate attacks, being some of the most famous Jacques L’Hermite, who wanted to capture Spanish silver ships and establish a Dutch colony in the Viceroyalty, and Sir Francis Drake, who captured eighty pounds of gold, a golden crucifix, jewels, thirteen chests full of royals of plate and twenty-six tons of silver in a single ship. The constant pirate attacks affected the Viceroyalty economically, so between 1684 and 1687 city walls were built around Lima, as well as the fortress of Real Felipe (Fig. 1.7).
By the early 19th century, Lima was declining economically and losing its influence over other regions of the Spanish Empire in South America. The Bourbon reforms transferred the mining region of Upper Peru (present Bolivia) to the Viceroyalty of the Río de la Plata, making the city of Lima dependent on Spain. This dependency made the Viceroyalty reluctant to independence, ideas brought by the rest of the Spanish colonies. However, in 1820, patriot armies led by José de San Martín and Simón Bolívar defeated the Spaniards and invaded Lima. The Declaration of independence was signed on July 1821, but battles continued until 1824 with the final Battle of Ayacucho. In 1866, Spaniards attempted to regain possession of Peru, but failed; and in 1871 an armistice was signed and Peru’s
independence was finally recognized by Spain in 1879.

After the war, the Viceroyalty of Peru became the Republic of Peru with Lima as its capital. Political turmoil and lack of economic resources made it very difficult for the new country to recover; nevertheless, guano exports in the 1850’s allowed several improvements on the city’s infrastructure. The city funded several public projects to replace colonial establishments such as the Central Market, the General Slaughterhouse, the Mental Asylum, the Penitentiary, and the Dos de Mayo Hospital. Additionally, a railroad connecting Lima and Callao opened, the first railroad in South America; and gas lighting and the telegraph were installed. Lima’s city walls were torn down in 1872 to allow for the city’s expansion.

Peru’s development became stagnant once again with their involvement in the War of the Pacific, in which Chile defeated Peruvian and Bolivian forces. Chilean troops occupied Lima from 1881 to 1883, destroying and looting museums, libraries and educational institutions. Peru was forced to sign the Treaty of Ancón in 1883, in where the provinces of Tarapacá and Arica were surrendered to Chile.

After the war, Lima went through a period of urban renewal to accommodate for the growth of population in downtown Lima. New neighborhoods were established, big avenues were constructed, and buildings such as the Government Palace were rebuilt. Unfortunately, another earthquake destroyed most of the city in 1940; many of these buildings were built in adobe+quincha. Increasing industrialization and modernization led to a massive migration of people from the Andean regions of Peru, creating huge shanty towns without proper infrastructure.
The population in Lima grew from 176,000 in the 1920's to 1.9 million by 1960 and 4.8 million by 1980, causing the collapse of public services. Today, Lima is the fourth largest city in the Americas with a population approaching 9 million, behind Sao Paulo, Mexico City and New York City.
2.1 Definition

According to the Royal Spanish Academy\(^3\): *Quincha*.

(From Quechua *qincha*, fence or palisade).

1. *f. Am. Mer.* Straw, reed or cane wall or roof reinforced with a weave or bulrush frame.

2. *Chile, Ec. and Peru.* Wall made of reed, sticks or other similar material usually covered in mud. Used in fences, huts, corrals, etc.

The word *quincha* has its origins in *Quechua*, the language of the American Indian people of Peru. According to Luis Cordero Crespo, it means “wall or fence built with sticks or poles.”\(^4\) However, the term became more than just a wall made out of sticks. In Peru, it was used to describe a distinctive construction system that used a wood frame within the city or in rural areas.

In the Historic Centre of Lima, *quincha* evolved and adapted according to the city’s seismicity, climate, availability of materials, construction traditions, aesthetics and economics. *Quincha*, which is fundamentally a wooden frame filled in with interlaced cane and covered with mud, is used in combination with adobe. Buildings were typically two or three

\(^3\) Real Academia Española. *Diccionario de la Lengua Española*. 22 Ed.

stories, where adobe was used on the first story, and upper stories were built with quincha. This light and flexible system proved to be very efficient against seismic movement.

2.2 History and Evolution of Quincha

Quincha as we know it today has its precedents in pre-Hispanic construction. Quincha started to be used in the coast of Peru due to the availability of cane and mud, and the climatic conditions, which made quincha the most suitable construction system for the region. It was very elemental and was used to build housing for the masses. Tree branches, trunks and wood logs were used for the structural frame, while cane was interlaced and tied to the frame to form the walls. Very simple techniques were used, both for connecting pieces of wood and for tying elements to each other. Huascas, which is also a Quechua term, are leather strings made from cow or lamb used for tying. Also, rope made out of vegetal fiber was often used. The frame and walls were then covered in mud, or could also be left exposed.

Colonial quincha, on the other hand, was the result of the adaptation of Spanish construction techniques and the need for new building types. At the beginning of the Colonial period, buildings were erected according to Spanish traditions and stone was the material of choice for monumental buildings along with brick, which started to be produced in 1538 for the construction of the Santo Domingo Convent. However, the production of brick remained limited due to a shortage of firewood. This led to the development of alternative construction methods, in where brick was only used for pillars and buttresses of adobe walls.

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5 Ibid. pp 11.
The sense of structural stability that stone and brick gave to the buildings was only apparent, since the high seismicity of the coast of Peru made buildings collapse. Buildings built with stone and brick work properly in compression; however, the performance of the structure under tension is poor, resulting in failure of the structures. Many changes such as adding thickness to the walls, using buttresses and vaulted arches were implemented, but these did not improve the performance of buildings. Lima was in a constant state of destruction followed by the rebuilding of the city.

A concern for people's safety and the pressures of a growing city, led to the adaptation of *quincha* for colonial buildings. Builders realized that vernacular buildings made with *quincha* performed better during earthquakes, and in an effort to improve the construction at the time, indigenous techniques were adopted. The lighter and more flexible construction system went through a process of trial and error. In 1666, Friar Diego Maroto used a wooden framework for the vaults of the central nave of the Santo Domingo Convent, substituting the deteriorated previous coffered ceiling.\(^6\) The next big step in adapting *quincha* was in 1675, when “Manuel de Escobar and the Portuguese architect Constantino de Vasconcellos perfected Maroto's use of *quincha* for the reconstruction of the Convent of San Francisco.”\(^7\) Buildings that used *quincha* suffered minor damages during the earthquake of 1687, and none of these collapsed. As a result, the use of *quincha* was adopted throughout

\(^6\)Ibid. pp 12.  
\(^7\)Valdez Hurtado, Pedro. "Estructuras Abovedadas de Quincha en el Virreinato del Peru." pp 5.
the city, while the use of brick and stone was reduced and limited to the construction of foundations, and lower portions of walls and columns. *Quincha* became popular since it proved to be safer against earthquakes, inexpensive and faster to build with. In addition, plaster, which was introduced by the Spaniards, made it possible for buildings to be finished giving them the appearance of a stone or brick building, which was very important for the City of the Kings.\(^8\)

In 1702, a law was passed in the city of Lima, enforcing the use of *quincha* in the upper stories of every building. After the earthquake of 1746, Viceroy Manso de Velasco implemented many regulations addressing building safety, and *quincha* was intensively adopted and massively used for the construction of both public and private buildings.

From the middle of the 19th century on, the population of Lima grew rapidly, driving many of the wealthier residents out of the city's historic center and into the suburbs. Many houses owned by the middle and upper classes were abandoned, to be later occupied by the city's escalating lower-class demographic. The houses were divided into several units, commonly with a large number of occupants in each unit. The over-occupancy, combined with the general lack of maintenance and devastating earthquakes, exacerbated the deterioration of the buildings.

The introduction of reinforced concrete, cast iron and steel at the end of the 19th century, combined with the poor performance of the *quincha* buildings in the

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\(^8\) Ibid. pp 1-2.
last years, led to the banning of the use of *quincha* in the 1960’s since it was thought to be unstable and unsafe. Consequently, the tradition of building with *quincha* in urban areas was lost.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Hispanic <em>Quincha</em></th>
<th>Colonial <em>Quincha</em></th>
</tr>
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<tbody>
<tr>
<td><strong>Origin</strong></td>
<td>Pre-Hispanic cultures on the coast of Peru</td>
<td>Vernacular techniques with Spanish contributions</td>
</tr>
<tr>
<td><strong>Aesthetics</strong></td>
<td>Simple and rustic</td>
<td>More complex and with fine finishes</td>
</tr>
<tr>
<td><strong>Type of construction</strong></td>
<td>Housing for peasants</td>
<td>Urban housing and monumental architecture</td>
</tr>
<tr>
<td><strong>Attachment of elements</strong></td>
<td>Simple techniques Elements were tied to each other</td>
<td>Carpentry techniques with more sophisticated joinery Elements were nailed to each other and often tied</td>
</tr>
<tr>
<td><strong>Wood</strong></td>
<td>Logs</td>
<td>Wooden scantling often carved or turned</td>
</tr>
</tbody>
</table>

Table 2.1: Characteristics of pre-Hispanic *quincha* and Colonial *quincha*

### 2.3 MATERIALS

**Stone**

Large stones were used for foundations. These were taken from the Rímac river.

**Adobe**

Building material made out of mud, clay, water, and a fibrous or organic material, such as animal hair or dried grass, shaped into bricks and dried under the sun.

**Wood**
Local mangrove wood was used until the city faced a shortage of wood. In 1551, a series of ordinances were approved by King Charles V, which included prohibiting the cutting of fruit trees in the city, prohibiting the cutting of trees without the council’s permission, and the planting of trees by property owners became a requirement.9

In the second half of the 16th century, wood started to be imported from Ecuador, Panama and Nicaragua. Later, when reliable transportation through the Andes was established, tropical woods were brought to Lima with the most common used in construction being *Miroxylon peruiferum* (Estoraque), *Aspidosperma macrocarpon* (Pumaquiro), *Ormosia coccinea* (Huayruro), *Brosimun uleanum* (Manchinga), *Hura crepitans* (Catahua amarilla), *Capaifera officinalis* (Copaiba), *Podocarpues sp.* (Diablo fuerte), and *Cedelinga catenaeformis* (Tornillo).

**Cane**

Cane was used to fill the spaces in between the studs. The cane used in *quincha* walls must be dried and with no signs of cracking or rot. The *carrizo*, *caña brava*, and *guadua*/bamboo are the most used for *quincha* because of their proven effectiveness and availability. The *Carrizo* (*Chusquea spp.*) is a hollow and rounded cane, with nodes strategically placed so that it avoids rupture when bent. *Carrizo* strips have resisted forces of 1,000 kg/cm² on tensile tests, due to the concentration of fibers in the outer layer, which makes the cane stronger.10

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10 SENCICO. *Quincha Pre-Fabricada: Fabricación y Construcción*. pp 10.
rivers, lakes, and beaches, and its growth is very rapid, reaching maturity at two years.

_Caña brava_ (Gynerium sagittatum) is another type of cane that is used in _quincha_ construction. Its leaves grow very strongly adhered to the stem, resulting in a very dense structure, which makes the cane very durable. It also grows near rivers, lakes, and beaches, and it is considered mature when it starts blooming. The diameter for both the _carrizo_ and the _caña brava_ should be of $\frac{1}{2}$ to $\frac{3}{4}$ inches and cut to a predetermined length.

Bamboo (Guadua angustifolia) is also widely used in _quincha_ due to its strength and growth rate. Bamboo is easy to bend and cut when wet, and becomes very firm when dry. It is estimated that bamboo grows from 15¾ to 31½ inches (40 to 80 cms) daily, and can reach up to 131 feet in less than two months, being suitable for its use in construction in approximately three years after being planted. The bamboo has a diameter of 2 1/3 to 4 in; therefore, it should be cut in half

**Mud**

Clay, silt, sand, water and straw were mixed in specific proportions to create mud to cover the surfaces of the walls. According to Hurtado, the proportions of this mud were: “15% of clay, 10% of silt, 55% of sand, and 20% of water. Animal hair and straw were added to the mix.”

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**Lime plaster**

Lime plaster was introduced by the Spaniards in the 16th century. It was used to cover the mud, so the surface could be finished, and also served as a protective layer.

**Huasca**

Cow or ram skin strips used to tie members of the wood frame. This is the only material in *quincha* not used in the present.

**Nails**

Used to attach the elements.

2.4 **QUINCHA IN THE CONSTRUCTION SYSTEM**

Even though *quincha* has been used in Peru continuously throughout history, most technological advances were developed during the XVIII century. *Quincha* was widely used and adapted, so buildings became larger and more embellished.

**Foundation and First Floor**

The structural system consists of members that carry and transfer loads. The adobe-*quincha* system that developed in the Historic Centre of Lima, uses heavier materials at the bottom of the building, moving to lighter ones at the top, with transitions in between. Stone with a lime based mortar was used for the foundations and areas close to the ground. This was followed by adobe for the supporting walls of the first floor, and finally *quincha* for the upper floors.
Quincha

Planning for the Frame

The basic structure of quincha consists of rectangular wood panels, that would resist dead and live loads by transmitting the weight to the adobe or brick walls supporting the frame. It was very important for the wood to not bend or warp due to the forces of compression as well as forces of wind and seismic activity.

A horizontal beam called entramado/solera (sill plate), which was placed along perimeter at the top of the adobe wall, provided a flat and even surface for the quincha wall. The entramado served to attach posts of the wood frame to the adobe wall, as well as bracing the latter one to avoid separation of the material in the case of an earthquake. It also received and distributed the weight to the adobe wall underneath it.

Floor framing

Beams were embedded into the adobe wall. Occasionally, columns were placed if spans were too large. Joists supported by the beams were also embedded into the adobe walls and run perpendicular to the beams. The standard joist spacing was (34 to 40 cms). Both beams and joists were connected to other pieces using halved joints or plain laps to extend their length. The subfloor fell directly over the joists, and finally the flooring.
Wall Framing

Studs were joined to the *entramado* by using very long tenons that allowed the studs to move vertically in the case of seismic activity without detaching from the *entramado*. The standard stud spacing was 12 to 31 inches (31 to 80 cms), with the spacing measured from center to center of the stud.

Bridging, which is a traditional feature of wood framing is also used in quincha. *Puntas/puentes* (horizontal wood blocking) and *tornapuntas* (diagonal bracing) were placed to provide additional support to the structure. *Puntas* ran between the studs at about 3½ ft. (110 cms) above the *entramado*, while *tornapuntas* ran diagonally from the *entramado* to the *punta*. The area between the *entramado* and the *punta*, was then filled with adobe bricks to serve as a transitional component in between the adobe wall and the *quincha*. The adobe bricks, being heavier than the rest of the frame, lowered the center of gravity, which increased the stability of the structure and made it more effective in resisting wind loads and movement produced by seismic activity.

The wood members were either nailed or tied with *huascas*, which were cow or ram skin strips of about ¾ inches (2 cm) thick. The *huascas* allowed movement to occur without damaging the building, creating movement joints which helped dissipate the vibrations and avoid the collapse of the structure. *Huascas* were tied while they were still humid, so that pressure would increase by the retraction of the material when dried, while keeping the joint flexible.
Finish/Enclosure

Interlaced cane was used to fill in the areas in between the studs. These created an even surface acting as a shear wall to resist lateral forces, such as wind and seismic activity.

The surfaces of the walls were later covered by a layer of mud, which protected the materials from the environment, served as insulation and as acoustical barrier. It was also very easy and fast to repair when it cracked due to seismic activity.

A layer of plaster was applied to seal the mud, which added to the versatility of the humble materials since this could be finished in different ways. This was important for the officials in the city who could not envision the center of the Viceroyalty built with adobe and wood. In some cases a thin layer of cactus juice was applied to the surfaces as a waterproofing agent.12

Roof

The roof framing for quincha buildings in Lima are very simple due to the mild weather conditions. With 1/3 to 1 inch of rainfall per year, and the lack of snow, roofs could be flat and with a minimal slope. The roof was very light, with wood joists covered with cane, a layer of about 1½ inches of mud, and straw or another waterproof material.

12 Ibid. pp 6.
Using wood as a building material has many advantages. Building with wood can be very simple and the tooling costs needed to fabricate structures are relatively low when compared to other building materials. It is also ideal when using it to build a single structure, or for mass production. Wood’s high strength to weight ratio, its excellent thermal insulation qualities, and its unique aesthetic makes it very appealing. Furthermore, wood can be farmed, adding to the uniqueness of this construction material given that brick, stone, metal and plastic are all derived from exhaustible mineral sources.

This chapter will give a comprehensive discussion of wood pathologies. It will begin with a survey of conditions commonly afflicting wood. A thorough description of the biodeterioration process, the most common cause of wood decay, will be examined. Finally, additional causes of wood deterioration will be looked at. This chapter will focus solely on the causes of wood pathologies; treatments of these pathologies will be discussed in later chapters.
3.1 CONDITIONS GLOSSARY

Stains

Stains are discolorations on the surface of the wood due to physical or chemical interaction between the wood and a foreign material. Stains can be caused by substances coming in contact with wood and getting trapped in the pores and indentations of the wood. Fungi also discolor the surfaces of wood depending on the type of fungi attacking the wood.

Cracks

Individual fissures visible to the naked eye resulting from the separation of one part from the other. Cracks can be stable or unstable. Stable cracks are when the separation of materials is not progressing in length, which means that the forces that caused it in the first place may have dissipated. When the forces are still present, the separation of materials will continue resulting in an unstable crack. These might be a concern as they continue to progress, jeopardizing the integrity of the structure. If a crack is determined as unstable, it is necessary to monitor them in order to know the rate of the separation of materials.

Fracture

Crack that crosses completely the piece of wood.

Fragmentation

Complete or partial breaking of wood into pieces of variable dimensions.
Detachment

Separation of parts or areas that are supposed to be connected are no longer connected.

Perforations (from insects)

Single or series of surface punctures or holes created by insects. The sizes of the perforations are millimetric to centrimetric scale, and are deeper than they are wide. The shapes vary depending on the organism attacking the wood, possibly cylindrical or conical.

Cavities / Tunneling (from insects)

Single or series of holes of centrimetric scale, larger in size and deeper than perforations. The shape of the holes is uneven and elongated.

Voids / Material loss

Empty spaces or gaps in where it is obvious that wood existed previously.

Presence of frass or fecal pellets

Accumulation of pellets on the surface or in the interior of the wood.

Deflection / Warp / Bending of wood

Change in shape without losing integrity

Repairs

Full replacement or partial replacement (Dutchmen)
3.2 Biological Deterioration

Wood decay is inevitable, but its service life can be extended by understanding the factors that accelerate its decay and taking measures to slow down the rate of deterioration to ensure adequate performance.

*Recognising Wood Rot and Insect Damage in Buildings*\(^{13}\) uses characteristics found in wood such as fruit-bodies, strands, mycelium, and appearance of wood to identify fungal growth, molds and insects causing damage. The book presents diagrams and colored photographs with possible symptoms that are easy-to-follow to aid recognition. It also discusses methods for treating damaged wood.

Another great source is *Conservation of Wood Artifacts* by A. Unger, A.P Schniewind and W. Unger.\(^{14}\) This book discusses in great detail the structure, properties and behavior of both recent and historical wood, the process of biodeterioration of wood and the organisms responsible of the deterioration, the different testing methods for diagnosing conditions, treatments including advantages and disadvantages of each of the treatments discussed, and the use of consolidants and fillers.

Deterioration of wood may occur due to weathering, leading to the decomposition of the surface layers of wood. Exposing dry wood to aerobic conditions results in darkening of the wood and may even form splits. However, the effects of weathering alone are very minimal.

\(^{13}\) Bravery, A.F., et.al. *Recognising Wood Rot and Insect Damage in Buildings*. 2010

33
The most detrimental form of wood deterioration is caused by wood destroying organisms such as insects, fungi, and bacteria.\textsuperscript{15} These attack wood only under anaerobic conditions and will leave marks on the wood surface or in its interior, such as frass and fecal pellets. Insects alter the macroscopic structure of sapwood or earlywood, leaving a system of exit holes characteristic to each species. Fungi, on the other hand, cause discoloration or even cracks on the surface of the wood.

The necessary and sufficient conditions for biodeterioration to occur include \textbf{moisture, oxygen, adequate temperatures}, and a \textbf{source of food}. Although the level of dependency of each one varies according to the organism present, all of these conditions must be present in order to sustain the organisms that attack the wood; if one condition is removed, biodeterioration cannot occur.

The adequate presence of moisture content, 20\% or above makes the wood susceptible to decay. Moisture content also determines the types of organisms present and the rate at which the wood deteriorates. Fungi and insects require moisture for many metabolic processes. In the case of fungi, moisture provides a diffusion medium for enzymes that degrade the wood structure. When water enters the wood, the microstructure swells until the fiber saturation point is reached, water then gets collected in the cell cavities, and fungi can begin to degrade the wood.

\textsuperscript{15} Only organisms that are prevalent in Lima, Peru will be examined. Other organisms, however common they may be to other geographic regions, have been omitted from this discussion.
Fungi require oxygen in the air for respiration, being the ideal content estimated to be 1 to 2%.\textsuperscript{16} However, mycelia growth rate dependence on oxygen varies from specie to specie. While depriving them of oxygen seems logical, it is very impractical.

Temperature greatly influences the life cycles of organisms. Larval activities cease when the ambient temperature falls below certain levels or rises above certain levels depending on the organism. Even though most organisms thrive at a temperature range of 70 to 85 °F, some are capable of surviving through a wider range. Most organisms' metabolisms slow down at below 32 °F, but when the temperature rises, they continue to attack the wood. Additionally, when the temperature rises above 90 °F the growth of organisms decline.

Organisms use wood as a food source. Some insects attack only hardwoods, others only softwoods, and another group can attack both. Treating the wood with preservatives is efficient against infestation as long as the treatment envelope is adequate and has not been broken. Also, some wood species are more resistant to attack, but this resistance can be reduced by weathering and leaching.

**Fungi**

Fungi are organisms that break down and utilize wood as a food source. They have four stages of development: spores, hypha, mycelium, and fruit body. Spores are the sexual or asexual reproductive cells (depending on the type of fungi present). They are found in almost every exposed surface because they are

produced in large quantities and are widely spread by wind and insects. When moisture is present, spores absorb the water, swell and germinate resulting in germ tubes. Hyphae are tube-shaped fungal cells that secrete cellulose, hemicellulose, or lignin and absorb the degraded material to complete the digestive process. Mycelium is the combination of hyphae, and its function is to decompose the wood. Fruit bodies are multicellular structures that bear spore deposits. They vary in shape and morphology, thus are crucial in the identification and taxonomy of fungi.

Wood rotting fungi affecting structures cause damage by breaking down the walls of wood cells, resulting in the loss of strength of the wood. Brown-rot, white-rot, fungal stains, and surface molds will be discussed since the necessary and sufficient conditions for them to flourish in Lima, are likely to be present.

**Brown-Rot**

Brown-rot fungi attack primarily the cellulose and hemicellulose of the wood cell wall, exposing the lignin to oxidation by the air giving it its characteristic brownish color. Brown rotted wood becomes brittle and causes cracks along and across the grain. This fungus is probably the one causing the greatest damage in buildings, since the decomposition they cause results in weight loss, reduction of mechanical strength and volumetric shrinkage of the wood. Most brown-rot fungi attack softwoods.

**White-Rot**

White-rots differ from brown-rots in that they attack the cellulose,
hemicellulose and the lignin. White-rots usually decompose lignin at a higher rate than cellulose; this explains the whitish or light tan color of wood attacked by white-rot fungi. White-rot fungi increases swelling and decreases strength; however, it causes less reduction of strength when compared to brown-rot because the cellulose is not attacked as much. The wood attacked by wet-rot fungi is also spongy when wet, soft in texture, and with individual fibers that can be peeled when dry. Most white-rot fungi attack hardwoods.

**Fungal Stains and Surface Molds**

Fungi not causing wood rot can be found, such as stain producers and molds. They cause surface and internal color changes in the wood. They are not detrimental to the performance of the wood in buildings; however, their presence can indicate conditions favorable for decay fungi to occur.

Fungal stains can cause various (irreversible) discolorations in wood depending on the species present such as brown, red, pink, green, and blue, being the latter the most important. Blue stains (*Ceratocystis* spp.) can be found on dead wood in service of softwoods, hardwoods, and some tropical woods. Blue stain in painted woods occurs when they are exposed to moisture, which can cause paint flaking and decay.

Mold fungi also cause discoloration in both unfinished and painted wood when air humidity and moisture content in the wood are high. It does not have an effect on wood strength, but they can damage wood surfaces, as well as paints and varnishes.
Fig. 3.1 – Joist from Hotel Comercio exhibiting white and gray stains. Source: author.

Fig. 3.2 – Beam from Hotel Comercio with peeling surface and staining. Source: author.
**Wood destroying insects**

Insects are the most important and frequently found pests attacking wood. They use wood for food, shelter, and breeding. They are often called xylophagous, a word derived from the Greek *xulaphagos* meaning “eating wood” from (*xulon*) “wood” and (*phagein*) “to eat”.

There are six orders of insects that cause wood damage. The beetles (Coleoptera), termites (Isoptera), ants (Hymenoptera), wasps, and bees. Their growth depends on nutrients, wood moisture content, and temperature.

**Coleoptera (Beetles)**

**Anobiidae Family (Furniture beetles)**

Adult beetles of the Anobiidae family are only a few millimeters in size and are brown in color. The larvae are a few millimeters in length, white to yellowish in color, and C-shaped. They attack untreated timbers, leaving circular exit holes that measure 1-4 mm in diameter.

*Ptilinus pectinicornis*

*Ptilinus pectinicornis* are present in South America as well as other parts of the world, including Mexico, certain countries of Europe, and Asia Minor. Adults are dark brown with cylindrical bodies of 3-5.5 mm long. The eggs are very thin (0.075 wide and 1.5 mm long). The larvae are golden yellow and 7 mm long. Galleries are circular in cross section. The frass is very fine, and the fecal pellets are pointy at one end. They attack hardwoods with small
pores leaving exit holes of 1-1.5 mm in diameter. These beetles are very destructive and the interior of wood can become completely destroyed.

*Oligomerus ptilinoides, Nicobium castaneum, Nicobium hirtum Illiger*

These beetles are found in Mediterranean climates. Adults have cylindrical bodies of 3-6 mm long. Fecal pellets are the color of the wood and shaped like shelled peanuts. They attack both hardwoods and softwoods, and their exit holes are 1-1.3 mm in diameter.

**Lyctidae Family (Powder Post Beetles)**

Adults are brown and a few millimeters in length. They attack only the sapwood of hardwoods and tropical woods, and require very low moisture in order to survive (wood with moisture content above 8 percent).

*Lyctus brunneus*

These can be found throughout the world, especially in the tropics. Adults are reddish brown to dark brown, and measure 2.5-8 mm long. The eggs are elongated, and the larvae are whitish, 6mm long and C-shaped. The frass is extremely fine and light colored. They cause great damage pulverizing the sapwood, usually leaving only the surface layer. Exit holes are circular and 1-1.5 mm in diameter, and the galleries are 1-2 mm wide.

**Bostrychidae Family (Auger Beetles)**

Present in the tropical regions of Africa, South Asia and the Americas. Adults are brown to black and 3-30 mm long depending on the species. Larvae are whitish
and C-shaped. Both larvae and adults bore into wood of dense hardwoods and heartwood of hardwoods causing great damage. The entrance bore holes and galleries are circular, and the exit holes are 2.5-12 mm depending on the species. 

*Apate monachus, Heterobostrychus brunneus, Dinoderus minutes*

Cerambycidae Family (Longhorn Beetles)

These beetles are larger than beetles from other families (10-30 mm), and usually have very long and curved antennae. They attack living, freshly harvested wood, and wood in service, depending on the species.

*Dynastes Hercules, Macrodontia cervicornis*

**Isoptera (Termites)**

Dry-wood Termites

Dry-wood termites attack wood that does not have direct contact with the earth and with low moisture content (5-6%). Their channels are large and have smooth walls extending many directions. Dry-wood termites constantly clean their nests by chewing holes and kicking out the debris, leaving piles of frass and fecal pellets below the infested wood, which is a good sign of attack.

Subterranean Termites

Subterranean termites attack all types of wood, but require moisture; therefore, they nest in the ground. They attack aboveground wood by building galleries, which are tubes built with earth, wood particles and fecal matter. These tubes shelter them from light and carry moisture to the wood. They differ with the
dry-wood termites in that the subterranean termites’ galleries contain earth (dry-wood termites’ galleries are clean and smooth) and would never contain fecal pellets.

3.3 **Possible Causes and Influencing Factors**

**Water**

Green wood has very high moisture content, varying typically from 60 to 200%. In the process of drying, free moisture is first lost from the cell spaces, which involves little change in physical properties, except for a change in density. Wood has a porous cellular structure, which makes it very vulnerable to water penetration. Wood looses strength when moisture content increases. It also makes wood susceptible to biodeterioration.

Water infiltration from precipitation is not a major concern since rainfall is very low in Lima. It receives around 1.2 inches of rainfall per year, which occurs in form of morning drizzle. However, water leaks are known to be detrimental for buildings, especially if these go undetected for long periods of time. These can be caused by punctures, fracture, cracks, microcracks, or inadequate sealing between components of the water supply or the wastewater system, causing water to escape. Historic buildings are more susceptible to leaks because of the age of its components such as pipes, tubes, or valves, which have been subject to wear and aging over the course of the years. This condition can be aggravated with unoccupied or unattended buildings, since leaks can go on undetected causing severe damage to wood and even building failure.
Wood as a Construction Material

Natural Durability

Natural durability refers to the resistance of wood against decay and biological hazards such as fungi and insect attack. It depends primarily on the species and area of the trunk from where the piece of wood is coming from. Heartwood is preferred because it usually contains toxic substances that prevent biological attack. Sapwood on the other hand, has little durability because it lacks of toxic substances and contains large amounts of starches, which are essential nutrients for fungi. Additionally, core wood is usually less durable than the rest of the heartwood since it is created when the tree is very young and the production of extractives is not fully developed.

Natural durability also depends on the environment. Factors such as moisture and temperature directly influence the durability of wood; therefore, measurements of durability cannot be used for different countries.

The Board of the Cartagena Agreement studied twenty Peruvian wood species for construction and classified them into three groups according to their durability and density. Group A includes the highly durable woods with densities in between 0.8 to 1.12 g/cm³ at 15% moisture content. Woods in this group should be used in structures exposed to moisture and areas where durability is essential such as in flooring and stair treads. Group B include moderately durable woods...
with densities in between 0.72 to 0.88 g/cm³. Wood in this group is often used for elements such as door and window frames, ceilings, walls, etc. Lastly, Group C comprises of the least durable woods with densities of 0.4 to 0.72 g/cm³ and should be used for elements in where detailing and workmanship is stringent.18

<table>
<thead>
<tr>
<th>Group</th>
<th>Common Name</th>
<th>Scientific Name</th>
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<tbody>
<tr>
<td>A</td>
<td>Estoraque</td>
<td><em>Miroxylon peruiferum</em></td>
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<tr>
<td>A</td>
<td>Pumaquiro</td>
<td><em>Aspidosperma macrocarpon</em></td>
</tr>
<tr>
<td>A</td>
<td>Palo sangre negro</td>
<td><em>Pterocarpus sp.</em></td>
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<tr>
<td>B</td>
<td>Huayruro</td>
<td><em>Ormosia coccinea</em></td>
</tr>
<tr>
<td>B</td>
<td>Manchinga</td>
<td><em>Brosimun uleanum</em></td>
</tr>
<tr>
<td>C</td>
<td>Catahua Amarilla</td>
<td><em>Hura crepitans</em></td>
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<tr>
<td>C</td>
<td>Copaiba</td>
<td><em>Copaifera officinalis</em></td>
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<tr>
<td>C</td>
<td>Diablo Fuerte</td>
<td><em>Podocarpus sp.</em></td>
</tr>
<tr>
<td>C</td>
<td>Tornillo</td>
<td><em>Cedrelinga catenaformis</em></td>
</tr>
</tbody>
</table>

Table 3.1- Classification of Peruvian woods according to durability.

**Quality Control**

Wood used in construction must undergo inspection to ensure its quality, and its species should be known so durability can be assessed. Wood must be properly dried to avoid defects during drying process such as warp, fragmentation, and fractures. Each piece should be free of biological attack. Properties of knots are different that in the surrounding wood; therefore, these cannot be more than 25% the width of the piece or larger than 25mm in diameter. Loose knots are not acceptable. In case perforations are found, the piece is allowable as long as the

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perforations are no larger than 3mm in diameter and are distributed very sparsely.

**Preservatives**

Preservatives in wood can be naturally occurring or synthetically produced to protect it from biological degradation and extend the service life of the wood member. Treated wood with preservatives achieves its protection by becoming poisonous or repellent to biological agents that would otherwise attack the wood. Chemical preservatives are usually solid compounds that require a solvent (water based or oil based) to penetrate into the wood. Preservatives applied only on surfaces are not efficient since these can weather or crack, which will make the member susceptible to biological attack.

**Seismic Activity**

This section investigates seismic movement in Lima as an attempt to explain its implication in the city’s architecture. Peru’s coast is a segment of the circum-Pacific seismic belt, where more than two-thirds of the world’s large-magnitude earthquakes occur. This belt, also known as the Ring of Fire, is located at the borders of the Pacific plate and other major tectonic plates, which often slide next to, collide with, and are forced underneath other plates. In the coast of Peru, the collision of the Nazca and South American tectonic plates caused strain forcing the subduction of the Nazca plate underneath the South American plate, which created the Andes. The movement of tectonic plates continues at a rate of 77 mm per year causing earthquakes, which in turn can cause ground shaking, liquefaction, and
landslides. 19

Since its founding, Lima has been in a constant state of devastation followed by the rebuilding of the city. This played an important role in the city’s building’s massing and therefore, the character of the whole city. Regulations were developed after some very destructive earthquakes in order to improve construction techniques as well as to safeguard people’s well being. A building was not built according to what its builder wanted it to be, but what it could be.

Summary of Seismic Data

Seismic activity in Peru has been recorded since the arrival of the Spaniards, and there are indications of ancient cultures learning to deal with this type of natural disaster by the way they built their structures. The effects of seismic activity have been very devastating ranging from destruction of structures, floods, to fatalities. Table 3.2 illustrates seismic activity in Peru from 1650 until 2007, with date, location, moment magnitude (Mw), number of fatalities, and comments if available.

The Peruvian National University of Engineering created a map showing the distribution of maximum intensities of seismic activity in Peru (Fig. 3.3). This was part of a project studying the mitigation of damage caused by an earthquake in the Andes. Historical data as well as geological data until December of 2001 was

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analyzed to estimate the hazards of each region due to seismic activity.\textsuperscript{20} The map shows maximum intensities of isoseismal curves in the Modified Mercalli Intensity Scale (MM), which is composed by 12 increasing levels of intensity that range from I (imperceptible) to XII (catastrophic). These values are arbitrary and depend on the effects the earthquake had on the place.

Table 3.2 - Seismic Activity affecting Lima since 1650 until 2007\textsuperscript{21}

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>M$_{w}$</th>
<th>Fatalities</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 31, 1650</td>
<td>Cuzco</td>
<td>7.6</td>
<td></td>
<td>Left Cuzco in ruins</td>
</tr>
<tr>
<td>Oct. 20, 1687</td>
<td>Lima</td>
<td>8.5</td>
<td>600</td>
<td>Tsunami caused destruction in Callao, Ica, Palpa and Nasca</td>
</tr>
<tr>
<td>Oct. 28, 1746</td>
<td>Lima</td>
<td>8.7</td>
<td>5,000</td>
<td>Tsunami caused destruction to all ports. Destruction of churches, residences, damage food and water supplies</td>
</tr>
<tr>
<td>March 27, 1725</td>
<td>Coast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 10, 1821</td>
<td>Camaná</td>
<td>7.9</td>
<td>162</td>
<td></td>
</tr>
<tr>
<td>Dec. 12, 1908</td>
<td>Central Coast</td>
<td>8.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug. 24, 1942</td>
<td>Central Coast</td>
<td>8.2</td>
<td>30</td>
<td>Deaths due to collapse of structures</td>
</tr>
<tr>
<td>Oct. 17, 1966</td>
<td>Coast</td>
<td>8.1</td>
<td>125</td>
<td>Collapse of churches, landslides, cracks along the Pan American Highway, around 2000 houses suffered structural damages, 3000 injured</td>
</tr>
</tbody>
</table>

\textsuperscript{20} INDECI (Instituto Nacional de Defensa Civil), “Atlas de Peligros del Peru 2010.”
\textsuperscript{21} Based on U.S. Geological Survey, "Earthquake Hazards Program: Historic World Earthquakes" and INDECI "Compendio Estadistico de Prevencion y Atencion de Desastres 2006."
<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 8, 1967</td>
<td>Lima/Huacho</td>
<td></td>
</tr>
<tr>
<td>July 31, 1967</td>
<td>Lima</td>
<td></td>
</tr>
<tr>
<td>Aug. 22, 1967</td>
<td>Lima</td>
<td></td>
</tr>
<tr>
<td>Feb. 3, 1968</td>
<td>Lima</td>
<td>Landslides, ground fractures</td>
</tr>
<tr>
<td>May 31, 1970</td>
<td>Coast</td>
<td>Landslides, flooding</td>
</tr>
<tr>
<td>June 10, 1971</td>
<td>Huánuco, Junín,</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Chincha, Ica</td>
<td></td>
</tr>
<tr>
<td>June 19, 1972</td>
<td>Lima</td>
<td>Moderate damage in the city</td>
</tr>
<tr>
<td>Oct. 3, 1974</td>
<td>Central Coast</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Damage to churches, historical monuments, public buildings, and residences</td>
</tr>
<tr>
<td>April 18, 1993</td>
<td>Lima</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 injured, 7 collapsed structures</td>
</tr>
<tr>
<td>Sep. 23, 1995</td>
<td>Coast</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Landslides in the north of Lima</td>
</tr>
<tr>
<td>June 23, 2001</td>
<td>Central Coast</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>138</td>
</tr>
<tr>
<td>July 7, 2001</td>
<td>Coast</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Oct. 20, 2006</td>
<td>Central Coast</td>
<td>6.7</td>
</tr>
</tbody>
</table>
Fig. 3.3 – Map of Peru showing the distribution of Maximum Intensities of Seismic Activity. Source: INDECI
Lack of Maintenance

Housing is a valuable asset for all income groups, and building maintenance is very important since it can directly affect the service life of buildings. Lack of maintenance is a common occurrence in buildings in developing countries such as in Peru, where resources are scarce and they often do not even meet people’s basic needs. Faults in buildings can usually be easily fixed when noticed at an early stage, but can become a heavy financial burden if they remain untreated for a long period of time. Building deterioration is often overlooked by its inhabitants, which results in the cumulative decay of the structure and can lead to its collapse or buildings having to be demolished, presenting an even more alarming situation. This affects people’s valuables and their ability to reside in these buildings, but most importantly, it is a hazard to their health and well being.

Quality of Construction and Design

Most of a building’s deterioration comes from factors that occur only after the building has been assembled. However, there are cases in which the building’s construction itself can be the origin of its own demise. Usually, the ultimate culprit in these cases is a novice builder or designer, who lacks the expertise to take into account the multitude of variables that need to be considered in the construction of a building, such as weight requirements, proper joint assembly, and climatic concerns.
One factor that may seem obvious, but is often miscalculated by builders, is the support requirements needed to sustain the weight of the building’s load. Even a relatively minor deviation in support structure to load ratio, could have catastrophic consequences. If the balance is off only negligibly, the building may stand for years, but the integrity of the structure will suffer over time, much faster than with adequate support. In these cases, even everyday wear-and-tear may lead to the wood deflecting, cracking, fracturing, or fragmenting. With more profound trauma, such as an earthquake, the force may be enough to cause a partial or total collapse.

A similar prognosis can be expected when a building’s connecting elements are not properly installed. Even when the building’s support system is sufficient, a poorly fixed joint could be hazardous to the integrity of the entire building. A faulty or improperly constructed joint may be vulnerable to even modest levels of trauma, which could give way to even greater damage.

Climatic factors and the topographical location of a building also need to be considered in its design, especially when wood is a major component in its structure. Knowing how much rainfall is to be expected at any time during the year should be a primary concern for a building’s designer, since this information dictates many of the building’s characteristics, such as the angle of the roof to allow water run-off, as well as the number and placement of gutters, eaves troths, and downspouts. The annual rainfall is not as important to consider as the quantity of rain at any time during the year. For example, in Lima, a mostly arid city, the
expected rainfall during any given year would make it appear that a proper drainage system would be unnecessary. However, during the winter, the rainiest season in Lima, it can rain for many days consecutively, which could accumulate enough moisture in a building to permanently damage the wood. A related feature in the building’s design would be its ventilation system. A good ventilation system allows the wood to dry more rapidly, in order to avoid prolonged exposure to the moisture, and slow the wood's deterioration. Topographical concerns would be, for example, the building's altitude and/or position in relation to higher ground. Water run-off from surrounding areas may accumulate at the base of the structure. In order to forestall major damage to the wood components, the building should include water deterrents, such as a water-resistant coating, and the designer should include structural elements, such as water tables, and possibly even elevations, as needed.

**Misuse**

Every building has a purpose for its construction. The original purpose for a building’s creation largely determines how the building will be designed and built. The size of the building’s spaces, strength of its foundation and supporting structures, and the materials used are all aspects of a building’s composition that an architect will consider in the original design. A quick glance at many cities today proves that buildings frequently outlive their original use. Often times a building may go through many metamorphoses in a single lifetime. However, a building is not inherently equipped to endure all these manifestations equally as well. An
apartment building, for example, that was erected to house living occupants with a relatively low life load, will often suffer structurally if it is used, without modification, to hold heavier loads.

From the time the Hotel Comercio was built in the 19th Century until the mid 20th Century, it was used for its original use as a hotel. Since hotels typically house a sub-maximal number of occupants at any given time, we can presume that the life load was generally quite low. However, beginning around the middle of the 20th Century, the hotel closed and the building’s use from that point on changed. For a time, it was used as a storage space for government documents, and also as an armory for the Casa Militar de la Presidencia de la Republica. As a result of stockpiling heavy armory in a building originally intended to be used only for low occupancy, much of the structure’s wood suffered, as evidenced by a visible deflection in rooms that were presumably housing the heavier loads.

This is just one example of how the originally intended use of a building should be considered by proprietors when deciding on the appropriateness of a building’s new use. A new function of a building should not, however, be restricted only to the parameters of its original purpose, but attention should be given by the property owner to any modifications that need be made to the structure to accommodate its next application.
Adaptations

Just as a building may be used for a purpose not originally intended for it, property owners may just as likely make physical alterations to a building’s construction that could compromise the building’s integrity. It is not infrequent for new property owners to tear down a wall, for instance, to expand the dimensions of a room. Interior designers may consider this to be a positive change, since it “creates space” in a room. From an architect’s standpoint, however, these reconfigurations could mean sacrificing the strength of the structures in between rooms (the room above the modified room), for added space inside the room. In this case, increased space in a room through removing a wall means the supporting structures in the ceiling need to bear a greater load, and without the support of the original wall. This is not necessarily the case, if the wall is only a partition wall. However, if it happens to be a load-bearing wall, it could be severely detrimental to the structure’s integrity.
4.1 Diagnosis of Wood Pathologies

Wood diagnosis test methods are classified as being either destructive or nondestructive. If the diagnostic procedure only requires minimal damage then it can be said to be a near-nondestructive test. It should be definitively determined at the beginning of the diagnostic stage, which option will do the absolute minimal damage while still providing a positive identification of the wood’s pathology. The objectives for a wood diagnosis are multifold. The first objective is to accurately determine the pathology’s properties, or symptoms. The extent of these properties should be noted and recorded. The nature and intensity should be noted next. The previous step would include information about the quality of the damage, such as how recent exit holes were formed in the case of insect attack, and their characteristics, such as color, size, and presence of frass. After all this data has been collected, it should be possible to deduce the origin of the pathology. The final step is determining a remedial treatment, which is beyond the scope of this paper.

Inspection methods for wood can be categorized by the physical method used. These categories can be roughly divided into eight methods: mechanical;
electrical; optical; acoustic; thermographic; radiographic; nuclear magnetic; and chemical/biological. For each category there may be one or more procedures that may be more or less suitable for an individual case. For any given case, a combination of two or more of these methods may be utilized. For the sake of this paper, the diagnostic tests discussed will be limited to those that are logistically plausible for use in Peru, in terms of portability, cost, effectiveness, and ease of use.

Mechanical procedures are destructive, and therefore should only be used in the case of wood structures of less cultural importance, where portions of the structure can be sacrificed in order to attain a positive identification of the underlying pathology. Their usefulness is mostly in determining water content within wood, which can be helpful information on its own, as well as being an indicator of real or possible biological infestation (since microorganisms thrive in moist areas). The different mechanical procedures used are increment cores, measuring the depth of penetration using a pilodyn and measuring resistance to boring using a resistograph. With increment cores, an increment borer is inserted into structural wood and dried at around 103°C to constant mass in order to verify the moisture content of the wood. The benefit of using this method is that it is very cost-efficient and is easy to facilitate using simple tools. The drawback is that the test only measures a relatively small portion of a structure or building.

Measuring the depth of penetration is the next option under mechanical methods. This test will usually employ a portable pilodyn (Fig 4.1), a device
developed in Denmark, which delivers a steel needle into wood at a premeasured intensity. How deep into the wood the needle travels determines the health of the wood. If the needle travels deeper into the wood than expected, it is very likely that the wood has been damaged by biodeterioration. Again, this test is simple to perform, since a pilodyn is easy to carry around and can even be used under water. It is also very low-cost, just as with the increment cores test. The disadvantage is that the test gives inexact measurements, which leads to unreliable data.

Fig. 4.1 – Pilodyn. Source: InspectApedia

The last mechanical test is the resistograph, which was developed in Germany, and is more technologically complex than the two previously mentioned tests. A resistograph consists of a drill, built-in printer, battery, and computer memory. The principle behind the resistograph is similar to the pilodyn, in that it is essentially a needle being injected into the wood to assess the resistance of the wood. That
Resistance is translated into data figures about the wood’s density in the tested location; the wood’s health can subsequently be deduced from this information. Despite the comparatively complex set of instruments needed for this, it is still portable and easy to use. The drawbacks of using a resistograph are basically the same as for using a pilodyn.

Fig. 4.2 – Resistograph. Source: IML Wood Decay Detection Instruments.

For optical evaluation, the most elementary option is the visual method. This is straightforward and involves only using an unaided visual examination of the exterior of the wood for biodeterioration. This option is clearly subjective, and is
obviously limited to the most superficial layers of wood damage. However fundamental it may seem, a comprehensive visual assessment of a wood structure should not be overlooked, and should indeed precede all other stages of wood diagnosis.

Light and electron microscopy, and endoscopy are both relatively simple and on hand procedures that can be used to attain an amplified, high-resolution image of the biodeterioration. The only disadvantage to these procedures is that they involve some degree of destructive preparation for the samples. This rules them out for use on artistic and cultural artifacts.

Two additional optic tests are used frequently enough to be mentioned here: infrared thermography and holography. Traditionally, these technologies were not widely used because they were not very developed, and because they were not portable and, therefore, used exclusively in the lab. These technologies have improved in leaps and bounds over recent years, and today are not only small and portable for field study, but are also much more affordable than their predecessors. One of the main benefits of using these technologies is that they are nondestructive, and yet can also give highly accurate assessments of wood damage, even deep below the surface. For all these reasons, infrared thermography is an ideal method for wood analysis and diagnosis in Peru.

The last category that could be logistically practical for wood diagnosis in Peru would be portable radiographic tests. While this classification includes conventional
X-rays, computer tomography, gamma-ray densitometry, and neutron radiography, this section will focus on X-rays and CT scans, because of their ease of transport in the field, as well as their accessibility. Conventional X-rays are capable of elucidating the inner structure of almost any solid object. X-rays are, of course, nondestructive, and can therefore be used on art objects and other cultural property. Since X-rays are incapable of detecting certain types of decomposition, such as that caused by fungi, combined with the fact that there are newer radiographic tests, like the CT scan, that are able to give detailed images of these types of decay, the X-ray has become less prevalent for these purposes. However, X-rays are still continually used for determining the internal structure of wood, pottery, and other materials.

A newer, and many times more useful, test is using computer tomography to determine the internal structure of wood objects. In computer tomography, a spatial distribution of the absorption coefficient of the radiation is determined using a computer. The image is created by the computer analyzing the object, layer by layer, as the radiation gets absorbed. This means that the image produced with a CT scan is 3-dimensional in its computerized reconstruction. Computer tomography can also be used specifically with insect-damaged wood, in combination with sound wood, to create calibration curves that represent the relationship between the amount of radiation absorbed in each, and qualities of the wood, like density and

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22 Unger, Achim, et.al., Conservation of wood artifacts: A handbook. pp 159
strength. With this information, it is easy to discover which wood has been damaged by insects, and also to determine the extent of the damage.

4.2 **Fungal Damage**

Fungal damage is usually noticed in the advanced stages of development when fruiting bodies form a dense and fuzzy layer on the surface, in addition to a distinctive and unpleasant odor. However, early detection should be pursued in order to safeguard the integrity of the wood (and subsequently the building) and also because treatments are more economical. Test methods have been developed in order to identify between living and dead mycelium and also the type of fungus attacking the wood.

**Growth Test**

This test assesses how fungal growth may affect the material, performance, and the rate of growth. The growth test consists on placing affected pieces of wood on an artificial food source or in moist chamber. The fungus is cultivated under optimum conditions for a period of time. The mycelial growth or mass loss of the wood can then be observed and recorded.

in an Environmental Chamber.” ASTM G21 consists on placing the samples on a carbon-free nutrient salts agar and directly inoculated with a known concentration of fungal spores. ASTM D3273 suspends samples in a chamber at 32.5°C and 95 to 98 percent relative humidity, which are maintained by heating water in the bottom of the chamber. Samples are exposed to fungi by placing a soil bed above the water for four weeks, and fungal growth is recorded and compared to ASTM 3274.

**Color Indicators**

**Bromophenol blue and Bromocresol green to indicate changes in pH**

Brown-rot and white-rot fungi liberate organic acids while attacking wood. This results in the alteration of the acidity of wood, lowering its pH. The changes can be detected by color indicators such as Bromophenol blue and bromocresol green, which are sprayed on the wood in 0.04% solution in ethanol diluted with equal parts of water. A change in color of bromocresol blue to green or yellow indicates the presence of fungi since dead mycelium does not produce a change in color.

**Janus green to stain fungus cells**

Stains reveal the presence of living cells when applied to samples with wood-destroying fungi. A stain called Janus green is used to identify living mitochondria of

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23 ASTM Standard G21, "Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi"
26 Unger, Achim, et.al., Conservation of wood artifacts: A handbook. pp 128
mycelium cells. The stain is applied and will color the oxidizing agent (cells) right away becoming dark green, and will fade after a few minutes.

**Flourescein-Diacetate (FDA)**

Flourescein-diacetate is a dye that stains living cells green, which can be seen with a confocal laser scanning microscope.

**Determination of Adenosine Triphosphate (ATP)**

Adenosine Triphosphate is a nucleoside triphosphate which acts in cells as a coenzyme. It is responsible for transferring chemical energy within cells for metabolism. Since ATP is found only in living organisms, its presence in a wood sample indicates that there are active living cells existing in the wood. For instance, with *Serpula lacrymans*, the most detrimental wood-destroying fungi, the ATP is extracted using 80% dimethyl sulfoxide for 30 minutes at 20°C.

**Immunological Determination**

Immunological determination is a valuable tool for detecting wood-rot in its early stages, even before mass loss in the wood has taken place. The technique involves extracting protein antigens from a possible wood-destroying microbe, such as *Serpula lacrymans*, injecting it into a test mammal, and then extracting the mammal’s antiserum, which was created through exposure to the microorganism. The antiserum contains the antibodies that suppress the antigen. The final
determination is made with fluorescence combined with a fluorescence dye, after the antiserum has been applied to the new strain found on the wood being treated.

**Detection of Volatile Organic Compounds (VOC)**

By using a gas chromatograph and a mass spectrometer, it is possible to detect volatile metabolites on wood samples that are released by fungi. During normal metabolic processes, fungi emit volatile metabolites into their environment. Since each species of fungi release their own signature volatile metabolites, identification of these biochemicals informs the researcher not only of the presence of a fungus, but also which type is afflicting the wood. Another way of detecting a fungus’ presence via VOCs is by analyzing volatile compounds released not by the fungus, but by the wood when it is in contact with the fungus. It is also now possible to use an “electronic nose” to detect VOCs. These devices are now able to perform analytical measurements of VOCs in near real-time with part-per-trillion sensitivity, making them one of the most accurate and viable options for wood fungi detection and identification.

### 4.3 Insect Infestation

The methods of diagnosing insect infestations are much different than the

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methods for diagnosing other forms of biodeterioration. Since insects can readily be seen by the naked eye, the most common way of making a diagnosis is by identifying living or dead adult insects; usually on windows or window sills, but they could be found anywhere in proximity to the wood being examined. The identification of an active infestation can also be made indirectly by noting the existence of the wood-destroying insect’s enemies. To attain a more precise estimation of the extent of an infestation, as well as its approximate location, pheromone traps can be employed for certain anobiid species. However, because of the volatility of pheromones, these traps can only be used for a period of around 0.5-2 months.

When exit holes are present, bright rims and fresh, light yellow piles of frass signify that there are larvae of wood-destroying insects existing in the wood. If the exit holes are old, they will have gray rims because of dust deposition and the effect of UV radiation.

With objects or areas of a building that show damage, it may be difficult to discern whether the origin of the damage came from the larvae of insects or termites. If it is permissible to destroy a segment of the wood structure, such as a wall in a historic building for example, then the easiest way to identify the source of damage is to dig into the wood with a chisel or axe. This allows for a direct examination of the infestation. In many cases, however, a destructive method like this one will not be appropriate, such as with art objects or cultural property. In these cases, there are a number of alternative options that allow for indirect
observation of an infestation. Some species of wood-destroying larvae, like the
*Hylotrupes bajulus*, unaided auscultation will suffice to hear these particular larvae,
since their feeding noises are completely audible already. With other, less audible
species, either a stethoscope or a combination of microphone, amplifier, and
earphones can be implemented.

Acoustic emission technology can be used to record ultrasonic vibrations
produced by active insect infestations. When trying to locate active larvae in mobile
objects, conventional X-ray technology and CT scans may be used. Finally, since the
normal respiratory metabolism of living larvae releases carbon dioxide into the
environment, levels of this molecule can be tested and analyzed to check for the
likelihood of an infestation.
Located at the Historic Center of Lima, the Hotel Comercio is an archetypal example of a low-rise *quincha* and adobe construction in Lima because materials used, symmetry, and repetition of architectural details. It was declared Historical Monument and Cultural Heritage by the *Instituto Nacional de Cultura* (INC, Peruvian National Institute of Culture) because of its architectural and urban significance. The building is part of a group of historic buildings that extend from *Plaza de Armas* to *Plaza de San Francisco*, which is one of the most cohesive units that have been preserved in the Historic Centre of Lima. Furthermore, the design of the Hotel Comercio is representative of the architecture that developed in the time of Spanish presence in Peru. The hotel has not been in operation for almost 40 years; however, the building is still named after it. Nearly 70% of the built area stands vacant, while the other 30% houses the legendary restaurant and bar El Cordano, and shoe store Distribuidora Vallejo.

## 5.1 Architectural Description

The Hotel Comercio sits at the corner of Jirón Carabaya and Jirón Ancash, just south of the Rímac River. The hotel is a three story building with each story being of
a different height. It is attached to a four story Modern building of the same height on Jirón Carabaya, and a two story early Republican building on Jirón Ancash. Even though the attached buildings differ to the hotel in style (the Modern building) and height (the early Republican building), the block and surroundings still preserve the overall aesthetic unity of the historic area. The building's footprint is the shape of two interlocking rectangles or “L” shape, with a total area of 4,862.90 ft$^2$ and a built area of 3,590 ft$^2$.

**Exterior**

**Northwest Wall**

The façade of the hotel, the northwest wall is 130 feet in length. The plastered vermilion colored walls are smooth in texture. The base of the building slightly protrudes from the façade and rises 5½ ft. from the ground, encircling the other exterior wall as well and giving the building the sense of stability. The base exhibits an uneven rough texture, and its burnt umber color contrasts and complements the opaque vermilion of the walls. Wooden trims on the façade delineate each floor, being the trim between the second and third stories much wider than the one between the ground floor and second story. A wooden cornice projecting from the façade, along with the trims and the base are the horizontal elements that act as ornament, as well as breaking with the verticality of the doors and windows of the façade.

The ground floor has six arched openings of varying widths containing
double doors with fanlights. The second story contains thirteen openings of the same width, in where seven are French doors alternating with French windows that align with the arched openings of the ground floor. The doors are full-length and lead to balconies with wooden floors and delicate iron railings that project 2 feet from the façade. Identical heavy moldings are found at the head of both the doors and windows, giving the façade a sense of uniformity.

The third story is shorter than the lower stories and has simpler architectural details. It has eight full-length French doors, each one leading to a balcony that projects approximately six inches from the façade. These balconies not only differ in size from the balconies on the second story, but on the ornamental pattern of the iron railings. Also, the doors lack of the molding found on the heads of doors and windows of the second story.

Northeast Wall

The other exterior wall, the northeast wall, is 40 feet in length. Its design is consistent with the design of the façade, carrying around the horizontal elements such as the base, trims and cornice. The doors, windows and balconies are also consistent with the ones found on the façade; however, there are only two doors placed on the ground floor, one door with a balcony flanked by two windows on the second story; and three windows with balconies on the third story.
Fig. 5.1 – View of Hotel Comercio. Source: author
Fig. 5.2 – Entrance to restaurant and bar El Cordano on Jirón Ancash. Source: author.
**Interior**

The configuration of the Hotel Comercio is follows famous Lima *Casonas*. *Casonas* developed in the Colonial era, and were modeled after the design of Spanish houses, particularly the area of Andalusia, and with Moorish influences. Distinctive for having a *zaguán* (vestibule) and rooms organized around one or two patios.

**First Floor**

The only area of the building that is still being occupied is the northeast section of the property, facing Jirón Carabaya and Jirón Ancash. Portion of the first floor is occupied by El Cordano, which is accessed by two doors, one on Jirón Carabaya and the other one on Jirón Ancash. The restaurant uses three main spaces as dining rooms; there is also a kitchen, storage rooms and bathrooms. Also on the first floor and adjacent to El Cordano on Jirón Carabaya, we find Distribuidora Vallejo, a shoe store that uses a space for the showroom, another one as a backroom, and a small bathroom.

Two sets of wooden doors lead to the interior of the Hotel Comercio; a double door on Jirón Carabaya, opens up to a three flight staircase with half-space landings and ballustrated wood railings. The steps on the staircase were reconstructed with wood, since the original marble steps were looted when the building was unoccupied. The other entrance is through a large door also on Jirón Carabaya, leading to the *zaguán*. A small hallway containing a bathroom, connects the entrance with the staircase to the *zaguán*. 

72
To the front of the *zagúan*, the first patio opens up containing seven rounded wood columns, which support a corridor above. Three large rooms surround the first patio on the right side, while a three step raise on the front leads to a covered hall. Two rooms can be accessed from the hall, as well as a second patio. This second patio has five rounded wood columns, smaller in diameter than the ones found on the first patio, also supporting a corridor above. The second patio is surrounded by rooms to the south and northeast, and two bathrooms to the east. One bathroom contains five stalls, while the other one contains six stalls. A straight-run staircase decorated with a criss-cross pattern on the railing leads to the second floor.
Ceramic tile floors, a remarkable architectural detail, are found on most of the first floor. El Cordano and the Distribuidora Vallejo’s floors are adorned with 15 x 15 cm (~6 x 6 in) tiles with geometric shapes, while the hotels’ entrance, zagúan, small hallway, both patios, hall, and some rooms are ornamented with 20 x 20 cm (~8 x 8 in) tiles. The designs on the ceramic tiles of the hotel have geometric and floral patterns, present no reliefs, and were finished with muted earth tone glazes that compliment the materials on the rest of the building (Fig. 5.4). Additionally, all the rooms on the ground floor are connected to each other, which is a characteristic of the casonas. (Appendix B2 - First Floor Plan).
Fig. 5.4 – Ceramic tiles in Hotel Comercio. Source: author
Fig. 5.5 – View of first patio. Source: author.
Second Floor

The second story was occupied by the Hotel Comercio in its entirety, and now lies vacant except for two rooms facing Jirón Carabaya, that are been occupied by a caretaker. There are eighteen rooms with two spaces each and nine rooms with a single space; all organized around the two patios. Open corridors run along both patios serving as the main circulation element and providing access to the rooms. These corridors overhang from the top of the ground floor walls. The bathrooms are located on the southeastern end of the building and served the whole floor (Appendix B3 - Second Floor Plan).

Third Floor

The third story was also used solely by the hotel. It is accessed by a two-flight staircase near the first patio. There are 19 rooms with two spaces each and 25 rooms with a single space. The layout of this floor follows the one on the second story (Appendix B4 - Third Floor Plan).

5.2 Summary of History

Little is known about the former Hotel Comercio’s origins; however, documents found at the Ministry of Culture provide information about the property and its history. The land occupied by the Hotel Comercio was part of the original outline of the city of Lima, traced by Francisco Pizarro in 1535. The entire block belonged to Alonso Riquelme, who was Pizarro’s Secretary and Royal Treasurer, to
later be owned by Antonio de Ribera. A 1685 plan of the city of Lima, drawn by father Pedro Nolasco Mere, shows the site of the Hotel Comercio as a two story building with one courtyard. This plan was published by the scientists Jorge Juan and Antonio de Ulloa in 1748, stating that this plan was one of the most beautiful and detailed plan of the Viceroyalty of Lima (Fig. 5.6). In 1839, Mrs. María Rosa Orué transfers the property to Isidro Aramburú, who in 1848 builds a “large edifice.” No descriptions or details describing the building could be found, so there is no clear indication if the building of 1848 is the one still standing today. The property was sold several times in the following years, and in 1897 the “three story building with an area of 1,482 m.² (4,862.204 ft.²) is sold to Manuel Quimper,” who rents portion of it to Mateo Valdettaro to be used as shops. By 1924 the building had its current shape, two interlocking rectangles or “L” shaped, as shown in the isometric perspective drawn by Julio E. Berrocal described as giving a real view of the city of Lima (Fig. 5.7).

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28 Villa Esteves, Deolinda. Informe No. 063-2006-INCDPHCRSDIH/DMVE. pp 01.
29 Ibid.
30 Villa Esteves, Deolinda. Informe No. 063-2006-INCDPHCRSDIH/DMVE. pp 02.
Fig. 5.6 – Plan of Lima, 1685. Drawn by Pedro Nolasco Mere. Source: Archivo JGD.

Fig. 5.7 – Isometric perspective of the city of Lima, 1924. Drawn by Julio E. Berrocal. Source: Biblioteca Nacional de Lima (National Library of Lima).
In 1905, the Genovese brothers Fortunato and Andrés Cordano, found the restaurant named El Cordano on the ground floor of the building’s corner. The restaurant was later transferred to Antonio and Luis Cordano, nephews of Fortunato and Andrés (Fig. 5.8). The restaurant became popular serving a large number of people traveling through the Estación Desamparados, the main train station connecting Lima to the central Andes, located just across the street from Hotel Comercio. El Cordano soon became the preferred spot for travelers, journalists, artists, politicians and intellectuals. The Cordanos left the restaurant to their workers in 1978, and it is still functioning today, being one of the oldest restaurants in continuous operation in Lima.

Fig. 5.8 - Bar of El Cordano with Luis and Antonio Cordano on the right. Source: Caretas

Distribuidora Vallejo sits right next to El Cordano on Jirón Carabaya. It is a

legendary shoe store that opened in the 1970’s, and is known for their handmade shoes made by craftsmen who use traditional shoemaking methods.

The Hotel Comercio on the other hand, did not enjoy the fortunate fate that the restaurant or shoe store did. In June of 1930, the Hotel Comercio was the site of a high profile murder case explored by Peruvian journalist and writer Luis Jochamowitz in his book *The Dismemberer of Hotel Comercio*. This case gave great popularity to the hotel, which attracted many writers and poets such as William Burroughs, Allen Ginsberg, and Martin Adán. Nevertheless, the increase of tourism in Lima resulted in demand for larger and more luxurious accommodations, so numerous hotels with European standards began to be built. The Hotel Comercio could not compete with the new hotels, closing doors in the 1960’s.

In 1989, the entire building was declared Historical Monument and Cultural Heritage by the INC. The area once occupied by the hotel remained vacant for at least two decades, which resulted in an accelerated deterioration of the building and two adobe walls on the first floor were documented as “collapsed;” the first one in December of 1994 and the second one in July of 1998. The exact location and degree of failure are unclear in the documentation. The Casa Militar del Presidente de la República, owner of the areas that constituted the hotel, used the first patio as a woodshop and the rooms for storing government documents, furniture and

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weapons as recorded by Cortez and Morales in August of 2000. On September of 2000, the Casa Militar del Presidente de la República ordered a visual inspection of the building, which urged El Cordano and the Distribuidora Vallejo to vacate the building because of its "hazardous condition". Nonetheless, El Cordano and Distribuidora Vallejo refused to leave the building. Predicaments did not stop there and in September of 2001, El Cordano restaurant’s manager notifies the Casa Militar del Presidente de la República that a wall on the first floor collapsed causing serious damage to the restaurant’s adjacent spaces. Finally, the Casa Militar del Presidente de la República transferred ownership of the Hotel Comercio to the INC on June of 2004. Architect Jaime Exebio Lopez conducted a visual inspection in October of the same year, concluding that the deterioration of the building was due to lack of maintenance and abandonment. Sections of adobe walls on the first floor collapsed due to humidity caused by the failure of water pipes, compromising the structural stability of the adjacent spaces and stories above.

The Ministry of Culture continues to own the building, and has been active in the process of stabilizing the building and contributing to the study of the adobe-quincha building’s performance.

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36 Lopez Delgado, Jacinto. “Letter to Casa Militar del Presidente de la República
37 Lumbreras Salcedo, Luis Guillermo. “Resolución No. 011-204/SBN-GO-JAD.”
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
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<tbody>
<tr>
<td>Jan. 1535</td>
<td>Land belonged to Alonso Riquelme(^{39})</td>
</tr>
<tr>
<td>1839</td>
<td>Mrs. María Rosa Orué transfers property to Isidro Aramburú</td>
</tr>
<tr>
<td>1860</td>
<td>Mr. Aramburú sells house to Manuel Arrieta(^{40})</td>
</tr>
<tr>
<td>1864</td>
<td>Mr. Francisco Esteban de Ingunza rents house in Pescadería to Mrs.</td>
</tr>
<tr>
<td></td>
<td>Manuela Malarín.(^{41})</td>
</tr>
<tr>
<td>1873</td>
<td>Mr. Francisco Esteban de Ingunza sells property to Mr. Santiago</td>
</tr>
<tr>
<td></td>
<td>Chepote</td>
</tr>
<tr>
<td>1897</td>
<td>Manuel Quimper, who rents stores in the property to Mateo Valdettaro.</td>
</tr>
<tr>
<td>1905</td>
<td>Fortunato and Andrés Cordano found the restaurant El Cordano(^{43})</td>
</tr>
<tr>
<td>1941</td>
<td>License under Mr. Espinoza and Mr. Hernandez(^{44})</td>
</tr>
<tr>
<td>1951</td>
<td>License under Enriqueta Espinoza, Carlos Aristizales, and Waldemar</td>
</tr>
<tr>
<td></td>
<td>Falckenheiner(^{45})</td>
</tr>
<tr>
<td>? - 2000</td>
<td>Casa Militar del Presidente de la República is listed as owner of the</td>
</tr>
<tr>
<td></td>
<td>building(^{46})</td>
</tr>
<tr>
<td>June 2004</td>
<td>Ownership is transferred to the INC (now Ministry of Culture)</td>
</tr>
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</table>

Table 5.1 - Ownership Timeline

### 5.3 Present Site and Situational Context

The Hotel Comercio is located in the province of Lima in the Cercado district, which is part of the Historic Centre of Lima. The Hotel Comercio is bound by Jirón Carabaya to the northwest (with address numbers 103-119) and Jirón Ancash to the northeast (with address numbers 200-202). The area in which it is located is probably the most concurred by tourists since it is only one block away from the Plaza de Armas (Square of Arms, Lima’s main square), in where the Cathedral and

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\(^{39}\) Villa Esteves, Deolinda. "Informe No. 063-2006-INC/DPHCR/SDIH/DMVE." pp 01.

\(^{40}\) Ibid.

\(^{41}\) De los Santos, Gloria. Memorandum No. 006-75 DMHA.

\(^{42}\) Villa Esteves, Deolinda. "Informe No. 063-2006-INC/DPHCR/SDIH/DMVE." pp 02.

\(^{43}\) De los Santos, Gloria. "Memorandum No. 006-75 DMHA."

\(^{44}\) Ibid

\(^{45}\) Ibid.

\(^{46}\) Ibid.

\(^{47}\) Lumbreras Salcedo, Luis Guillermo. “Resolución No. 011-204/SBN-GO-JAD.”
the famous Casa del Oidor, the house of a well known magistrate of the Spanish court during the Viceroyalty of Peru, are. Furthermore, it sits right across the street from the Palacio de Gobierno (Presidential Palace), and Estación Desamparados (Desamparados Train Station), both being historically significant; and blocks away from historic landmarks such as El Parque de la Muralla, a public space designed to exhibit the archaeological excavation of the city wall of Lima built in the 1680’s, and Plaza de San Francisco (Saint Francis’ square), an impressive complex known for its library, catacombs, art, and declared a World Heritage site by UNESCO even before the city of Lima (Appendix B1 - site plan).

Fig: 5.10 – View of Jirón Carabaya with Palacio de Gobierno to the left, Estación Desamparados at the center, and Hotel Comercio to the right.
Fig. 5.9 - Hotel Comercio from Estación Desamparados. Source: author
Because of its proximity to Lima’s most remarkable pieces of architecture, the views when approaching Hotel Comercio are remarkably stunning. From Plaza de Armas, the Casa del Oidor and a series of colorful Hispano-Baroque buildings including the hotel are located on the southeast side of Jirón Carabaya, while the Palacio de Gobierno takes up the whole block on the opposite side of the street. The imposing three-story French Baroque façade of the Estación Desamparados acts as the focal point, drawing attention to the end of the street. Furthermore, the views from the building are very impressive as well. Besides been able to see the Estación Desamparados, the upper stories of the hotel give a privileged view of the Palacio de Gobierno’s courtyard, Cerro San Cristóbal, and the tops and bell towers of both the Cathedral and the San Francisco Church.

The site is easily accessible by foot, car and public transportation, such as the Metropolitano, a bus rapid transit (BRT) that connects the north and south of Lima and goes through 16 districts. The site is also very pedestrian friendly, with wide sidewalks and plenty security guards around the area. There is not a parking lot on site, but there are several parking lots nearby.
Fig. 5.11 – View of Jirón Ancash from the second floor of Hotel Comercio towards the San Francisco Complex. Source: author
5.4 Existing Conditions

Construction (See Appendix B and C)

Stone and a lime based mortar were used for the foundations. The ground floor walls are built with adobe with areas filled in with fired brick. The adobe exterior walls are 2½ ft wide, while the adobe walls on the interior are 2 ft wide. There are five wood columns in the main patio and six wood columns in the second patio; both sets of columns supporting rim joists of the corridors above.

The second and third stories are built with quincha. The entramado sits on top of the adobe walls, 12 x 4 in wooden posts were fitted in between the entramado and beam, using mortise and tenon; the distances in between posts varied according to wall (approximately 1 ft in exterior walls, 2½ ft in interior walls, and 5 ft when a window was placed). Wood blocks were nailed to the posts and entramado at both sides for additional support. Puntas were not found; however, 2¼ x 2¼ in contrapuntas going from the entramado to the posts were found on all walls. Additionally, an interwoven cane mesh was placed in between the framework, which was achieved by laying canes through the posts and weaving the vertical canes through these. The area in between the entramado and the first set of horizontal canes was then filled with adobe bricks serving as transition for both materials (the adobe wall and the quincha) to meet. Finally, walls were covered in mud, plaster, and were painted.

The floors on the second story are all made out of wood planks. Beams embedded on the adobe walls support joists which in turn support a subfloor. Some
of the beams are single 1 x 1 ft while others are three 8 x 9½ in attached to each other. The joists, which are 8 x 9½ in, were placed every 13½ ft and sit perpendicular to the beams.

The roofs are flat and consist of wooden joists and beams supporting a wooden deck covered with mud. *Huascas* were only found on the roof beams, connecting two or three pieces with halved joints and/or plain laps.

**Current Conditions**

In this section of the chapter, the building has been divided into three sectors according to level of deterioration, being sector 1 in moderate to good condition, sector 2 in moderate condition, and sector 3 in poor condition.

(Appendix B6 – First floor plan showing 3 sectors)

**Sector 1**

This sector comprehends the three floors from the façade up to the first patio.

The areas occupied by El Cordano and Distribuidora Vallejo on the first floor are stable, since both of these commercial establishments have structurally reinforced their spaces. Furthermore, an assessment was performed in the restaurant’s storage room to determine the condition of the structure. One beam was inaccessible, so seven of the eight beams were analyzed; these exhibited small
cavities just below the surface. Also, one of the beams cracked diagonally; therefore, it was braced. The adobe walls are in good condition; however, there are moist areas at the base of the walls. The wood columns in main patio are severely decayed, exhibiting large oval cavities, numerous and close together. The tile floors in the vestibule, patios, hall, and rooms exhibit various conditions, such as discoloration, staining, missing parts, and replacement of entire tiles. The three-flight staircase by the vestibule has been reconstructed with wood, given that the original marble steps were looted. Furthermore, El Cordano, the Distribuidora Vallejo, and the small bathroom located in between the vestibule and the staircase are the only spaces with electricity and running water.

The second floor is all built with quincha. This area is in moderate to good condition except for room 243 located on the northeast corner, which is severely deteriorated. The partition wall in this room has been taken down, and several wooden posts were placed to support the structure above. Some posts do not connect to the floor, which compromises the structural stability of the building. The plastered walls have vertical cracks following the location of the posts. Wood windows, frames and balconies show signs of decay, extensive fabric loss, and accumulation of bird fecal matter. Wood flooring in the rooms and tile on the corridor are missing in some areas, leaving holes and exposing the joists. Canes are in good condition, they do not show signs of biodeterioration. There are also

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48 Mandujano Montalvo, Edgar. "Evaluación de la Estructura de Madera del Ambient de Trabajo del Restaurante El Cordano."
numerous areas with mud and plaster detachment, particularly at the bottom of the walls where they meet the floor. Accumulation of debris is present throughout the second floor of sector 1. There is only one sink with running water on the entire floor, which is used by the caretaker as a kitchen sink

The third floor is also constructed with quincha and presents very similar conditions than the second floor. These include vertical cracks following the location of the posts, cavities on the wood and loss of material, and plaster and paint detachment. In addition to these conditions, a pile of frass was found on the wood flooring of room 350.

**Sector 2**

The Sector 2 refers to the area between the first patio and the second patio. The first floor walls are constructed of adobe and areas of brick. Walls have vertical cracks; and detached plaster and paint. The adobe wall on room 104 has partially collapsed, so supporting posts have been placed. The tile floors on the hall are in good condition, with some signs of wear.

The walls on the second floor exhibit extensive paint failure, plaster and mud detachment, some areas are bulging out, and horizontal and vertical cracks follow the length of the posts. Supporting posts have been placed in rooms 211 and 214. Floor boards on the southwest wall of room 214 are not connected to the wall. Wood elements, such as window sills and frames are very deteriorated having lost approximately 20% of their fabric.

The walls on the third floor have vertical cracks and plaster detachment,
particularly notorious in rooms 313 and 317. A pile of brown colored frass was found on the wooden floor of room 313. The wood floor boards in room 317 are bowing with the center of the room being the highest point, thus three supporting posts have been placed in the center of the room. Rooms 314, 315, 316 have also been braced.

**Sector 3**

First floor walls are constructed with brick as opposed to the ones in Sector 1 that are adobe. The difference in materials and construction suggests that this sector was built in a different phase than Sector 1, but no documentation was found to corroborate this. This sector contains the bathrooms for the entire floor, and it is the most deteriorated area of the building, making it inaccessible.

The second floor walls are built with *quincha* and are in very poor condition. They have a significant number of cracks, and paint and plaster detachment on rooms 216, 217, 218, 219. Nine rooms have been braced with wood posts, which are rooms 216, 218, 221, 222, 223, 224, 226, 226, and 227.

The third floor is in similar condition as the second floor with almost all rooms having to be braced. These are rooms 318, 319, 320, 323, 324, 325, and 326.

**Collapsed Area**

The three floors of an entire section of the hotel have collapsed. This area has been cleaned and wood has been organized in piles. Records indicate that in December of 1994, the wall on the first floor collapsed, which affected areas in the
floors above where cracks and sunken elements can be found. Four years later in the month of July, an adobe wall on the first floor collapsed. Adjacent rooms have been braced with wooden posts. Adjacent areas have been inspected to ensure their stability.

5.5 Wood Identification

Sampling

Eight wood samples were extracted from different elements of the Hotel Comercio to be brought to the U.S. for analysis during two separate site visits. The elements were photographed before and after the extraction of the samples for documentation. The samples were cut with a handsaw, labeled and stored in plastic bags. During the first site visit in January of 2011, two samples were extracted from two elements on the northeastern room on the second story. The elements sampled were chosen due to accessibility, structural function, and condition of wood. The first sample, rectangular in shape and with measurements of approximately 4 x 2 x 2 in, was taken from an exposed post on the southeast wall, a load bearing wall. The second sample, measuring 1 x 1 x 1 in, was taken from the joist supporting the second story subflooring. Both samples did not show signs of biological deterioration, which made them suitable for wood identification.

Six more samples were extracted during the second site visit on October of

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\(^{49}\) Cortez Morales, Ever, Hugo Casso Valdivia. “Informe Técnico de Oficio No. 061-2000-OPNS.”

\(^{50}\) Ibid.
2012. These second set of samples were chosen for their accessibility, varied locations, and the different conditions of wood. All samples were from elements already with exposed surfaces. They were also taken from different structural elements in different floors and sectors. Four samples did not have visual signs of biological deterioration, while two showed signs of insect attack. Although damaged wood is not ideal for wood identification, it is very useful to be analyzed for insect identification. (See Appendix E).

**Preparation of Samples**

Wood samples were placed in a dessicator at the Architectural Conservation Laboratory at the University of Pennsylvania. All samples were photographed using a Leica MZ16 microscope, a Leica KL2500 lighting, and a Nikon DS-Fi1 camera. Then, the samples were cut at the Fabrication Laboratory at the University of Pennsylvania using a band saw to reduce their size. Each sample was cut into three separate pieces with a dovetail saw, in the tangential, radial and longitudinal planes. The cuts resulted in 24 samples of rough rectangular shapes of \( \frac{3}{4} \times \frac{1}{2} \times \frac{1}{2} \) in. The goal was to get even shaped and clean samples; however, this was difficult with the smaller and uneven samples extracted from Hotel Comercio. Lastly, each of the samples was boiled and thin sections were cut with a single edged razor blade. It was very important to keep the blade sharp in order to get high quality surfaces.

Each thin section was mounted on a microscope glass slide, a drop of Stoddard solvent was applied to the surface of the sample with an eyedropper, and
covered with a cover glass for examination.

Fig. 5.12 - Laboratory tray with wood samples. Source: author

Fig. 5.13 - Stored wood samples. Source: author
Macroscopic and Microscopic Examinations

Each sample was analyzed and observations were recorded. First, the eight samples were examined with the unaided eye for gross features such as color, grain, pattern, and smell. After they were cut into 24 smaller pieces and the three planes were exposed, the samples were inspected with a 10x hand lens for any perceptible features such as presence and distribution of pores, vessels, and rays. After cutting thin sections, these were placed under the microscope for examination and photographing the samples.

A source consulted for wood identification was *The Woodbook: The Complete Plates*,\(^{51}\) which includes hundreds of species of wood found in the U.S. and Europe along with their scientific names, narrative descriptions, and images of the three planes. Another source consulted was Hoadley’s *Identifying Wood*,\(^{52}\) which gives magnified longitudinal sections of the most commonly used woods in the U.S. "The Wood Database"\(^{53}\) provides 10x magnification images of longitudinal sections, and was also consulted for visual comparison. The only publication available to me about Peruvian wood is the *Atlas de Maderas del Peru*,\(^{54}\) offering both common and scientific names, description of wood, anatomical characteristics, and images of the wood pattern and the three sections in 40x, 50x and 100x magnifications.

Samples S-1-II-a and S-1-II b, both extracted from the same room but from

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\(^{52}\) Hoadley, R. Bruce. *Identifying Wood: Accurate Results with Simple Tools.*


\(^{54}\) Acevedo Mallque, Moisés, Yoji Kiyata. *Atlas de Maderas del Peru.*
different structural members have identical anatomical characteristics. The lack of pores in both indicated that they are softwoods. Observations included a cedar-like odor, yellowish brown color, fine texture (tracheids cannot be seen clearly), presence of one bordered pits, non-resinous canals, and cupressoid cross field pitting. All these features observed indicate that the samples are a type of cedar; however, the specific specie cannot be determined since cedar anatomies are very similar. Figures 5.14, 5.15 and 5.16 show longitudinal sections of sample S-1-II-a from Hotel Comercio, Atlantic White-Cedar (*Chamaecyparis thyoides*), and Northern White-Cedar (*Thuja occidentalis*) for visual comparison.

Samples S1-III-a, S2-III-a, and S3-II-a were extracted from the second and third floors from the three different sectors and have very similar anatomical characteristics. All three are softwoods with dark red to brown heartwood and very abrupt transitions between earlywood and latewood. They exhibit resinous canals, abundant spiral thickening in tracheids, and piceoid crossfield pitting. The anatomy of the three samples is very similar to Douglas-fir, an evergreen conifer species native to western North America with a very distinctive anatomy. If it is in fact Douglas-fir, this means that the wood was imported since it does not grow in Peru. The other possibility would be that the sample is not Douglas-fir, but another species that resembles it; in this case I was not able to find a Peruvian specie that would fit the anatomical characteristics of Douglas-fir. Figures 5.17 to 5.20 show radial and tangential sections of S1-III-a from Hotel Comercio and from *Identifying Wood* for visual comparison.
<table>
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<tr>
<th>Fig. 5.14</th>
<th>Sample S1-II-a from Hotel Comercio, longitudinal section, 40x magnification</th>
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<tr>
<td>Fig. 5.15</td>
<td>Atlantic White-Cedar longitudinal section. Source: Hoadley, R. Bruce. <em>Identifying Wood</em>. pp 159</td>
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<td>Fig. 5.16</td>
<td>Northern White-Cedar longitudinal section. Source: Hoadley, R. Bruce. <em>Identifying Wood</em>. pp 159</td>
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Fig. 5.17 - Sample S1-III-a from Hotel Comercio, longitudinal section, 40x magnification

Fig. 5.18 - Douglas-fir longitudinal section. Source: Hoadley, R. Bruce. *Identifying Wood*. pp 150

Fig. 5.19 - Sample S3-II-a radial section from Hotel Comercio. 200x magnification

Fig. 5.20 - Douglas-fir spiral thickening in longitudinal tracheids with resin canals. Source: Hoadley, R. Bruce. *Identifying Wood*. pp 151
Samples S2-I-b and S3-II-b also exhibit identical anatomical features, therefore, they are likely to be the same species. Sample S2-I-b was extracted from a beam lying on Room 120, but probably belonged to the collapsed area and placed in Room 120 for purposes of storing it. Sample S3-II-b was taken from a joist in Room 228. The tangential and radial sections have dark brown and yellow stripes, while the longitudinal sections are dark brown. Both samples are hardwoods with diffuse pores visible to the naked eye. The pores are solitary, with presence of tyloses and gums. They exhibit a medium texture and high luster. By examining the features, it was determined that the sample was very likely to belong to the Walnut genius. The samples S2-I-b and S3-II-b were compared to Peruvian walnut (Juglans neotropica), commonly known in Peru as Nopal, and was found very similar to the Peruvian specimen. The samples were also compared with Black Walnut (Juglans nigra), and was found to be very similar. However, the latter one is semi-diffuse porous. Figures 5.21 to 5.26 show longitudinal sections of both samples extracted from Hotel Comercio, a longitudinal sections of Peruvian walnut and Black walnut, tangential sections of sample S2-I-b and Black walnut.

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Fig. 5.21 - Sample S3-II-b from Hotel Comercio, longitudinal section, 40x magnification

Fig. 5.22 - Peruvian walnut longitudinal section. Source: Wood Database. www.wood-database.com/wood-identification/

Fig. 5.23 - Sample S2-I-b from Hotel Comercio, longitudinal section, 40x magnification

Fig. 5.24 - Black walnut longitudinal section. Source: Hoadley, R. Bruce. *Identifying Wood*. pp 116

Fig. 5.25 - Sample S2-I-b from Hotel Comercio, tangential section, 40x magnification

Fig. 5.26 - Black walnut tangential section. Source: Hoadley, *Identifying Wood*. pp 117
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<td>S1-II-a post</td>
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</tr>
<tr>
<td>S1-II-b joist</td>
<td>A type of Cedar (exact species unknown)</td>
<td>Non-resinous, cedar like odor; cupressoid cross field pitting</td>
<td>Room 243 Floor</td>
<td></td>
</tr>
<tr>
<td>S1-III-a joist</td>
<td>Douglas-fir, <em>Pseudotsuga menziesii</em></td>
<td>Resinous, abundant spiral thickening in tracheids, piceoid crossfield pitting, dark red heartwood</td>
<td>Room 344 Floor (likely from collapsed area)</td>
<td></td>
</tr>
<tr>
<td>S2-I-a-post</td>
<td>A type of cedar (different from # 3&amp;4 below)</td>
<td>Non-resinous, cupressoid-taxodioid cross field pitting, dark red heartwood, sweet odor</td>
<td>Second patio (likely from collapsed area)</td>
<td></td>
</tr>
<tr>
<td>S2-I-b-beam</td>
<td>Walnut genus—very similar to black walnut</td>
<td>Semi-diffuse porous</td>
<td>Room 120 (likely from collapsed area)</td>
<td></td>
</tr>
<tr>
<td>S2-III-a joist</td>
<td>Douglas-fir, <em>Pseudotsuga menziesii</em></td>
<td>Resinous, abundant spiral thickening in tracheids, piceoid crossfield pitting, dark red heartwood</td>
<td>Hallway floor (next to room 336)</td>
<td></td>
</tr>
<tr>
<td>S3-II-a post</td>
<td>Douglas-fir, <em>Pseudotsuga menziesii</em></td>
<td>Resinous, abundant spiral thickening in tracheids, piceoid crossfield pitting, dark red heartwood</td>
<td>Room 327</td>
<td></td>
</tr>
<tr>
<td>S3-II-b?</td>
<td>Walnut genus—very similar to black walnut</td>
<td>Diffuse porous</td>
<td>Room 228</td>
<td></td>
</tr>
</tbody>
</table>
Lastly, samples were sent to three specialists in wood identification. Manuel Chavesta Custodio, engineer at the Forestry Department at the Peruvian National University for Agrarian Studies, analyzed samples S1-II-a and S1-II-b. It was determined that both samples were the same species, being these Eastern Red Cedar (*Juniperus virginiana*).

Harry A. Alden from Alden Identification Service analyzed samples S1-II-a, S1-II-b, S1-III-b, S2-I-a, and S1-III-a. According to his analysis, S1-II-a is Atlantic White Cedar (*Chamaecyparis thyoides*), a coniferous species found in North America. S1-II-b is Podocarpus (*Podocarpus sp.*), a primitive conifer native to the southern temperate regions through the tropical highlands, such as South America, South Africa, Japan, and the West Indies. S1-III-a is Douglas-fir (*Pseudotsuga menziesii*) a species native to North America. S1-III-b is Keruing (*Dipterocarpus sp.*), composed of over seventy species found throughout Indo-Malasia. S2-I-a is Eastern Red Cedar (*Juniperus virginiana*), species native to eastern North America.

Joseph R. Loferski from the Virginia Polytechnic Institute and State University analyzed all eight samples. He determined that S1-II-a and S1-II-b are the same species, both a type of cedar, but not Eastern Red Cedar as identified by Chavesta Custodio. S1-III-b is Douglas-fir (*Pseudotsuga menziesii*), agreeing with Loferski’s identification of the sample. S1-III-b was found to be from the Walnut genus. S2-I-a was identified as a type of cedar different from S1-II-a and S1-II-b. S2-I-b belongs to the Walnut genus, possibly the same as S1-III-b. Finally, S3-II-a and S2-III-a were also found to be Douglas-fir (*Pseudotsuga menziesii*). Their
analyses reports can be found in Appendix F.

5.6 **ANALYSIS OF CONDITIONS (AFFECTING PERFORMANCE OF THE BLDG) AND PROBABLE DETERIORATION MECHANISMS**

According to Ever Cortéz Morales and Hugo Casso Valdivia, both engineers from *Segunda Región de Defensa Civil*, who made a visual inspection of the building, the deterioration of the building has been due to age and humidity.\(^56\) Humidity on the base of the adobe walls have resulted in settlement of the walls, causing cracks on the walls themselves and warping the floors above. Some of the voids of the adobe walls have been filled in with brick and mortar cement.

Architect Jaime Exebio Lopez states that wall collapsed on September of 2001 was due to humidity.\(^57\) In October of 2004, it was determined that deterioration of the building was due to lack of maintenance and abandonment. Also, sections of adobe walls on the first floor rooms have collapsed compromising the structural stability of the stories above. The humidity was caused due to the failure of water pipes.\(^58\)

\(^{56}\) Lopez, Jaime Exebio. “Informe No. 238-2004-INC/DPHCR-SDCR-JMEL.”

\(^{57}\) Ibid.

\(^{58}\) Ibid.
6.1 SUMMARY OF RESEARCH

Historic centres in Latin America, such as Lima have gone through a process of renewal in the last decade that has improved the quality of life of their population. This has only been possible through preservation strategies that delineate protected areas, the collaboration of local authorities and international institutions, the encouragement of local tourism, and by empowering their inhabitants. However, political instability and financial bounds have slowed down the revitalization process and have had an insidious effect on historic buildings such as in the case of the Hotel Comercio in the Historic Centre of Lima.

Historic buildings in Lima are a testimony of the rich history of the country, and should be preserved because they are as important to the urban fabric of the surrounding environment as its surrounding environment is for the buildings. Lima was found in the 16th century around a main plaza, which was the center of the Spanish town in where the official functions would take place. This is reflected on the architectural heritage, which contributes to the homogeneity of the city in where buildings tell the story of a colonial town that held great political, economic and cultural importance. Large wood doors, decorative ironwork, Sevillian tiles, and
patios as found in the Hotel Comercio, make Lima a city full of richness and character.

_Quincha_ construction is vital to Lima’s architectural heritage, since it presents valuable information for architects and conservators, who will have to restore and preserve the structures throughout the country. The study of _quincha_ will also aid in the development of an efficient and economical way to build housing that is resistant to seismic activity and that is accessible to all. Fortunately, institutions such as ININVI, SENCICO, The Getty Conservation Institute, and the Pontifical Catholic University of Peru among others have been very active in the study and testing of quincha for both old and new construction. The ININVI for example, explored _quincha_ construction since the 1970’s. It published several manuals such as _Adobe, Nuevas Casas Resistentes de Adobe, Diseño y Construcción con Madera Norma Técnica de Edificación_, and _Quincha Pre-Fabricada: Fabricación y Construcción_, all dedicated in the research of traditional and modern materials to provide safe, economical and comfortable housing for the Peruvian population. The ININVI became part of SENCICO in 1995, eventually disappearing. As a result, SENCICO assumed many ININVI’s functions and continues to research traditional construction techniques and their use in modern construction. SENCICO revised and republished ININVI’s _Quincha Pre-Fabricada: Fabricación y Construcción_ in 1995 and 1997, and is also responsible for the development of the Peruvian National Building Code.

Wood, as any other construction material has its limitations, being the most
important ones its susceptibility to biological attack and fire. Preserving wood in structures may be a financial burden for the owner; however, these can be justified since the service life of the structures can be extended considerably. The demand for replacement wood would be reduced, as well as labor costs involved for repairs and reconstruction, and costs involving structural failure. The natural durability of wood can be extended by the use of preservatives, impervious coatings, and adequate drying methods.

### 6.2 Wood Identification

Identifying wood to an exact genus and species is extremely difficult. For one, wood is a complex material exhibiting great variability depending on the environment in where it grows. Two pieces of wood from two different trees of the same species can vary in appearance; even two pieces of wood from the same tree can be surprisingly variable. Secondly, wood identification is not an exact science; it relies on experience, intuition, and sensory evaluation. Most of the information required for identification comes observing the anatomical structure (cell structure), physical properties (such as color, density, and hardness), smell, and even taste, making this a somewhat subjective process. Additionally, closely related species cannot be separated by only analyzing the wood characteristics; other information such as its leaves, flowers, fruits, and bark is needed in order to differentiate the from one to another.

Identification was also difficult because of the lack of sources for microscopic
structure of wood. There is plenty of research conducted on woods from the United States and Europe, but very little for woods from the rest of the world. This made it difficult to visually compare the samples from Hotel Comercio to a larger database.

It is helpful to know the origin of the piece to be examined. Knowing the geographic location, the approximate year of construction of the structure from where the piece came from, and also having information about the member from where it was extracted from can narrow down the possibilities significantly. However, this information is not always known and with so many species of wood around the world, the possibilities are endless.

### 6.3 Recommendations for Conservation and Maintenance

Conservation for *quincha* buildings including Hotel Comercio should involve minimal intervention to retain as much original fabric as possible. Non-intervention was considered for the soiled and discolored surfaces, since they do not compromise structural stability of the building. Replacement of original wood should be limited with dutchmen being preferred for areas severely deteriorated. All conservation projects should be supported by an ongoing maintenance routine.

**Local Expertise**

Local professionals and institutions should be gathered and consulted. SENCICO for example, has an established training program aimed at studying and implementing the use of *quincha* for new construction. Their knowledge can be very
valuable for the conservation of historic quincha buildings. Additionally, Taller de Lima, a technical school in Peru, has a program focused on the conservation of historic structures and has played an important role in the preservation of buildings in the Historic Centre of Lima.

**Inspection and Emergency Intervention**

Preventive conservation measures must be adopted to safeguard the building's fabric as well as the occupants. Since high moisture content in wood is the most common issue conducive to wood decay, it is very important to monitor for water infiltration. If there is an indication of water entering the building, the sources of the water infiltration must be detected. Pipes must be monitored for failure, roofs and openings on the building envelope and runoff water systems must be inspected. In the case of unoccupied buildings such as Hotel Comercio, water should be shut off to prevent water from escaping and causing damage. In addition, direct contact of wood with the soil or other sources of water must be avoided. Moisture from the soil, standing water, or waterlogging will damage the wood altering its composition and affecting its physical and chemical properties, which in turn will reduce its structural strength.

An assessment should be performed for structural damage related to water infiltration, insect and fungal attack. Structural assessments are needed to ensure the stability of the building. Structural shoring must be implemented if needed, and members that threaten life safety must be addressed immediately. Temporary
roofing should be placed to prevent further damage to the exposed remaining structure.

**Wood and Insect Identification**

The wood samples analyzed from the Hotel Comercio provided promising candidates for woods used in Lima historically. However this is only a start. Further research should be performed to come into a more accurate identification. It was very surprising to see that some of the samples resemble a lot to North American wood species such as Black walnut and Douglas-fir. Whether there are native species in Peru which anatomies resemble the North American species, or the possibility of wood being imported from North America are both plausible scenarios. My research only found Ecuador, Panama, and Nicaragua as sources for imported wood in Peru before the 20th century. There is a possibility that these countries might have been importing their wood from North America, and that is how they became available in Lima; however, a definitive answer cannot be determined at the time.

A similar scenario was encountered when analyzing the pathologies of wood for insect identification. The lacks of sources of Peruvian pests as well as not having encountered the insects themselves, made it very difficult accurately identify them. In addition, I was not able to find a single source about any type of wood destroying insect being identified or studied in Peru, but only mention of the existence of termites. Consequently, the extensive list of pests found in the world was narrowed
down to wood destroying organisms that are likely to attack in Lima due to living
requirements of each and signs of their presence left behind such as exit holes and
frass. The insects most likely to be attacking the wood in Hotel Comercio are
Furniture beetles and dry-wood termites. This was determined by the size and
shape of the exit holes, characteristics of the attacked wood, and the piles of frass
left behind.

**Testing**

Testing for characterization and diagnosis of deterioration mechanisms
should be performed. Wood diagnosis test methods are provided in Chapter 4:
Testing Methods and Diagnosis. The tests are limited to those that are most suitable
for application in Peru. Some of these tests are:

- Visual evaluation: preliminary examination for signs of biodeterioration on
  exterior of wood and general condition of wood
- Examine exit holes, piles of frass, characteristics on deteriorated wood: to
diagnose insect infestation
- Unaided auscultation/stethoscope: to hear feeding noises
- Increment cores: to determine water content within wood
- Light and electron microscopy: simple procedure to obtain an image of
  biodeterioration
- Bromophenol blue and Bromocresol green: color indicators to detect
  presence of brown-rot and white-rot fungi
After establishing the mechanisms, testing for possible treatments is needed and can be accomplished by performing mockups of various treatments in situ.

- **Flufenoxuron (Flurox):** wood preservative to control larvae of wood-destroying insects. Also has preventive effectiveness against attack

- **Impregnation via bore holes of liquid preservatives:** to prevent the spread of decay to sound wood while preserving as much original material as possible

- **Carbon dioxide:** fumigant against wood destroying insects

- ***Metarhizium anisopliae***: fungus used as a termite repellent in the form of powder

**Consolidation**

Consolidation treatments should be used to reestablish cohesion stabilization of members damaged by mechanical, chemical, or biological agents.
Bibliography


Peru. SENCICO (Servicio Nacional de Normalización, Capacitación e Investigación para la Industria de la Construcción). *Quincha Pre-Fabricada: Fabricación y Construcción.* Lima: , Print.


Appendix A – Data Sheets
A1 - Bromocresol Green

Material Safety Data Sheet

Hazard Alert Code Key:

EXTREME  HIGH  MODERATE  LOW

Section 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME
Bromocresol Green

STATEMENT OF HAZARDOUS NATURE

NFPA

SUPPLIER
Santa Cruz Biotechnology, Inc.
2145 Delaware Avenue
Santa Cruz, California 95060
800-457.3503 or 831-457.3500
EMERGENCY
ChemWatch
Within the US & Canada: 877-715-8305
Outside the US & Canada: +1-800-248-2255
(1-800-CHEMICALL) or call #613-35073-3172

SYNONYMS
C21H14Br6Cl2N2O2S, "phenol, 4, 4'-(2, 2-dioxido-3H-1, 2-benzoxathiol-3-yldiene)bis[2, 6'-"dibromo-3-methyl, sodium salt (1:1) (CAS RN: 62525-32-8), "phenol, 4, 4'-(1, 1-dioxido-3H-2, 1-benzoxathiol-3-ylidene)bis[2, 6'-"dibromo-3-methyl (CAS RN: 7669-8)"], BCS, "Bromocresol blue", "Bromocresol green (BG)", "BG Indicator", "Bromocresol blue indicator", "Bromocresol indicator", "Bromocresol green", "Bromocresol indicator", "2', 3', 5', 5'-tetrametho-m-cresol sulphonphthalein", "tetrametho-m-cresolthiazin sulphon", "m-cresol, 4, 4'-dihydro-3', 1-benzoxathiol-3-yldiene-bis[2, 6-dibromo-3'], "metil phenol) S, S-dicocle"

Section 2 - HAZARDS IDENTIFICATION

CHEMWATCH HAZARD RATINGS

<table>
<thead>
<tr>
<th>Hazardity</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammability</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Toxicity</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Body Contact</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Reactivity</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

CANADIAN WHMIS SYMBOLS
EMERGENCY OVERVIEW

RISK
Inhalation to eye, respiratory system and skin.
Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
Cumulative effects may result following exposure.
May be harmful to the fetus/embryo*.
* (limited evidence).

POTENTIAL HEALTH EFFECTS

ACUTE HEALTH EFFECTS

SWALLOWED

The material has NOT been classified by EC Directives or other classification systems as 'harmful by ingestion'. This is because of the lack of reproducing animal or human evidence. The material may still be damaging to the health of the individual, following ingestion, especially where pre-existing organ (e.g. liver, kidney) damage is evident. Present definitions of harmful or toxic substances are generally based on doses producing mortality rather than those producing morbidity (disease, ill-health). Gastrointestinal tract discomfort may produce nausea and vomiting. In an occupational setting however, ingestion of insignificant quantities is not thought to be cause for concern.

EYE

This material can cause eye irritation and damage in some persons.

SKIN

This material can cause inflammation of the skin contact in some persons.
The material may exacerbate any pre-existing dermatitis condition.
Skin contact is not thought to have harmful health effects (as classified under EC Directives), the material may still produce health damage following entry through wounds, lesions or abrasions.
Open cuts, abrasions or irritated skin should not be exposed to this material.
Entry into the blood-stream, through, for example, cuts, abrasions or lesions, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

INHALED

This material can cause respiratory irritation in some persons. The body's response to such irritation can cause further lung damage.
Paroxysmal with impaired respiratory function, airway diseases and conditions such as emphysema or chronic bronchitis, may incur further disability if excessive concentrations of particulates are inhaled.
If prior damage to the circulatory or nervous systems has occurred or if kidney damage has been sustained, proper screening should be conducted on individuals who may be exposed to further risk if handling and use of the material result in excessive exposures.

CHRONIC HEALTH EFFECTS

Long-term exposure to respiratory irritants may result in disease of the airways involving difficult breathing and related systemic problems. Substance accumulation, in the human body, may occur and may cause some concern following repeated or long-term occupational exposure.
There is some evidence from animal testing that exposure to this material may result in toxic effects to the unborn baby.
Long term exposure to high dust concentrations may cause changes in lung function, e.g. pneumoconiosis, caused by particles less than 0.5 micron penetrating and remaining in the lung. Prime symptom is breathlessness; lung shadows show on X-ray.
Chronic interaction with inorganic bromides, historically, has resulted from medical use of bromides but not from environmental or occupational exposure; depression, hallucinations, and subcortical psychosis can be seen in the absence of other signs of intoxication. Bromides may also induce sedation, irritability, agitation, delirium, memory loss, confusion, disorientation, forgetfulness (aphasia), dysarthria, weakness, lassitude, fatigue, vertigo, stupor, coma, decreased appetite, nausea and vomiting, diarrhea, hallucinations, an acne-like rash on the face, legs and trunk, known as bromoderma (seen in 25-30% of cases involving bromide loss), and a profuse discharge from the nostrils (coryza).
Acute and generalised hyperthermia have also been observed. Correlation of neurologic symptoms with blood levels of bromide is indirect.
The use of substances such as bromphenamine, as antihistamines, largely reflect current day usage of bromides; toxic bromides have been largely withdrawn from therapeutic use due to their toxicity. Several cases of foetal abnormalities have been described in mothers who took large doses of bromides during pregnancy.

Section 3 - COMPOSITION / INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>NAME</th>
<th>CAS RN</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>bromocresol green</td>
<td>76-50-8</td>
<td>100</td>
</tr>
</tbody>
</table>

Section 4 - FIRST AID MEASURES

SWALLOWED
• Immediately give a glass of water.
• First aid is not generally required. If in doubt, contact a Poisons Information Centre or a doctor.

**EYE**
If this product comes in contact with the eyes:
• Wash out immediately with fresh running water.
• Ensure complete irrigation of the eye by keeping eyelids apart and away from eye and moving the eyelids by occasionally lifting the upper and lower lids.
• Seek medical attention without delay. If pain persists or recurs seek medical attention.
• Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

**SKIN**
If skin contact occurs:
• Immediately remove all contaminated clothing, including footwear.
• Flush skin and hair with running water (and soap if available).
• Seek medical attention in event of irritation.

**INHALED**
• If fumes or combustion products are inhaled from contaminated area.
• Lay patient down. Keep warm and rested.
• Prostheses such as false teeth, which may block airway, should be removed, where possible, prior to initiating first aid procedures.
• Apply artificial respiration if not breathing, preferably with a demand valve resuscitator, bag-valve mask device, or pocket mask as trained. Perform CPR if necessary.
• Transport to hospital, or doctor, without delay.

**NOTES TO PHYSICIAN**
• Treat symptomatically.

<table>
<thead>
<tr>
<th>Section 5 - FIRE FIGHTING MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vapour Pressure (mmHg): Negligible.</td>
</tr>
<tr>
<td>Upper Explosive Limit (%): Not available.</td>
</tr>
<tr>
<td>Specific Gravity (water=1): Not available.</td>
</tr>
<tr>
<td>Lower Explosive Limit (%): Not available.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXTINGUISHING MEDIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foam.</td>
</tr>
<tr>
<td>Dry chemical powder.</td>
</tr>
<tr>
<td>BCF (where regulations permit).</td>
</tr>
<tr>
<td>Carbon dioxide.</td>
</tr>
<tr>
<td>Water spray or fog - Large fires only.</td>
</tr>
</tbody>
</table>

**FIRE FIGHTING**
• Alert Fire Brigade and tell them location and nature of hazard.
• Wear breathing apparatus plus protective gloves.
• Prevent any means available, spillage from entering drains or water courses.
• Use water delivered as a fine spray to control fire and cool adjacent area.
• Do NOT approach containers suspected to be hot.
• Cool fire exposed containers with water spray from a protected location.
• If safe to do so, remove containers from path of fire.
• Equipment should be thoroughly decontaminated after use.

When any large container (including road and rail tankers) is involved in a fire, consider evacuation by 100 metres in all directions.

**GENERAL FIRE HAZARDS/HAZARDOUS COMBUSTIBLE PRODUCTS**
• Combustible solid which burns but propagates flame with difficulty; it is estimated that most organic dusts are combustible (circa 70%) - according to the circumstances under which the combustion process occurs, such materials may cause fires and / or dust explosions.
• Organic powders when finely divided over a range of concentrations regardless of particulate size or shape and suspended in air or some other oxidizing medium may form explosive dust-air mixtures and result in a fire or dust explosion (including secondary explosions).
• Avoid generating dust, particularly clouds of dust in a confined or unventilated space as dusts may form an explosive mixture with air, and any source of ignition, i.e. flame or spark, will cause fire or explosion. Dust clouds generated by the fine grinding of the solid are a particular hazard; accumulations of fine dust (420 micron or less) may burn rapidly and forcefully if ignited - particles exceeding this limit will generally not form flammable dust clouds; once initiated, however, larger particles up to 1400 microns diameter will contribute to the propagation of an explosion.
• In the same way as gases and vapours, dusts in the form of a cloud are only ignitable over a range of concentrations; in principle, the lower explosive limit (LEL) and upper explosive limit (UEL) are applicable to dust clouds but only the LEL is of practical use.
• This is because of the inherent difficulty of achieving homogeneous dust clouds at high temperatures (for dusts the LEL is often called the "Minimum Explosible Concentration", MEC).
• When processed with flammable liquids/vapors/mists, ignitable (hybrid) mixtures may be formed with combustible dusts. Ignitable mixtures will increase the rate of explosion pressure rise and the Minimum Ignition Energy (the minimum amount of energy required to ignite dust clouds - MIE) will be lower than the pure dust in air mixture. The Lower Explosive Limit (LEL) of the vapour/dust mixture will be lower than the individual LEL for the vapors/mists or dusts.
A dust explosion may release of large quantities of gaseous products; this in turn creates a subsequent pressure rise of explosive force capable of damaging plant and buildings and injuring people.

Usually the initial or primary explosion takes place in a confined space such as plant or machinery, and can be of sufficient force to damage or rupture the plant. If the shock wave from the primary explosion enters the surrounding area, it will disturb any settled dust layers, forming a second dust cloud, and often initiate a much larger secondary explosion. All large scale explosions have resulted from chain reactions of this type.

Dry dust can be charged electrostatically by turbulence, pneumatic transport, pouring, in exhaust ducts and during transport.

Build-up of electrostatic charge may be prevented by bonding and grounding.

Powder handling equipment such as dust collectors, dryers and mills may require additional protection measures such as explosion venting.

All movable parts coming in contact with this material should have a speed of less than 1-meter/sec.

A sudden release of statically charged materials from storage or process equipment, particularly at elevated temperatures and/ or pressure, may result in ignition especially in the presence of an apparent ignition source.

One important factor of the particulate nature of powders is that the surface area and surface structure (and often moisture content) can vary widely from sample to sample, depending on how the powder was manufactured and handled; this means that it is virtually impossible to use flammability data published in the literature for dusts (in contrast to that published for gases and vapours).

Autoignition temperatures are often quoted for dust clouds (minimum ignition temperature (MIT)) and dust layers (layer ignition temperature (LIT)); LIT generally falls as the thickness of the layer increases.

Combustion products include: carbon monoxide (CO), carbon dioxide (CO2), sulfur oxides (SOx), other pyrolysis products typical of burning organic material.

FIRE INCOMPATIBILITY

Avoid contamination with oxidizing agents i.e. nitrates, oxidizing acids, chlorine bleaches, pool chlorine etc. as ignition may result.

Section 6 - ACCIDENTAL RELEASE MEASURES

MINOR SPILLS

Environmental hazard - contain spillage.

- Clean up all spills immediately.
- Avoid contact with skin and eyes.
- Wear impervious gloves and safety glasses.
- Use dry clean up procedures and avoid generating dust.
- Vacuum up (consider explosion-proof machines designed to be grounded during storage and use).
- Do NOT use air hoses for cleaning.
- Place spilled material in clean, dry, stable, labelled container.

MAJOR SPILLS

Environmental hazard - contain spillage.

Moderate hazard.

- CAUTION: Advise personnel in area.
- Alert Emergency Services and tell them location and nature of hazard.
- Control personal contact by wearing protective clothing.
- Prevent, by any means available, spillage from entering drains or water courses.
- Recover product wherever possible.
- IF DRY: Use dry clean up procedures and avoid generating dust. Collect residues and place in sealed plastic bags or other containers for disposal. IF WET: Vacuum/soak up and place in labelled containers for disposal.
- ALWAYS: Wash area down with large amounts of water and prevent runoff into drains.
- If contamination of drains or waterways occurs, advise Emergency Services.

Section 7 - HANDLING AND STORAGE

PROCEDURE FOR HANDLING

- Avoid all personnel contact, including inhalation.
- Wear protective clothing when risk of exposure occurs.
- Use in a well-ventilated area.
- Prevent concentration in hollows and sumps.
- DO NOT enter confined spaces until atmosphere has been checked.
- DO NOT allow material to contact humans, exposed food or food utensils.
- Avoid contact with incompatible materials.
- When handling, DO NOT eat, drink or smoke.
- Keep containers securely sealed when not in use.
- Avoid physical damage to containers.
- Always wash hands with soap and water after handling.
- Work clothes should be laundered separately. Launder contaminated clothing before re-use.
- Use good occupational work practice.
- Observe manufacturer's storing and handling recommendations.
- Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
- Organic powders when finely divided over a range of concentrations regardless of particulate size or shape and suspended in air or some other oxidizing medium may form explosive dust-air mixtures and result in a fire or dust explosion (including secondary explosions).
- Minimize airborne dust and eliminate all ignition sources. Keep away from heat, hot surfaces, sparks, and flame.
- Establish good housekeeping practices.
- Remove dust accumulations on a regular basis by vacuuming or gentle sweeping to avoid creating dust clouds.
- Use continuous suction at points of dust generation to capture and minimize the accumulation of dusts. Particular attention should be given to overhead and hidden horizontal surfaces to minimize the probability of a "secondary" explosion. According to NFPA Standard 654, dust layers 1/16 in (0.8 mm) thick can be sufficient to warrant immediate cleaning of the area.
- Do not use air hoses for cleaning.
- Minimize dry sweeping to avoid generation of dust clouds. Vacuum dust-accumulating surfaces and remove to a chemical disposal area. Vacuum with explosion-proof motors should be used.
- Control sources of static electricity. Dusts or their packages may accumulate static charges, and static discharge can be a source of ignition.
- Solid handling systems must be designed in accordance with applicable standards (e.g., NFPA including 654 and 77) and other national guidance.
- Do not empty directly into flammable solvents or in the presence of flammable vapors.

RECOMMENDED STORAGE METHODS
- Glass container is suitable for laboratory quantities
- Polyethylene or polypropylene container
- Check all containers are clearly labeled and free from leaks.

STORAGE REQUIREMENTS
- Store in original containers.
- Keep containers securely sealed.
- Store in a cool, dry area protected from environmental extremes.
- Store away from incompatible materials and foodstuffs.
- Protect containers against physical damage and check regularly for leaks.
- Observe manufacturer's storage and handling recommendations.

RECOMMENDED STORAGE METHODS
- Glass container is suitable for laboratory quantities
- Polyethylene or polypropylene container
- Check all containers are clearly labeled and free from leaks.

STORAGE REQUIREMENTS
- Store in original containers.
- Keep containers securely sealed.
- Store in a cool, dry area protected from environmental extremes.
- Store away from incompatible materials and foodstuffs.
- Protect containers against physical damage and check regularly for leaks.
- Observe manufacturer's storage and handling recommendations.

Section 3 - EXPOSURE CONTROLS / PERSONAL PROTECTION

EXPOSURE CONTROLS
The following materials had no OELs on our records:

PERSONAL PROTECTION

RESPIRATOR

EYE
- Safety glasses with side shields.
- Chemical goggles.

Contact lenses may pose a special hazard; soft contact lenses may absorb and concentrate irritants. A written policy document, describing the wearing of lenses or contact lenses on use, should be created for each workplace or task. This should include a review of lens absorption and absorption for the class of chemicals in use and an account of injury experience. Medical and first aid personnel should be trained to deal with emergency and suitable equipment should be readily available. In the event of chemical exposure, begin eye irritation immediately and remove contact lenses as soon as practicable. Lenses should be removed at the first signs of eye redness or irritation. Lenses should be removed in a clean environment only after wearing have washed hands thoroughly. (CDC NIOSH Current Intelligence Bulletin 99, [AS/NZS 1806 or national equivalent]

HANDS/FEET
Suitability and durability of glove type is dependent on usage. Important factors in the selection of gloves include:

- frequency and duration of contact,
- chemical resistance of glove material,
- glove thickness and
dexterity.

Select gloves tested to a relevant standard (e.g., EN 374, US F739, AS/NZS 2161.1 or national equivalent).

- When prolonged or frequently repeated contact may occur, a glove with a protection class of 5 or higher (breakthrough time greater than 240 minutes according to EN 374, AS/NZS 2161.1 or national equivalent) is recommended.
- When only brief contact is expected, a glove with a protection class of 3 or higher (breakthrough time greater than 60 minutes according to EN 374, AS/NZS 2161.1 or national equivalent) is recommended.
- Contaminated gloves should be replaced.

Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended.

Experience indicates that the following polymers are suitable as glove materials for protection against undisolved, dry solids, where abrasive particles are not present.

- polyvinyl chloride
- nitrile rubber
- butyl rubber
- fluorocarbofluorocarbons
- polyvinyl chloride

Gloves should be examined for wear and/or degradation constantly.

OTHER

- Overall.
- PVC apron.
- Barrier cream.
- Skin cleanser cream.
- Eye wash unit.

ENGINEERING CONTROLS

Engineering controls are used to remove a hazard or place a barrier between the worker and the hazard. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions to provide this high level of protection.

The basic types of engineering controls are:

Process controls which involve changing the way a job activity or process is done to reduce the risk.

- Enclosure and/or isolation of emission source which keeps a selected hazard "physically" away from the worker and ventilation that strategically "sucks" and "removes" air in the work environment. Ventilation can remove or dilute an air contaminant if designed properly. The design of a ventilation system must match the particular process and chemical or contaminant in use.

- Employers may need to use multiple types of controls to prevent employee overexposure.

- Local exhaust ventilation is required where solids are handled as powders or crystals; even when particulates are relatively large, certain proportion will be powdered by mutual friction.

- Exhaust ventilation should be designed to prevent accumulation and recirculation of particulates in the workplace.

- If in spite of local exhaust an adverse concentration of the substance in air could occur, respiratory protection should be considered.

Such protection might consist of:

- (a): particle dust respirators, if necessary, combined with an absorption cartridge;
- (b): filter respirators with absorption cartridge or canister of the right type;
- (c): fresh-air hoods or masks

- Build-up of electrostatic charge on the dust particle, may be prevented by bonding and grounding.

- Pointwise handling equipment such as dust collectors, dryers and mills may require additional protection measures such as explosion venting.

Air contaminants generated in the workplace possess varying "escape" velocities which, in turn, determine the "capture velocities" of fresh circulating air required to efficiently remove the contaminant.

Type of Contaminant: Air Speed:
direct spray, spray painting in shallow booths, drum filling,
conveyor loading, crusher dusts, gas discharge (active
1-2.5 m/s (200-500 f/min.)
generation into zone of rapid air motion)
grinding, abrasive blasting, tumbling, high speed wheel
generated dusts (released at high initial velocity into zone 2.5-10 m/s (500-2000 f/min.)
of very high rapid air motion).

Within each range the appropriate value depends on:

<table>
<thead>
<tr>
<th>Lower end of the range</th>
<th>Upper end of the range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Room air currents minimal or favourable to capture</td>
<td>1: Disturbing room air currents</td>
</tr>
<tr>
<td>2: Contaminants of low toxicity or of nuisance value only</td>
<td>2: Contaminants of high toxicity</td>
</tr>
<tr>
<td>3: Intermittent, low production.</td>
<td>3: High production, heavy use</td>
</tr>
<tr>
<td>4: Large hood or large air mass in motion</td>
<td>4: Small hood-local control only</td>
</tr>
</tbody>
</table>

Simple theory shows that air velocity falls rapidly with distance away from the opening of a simple extraction pipe. Velocity generally decreases with the square of distance from the extraction point (in simple cases). Therefore the air speed at the extraction point should be adjusted, accordingly, after reference to distance from the contaminating source. The air velocity at the extraction fan, for example, should be a minimum of 4-10 m/s (800-2000 f/min) for extraction of crusher dusts generated 2 metres distant from the extraction point. Other
mechanical considerations, producing performance deficits within the extraction apparatus, make it essential that theoretical air velocities are multiplied by factors of 10 or more when extraction systems are installed or used.

**Section 9 - PHYSICAL AND CHEMICAL PROPERTIES**

**PHYSICAL PROPERTIES**

Solid. Does not mix with water.

<table>
<thead>
<tr>
<th>State</th>
<th>Divided solid</th>
<th>Molecular Weight</th>
<th>698.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting Range (°F)</td>
<td>424-426</td>
<td>Viscosity</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Boiling Range (°F)</td>
<td>Not available.</td>
<td>Solubility in water (g/L)</td>
<td>Partly miscible</td>
</tr>
<tr>
<td>Flash Point (°F)</td>
<td>Not available.</td>
<td>pH (1% solution)</td>
<td>Not applicable.</td>
</tr>
<tr>
<td>Decomposition Temp (°F)</td>
<td>437</td>
<td>pH (as supplied)</td>
<td>Not applicable.</td>
</tr>
<tr>
<td>Autoignition Temp (°F)</td>
<td>Not available.</td>
<td>Vapour Pressure (mmHg)</td>
<td>Negligible.</td>
</tr>
<tr>
<td>Upper Explosive Limit (%)</td>
<td>Not available.</td>
<td>Specific Gravity (water=1)</td>
<td>Not available.</td>
</tr>
<tr>
<td>Lower Explosive Limit (%)</td>
<td>Not available.</td>
<td>Relative Vapour Density (air=1)</td>
<td>Not applicable.</td>
</tr>
<tr>
<td>Volatile Component (%vol)</td>
<td>Not applicable</td>
<td>Evaporation Rate</td>
<td>Not applicable.</td>
</tr>
</tbody>
</table>

**APPEARANCE**

Minute, odourless, slightly crystals or powder; sparingly soluble in water, readily soluble in alcohol, ether and ethyl acetate. Fairly soluble in benzene. Very sensitive to alkaline solutions.

**Section 10 - CHEMICAL STABILITY**

**CONDITIONS CONTRIBUTING TO INSTABILITY**

- Presence of incompatible materials.
- Product is considered stable.
- Hazardous polymerisation will not occur.

**STORAGE INCOMPATIBILITY**

- Avoid reaction with catalysis agents, bases and strong reducing agents.
- Reacts vigorously with alkalis.

For incompatible materials - refer to Section 7 - Handling and Storage.

**Section 11 - TOXICOLOGICAL INFORMATION**

[bromocresol green]

**TOXICITY AND IRRITATION**

**BROMOCRESOL GREEN:**

- unless otherwise specified data extracted from RTECS - Register of Toxic Effects of Chemical Substances.
- Asthma-like symptoms may continue for months or even years after exposure to the material causes. This may be due to a non-allergic condition known as reactive airways dysfuncion syndrome (RADS) which may occur following exposure to high levels of highly irritating compound. Key criteria for the diagnosis of RADS include the absence of preceding respiratory disease, in a non-atopic individual, with abrupt onset of persistent asthma-like symptoms within minutes to hours of a documented exposure to the irritant. A reversible airflow pattern, on spirometry, with the presence of moderate to severe bronchial hyperreactivity on methacholine challenge testing and the lack of minimal lymphocytic inflammation, without eosinophile, have also been included in the criteria for diagnosis of RADS. RADS (or asthma) following an irritating inhalation is an infrequent disorder with rates related to the concentration of and duration of exposure to the irritating substance. Industrial bronchitis, on the other hand, is a disorder that occurs as result of exposure due to high concentrations of irritating substance (often particulate in nature) and is completely reversible after exposure ceases. The disorder is characterised by dyspnea, cough and mucus production. No significant acute toxicological data identified in literature search.

**CARCINOGEN**

<table>
<thead>
<tr>
<th>ORGANIC BROMINE COMPOUNDS</th>
<th>US Environmental Defense Scorecard Suspected Carcinogens</th>
<th>Reference(s)</th>
<th>P65-MG</th>
</tr>
</thead>
<tbody>
<tr>
<td>bromocresol green</td>
<td>US - Maine Chemicals of High Concern List</td>
<td>Carcinogen</td>
<td></td>
</tr>
</tbody>
</table>
Section 12 - ECOLOGICAL INFORMATION

Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment. This material and its container must be disposed of as hazardous waste. Avoid release to the environment. Refer to special instructions/safety data sheets.

Ecotoxicity

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Half-life: Water/Soil</th>
<th>Persistence: Air</th>
<th>Bioaccumulation</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromoperosid green</td>
<td>HIGH</td>
<td>No Data Available</td>
<td>LOW</td>
<td>LOW</td>
</tr>
</tbody>
</table>

Section 13 - DISPOSAL CONSIDERATIONS

Disposal Instructions
All waste must be handled in accordance with local, state, and federal regulations. Legislation addressing waste disposal requirements may differ by country, state and/ or territory. Each user must refer to laws operating in their area. In some areas, certain wastes must be tracked.

- A hierarchy of Controls seems to be common - the user should investigate:
  - Reduction
  - Reuse
  - Recycling
  - Disposal (if all else fails)

This material may be recycled if unused, or if it has not been contaminated so as to make it unsuitable for its intended use. Shelf life considerations should also be applied in making decisions of this type. Note that properties of a material may change in use, and recycling or reuse may not always be appropriate. In most instances the supplier of the material should be consulted.

- DO NOT allow wash water from cleaning or process equipment to enter drains.
- It may be necessary to collect all wash water for treatment before disposal.
- In all cases disposal to sewer may be subject to local laws and regulations and these should be considered first.
- Where in doubt contact the responsible authority.
- Recycle wherever possible.
- Consult manufacturer for recycling options or contact local or regional waste management authority for disposal if no suitable treatment or disposal facility can be identified.
- Dispose of by burial in a landfill specifically licensed to accept chemical and / or pharmaceutical wastes or incineration in a licensed apparatus (after admixture with suitable combustible material).
- Decontaminate empty containers. Observe all safety precautions until containers are cleaned and destroyed.

Section 14 - TRANSPORTATION INFORMATION

DOT:

<table>
<thead>
<tr>
<th>Symbols:</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard class or Division:</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Identification Numbers:</td>
<td>UN3077</td>
</tr>
<tr>
<td>FG:</td>
<td>III</td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Special provisions:</td>
<td>8, 146, 335, B54, B8, IP3, N20, T1, T9, TP33</td>
</tr>
<tr>
<td>155</td>
<td></td>
</tr>
<tr>
<td>Packaging: Non-bulk:</td>
<td>213</td>
</tr>
<tr>
<td>155</td>
<td></td>
</tr>
<tr>
<td>Quantity limitations:</td>
<td>No limit</td>
</tr>
<tr>
<td>Passenger aircraft/rail:</td>
<td>No limit</td>
</tr>
<tr>
<td>Cargo aircraft only:</td>
<td>No limit</td>
</tr>
<tr>
<td>Vessel stowage: Location:</td>
<td>A</td>
</tr>
<tr>
<td>Vessel stowage: Other:</td>
<td>None</td>
</tr>
<tr>
<td>Hazardous materials descriptions and proper shipping names:</td>
<td>Environmentally hazardous substance, solid, n.o.s</td>
</tr>
</tbody>
</table>

Air Transport IATA:

| ICAO/IATA Class: | 9 |
| ICAO/IATA Subrisk: | None |
| UN/ID Number: | 3077 |
| Packing Group: | III |
bromocresol green (CAS: 76-60-8, 62625-32-5, 641-19-0) is found on the following regulatory lists:

- "Canada - Alberta Ambient Air Quality Guidelines",
- "Canada - Alberta Ambient Air Quality Objectives",
- "Canada - British Columbia Occupational Exposure Limits",
- "Canada - Ontario Occupational Exposure Limits",
- "Canada - Quebec Permissible Exposure Values for Airborne Contaminants (English)",
- "Canada CEPA Environmental Registry Substance Lists - List of substances on the DSL that are Bioaccumulative to the environment (English)",
- "Canada CEPA Environmental Registry Substance Lists - List of substances on the DSL that are Persistant, Bioaccumulative, and Inherently Toxic to the Environment (PBT) (English)",
- "Canada CEPA Environmental Registry Substance Lists - List of substances on the DSL that meet the ecological criteria for categorization (English)",
- "Canada Chemical Substances List (DSL)",
- "Canada National Pollutant Release Inventory (NPRI)",
- "Canada Toxicological Indox Service - Workplace Hazardous Materials Information System - WHMIS (English)",
- "US - California Air Toxics "Hi-Spots" List (Assembly Bill 2588) Substances for Which Emissions Must Be Quantified",
- "US - California Permissible Exposure Limits for Chemicals",
- "US - Maine Chemicals of High Concern List",
- "US - Michigan Exposure Limits for Air Contaminants",
- "US - Oregon Permissible Exposure Limits (2-1)",
- "US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants",
- "US - Wyoming Toxic and Hazardous Substances Table Z1 Limits for Air Contaminants",
- "US Clean Air Act (CAA) National Ambient Air Quality Standards (NAAQS)",
- "US DOE Temporary Emergency Exposure Exposures (TEER)",
- "US Toxic Substances Control Act (TSCA) - Chemical Substance Inventory"

Section 15 - REGULATORY INFORMATION

Section 16 - OTHER INFORMATION

LIMITED EVIDENCE

- Cumulative effects may result following exposure.
- May be harmful to the foetus/embryo.
  
  *(limited evidence)*

Ingredients with multiple CAS Nos

<table>
<thead>
<tr>
<th>Ingredient Name</th>
<th>CAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>bromocresol green</td>
<td>76-60-8, 62625-32-5, 641-19-0</td>
</tr>
</tbody>
</table>

- Classification of the preparation and its individual components has drawn on official and authoritative sources as well as independent review by the Chemwatch Classification committee using available literature references.

- A list of reference resources used to assist the committee may be found at: www.chemwatch.net/references.

- The (M)SDS is a Hazard Communication tool and should be used to assist in the Risk Assessment. Many factors determine whether the reported Hazards are Risks in the workplace or other settings. Risks may be determined by reference to Exposures Scenarios. Scale of use, frequency of use and current or available engineering controls must be considered.

- For detailed advice on Personal Protective Equipment, refer to the following U.S. Regulations and Standards:
  - OSHA Standards - 29 CFR:
1910.132 - Personal Protective Equipment - General requirements
1910.133 - Eye and face protection
1910.134 - Respiratory Protection
1910.136 - Occupational foot protection
1910.138 - Hand Protection
Eye and face protection - ANSI Z87.1
Foot protection - ANSI Z41
Respirators must be NIOSH approved.

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www.Chemwatch.net

Issue Date: Nov-2-2009
Print Date: May-22-2012
A2 - Bromophenol Blue

sc-24971

Hazard Alert Code Key: EXTREME HIGH MODERATE LOW

Section 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME
Bromophenol Blue

SYNONYMS
C19-H10-Bi4-O5-S, "bromophenol blue", "tetraphenyl blue", "bromophenol blue Acelux", "tetrahydrophenol sulphonthalein", "3', 3', 5', 5' -tetraphenylphenol sulphonthalein", "3', 3', 5', 5' -tetrahydrophenol sulphonthalein", "4', 4' -O(1H-2', 1-benzoxathiol-3-ylii)bi(2, 6-dibromophenol) S, S'-, diode, "4', 4' -O(1H-2', 1-benzoxathiol-3-ylii)bi(2, 6-dibromophenol) S, S'-, diode, "Abutest Indicator", "pH Indicator", "Acid-Based Indicator", "R0140", "R0140"

PROPER SHIPPING NAME
ENVIRONMENTAL HAZARDOUS SUBSTANCE, SOLID, N.O.S. (contains bromophenol blue)

PRODUCT USE
Used as an acid-based indicator in the pH range 3.0-4.6 (colour change yellow to blue), Intermediate

SUPPLIER
Company: Santa Cruz Biotechnology, Inc.
Address: 2145 Delaware Ave.
Santa Cruz, CA 95060
Telephone: 800.457.3801 or 831.457.3800
Emergency Tel: Luis Yanez at 831.251.2170

HAZARD RATINGS

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammability</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Toxicity</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Body Contact</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Reactivity</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Section 2 - HAZARDS IDENTIFICATION

DANGEROUS GOODS, NON-HAZARDOUS SUBSTANCE. According to NOHSC Criteria, and ADG Code.

POISONS SCHEDULE
None

RISK

- Very toxic to aquatic organisms. May cause long-term adverse effects in the aquatic environment.
- Cumulative effects may result following exposure
- May be harmful to the foetus/embryo

SAFETY

- Avoid exposure - obtain special instructions before use.
- To clean the floor and all objects contaminated by this material use water and detergent.
- This material and its container must be disposed of in a safe way.
- Use appropriate container to avoid environment contamination.
- Avoid release to the environment. Refer to special instructions/safety data sheets.
Bromophenol Blue
sc-24971

Material Safety Data Sheet

Hazard Alert Code Key: EXTREME HIGH MODERATE LOW

- This material and its containers must be disposed of as hazardous waste.

Section 3 - COMPOSITION / INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>NAME</th>
<th>CAS RN</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromophenol Blue</td>
<td>115-39-9</td>
<td>&gt;50</td>
</tr>
</tbody>
</table>

Section 4 - FIRST AID MEASURES

SWALLOWED
- Immediately give a glass of water.
- First aid is generally not required. If in doubt, contact a Poison Information Centre or a doctor.

EYE
- If this product comes in contact with eyes:
  - Wash out immediately with water.
  - If irritation continues, seek medical attention.
  - Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

SKIN
- If skin or hair contact occurs:
  - Wash skin and hair with running water (and soap if available).
  - Seek medical attention in event of irritation.

INHALED
- If dust is inhaled, remove from contaminated area.
- Encourage patient to blow nose to ensure clear passage of breathing.
- If irritation or discomfort persists seek medical attention.

NOTES TO PHYSICIAN
- Treat symptomatically.

Section 5 - FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA
- Foam.
- Dry chemical powder.
- CO2 (where regulations permit).
- Carbon dioxide.
- Water spray or fog - Large fires only.

FIRE FIGHTING
- Alert Fire Brigade and tell them location and nature of hazard.
- Wear breathing apparatus plus protective gloves.
- Prevent by any means available, spillage from entering drains or water courses.
- Use water delivered as a fine spray, to control fire and cool adjacent area.
- Do not approach containers suspected to be hot.
- Cool fire exposed containers with water spray from a protected location.
- If safe to do so, remove containers from path of fire.
- Equipment should be thoroughly decontaminated after use.

FIRE/EXPLOSION HAZARD
-
Bromophenol Blue
sc-24971

Material Safety Data Sheet

Hazard Alert Code Key: EXTREME HIGH MODERATE LOW

- Combustible solid which burns but propagates flame with difficulty.
- Avoid generating dust, particularly clouds of dust in a confined or unventilated space as dusts may form an explosive mixture with air, and any source of ignition, i.e. flame or spark, will cause fire or explosion. Dust clouds generated by the fine grinding of the solid are a particular hazard, accumulations of fine dust (400 microns or less) may burn rapidly and fiercely if ignited. Once ignited larger particles up to 1400 microns diameter will contribute to the propagation of an explosion.
- A dust explosion may release of large quantities of gas and dust; this in turn creates a subsequent pressure rise of explosive force capable of damaging plant and buildings and injuring people.
- Usually the initial or primary explosion takes place in a confined space such as a plant or machinery, and can be of sufficient force to damage or rupture the plant. If the shock wave from the primary explosion enters the surrounding area, it will disturb any settled dust layers, forming a second dust cloud, and often initiate a much larger secondary explosion. All large-scale explosions have resulted from chain reactions of this type.
- Dry dust can be charged electrostatically by turbulence, pneumatic transport, pouring, exhaust ducts and during transport.
- Build-up of electrostatic charge may be prevented by bonding and grounding.
- Powder handling equipment such as dust collectors, dryers and mills may require additional protection measures such as explosion vents.
- All movable parts coming in contact with this material should have a speed of less than 1 meter/sec.
- Combustion products include, carbon monoxide (CO), carbon dioxide (CO2), hydrogen bromide, sulfur oxides (SOx), other pyrolys products typical of burning organic material.

FIRE INCOMPATIBILITY
- Avoid contamination with oxidising agents i.e. nitrates, oxidising acids, chlorine bleaches, pool of brine etc. as ignition may result

HAZCHEM
22

PERSONAL PROTECTION
- Glasses:                 Respirator:
- Chemical goggles:     Particulate

Section 6 - ACCIDENTAL RELEASE MEASURES

EMERGENCY PROCEDURES

MINOR SPILLS
- Environmental hazard - contain spillage.
- Clean up all spill immediately.
- Avoid contact with skin and eyes.
- Wear impervious gloves and safety glasses.
- Use dry clean up procedures and avoid generating dust.
- Vacuum up (consider explosion-proof machines designed to be grounded during storage and use).
- Do NOT use air hoses for cleaning.
- Place spilled materials in clean, dry, sealable, labeled container.

MAJOR SPILLS
- Environmental hazard - contain spillage.
- Moderate hazard.
- CAUTION: Advise personnel in area.
- Alert Emergency Services and tell them location and nature of hazard.
- Control personnel by wearing protective clothing.
- Prevent, by any means available, spillage from entering drains or water courses.
- Recover products wherever possible.
- IF DRY: Use dry clean up procedures and avoid generating dust. Collect residues and place in sealed plastic bags or other containers for disposal. IF WET: Vacuum up and place in labeled containers for disposal.
- ALWAYS: Wash area down with large amounts of water and prevent run off into drains.
- If contamination of drains or waterways occurs, advise Emergency Services.

PROTECTIVE ACTIONS FOR SPILL

WARNING
- MAY DECOMPOSE EXPLOSIONLY AT HIGH TEMPERATURES.
Bromophenol Blue

sc-24971

FOOTNOTES

1. PROTECTIVE ACTION ZONE is defined as the area in which people are at risk of harmful exposure. This zone encompasses the area downwind from the source where concentrations of the material may exceed allowable levels. The protective action zone is determined on the basis of the emission rate and the wind direction and speed. The protective action zone is divided into two zones: the immediate protective action zone and the extended protective action zone.

2. PROTECTIVE ACTIONS should be initiated to the extent possible, beginning with those closest to the spill and working away from the site in the downwind direction. Within the protective action zone, people may be at risk of inhaling or ingesting harmful substances. The protective action zone is designed to protect people from exposure to harmful substances.

3. INITIAL ISOLATION ZONE is determined as an area, including upwind of the site, within which a high probability of dispersion wind conditions may expose nearby persons without appropriate protection to levels of the material that may be harmful.

4. SMLR, small quantities of material released, involves a small quantity of material that is not considered a major spill. LADDER, Leaking Arrangement with Drums Enclosed, is used to describe a small leak that is detected early, not a major spill. WASTE, Waste, involves a small quantity of material that is not considered a major spill.

5. Guide 171 is taken from the BOSH emergency response guidebook.

6. IERG information is derived from CAN/USC - Canada/United States of America.

Personal Protective Equipment advice is contained in Section 8 of the MSDS.

Section 7 - HANDLING AND STORAGE

PROCEDURE FOR HANDLING

- Avoid all personal contact, including inhalation.
- Wear protective clothing when risk of exposure occurs.
- Use in a well-ventilated area.
- Prevent concentration in hollows and sumps.
- DO NOT enter confined spaces until atmosphere has been checked.
- DO NOT allow material to contact burners, exposed food or food utensils.
- Avoid contact with incompatible materials.
- When handling, DO NOT eat, drink or smoke.
- Keep containers securely sealed when not in use.
- Avoid physical damage to containers.
- Always wash hands with soap and water after handling.
- Work clothes should be laundered separately. Launder contaminated clothing before re-use.
- Use good occupational health practice.
- Observe manufacturer's storing and handling recommendations.
- Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
- Empty containers may contain residual dust which has the potential to accumulate following settling. Such dust may explode in the presence of an appropriate ignition source.
- Do NOT cut, drill, grind or weld such containers.
Bromophenol Blue

sc-24971

Material Safety Data Sheet

Hazard Alert Code Key:
- **EXTREME**
- **HIGH**
- **MODERATE**
- **LOW**

- In addition ensure such activity is not performed near full, partially empty or empty containers without appropriate workplace safety authorisation or permit.

SUITABLE CONTAINER
- Polyethylene or polypropylene container.
- Check all containers are clearly labelled and free from leaks.

STORAGE INCOMPATIBILITY
- Avoid reaction with oxidising agents

STORAGE REQUIREMENTS
- Store in original containers.
- Keep containers securely sealed.
- Store in a cool, dry area protected from environmental extremes.
- Store away from incompatible materials and foodstuff containers.
- Protect containers against physical damage and check regularly for leaks.
- Observe manufacturer's storing and handling recommendations

For major quantities:
- Consider storage in bunded areas - ensure storage areas are isolated from sources of community water (including stormwater, ground water, lakes and streams).
- Ensure that accidental discharge to air or water is the subject of a contingency disaster management plan; this may require consultation with local authorities.

SAFE STORAGE WITH OTHER CLASSIFIED CHEMICALS

![Chemical Symbols]

X: Must not be stored together
O: May be stored together with specific precautions
+: May be stored together

Section 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION

EXPOSURE CONTROLS
The following materials had no OELs on our records
- Bromophenol blue: CAS:115-39-9

MATERIAL DATA
BROMOPHENOL BLUE:
- It is the goal of the ACGIH (and other Agencies) to recommend TLVs (or their equivalent) for all substances for which there is evidence of health effects at airborne concentrations encountered in the workplace.
- At this time no TLV has been established, even though this material may produce adverse health effects (as evidenced in animal experiments or clinical experience). Airborne concentrations must be maintained as low as is practically possible and occupational exposure must be kept to a minimum.

NOTE: The ACGIH occupational exposure standard for Particles Not Otherwise Specified (P.N.O.S) does NOT apply.

PERSONAL PROTECTION
Bromophenol Blue

sc-24971

Material Safety Data Sheet

Hazard Alert Code Key: EXtreme HIGH MODERATE LOW

EYE

- Safety glasses with side shields.
- Chemical goggles.
- Contact lenses may pose a special hazard; soft contact lenses may absorb and concentrate irritants. A written policy document, describing the wearing of lens or restrictions on use, should be created for each workplace or task. This should include a review of lens absorption and desorption for the class of chemicals in use and an account of injury experience. Medical and first-aid personnel should be trained in their removal and suitable equipment should be readily available. In the event of chemical exposure, begin eye irrigation immediately and remove contact lens as soon as possible. Lens should be removed at the first signs of eye redness or irritation. Lens should be removed in a clean environment only after workers have washed hands thoroughly. [COS/NOHSC Current Intelligence Bulletin 81-12]

HANDS/FEET

- Suitability and durability of gloves type is dependent on usage. Factors such as:
  - frequency and duration of contact,
  - chemical resistance of glove material,
  - glove thickness and
  - suitability,

are important in the selection of gloves.
- Wear chemical protective gloves, eg. PVC.
- Wear safety footwear or safety gumboots, eg. Rubber

OTHER

- Overalls.
- P.V.C. apron.
- Barrier cream.
- Skin cleansing cream.
- Eye wash unit.

- Respirators may be necessary when engineering and administrative controls do not adequately prevent exposure.
- The decision to use respiratory protection should be based on professional judgment that takes into account toxicity information, exposure measurement data, and frequency and likelihood of the worker’s exposure – ensure users are not subject to high thermal loads which may result in heat stress or distress due to personal protective equipment (powered, positive flow, full face apparatus may be an option).
- Published occupational exposure limits, where they exist, will assist in determining the adequacy of the selected respiratory. These may be government mandated or vendor recommended.
- Certified respirators will be useful for protecting workers from inhalation of particulates when properly selected and fit tested as part of a complete respiratory protection program.
- Use approved positive flow mask if significant quantities of dust becomes airborne.
- Try to avoid creating dust conditions.

RESPIRATOR

<table>
<thead>
<tr>
<th>Protection Factor</th>
<th>Half-Face Respirator</th>
<th>Full-Face Respirator</th>
<th>Powered Air Respirator</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 x ES</td>
<td>P1 Air-line*</td>
<td>-</td>
<td>PA/P-P1*</td>
</tr>
<tr>
<td>50 x ES</td>
<td>Air-line**</td>
<td>P2</td>
<td>PA/P-P2*</td>
</tr>
<tr>
<td>100 x ES</td>
<td>-</td>
<td>P3</td>
<td>-</td>
</tr>
<tr>
<td>100 + x ES</td>
<td>-</td>
<td>Air-line*</td>
<td>-</td>
</tr>
</tbody>
</table>

* - Negative pressure demand ** - Continuous flow.

The local concentration of material, quantity and conditions of use determine the type of personal protective equipment required.
Bromophenol Blue

sc-24971

Material Safety Data Sheet

Hazard Alert Code Key:  EXTREME  HIGH  MODERATE  LOW

For further information consult site specific CHEMWATCH data (if available) or your Occupational Health and Safety Advisor.

ENGINEERING CONTROLS

- Local exhaust ventilation is required where solids are handled as powders or crystals, even when particulates are relatively large, a certain proportion will be powdered by mutual friction.
- Exhaust ventilation should be designed to prevent accumulation and recirculation of particulates in the workplace.
- If, in spite of local exhaust an adverse concentration of the substance in air could occur, respiratory protection should be considered. Such protection might consist of:
  (a) particle dust respirators, if necessary, combined with an absorption cartridge;
  (b) filter respirators with absorption cartridge or canister of the right type;
  (c) fresh-air hoods or inlets
- Build-up of electrostatic charge on the dust particle, may be prevented by bonding and grounding.
- Powder handling equipment such as dust collectors, dryer and mills may require additional protection measures such as explosion venting.
- Air contaminants generated in the workplace possess varying “escape” velocities which, in turn, determine the “capture velocities” of fresh circulating air required to efficiently remove the contaminant.

Type of Contaminant  Air Speed:

direct spray, spray painting in shallow booth; drum filling, conveyer loading, cooler dusts; gas discharge (active generation into zone of 1-2.5 m/s (600-900 ft/min))
rapid air motion

grinding, abrasive blasting, tumbling, high speed wheel generated dusts (released at high initial velocity into zone of very high rapid air motion).

Within each range the appropriate value depends on:

1. Flow air currents minimum or favourable to capture
2. Contaminants of low toxicity or of nuisance value only
3. Intermittent, low production.
4. Large hood or large air mass in motion

Simple theory shows that an air velocity falls rapidly with distance away from the opening of a simple extraction pipe. Velocity generally decreases with the square of distance from the extraction point. Therefore the air speed at the extraction point should be adjusted, accordingly, after reference to distance from the contaminating source. The air velocity at the extraction fan, for example, should be a minimum of 4-10 m/s (1500-3000 ft/min) for extraction of cooler dusts generated 2 metres distant from the extraction point. Other mechanical considerations, producing performance deficits within the extraction apparatus, make it essential that theoretical air velocities are multiplied by factors of 10 or more when extraction systems are installed or used.

Section 9 - PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE

Light pink to purple or red crystalline powder. Odourless or faint odour. Limited solubility in water (0.4g/100g water @ 20°C). Soluble in alcohols, benzene and acetic acid. (Monosodium salt is water soluble).

PHYSICAL PROPERTIES

Solid. Does not mix with water.

<table>
<thead>
<tr>
<th>State</th>
<th>Dissolved solid</th>
<th>Molecular Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting Range (°C)</td>
<td>273</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Boiling Range (°C)</td>
<td>Not applicable</td>
<td>Solubility in water (gL)</td>
</tr>
<tr>
<td>Flash Point (°C)</td>
<td>Not Available</td>
<td>pH (1% solution)</td>
</tr>
<tr>
<td>Decomposition Temp (°C)</td>
<td>273</td>
<td>pH (as supplied)</td>
</tr>
<tr>
<td>Autoignition Temp (°C)</td>
<td>Not available</td>
<td>Vapour Pressure (kPa)</td>
</tr>
<tr>
<td>Upper Explosive Limit (%)</td>
<td>Not available</td>
<td>Specific Gravity (water=1)</td>
</tr>
<tr>
<td>Lower Explosive Limit (%)</td>
<td>Not available</td>
<td>Relative Vapour Density (air=1)</td>
</tr>
</tbody>
</table>
Bromophenol Blue

Material Safety Data Sheet

Hazard Alert Code Key:  EXTREME  HIGH  MODERATE  LOW

Volatile Component (V/C): Negligible  Evaporation Rate: Not applicable

Section 10 - CHEMICAL STABILITY

CONDITIONS CONTRIBUTING TO INSTABILITY

- Presence of incompatible materials.
- Product is considered stable.
- Hazardous polymerisation will not occur.

For incompatible materials - refer to Section 7 - Handling and Storage.

Section 11 - TOXICOLOGICAL INFORMATION

POTENTIAL HEALTH EFFECTS

ACUTE HEALTH EFFECTS

SWALLOWED

- The material has NOT been classified by EC Directives or other classification systems as "harmful by ingestion". This is because of the lack of corroborating animal or human evidence. The material may still be damaging to the health of the individual, following ingestion, especially where pre-existing organ (e.g., liver, kidney) damage is evident. Present definitions of harmful or toxic substances are generally based on doses producing morbidity rather than those producing mortality (i.e., lethality). Gusto-industrial trial discomfort may produce nausea and vomiting. In an occupational setting, however, ingestion of insignificant quantities is not thought to be cause for concern.

EYE

- Although the material is not thought to be an irritant (as classified by EC Directives), direct contact with the eye may cause transient discomfort characterised by tearing or conjunctival redness (as with wound). Slight abrasion damage may also result. The material may produce foreign body irritation in certain individuals.

SKIN

- The material is not thought to produce adverse health effects or skin irritation following contact (as classified by EC Directives using animal models). Nevertheless, good hygiene practice requires that exposure be kept to a minimum and that suitable gloves be used in an occupational setting.

Open cuts, abrasions or irritated skin should not be exposed to this material.

Entry into the bloodstream, though, for example, cuts, abrasions or defects, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

INHALED

- The material is not thought to produce adverse health effects or irritation of the respiratory tract (as classified by EC Directives using animal models). Nevertheless, good hygiene practice requires that exposure be kept to a minimum and that suitable control measures be used in an occupational setting.

Persons with impaired respiratory function, allergy diseases and conditions such as asthma or chronic bronchitis, may incur further disability if excessive concentrations of particulate are inhaled.

If prior damage to the circulatory or nervous systems has occurred or if kidney damage has been sustained, proper screenings should be conducted on individuals who may be exposed to further risk if handling and use of the material result in excessive exposures.

CHRONIC HEALTH EFFECTS

- Substance accumulation in the human body may occur and may cause some concern following repeated or long-term occupational exposure.

There is some evidence from animal testing that exposure to this material may result in toxic effects to the unborn baby.

Long-term exposure to high dust concentrations may cause changes in lung function i.e., pneumoniosis, caused by particles less than 0.5 micron penetrating and remaining in the lung. Pneumoniosis symptoms include breathlessness, lung shadows shown X-ray. Chronic irritation with bronchiotics, historically, has resulted from medical use of bronchics but not from environmental or occupational exposure; depression, hallucinosis, and explosive form psychosis can be seen in the absence of other signs of intoxication. Bronchiotics may also induce sedation, irritability, agitation, delirium, memory loss, confusion, disorientation, fearfulness (apophasia), dystonia, weakness, fatigue, vertigo, stupor coma, decreased appetite, nausea and vomiting, diarrhoea, hallucinations, an acne-like rash on the face, legs and trunk, known as bromoderma (seen in 25-30% of cases involving bromides km), and profuse discharge from the nostrils (bromna). Asthma and generalised hyperaesthesia have also been observed. Generalisation of nervous symptoms with blood levels of bromide is inhibit. The use of substances such as bromphenol blue, as antihistamines, largely reflects current day usage of bromides; i.e., bromides have been largely withdrawn from therapeutic use due to their toxicity. Several cases of foetal abnormalities have been described in mothers who took large
Bromophenol Blue

Material Safety Data Sheet

sc-24971

Hazard Alert Code Key: EXTREME HIGH MODERATE LOW

doses of bromides during pregnancy.

TOXICITY AND IRRITATION

- No significant acute toxicological data identified in literature search.

Section 12 - ECOLOGICAL INFORMATION

Refer to data for ingredients, which follows:

**BROMOPHENOL BLUE**

- Very toxic to aquatic organisms.
- Do NOT allow product to come in contact with surface waters or to interstitial areas below the mean high water mark. Do not contaminate water when cleaning equipment or disposing of equipment wash water.
- Waste resulting from use of the product must be disposed of off-site or at approved waste sites.
- Bromide ion may be introduced to the environment after the dissociation of various salts and complexes or the degradation of organobromide compounds.

Although not a significant toxin in mammalian or avian systems, it is highly toxic to rainbow trout and Daphnia magra. Bromides may also affect the growth of microorganisms and have been used for this purpose in industry.

Bromides in drinking water are occasionally subject to disinfection processes involving ozone of chlorine. Bromide may be oxidised to produce hypobromous acid which in turn may react with natural organic matter to form brominated compounds. The formation of bromoform has been well documented, as has the formation of bromoacetic acids, bromopinacol, cyanogen bromide, and bromosulphone. Bromates may also be formed following chlorination or chlorination if pH is relatively high. Bromates may be killed by chlorination.

- DO NOT discharge into sewer or waterways.

Ecotoxicity

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Persistence Water/Soil</th>
<th>Persistence Air</th>
<th>Bioaccumulation</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromophenol Blue</td>
<td>HIGH</td>
<td></td>
<td></td>
<td>LOW</td>
</tr>
</tbody>
</table>

Section 13 - DISPOSAL CONSIDERATIONS

- Legislation addressing waste disposal requirements may differ by country, state and/or territory. Each user must refer to laws operating in their area. In some areas, certain wastes must be tracked.
- A hierarchy of controls exists to be considered - the user should investigate:
  - Reduction,
  - Reuse,
  - Recycling
  - Disposal (if all else fails).
  - This material may be recycled if unused, or if it has not been contaminated so as to make it unsuitable for its intended use. Shelf life considerations should also be applied in making decisions of this type. Note that properties of a material may change in use, and recycling or reuse may not always be appropriate.
  - DO NOT allow washwater from cleaning or processing equipment to enter drains.
  - It may be necessary to collect all wash water for treatment before disposal.
  - In all cases disposal to sewer may be subject to local laws and regulations and these should be considered first.
  - Where in doubt contact the responsible authority.
  - Recycle whenever possible.
  - Consult manufacturer for recycling options or consult local or regional waste management authority for disposal if no suitable treatment or disposal facility can be identified.
  - Dispose of by: Burial in a licensed landfill or incineration in a licensed apparatus (after mixing with suitable combustible material).
  - Decontaminate empty containers. Observe all label safeguards until containers are cleaned and destroyed.

Section 14 - TRANSPORTATION INFORMATION
Bromophenol Blue

sc-24971

Material Safety Data Sheet

Hazard Alert Code Key:

<table>
<thead>
<tr>
<th>EXTREME</th>
<th>HIGH</th>
<th>MODERATE</th>
<th>LGW</th>
</tr>
</thead>
</table>

- Environmentally Hazardous Substances meeting the descriptions of UN 3077 or UN 3082 are not subject to this Code when transported by road or rail in:
  - (a) packaging;
  - (b) IRCs; or
  - (c) any other receptacle not exceeding 500 kg (L)
- Australian Special Provisions (SP AU 707) - ADG Code 7th Ed.

Labels Required: MISCELLANEOUS

HAZCHEM:
- 2X (A066)
- Land Transport UNDG:
  - Class or Division: 9
  - Subsidiary Risk: None
  - UN No.: 3077
  - UN Packing Group: I
  - Shipping Name: ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S.
    - contains bromophenol blue

Air Transport IATA:
- ICAO/IATA Class: 9
- ICAO/IATA Subrisk: 1F
- UNID Number: 3077
- Packing Group: II
- Special provisions: A97
- Shipping Name: ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S. (CONTAINS BROMOPHENOL BLUE)

Maritime Transport IMDG:
- IMDG Class: 5
- IMDG Subrisk: None
- UN Number: 3077
- Packing Group: II
- EMS Number: F-A-S-F
- Special provisions: 274 309 844
- Limited Quantities: 5 kg
- Shipping Name: ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S. (contains bromophenol blue)

Section 15 - REGULATORY INFORMATION

POISONS SCHEDULE
None

REGULATIONS
bromophenol blue (CAS: 115-39-0) is found on the following regulatory lists:
- Australia Inventory of Chemical Substances (AICS)

Section 16 - OTHER INFORMATION

- Classification of the preparation and its individual components is based on official and authoritative sources as well as independent review by the Chemwatch Classification committee using available literature references.
- A list of reference resources used to assist the committee may be found at www.chemwatch.net/references.
- The WNDS is a Hazard Communication tool and should be used to assist in the Risk Assessment. Many factors determine whether the reported hazards are Risks in the workplace or other settings. Risks may be determined by reference to Exposures Scenarios. Scale of use, frequency of use, and current or available engineering controls must be considered.

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Bromophenol Blue

sc-24971

Hazard Alert Code Key:

EXTREME  HIGH  MODERATE  LOW

Issue Date: 19-May-2008
Print Date: 5-Feb-2010
A3 - Flourescein Diacetate

Flourescein Diacetate

sc-294598

Section 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME
Flourescein Diacetate

STATEMENT OF HAZARDOUS NATURE
CONSIDERED A HAZARDOUS SUBSTANCE ACCORDING TO OSHA 29 CFR 1910.1209.

NFPA

SUPPLIER
Company: Santa Cruz Biotechnology, Inc.
Address:
2145 Delaware Ave.
Santa Cruz, CA 95062
Telephone: 800-457-3801 or 831-467-3800
Emergency Tel: CHEMWATCH: From within the US and Canada:
877-715-9305
Emergency Tel: From outside the US and Canada: +800-2436 2255
(+1-800-CHEMICAL) or call +877-6573 3112

PRODUCT USE
Flourescent substrate for studies involving intracellular reactions and membrane permeability. Lipase substrate.

SYNONYMS
C24-H18-O7, 3,6-diacetoxyfluorescein, 3,6-diacetoxyfluorescin, di-o-acetyfluorescein, di-o-acetyfluorescin

Section 2 - HAZARDS IDENTIFICATION

CANADIAN WHMIS SYMBOLS

EMERGENCY OVERVIEW
RISK
POTENTIAL HEALTH EFFECTS
ACUTE HEALTH EFFECTS
Fluorescein Diacetate

Material Safety Data Sheet

sc-294598

Hazard Alert Code Key:

EXTREME
HIGH
MODERATE
LOW

The material has NOT been classified as "harmful by ingestion". This is because of the lack of corroborating animal or human evidence. The material may still be damaging to the health of the individual, following ingestion, especially where pre-existing organ (e.g., liver, kidney) damage is evident. Present definitions of harmful or toxic substances are generally based on doses producing mortality (death) rather than those producing morbidity (disease, ill-health). Gastrointestinal tract disorders may produce nausea and vomiting. In an occupational setting however, unintentional ingestion is not thought to be cause for concern.

EYE
Although the material is not thought to be an irritant, direct contact with the eye may cause transient discomfort characterized by tearing or conjunctival redness (as with windburn). Slight abrasive damage may also result. The material may produce foreign body irritation in certain individuals.

SKIN
Skin contact is not thought to have harmful health effects, however the material may still produce health damage following entry through wounds, lesions or abrasions.

There is some evidence to suggest that this material can cause inflammation of the skin on contact with some persons.

Open cuts, abrased or irritated skin should not be exposed to this material.

Entry into the bloodstream, through, for example, cuts, abrasions or lesions, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

Exposure to this product can cause sensitization of skin under sunlight. The product can reach the skin via the bloodstream either if swallowed or ingested. Swelling and redness are common; blistering may also occur. The skin may become warm and itchy. There may also be discoloration. Photosensitivity is a non-allergic condition and severity depends on the concentration of the offending chemical and the amount of radiation of particular wavelengths, usually in the UV spectrum. Sensitization develops on uncovered areas such as the hands and face; covered areas are usually spared. This is usually more the summer than the winter. Oral tar products often cause phototoxic reactions. Phototoxic compounds may show their nature either by generating free radicals or reacting directly with target molecules under UV light.

INHALED
The material is not thought to produce adverse health effects or irritation of the respiratory tract (as classified using animal models). Nevertheless, good hygiene practice requires that exposure be kept to a minimum and that suitable control measures be used in an occupational setting.

Persons with impaired respiratory function, airway diseases and conditions such as emphysema or chronic bronchitis, may incur further disability if excessive concentrations of particulate are inhaled.

Not normally a hazard due to non-volatile nature of product.

CHRONIC HEALTH EFFECTS
Limited evidence suggests that repeated or long-term occupational exposure may produce cumulative health effects involving organs or biochemical systems.

Long term exposure to high dust concentrations may cause changes in lung function (e.g., pneumoconiosis caused by particles less than 0.5 micrometer penetrating and remaining in the lung). Primary symptoms are breathlessness; long shadows see on X-ray. Exposure to small quantities may induce hyper-responsiveness characterized by acute bronchospasm, hilum (urticaria) deep thermal wheals (anaphylactic edema), running nose (rhinitis) and blunted vision. Anaphylactic shock and skin rash (non-hypersensitivity purpura) may occur. An individual may be predisposed to such anti-body mediated reaction if other chemical agents have caused prior sensitization (cross-sensitivity).

Section 3 - COMPOSITION / INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Hazard Ratings</th>
<th>Mn</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammability</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Toxicity</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Body Contact</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Reactivity</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chronicity</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NAME</th>
<th>CAS RN</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>fluorescein diacetate</td>
<td>E96-09-8</td>
<td>&gt;95</td>
</tr>
</tbody>
</table>
Section 4 - FIRST AID MEASURES

SWALLOWED
- Immediately give a glass of water.
- Firstaid is not generally required. If in doubt, contact a Poison Information Center or a doctor.

EYE
- If the product causes in contact with eyes:
  - Wash out immediately with water.
  - If irritation continues, seek medical attention.
- Removal of contact lenses after an eye injury should only be undertake by skilled personnel.

SKIN
- If skin contact occurs:
  - Immediately remove all contaminated clothing, including footwear.
  - Flush skin and hair with running water (and soap if available).
  - Seek medical attention in event of irritation.

INHALED
- If dust is inhaled, remove from contaminated area.
- Encourage patient to blow nose to ensure clear passage of breathing.
- If irritation or discomfort persists seek medical attention.

NOTES TO PHYSICIAN
- Treat symptomatically.

Section 6 - FIRE FIGHTING MEASURES

Vapour Pressure (mmHg): Not applicable.
Upper Explosive Limit (%): Not available.
Specific Gravity (water=1): Not available.
Lower Explosive Limit (%): Not available.

EXTINGUISHING MEDIA
- Water spray or fog.
- Foam.
- Dry chemical powder.
- BCF (where regulations permit).
- Carbon dioxide.

FIRE FIGHTING
- Alert Emergency Responders and tell them location and nature of hazard.
- Wear breathing apparatus plus protective gloves.
- Prevent, by any means available, spillage from entering drains or water course.
- Use water delivered as a fine spray to control fire and cool adjacent area.
- DO NOT approach containers suspected to be hot.
- Cool fireproofed containers with water spray from a protected location.
- If safe to do so, remove containers from path of fire.
- Equipment should be thoroughly decontaminated after use.

GENERAL FIRE HAZARDS/HAZARDOUS COMBUSTIBLE PRODUCTS
- Combustible solid which burns but propagates flame with difficulty.
- Avoid generating dust, particularly clouds of dust in a confined or unventilated space as dusts may form an explosive mixture with air, and any source of ignition, i.e. flame or spark, will cause fire or explosion. Dust clouds generated by the fine grinding of the solid are a particular hazard; accumulations of fine dust may burn rapidly and fiercely if ignited.
Fluorescein Diacetate
sc-294598

Material Safety Data Sheet

Hazard Alert Code Key:

EXTREME HIGH MODERATE LOW

- Dry dust can be charged electrostatically by turbulence, pneumatic transport, pouring, in exhaust ducts, and during transport.
- Build-up of electrostatic charge may be prevented by bonding and grounding.
- Powder handling equipment such as dust collectors, dryers and mills may require additional protection measures such as explosion venting.
- Combustion products include carbon monoxide (CO), carbon dioxide (CO₂), other pyrolysis products typical of burning organic material.
- May emit poisonous fumes.

FIRE INCOMPATIBILITY
- Avoid contamination with oxidizing agents i.e. nitrates, oxidizing acids, chlorine bleaches, pool chlorine etc as ignition may result.

PERSONAL PROTECTION
- Glasses:
- Chemical goggles.
- Goggles:
- Respirator:
- Particulate

Section 6 - ACCIDENTAL RELEASE MEASURES

MINOR SPILLS

- Clean up all spills immediately.
- Avoid breathing dust and contact with skin and eyes.
- Wear protective clothing, gloves, safety glasses and dust respirator.
- Use dry clean up procedures and avoid generating dust.
- Sweep up, shovel up or vacuum up (consider explosion-proof machines designed to be grounded during storage and use).
- Place spilled material in clean, citable, sealed, labeled container.

MAJOR SPILLS

- Moderate hazard.
- CAUTION: Advise personnel in area.
- Alert Emergency Responders and tell them location and nature of hazard.
- Control personnel by wearing protective clothing.
- Prevent, by any means available, spillage from entering drains or watercourses.
- Recover product whenever possible.
- IF Dry: Use dry clean up procedures and avoid generating dust. Collect residues and place in sealed plastic bags or other containers for disposal.
- IF WET: Vacuum/shovel up and place in labeled containers for disposal.
- ALWAYS: Wash area down with large amounts of water and prevent runoff into drains.
- If contamination of drains or waterways occurs, advise emergency services.

ACUTE EXPOSURE GUIDELINE LEVELS (AEGL) (in ppm)

AEGL 1: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience reliable discomfort, irritation, or certain asymptomatic sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL 2: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience impermanent or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL 3: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Section 7 - HANDLING AND STORAGE

PROCEDURE FOR HANDLING

-
Fluorescein Diacetate

Material Safety Data Sheet

sc-294598

Hazard Alert Code Key:

- **EXTREME**
- **HIGH**
- **MODERATE**
- **LOW**

- Avoid all personal contact, including inhalation.
- Wear protective clothing when risk of exposure occurs.
- Use in a well-ventilated area.
- Prevent concentration in hollows and sumps.
- DO NOT enter confined spaces until atmosphere has been checked.
- DO NOT allow material to contact humans, exposed food or food utensils.
- Avoid contact with incompatible materials.
- When handling, DO NOT eat, drink or smoke.
- Keep containers securely sealed when not in use.
- Avoid physical damage to containers.
- Always wash hands with soap and water after handling.
- Work clothes should be laundered separately.
- Launder contaminated clothing before re-use.
- Use good occupational work practice.
- Observe manufacturer's storing and handling recommendations.
- Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.

Empty containers may contain residual dust which has the potential to accumulate following settling. Such dusts may explode in the presence of an appropriate ignition source.

- Do NOT cut, drill, grind or weld such containers.
- In addition ensure such activity is not performed near full, partially empty or empty containers without appropriate workplace safety authorisation or permit.

**RECOMMENDED STORAGE METHODS**

- Glass container.
- Polyethylene or polypropylene container.
- Check all containers are clearly labelled and free from leaks.

**STORAGE REQUIREMENTS**

- Store in original containers.
- Keep containers securely sealed.
- Store in a cool, dry, well-ventilated area.
- Store away from incompatible materials and foodstuffs contents.
- Protect containers against physical damage and check regularly for leaks.
- Observe manufacturer's storing and handling recommendations.

**SAFE STORAGE WITH OTHER CLASSIFIED CHEMICALS**

| X | + | + | + | + | X | + |

X: Must not be stored together
O: May be stored together with specific precautions
+: May be stored together

**Section 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION**

**EXPOSURE CONTROLS**

<table>
<thead>
<tr>
<th>Source</th>
<th>Material</th>
<th>TWA ppm</th>
<th>TWA mg/m³</th>
<th>STEL ppm</th>
<th>STEL mg/m³</th>
<th>Peak ppm</th>
<th>Peak mg/m³</th>
<th>TWA F/CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>US - Oregon Permissible</td>
<td>Fluorescein diacetate (Inert or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure Limits (25)</td>
<td>Nuisance Dust: (d) Total dust)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fluorescein Diacetate

sc-294598

Material Safety Data Sheet

<table>
<thead>
<tr>
<th>Hazard Alert Code Key</th>
<th>EXTREME</th>
<th>HIGH</th>
<th>MODERATE</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>US OSHA Permissible Exposure Levels (PELs) - Table Z3</td>
<td>fluorescein diacetate [enriched] dust (a) total dust</td>
<td>5</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>US - Hawaii Air Contaminant Limits</td>
<td>fluorescein diacetate [enriched] dust (b) total dust</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US - Oregon Permissible Exposure Limits (LEL)</td>
<td>fluorescein diacetate [enriched] dust (b) total dust</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US - Tennessee Occupational Exposure Limits - LEL Airborne Contaminants</td>
<td>fluorescein diacetate [enriched] dust (b) total dust</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US - Wisconsin Exposure Limits for Air Contaminants</td>
<td>fluorescein diacetate [enriched] dust (b) total dust</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MATERIAL DATA

FLUORESCIN DIACETATE:
- It is the goal of the ACGIH (and other Agencies) to recommend TLVs (or their equivalent) for all substances for which there is evidence of health effects at airborne concentrations encountered in the workplace.
- At this time no TLV has been established, even though this material may produce adverse health effects (as evidenced in animal experiments or clinical experience). All recommended concentrations must be maintained as low as is technically and commercially practical and occupational exposure must be kept to a minimum.
- NOTE: The ACGIH occupational exposure standard for Particles Not Otherwise Specified (P.N.O.S) does NOT apply.
- Sensory irritants are chemicals that produce temporary and undesirable side-effects on the eyes, nose, or throat. Historically occupational exposure standards for these irritants have been based on observation of workers' responses to various airborne concentrations. Present day expectations require that nearly every individual should be protected against even minor sensory irritation and exposure standards are established using an irritancy index factor of 3 to 10 or more. On occasion animal no-observed-effect levels (NOEL) are used to determine these limits where human results are unavailable. An additional approach, typically used by the TLV committee (USA) in determining respiratory exposure standards for this group of chemicals, has been to assign ceiling values (TLV C) to rapidly acting irritants and to assign short-term exposure limits (TLV STELs) when the weight of evidence from irritation, bioaccumulation and other effects combine to warrant such a limit. In contrast the MAK Commission (Germany) uses a three-category system based on irritative, local irritation, and elimination half-life. However this system is being replaced to be consistent with the European Union (EU) Scientific Committee for Occupational Exposure Limits (SCHEL), which is more closely allied to that of the USA.
- OSHA (USA) concluded that exposure to sensory irritants can:
  - cause inflammation
  - cause increased susceptibility to other irritants and toxic agents
  - lead to permanent impairment or death
  - permit greater absorption of hazardous substances and
  - accentuate the worker in the irritant warning properties of these substances thus increasing the risk of overexposure.

PERSONAL PROTECTION
Fluorescein Diacetate

sc-294598

Hazard Alert Code Key: EXTREME HIGH MODERATE LOW

Consult your EHS staff for recommendations

EYE

- Safety glasses with side shields.
- Chemical goggles.
- Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. DO NOT wear contact lenses.

HANDS/FEET

- Suitability and durability of glove type is dependent on usage. Important factors in the selection of gloves include: such as:
  - frequency and duration of contact;
  - chemical resistance of glove material;
  - glove thickness and
  - dexterity

Select gloves tested to a relevant standard (e.g. Europe EN 374, US F738).
- When prolonged or frequently repeated contact may occur, a glove with a protection class of 5 or higher (breakthrough time greater than 240 minutes according to EN 374) is recommended.
- When only brief contact is expected, a glove with a protection class of 3 or higher (breakthrough time greater than 60 minutes according to EN 374) is recommended.
- Contaminated gloves should be replaced.

Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended.

Experience indicates that the following polymers are suitable as glove materials for protection against undissolved, dry solids, where abrasive particles are not present:
- polyvinylpyrrolidone
- nitrile rubber
- butyl rubber
- fluoroelastomer
- polyvinyl chloride

Gloves should be examined for wear and/or degradation constantly.

OTHER

- Overalls.
- F.V.G. apron.
- Barrier cream.
- Skin cleansing cream.
- Eye wash unit.

Respirators may be necessary when engineering and administrative controls do not adequately prevent exposures.

The decision to use respiratory protection should be based on professional judgment that takes into account toxicity information, exposure measurement data, and frequency and likelihood of the worker's exposure - ensure users are not subjected to high thermal loads which may result in heat stress or distress due to personal protective equipment (powered, positive flow, full face apparatus may be an option).

Published occupational exposure limits, where they exist, will assist in determining the adequacy of the selected respiratory protection. These may be government mandated or vendor recommended.

Certified respirators will be useful for protecting workers from inhalation of particulates when properly selected and fitted as part of a complete respiratory protection program.

Use approved positive flow mask if significant quantities of dust becomes airborne.

Try to avoid creating dust conditions.

RESPIRATOR
**Fluorescein Diacetate**

**sc-294598**

<table>
<thead>
<tr>
<th>Hazard Alert Code Key</th>
<th>EXTREME</th>
<th>HIGH</th>
<th>MODERATE</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection Factor</td>
<td>Half-Face Respirator</td>
<td>Full-Face Respirator</td>
<td>Powered Air Respirator</td>
<td></td>
</tr>
<tr>
<td>10 x PEL</td>
<td>P1</td>
<td>-</td>
<td>-</td>
<td>PAPR-P1</td>
</tr>
<tr>
<td>50 x PEL</td>
<td>Air-line*</td>
<td>-</td>
<td>-</td>
<td>PAPR-P2</td>
</tr>
<tr>
<td>100 x PEL</td>
<td>Air-line**</td>
<td>P2</td>
<td>-</td>
<td>PAPR-P3</td>
</tr>
<tr>
<td>100+ x PEL</td>
<td>-</td>
<td>P3</td>
<td>-</td>
<td>PAPR-P3</td>
</tr>
</tbody>
</table>

* - Negative pressure demand  **- Continuous flow

**Explanation of Respirator Codes:**
- Class 1 low to medium absorption capacity filters.
- Class 2 medium absorption capacity filters.
- Class 3 high absorption capacity filters.
- PAPR Powered Air Purifying Respirator (positive pressure) cartridge.
- Type A for use against certain organic gases and vapors.
- Type AX for use against low boiling point organic compounds (less than 65°C).
- Type B for use against certain inorganic gases and other acid gases and vapors.
- Type E for use against sulfur dioxide and other acid gases and vapors.
- Type K for use against ammonia and organic amine derivatives.

Class P1 intended for use against mechanically generated particulates of sizes most commonly encountered in industry, e.g., asbestos, silica.
Class P2 intended for use against mechanically and thermally generated particulates, e.g., metal fume.
Class P3 intended for use against all particulates containing high toxic materials, e.g., benzyl.

The local concentration of material, quantity and conditions of use determine the type of personal protective equipment required.

Use appropriate NIOSH-certified respirator based on informed professional judgment. In conditions where no reasonable estimate of exposure can be made, assume the exposure is in a concentration IDLH and use NIOSH-certified full face pressure demand SCBA with a minimum service life of 30 minutes, or a combination full face pressure demand SAR with auxiliary self-contained air supply. Respirators provided only for escape from IDLH atmospheres shall be NIOSH-certified for escapes from the atmospheres in which they will be used.

**ENGINEERING CONTROLS**

- Local exhaust ventilation is required where solids are handled as powders or crystals; even when particulates are relatively large, a certain portion will be powdered by mutual friction.
- Exhaust ventilation should be designed to prevent accumulation and reaccumulation of particulates in the workplace.
- If in spite of local exhaust, an advance concentration of the substance in air could occur, respiratory protection should be considered. Such protection might consist of:
  - (a) half-mask respirators, if necessary, combined with an absorption cartridge;
  - (b) respirators with an absorption cartridge or canister of the right type;
  - (c) fresh-air hoods or masks.
- Build-up of electrostatic charge on the dust particle may be prevented by bonding and grounding.
- Powder handling equipment such as dust collectors, dryers, and mills may require additional protection measures such as explosion venting.
- Air contaminants generated in the workplace process varying “escape” velocities which, in turn, determine the “capture velocities” of fresh circulating air to efficiently remove the contaminant.

**Type of Contaminant**: Air Speed:

- Direct spray, spray painting in shallow booths, drum filling, conveyors, loading, crushing, dusts, gas discharge (active generation into contact) 1-2.5 m/s (200-500 ft/min) rapid action
- Grinding, abrasive blasting, tumbling, high-speed wheel generated dusts (released at high initial velocity in zone of very high air motion) 2.5-10 m/s (500-2000 ft/min)

**Within each range the appropriate value depends on:**

- *Lower end of the range*
- *Upper end of the range*
- 1: Room air currents, minimal or favorable to capture
- 2: Contaminants of low toxicity or of nuisance value only
- 3: Intermittent, low production
- 4: Large hood or air current in motion

Simple theory shows that air velocity falls rapidly with distance away from the opening of a simple extraction pipe. Velocity generally decreases with the square of distance from the extraction point (in simple cases). Therefore the air speed at the extraction point should be
Section 9 - Physical and Chemical Properties

**Physical Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>Mixture with water</td>
</tr>
<tr>
<td>Melting Range (°F)</td>
<td>343–397.4</td>
</tr>
<tr>
<td>Boiling Range (°F)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Flash Point (°F)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Decomposition Temp (°F)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Autoignition Temp (°F)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Upper Explosive Limit (%)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Lower Explosive Limit (%)</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

**Appearance**

Light yellow powder; mixture with water. No odor.

Section 10 - Chemical Stability

**Conditions Contributing to Instability**

- Presence of incompatible materials
- Product is considered stable
- Hazardous polymerization will not occur

**Storage Incompatibility**

Avoid reaction with oxidizing agents.

For incompatible materials - refer to Section 7 - Handling and Storage.

Section 11 - Toxicological Information

Fluorescein diacetate is a hazardous substance. It is highly toxic by ingestion, inhalation, and skin contact. It is also easily absorbed through the skin. Inhalation of the dust can cause respiratory irritations, including coughing, wheezing, and chest tightness. The symptoms are usually temporary and disappear within a few hours. However, repeated or prolonged exposure may lead to chronic respiratory problems.

**Toxicity and Irritation**

- Skin: Fluorescein diacetate is a skin irritant. It can cause redness, itching, and swelling.
- Eye: Fluorescein diacetate is a strong eye irritant. It can cause pain, burning, and incapacitating vision.
- Inhalation: Fluorescein diacetate is a respiratory irritant. It can cause coughing, sneezing, and difficulty breathing.
- Ingestion: Fluorescein diacetate is a severe irritant to the digestive system. It can cause nausea, vomiting, and abdominal pain.

**For Fluorescein**

- Inhalation: Inhalation of fluorescein diacetate dust can cause respiratory irritation, including coughing, wheezing, and chest tightness. The symptoms are usually temporary and disappear within a few hours. However, repeated or prolonged exposure may lead to chronic respiratory problems.
- Ingestion: Ingestion of fluorescein diacetate can cause severe stomach irritation, including nausea, vomiting, and abdominal pain. It is also a potential carcino gen, and can cause cancer if ingested continuously over a long period of time.
- Skin: Fluorescein diacetate can cause skin irritation, including redness, itching, and swelling. It can also cause skin irritation and dermatitis.

**Reactivity**

Fluorescein diacetate is a strong oxidizer and should be stored away from reducing agents. It should be kept away from incompatible materials and should not be mixed with water or other substances.

**Precautions**

- Use in a well-ventilated area.
- Wear appropriate protective clothing and eyewear.
- Avoid contact with skin, eyes, and mouth.
- In case of spill, flush with大量 water.
- In case of ingestion, seek medical attention immediately.
- In case of respiratory irritation, seek medical attention immediately.
- In case of skin irritation, seek medical attention immediately.
- In case of eye irritation, seek medical attention immediately.

**Emergency Response**

- Call emergency services immediately in case of an accident.
- Ensure a proper working environment and immediate evacuation.
- Provide appropriate medical treatment.

**Disposal**

- Disposal should be in accordance with local regulations.
- Avoid mixing with other hazardous materials.
- Do not incinerate or flush down the drain.

**References**

- RTECS - Register of Toxic Effects of Chemical Substances.
- Other sources as appropriate.
Fluorescein Diacetate

Section 12 - ECOLOGICAL INFORMATION

Refer to data for ingredients, which follows:

**FLUORESCINE DIACETATE:**
- DO NOT discharge into sewer or waterways.

### Ecotoxicity

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Persistence: Water/Soil</th>
<th>Persistence: Air</th>
<th>Bioaccumulation</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>fluorescein diacetate</td>
<td>HIGH</td>
<td></td>
<td>LOW</td>
<td>LOW</td>
</tr>
</tbody>
</table>

Section 13 - DISPOSAL CONSIDERATIONS

Disposal Instructions

All waste must be handled in accordance with local state and federal regulations.

- Legislation addressing waste disposal requirements may differ by country, state, and/or territory. Each user must refer to laws operating in their area. In some areas, certain wastes must be treated.
- A hierarchy of controls seems to be common - the user should investigate:
  - Reduction
  - Reuse
  - Recycling
  - Disposal (Fall back)

This material may be recycled if unused, or if it has not been contaminated so as to make it unsuitable for its intended use. Shelf life considerations should also be applied in making decisions of this type. Note that properties of a material may change in use, and recycling or reuse may not always be appropriate.

- DO NOT allow washwater from cleaning equipment to enter drains. Collect all wash water for treatment before disposal.
- Recycle whenever possible.
- Consult manufacturer for recycling options or consult Waste Management Authority for disposal if no suitable treatment or disposal facility can be identified.
- Dispose of by burial in a licensed landfill or incineration in a licensed incinerator (after admixture with suitable combustible material).
- Discontinue use of empty containers. Observe all label safeguards until containers are cleansed and destroyed.

Section 14 - TRANSPORTATION INFORMATION

NOT REGULATED FOR TRANSPORT OF DANGEROUS GOODS: DOT, IATA, IMDG

Section 15 - REGULATORY INFORMATION

fluorescein diacetate (CAS: 566-09-8) is found on the following regulatory lists:
- "Canada Domestic Substances List (DSL)", "U.S Toxic Substances Control Act (TSCA) - Inventory"

Section 16 - OTHER INFORMATION

LIMITED EVIDENCE

- Cumulative effects may result following exposure.
- May produce skin discomfort.
Fluorescein Diacetate

sc-294598

Hazard Alert Code Key: EXTREME HIGH MODERATE LCW

* (limited evidence)

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Classification of the mixture and its individual components has drawn on official and authoritative sources as well as independent review by the Chemwatch Classification committee using available literature references. A list of reference resources used to assist the committee may be found at: www.chemwatch.net/references.

The NIOSH is a Hazard Communication tool and should be used to assist in the Risk Assessment. Many factors determine whether the reported Hazards are Risks in the workplace or other settings. Risks may be determined by reference to Exposures Scenarios. Scale of use, frequency of use and current or available engineering controls must be considered.

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Issue Date: Oct-24-2009
Print Date: May-22-2010
A4 - Janus Green B

Janus Green B
sc-203740

Section 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME
Janus Green B

STATEMENT OF HAZARDOUS NATURE

NFPA

SUPPLIER
Santa Cruz Biotechnology, Inc.
2145 Delaware Avenue
Santa Cruz, California 95060
800-457-2801 or 831-457-2800
EMERGENCY
ChemWatch
Within the US & Canada: 877-745-0305
Outside the US & Canada: +800-243-2285
(1-800-CHEMALL) or call +1-315-387-3112

SYNONYMS
O2O-101-01-55: "Phenazinum.", "3-(diethylamino)-7"-(p-dimethylaminophenyl)-azo-8-phenyl-
"N1": "3-(diethylamino)-7"-(p-dimethylaminophenyl)azo-8-phenylphenazinium
"O1": "3-dimethylamino-7"-(4-dimethylamino phenylazo)-8-
phenylphenazinium chloride", "Janus Green V"

Section 2 - HAZARDS IDENTIFICATION

CHEMWATCH HAZARD RATINGS

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammability</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Toxicity</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Bodily Contact</td>
<td>0</td>
<td>Min/All-0 Low-1 Moderate-2 High-3</td>
</tr>
<tr>
<td>Reactivity</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Corrosive</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

CANADIAN WHMIS SYMBOLS
EMERGENCY OVERVIEW
RISK
Cumulative effects may result following exposure*.
* (limited evidence).

POTENTIAL HEALTH EFFECTS
ACUTE HEALTH EFFECTS

SWALLOWED
- The material has NOT been classified by EC Directives or other classification systems as "harmful by ingestion".
  This is because of the lack of corroborating animal or human evidence.

EYE
- Although the material is not thought to be an irritant (as classified by EC Directives), direct contact with the eye may cause transient discomfort characterized by tearing or conjunctival redness (as with windows).
  Slight abrasive damage may also result.

SKIN
- The material is not thought to produce adverse health effects or skin irritation following contact (as classified by EC Directives using animal models).
  Nevertheless, good hygiene practice requires that exposure be kept to a minimum and that suitable gloves be used in an occupational setting.
- Open cuts, abrasions or irritated skin should not be exposed to this material.
- Entry into the blood-stream, though, for example, cuts, abrasions or lesions, may produce systemic injury with harmful effects.
  Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

INHALED
- The material is not thought to produce adverse health effects or irritation of the respiratory tract (as classified by EC Directives using animal models).
  Nevertheless, good hygiene practice requires that exposure be kept to a minimum and that suitable control measures be used in an occupational setting.
- Persons with impaired respiratory function, asthma and other respiratory conditions such as emphysema or chronic bronchitis, may incur further disability if excessive concentrations of particulate are inhaled.
  If prior damage to the circulatory or nervous systems has occurred or if kidney damage has been sustained, proper screenings should be conducted on individuals who may be exposed to further risk if handling and use of the material result in excessive exposures.

CHRONIC HEALTH EFFECTS
- Substances accumulated, in the human body, may occur and may cause some concern following repeated or long-term occupational exposure.
- Long term exposure to high dust concentrations may cause changes in lung function (i.e. pneumoconiosis; caused by particles less than 0.5 micron perforating and remaining in the lung). A local symptom is breathlessness; long shadows show on X-ray.
- Animal testing has shown that many azo dyes have cancer-causing activity affecting the liver, bladder and gut. Specific effects in humans are unclear, but some dyes are known to cause mutations. Benzidine and its metabolic products have been detected in the urine of workers exposed to dyes azo dyes. Studies have shown a relationship between exposure to benzidine and the development of bladder cancer.
- The azo dyes which are simpler in structure have a specific group that is the responsible for any cancer-causing activity. This group undergoes biochemical oxidation and further reaction to form reactive electrophiles. The DNA adducts formed in this way have been identified. However, this activity is not found in all azo compounds, and, subtle changes to structure can change the cancer-causing activity of the compound, thereby reducing or eliminating it. Complex dyes with more than one azo linkage (double bond between two nitrogen atoms) may be metabolized to produce toxic cancer-causing aromatic amines, such as benzidine.

Section 3 - COMPOSITION / INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>NAME</th>
<th>CAS RN</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Janus Green B</td>
<td>2863-83-2</td>
<td>&gt;98</td>
</tr>
</tbody>
</table>

Section 4 - FIRST AID MEASURES

SWALLOWED
- Immediately give a glass of water.
First aid is not generally required. If in doubt, contact a Poisons Information Centre or a doctor.

EYE
If this product comes in contact with eyes:
- Wash out immediately with water.
- If irritation continues, seek medical attention.
- Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

SKIN
If skin or hair contact occurs:
- Flush skin and hair with running water (and soap if available).
- Seek medical attention in event of irritation.

INHALED
- If dust is inhaled, remove from contaminated area.
- Encourage patient to blow nose to ensure clear passage of breathing.
- If irritation or discomfort persists seek medical attention.

NOTES TO PHYSICIAN
- Periodic medical surveillance should be carried out on persons in occupations exposed to the manufacture or bulk handling of the product and this should include hepatic function tests and urinalysis examination. [ILO Encyclopaedia].

### Section 5 - FIRE FIGHTING MEASURES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vapour Pressure (mmHg)</td>
<td>Negligible</td>
</tr>
<tr>
<td>Upper Explosive Limit (%)</td>
<td>Not available</td>
</tr>
<tr>
<td>Specific Gravity (water=1)</td>
<td>Not available</td>
</tr>
<tr>
<td>Lower Explosive Limit (%)</td>
<td>Not available</td>
</tr>
</tbody>
</table>

**EXTINGUISHING MEDIA**
- Foam.
- Dry chemical powder.
- BCF (where regulations permit).
- Carbon dioxide.

**FIRE FIGHTING**
- Alert Fire Brigade and tell them location and nature of hazard.
- Wear breathing apparatus plus protective gloves.
- Prevent, by any means available, spillage from entering drains or water courses.
- Use water delivered as a fine spray to control fire and cool adjacent areas.

**GENERAL FIRE HAZARDS/HAZARDOUS COMBUSTIBLE PRODUCTS**
- Combustible solid which burns but propagates flame with difficulty; it is estimated that most organic dusts are combustible (circa 70%) - according to the circumstances under which the combustion process occurs, such materials may cause fires and dust explosions.
- Avoid generating dust, particularly clouds of dust in a confined or unventilated space as dusts may form an explosive mixture with air, and any source of ignition, i.e. flame or spark, will cause fire or explosion. Dust clouds generated by the fine grinding of the solid are a particular hazard; accumulations of fine dust (420 micron or less) may burn rapidly and fiercely if ignited - particles exceeding this limit will generally not form flammable dust clouds; once ignited, however, larger particles up to 1400 microns diameter will contribute to the propagation of an explosion.
- In the same way as gases and vapours, dusts in the form of a cloud are only ignitable over a range of concentrations; in principle, the concepts of lower explosive limit (LEL) and upper explosive limit (UEL) are applicable to dust clouds but only the LEL is of practical use; this is because of the inherent difficulty of achieving homogeneous dust clouds at high temperatures (for dusts the LEL is often called the "Minimum Explosible Concentration", MEC)
- A dust explosion may release of large quantities of gaseous products; this in turn creates a subsequent pressure rise of explosive force capable of damaging plant and buildings and injuring people.

Combustion products include: carbon monoxide (CO), carbon dioxide (CO2), hydrogen chloride, phosgene, nitrogen oxides (NOx), other pyrolysis products typical of burning organic material.
- May emit poisonous fumes.

**FIRE INCOMPATIBILITY**
- Avoid contamination with oxidising agents i.e. nitrates, oxidising acids, chlorinated bleaches, pool chlorines etc. as ignition may result.

### Section 6 - ACCIDENTAL RELEASE MEASURES

**MINOR SPILLS**
- Clean up all spills immediately.
- Avoid breathing dust and contact with skin and eyes.
- Wear protective clothing, gloves, safety glasses and dust respirator.
Section 7 - HANDLING AND STORAGE

PROCEDURE FOR HANDLING
- Avoid all personal contact, including inhalation.
- Wear protective clothing when risk of exposure occurs.
- Use in a well-ventilated area.
- Prevent concentration in hollows and sumps.
- Empty containers may contain residual dust which has the potential to accumulate following settling. Such dusts may explode in the presence of an appropriate ignition source.
- Do not cut, drill, grind or weld such containers.
- In addition ensure such activity is not performed near full, partially empty or empty containers without appropriate workplace safety authorisation or permit.

RECOMMENDED STORAGE METHODS
- Polyethylene or polypropylene container.
- Check all containers are clearly labelled and free from leaks.

STORAGE REQUIREMENTS
- Store in original containers.
- Keep containers securely sealed.
- Store in a cool, dry, well-ventilated area.
- Store away from incompatible materials and foodstuffs.
- Store at 4 °C.

Section 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION

EXPOSURE CONTROLS
The following materials had no OELs on our records
- Janus Green B: CAS: 2869-83-2

PERSONAL PROTECTION

RESPIRATOR
- Particulate: (AS/NZS 1716 & 1715, EN 143 2006 & 149 2001, ANSI Z88 or national equivalent)

EYE
- Safety glasses with side shields.
- Chemical goggles.
- Contact lenses may pose a special hazard; soft contact lenses may absorb and concentrate irritants. A written policy document, describing the wearing of lens or restrictions on use, should be created for each workplace or task. This should include a review of lens absorption and absorption for the class of chemicals in use and an account of injury experience. Medical and first-aid personnel should be trained in their removal and suitable equipment should be readily available. In the event of chemical exposure, begin eye irrigation immediately and remove contact lenses as soon as practicable. Lenses should be removed at the first signs of eye redness or irritation - lens should be removed in a clean environment only after workers have washed hands thoroughly. [CDC NIOSH Current Intelligence Bulletin 58, [AS/NZS 1336 or national equivalent]

HANDS/FEET
Suitability and durability of glove type is dependent on usage. Important factors in the selection of gloves include:
- frequency and duration of contact,
- chemical resistance of glove material,
- glove thickness and
dust tightness

Experience indicates that the following polymers are suitable as glove materials for protection against undissolved, dry solids, where abrasive particles are not present.
- polychloroprene
- nitrile rubber
- butyl rubber
- fluorocarbon rubber

OTHER
- Overalls.
- P.V.C. apron.
- Barrier cream.
- Skin cleansing cream.

ENGINEERING CONTROLS
- Engineering controls are used to remove a hazard or place a barrier between the worker and the hazard. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions to provide this high level of protection.
- The basic types of engineering controls are:
  - Process controls which involve changing the way a job activity or process is done to reduce the risk.
  - Enclosure and/or isolation of emission source which keeps a selected hazard "physically" away from the worker and ventilation that strategically "adds" and "removes" air in the work environment.

### Section 9 - PHYSICAL AND CHEMICAL PROPERTIES

**PHYSICAL PROPERTIES**

Solid.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>Divided solid</td>
</tr>
<tr>
<td>Melting Range (°F)</td>
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</tr>
<tr>
<td>Boiling Range (°F)</td>
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</tr>
<tr>
<td>Flash Point (°F)</td>
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<tr>
<td>Decomposition Temp (°F)</td>
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<tr>
<td>Autoignition Temp (°F)</td>
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</tr>
<tr>
<td>Upper Explosive Limit (%)</td>
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<td>Lower Explosive Limit (%)</td>
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<tr>
<td>Solubility in water (g/L)</td>
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<tr>
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<tr>
<td>pH (as supplied)</td>
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<tr>
<td>Vapour Pressure (mmHg)</td>
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<tr>
<td>Specific Gravity (water=1)</td>
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<tr>
<td>Relative Vapour Density (air=1)</td>
<td>&gt;1</td>
</tr>
<tr>
<td>Evaporation Rate</td>
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</table>

**APPEARANCE**

Powder; does not mix well with water.

### Section 10 - CHEMICAL STABILITY

**CONDITIONS CONTRIBUTING TO INSTABILITY**

- Presence of incompatible materials.
- Product is considered stable.
- Hazardous polymerisation will not occur.

**STORAGE INCOMPATIBILITY**

- Toxic gases are formed by mixing azo and azido compounds with acids, aldehydes, amides, carbamates, cyanides, inorganic fluorides, halogenated organics, isocyanates, ketones, metals, nitriles, peroxides, phenols, epoxides, acyl halides, and strong oxidising or reducing agents.
- Flammable gases are formed by mixing azo and azido compounds with alkali metatals.
- Explosive combination can occur with strong oxidising agents, metal salts, peroxides, and sulfides.
- Azo, diazo and azido compounds can detonate especially where organic azides have been sensitised by the addition of metal salts or strong acids.
- Avoid reaction with oxidising agents.
For incompatible materials - refer to Section 7 - Handling and Storage.

Section 11 - TOXICOLOGICAL INFORMATION
Janus Green B

TOXICITY AND IRRITATION
No data for this material.

Section 12 - ECOLOGICAL INFORMATION

No data

Ecotoxicity

<table>
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<th>Ingredient</th>
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<th>Persistence: Air</th>
<th>Bioaccumulation</th>
<th>Mobility</th>
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<td>HIGH</td>
<td>No Data Available</td>
<td>LOW</td>
<td>LOW</td>
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</table>

Section 13 - DISPOSAL CONSIDERATIONS

Disposal Instructions
All waste must be handled in accordance with local, state and federal regulations. Legislation addressing waste disposal requirements may differ by county, state and/or territory. Each user must refer to laws operating in their area. In some areas, certain wastes must be tracked. A Hierarchy of Controls seems to be common - the user should investigate:
- Reduction
- Reuse
- Recycling
- Disposal (if all else fails)

This material may be recycled if unused, or if it has not been contaminated so as to make it unsuitable for its intended use. Shelf life considerations should also be applied in making decisions of this type. Note that properties of a material may change in use, and recycling or reuse may not always be appropriate. In most instances the supplier of the material should be consulted.
- DO NOT allow wash water from cleaning or process equipment to enter drains.
- It may be necessary to collect all wash water for treatment before disposal.
- In all cases disposal to sewer may be subject to local laws and regulations and these should be considered first.
- Where in doubt contact the responsible authority.
- Recycle wherever possible.
- Consult manufacturer for recycling options or consult local or regional waste management authority for disposal if no suitable treatment or disposal facility can be identified.
- Dispose of by: burial in a land-fill specifically licenced to accept chemical and/or pharmaceutical wastes or incineration in a licenced apparatus (after admixture with suitable combustible material)
- Discontinue empty containers. Observe all label safeguards until containers are cleaned and destroyed.

Section 14 - TRANSPORTATION INFORMATION

NOT REGULATED FOR TRANSPORT OF DANGEROUS GOODS: DOT, IATA, IMDG

Section 15 - REGULATORY INFORMATION

Janus Green B (CAS: 2869-83-2) is found on the following regulatory lists:
- "Canada - Alberta Air Quality Guidelines",
- "Canada - Alberta Ambient Air Quality Objectives",
- "Canada - British Columbia Occupational Exposure Limit",
- "Canada - Ontario Occupational Exposure Limit",
- "Canada - Quebec Permissible Exposure Values for Airborne Contaminants (English)",
- "Canada CEPA Environmental Registry Substance Lists - List of substances on the DSL that are Inherently Toxic to the Environment (English)",
- "Canada CEPA Environmental Registry Substance Lists - List of substances on the DSL that are Inherently Toxic to the Environment - (French)",
- "Canada CEPA Environmental Registry Substance Lists - List of substances on the DSL that are Persistent and Inherently Toxic to the Environment (PIT) (English)",
- "Canada CEPA Environmental Registry Substance Lists - List of substances on the DSL that meet the ecological criteria for categorization (English)",
- "Canada Domestic Substances List (DSL)",
- "Canada List of Prohibited and Restricted Cosmetic Ingredients (The Cosmetic Ingredient ""Hollist")",
- "Canada National Pollutant Release Inventory (NPR)",
- "Canada Toxicological Index Service - Workplace Hazardous Materials Information System - WHMIS (English)",
- "US - California Permissible Exposure Limits for Chemical Contaminants",
- "US - Michigan Exposure Limits for Air Contaminants",
- "US - Oregon Permissible Exposure Limits (Z-1)",
- "US - Tennessee Occupational Exposure Limits - Limits For Air"
LIMITED EVIDENCE

- Cumulative effects may result following exposure.
  *(limited evidence).*

Denmark Advisory list for selfclassification of dangerous substances

<table>
<thead>
<tr>
<th>Substance</th>
<th>CAS</th>
<th>Suggested codes</th>
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<tr>
<td>Janus Green B</td>
<td>2869-83-2</td>
<td>N, R50/53</td>
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</table>

- Classification of the preparation and its individual components has been drawn on official and authoritative sources as well as independent review by the Chemwatch Classification committee using available literature references.

- A list of reference resources used to assist the committee may be found at:
  www.chemwatch.net/references.

- The (MSDS) is a Hazard Communication tool and should be used to assist in the Risk Assessment. Many factors determine whether the reported Hazards are Risks in the workplace or other settings.

- For detailed advice on Personal Protective Equipment, refer to the following U.S. Regulations and Standards:
  OSHA Standards - 29 CFR:
  1910.132 - Personal Protective Equipment - General requirements
  1910.133 - Eye and face protection
  1910.134 - Respiratory Protection
  1910.135 - Occupational foot protection
  1910.138 - Hand Protection
  Eye and face protection - ANSI Z87.1
  Foot protection - ANSI Z41
  Respirators must be NIOSH approved.

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www.Chemwatch.net

Issue Date: Sep-30-2009
Print Date: Apr-12-2012
Appendix B – Hotel Comercio's Architectural Drawings
First Floor Plan

Based on a plan drawn by Junior Cárdenas (Ministry of Culture), 2010

Hotel Comercio
Jirón Carabaya No. 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash No. 200, 202
Lima, Peru

University of Pennsylvania
School of Design
Based on a plan drawn by Junior Cárdenas (Ministry of Culture), 2010.

Second Floor Plan

Hotel Comercio
Jirón Carabaya N° 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash N° 200, 202
Lima, Peru

University of Pennsylvania
School of Design

Plan

Sheet N°: B3

N

0 5m 5m 0
Based on a plan drawn by Junior Cárdenas (Ministry of Culture), 2010

Roof Plan

1

B5

5m 0 5m

N
First Floor Plan showing the 3 Sectors and the Collapsed Area
Based on plan drawn by Junior Cárdenas (Ministry of Culture), 2010

Second Floor Plan showing Floor Details
Third Floor Plan showing Floor Details

Based on plan drawn by Junior Cárdenas (Ministry of Culture), 2010

Hotel Comercio
Jirón Carabaya N° 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash N° 200, 202
Lima, Peru

University of Pennsylvania
School of Design

Sheet No:

B9
Plan

Based on plan drawn by Junior Cárdenas (Ministry of Culture), 2010

Third Floor Plan showing Floor Details

- Detail Floor 1: Ceramic Tile 15 x 15 cm
- Detail Floor 2: Ceramic Tile 20 x 20 cm
- Detail Floor 3: Ceramic Tile 20 x 20 cm
- Detail Floor 4: Ceramic Tile 20 x 20 cm
- Detail Floor 5: Ceramic Tile 15 x 15 cm
- Detail Floor 6: Ceramic Tile 20 x 20 cm
- Detail Floor 7: Wood Planks 4" x 1"
Appendix C – Hotel Comercio’s Conditions
Based on a plan drawn by Junior Cárdenas (Ministry of Culture), 2010

First Floor Plan

Hotel Comercio
Jirón Carabaya Nº: 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash Nº: 200, 202
Lima, Peru

University of Pennsylvania
School of Design

1085x127
Sheet No:

1110x306
Hotel Comercio
Jirón Carabaya No 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash No 200, 202
Lima, Peru

1139x228
and Jirón Ancash No 200, 202
Lima, Peru

1158x306
University of Pennsylvania
School of Design

1179x364
Based on a plan drawn by junior Cárdenas (Ministry of Culture), 2010

183x84
First Floor Plan

943x157
05m 5m

221x739
Jirón Ancash

968x58
1

5m 0 5m

1085x677
Based on a plan drawn by junior Cárdenas (Ministry of Culture), 2010

1084x703
University of Pennsylvania
School of Design

1085x725
Based on a plan drawn by junior Cárdenas (Ministry of Culture), 2010

1107x78
Plan B2
Based on a plan drawn by Junior Cárdenas (Ministry of Culture), 2010.

Second Floor Plan

University of Pennsylvania
School of Design

Hotel Comercio
Jirón Carabaya N° 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash N° 200, 202
Lima, Peru

Sheet N°:
B3
Plan
Hotel Comercio
Jirón Carabaya N° 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash N° 200, 202
Lima, Peru

Based on a plan drawn by Junior Cárdenas (Ministry of Culture) 2010
First Floor Plan showing the 3 Sectors and the Collapsed Area
First Floor Plan showing Floor Details

Based on plan drawn by Junior Cárdenas (Ministry of Culture), 2010
Second Floor Plan showing Floor Details

Based on plan drawn by Junior Cárdenas (Ministry of Culture), 2010

Hotel Comercio
Jirón Carabaya N° 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash N° 200, 202
Lima, Peru

University of Pennsylvania
School of Design

Sheet No: B8

Plan
Hotel Comercio

Jirón Carabayllo No 119, 117, 113, 109, 107, 105, 103; and Jirón Ancash No 200, 202
Lima, Peru

Source: The Getty Conservation Institute, Seismic Retrofitting Project, 2010

Elevations

Northwest Elevation

Northeast Elevation

1
B7

2
B7

C1
Elevations
C2 – Current Conditions Images

Sector 1: First Floor

First Floor Plan highlighting Sector 1
Post on first patio with voids caused by insect attack. Yellowish frass can be seen on the photo on the right.

Plaster detachment on the bottom of the wall in room 103, exposing adobe bricks.
Ceramic floor tiles in the *zaguán* exhibit discoloration, loss of surface, cracking, and depressions. Large areas have been filled in with concrete.

Ceramic tiles in the first patio show discoloration, and loss of surface and pattern. Tiles on the edges have been replaced with solid dark red tiles.
Staircase leading to the second floor with replaced steps
Sector 1: Second Floor

Second Floor Plan highlighting Sector 1

176
Vertical cracks on plastered walls on corridor

177
Vertical crack and plaster loss in room 234

178
Detachment of post from the floor in room 243

Detachment of wall from the floor in room 234
Missing tiles in the corridor

Missing wood planks on flooring in rooms 241 and 243
Numerous circular perforations on wood post in room 243

Oval cavities, tunneling, and extensive material loss on wood post in room 243
Dark brown and yellowish frass on floor boards in room 204

Depressions on stair treads, material loss, and large cavities
Bracing on rooms 233 and 243
Sector 1: Third Floor

Third Floor Plan highlighting Sector 1
Plaster and mud detachment on base of wall, lifted floor boards in room 339

Plaster detachment (horizontal and diagonal over post) in room 350
Light brown and yellowish frass on floor boards of room 350

Surface peeling, large cavities, material loss on wood in room 350
Plaster and mud detachment, extensive material loss on wood in room 345
Large opening on floor at corner of room 334, mud detachment and exposed cane.

Plaster and mud detachment, stained wood beam in room 345
Removed partition wall in room 350
Sector 2: First Floor

First Floor Plan highlighting Sector 2

190
Large oval cavities and extensive material loss on second patio post
Bracing in room 104

192
Placement of posts for supporting beams in room 104 and in between rooms 104 and 105
Partial collapsed of adobe wall in between rooms 105 and 106. Supporting posts have been placed. Mud detachment of wall exposing brick.
Bracing on second patio, outside of room 106
Bracing in room 120

Plaster detachment exposing adobe bricks and accumulation of debris in room 120
Decorative plaster wall on room 104 is in poor condition. Large patches, dark vertical stains on the bottom, soiling, vertical crack running from one of the ceiling joists towards the middle of the wall
Ceramic tile floor in room 120 in good condition, but with some powdering and discoloration

Ceramic tile floor in second patio in moderate condition. Exhibit discoloration, staining and minimal loss of surface
Sector 2: Second Floor

Second Floor Plan highlighting Sector 2
Severely deteriorated wood frame of window on room 213. Extensive material loss, wood seems brittle.

Plaster and mud detachment below window of room 213
Floor boards of room 214 do not connect to the wall. There is some material loss of wood.

Plaster and mud detachment on the bottom of northeast wall of room 234, exposed punta, accumulation of debris.
Cracks on southeast wall of room 209: vertical cracks running from floor to ceiling and horizontal cracks running in between vertical cracks. Paint peeling.
Vertical cracks running from floor to ceiling, paint peeling following cracks, and some mud detachment on southeast wall of room 210
Sector 2: Third Floor

Third Floor Plan highlighting Sector 2
Floor joists on corridor next to room 336 exhibit tunneling and material loss. Wood appears to be brittle and has dark spots.

Dark brown and light brown frass found on flooring of room 313 along with a cream colored unidentified matter with spongy texture.
Bowed floor boards and bracing in room 317

206
Partition wall in room 313 has been removed. Sections of northwest wall have delaminated paint, and wall is bulging out causing cracks on the plaster.
Northwest wall of room 313 exhibits diagonal cracks, delaminated paint, and plaster detachment.
Sector 3

First Floor Plan highlighting Sector 3
Wood of room 324 door is severely deteriorated. There is extensive material loss, accumulation of frass, and flaking paint.
All spaces in Sector 3 have been braced to support the structures above as well as the walls.
Detachment of plaster exposing brick underneath

212
Collapsed Area

First Floor Plan highlighting Collapsed Area

213
Broken beam with a fracture running along the wood grain and broken *huascas*.

Detached posts
Collapsed brick wall
Warped beam
217
Dark stains on wood beam

Dark spots on wood beam
Ground was excavated to expose foundation
Appendix D – Field Notes
# D1 - Survey Forms

<table>
<thead>
<tr>
<th>A. Number</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Orientation</td>
<td>N</td>
</tr>
<tr>
<td>C. General Description</td>
<td>Exit wall to Ancash</td>
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<tr>
<td>D. Dimensions</td>
<td></td>
</tr>
<tr>
<td>E. Materials</td>
<td>Adobe, bricks, wood, cane, mud/plaster, nails</td>
</tr>
<tr>
<td>F. Wood ID</td>
<td></td>
</tr>
<tr>
<td>G. Sketch</td>
<td></td>
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</tbody>
</table>

**H. Notes**

- Sector 1
- RM 245
- North wall to Exit (JR. Ancash)
<table>
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<th>A. Number</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>B. Orientation</td>
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<td>C. General Description</td>
<td></td>
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<tr>
<td>D. Dimensions</td>
<td></td>
</tr>
<tr>
<td>E. Materials</td>
<td>WOOD, ADOBEBRICK, CANE, MUD/PLASTER, NAILS</td>
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<tr>
<td>F. Wood ID</td>
<td>INSECT ATTACK</td>
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<tr>
<td>G. Sketch</td>
<td>![Sketch of wall structure]</td>
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<td>H. Notes</td>
<td>SECTOR 1 HALLWAY ON NORTH END. DOUBLE WALL: INT WALL DRAWN.</td>
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<tr>
<td>A. Number</td>
<td></td>
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<tr>
<td>-----------</td>
<td>---</td>
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<tr>
<td>B. Orientation</td>
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<td></td>
</tr>
<tr>
<td>F. Wood ID</td>
<td>INSECT</td>
</tr>
<tr>
<td>G. Sketch</td>
<td>FUSED WITH ARTIFICIAL BRICK</td>
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<tr>
<td></td>
<td></td>
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| H. Notes | SECTOR A  
HALLWAY ON NORTH END |
<p>|             | DOUBLE WALL; EXIT WALL DRAWN. |</p>
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<th>A. Number</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>C. General Description</td>
<td></td>
</tr>
<tr>
<td>D. Dimensions</td>
<td></td>
</tr>
<tr>
<td>E. Materials</td>
<td>WOOD, CANE, MUD/PASTER, NAILS, LEATHER?</td>
</tr>
<tr>
<td>F. Wood ID</td>
<td>INSECT</td>
</tr>
<tr>
<td>G. Sketch</td>
<td>![Sketch Diagram]</td>
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</table>
| H. Notes                  | COLLAPSED AREA
                           | SECTOR 1                         |

---

224
<p>| <strong>A. Number</strong> |  |
| <strong>B. Orientation</strong> |  |
| <strong>C. General Description</strong> |  |
| <strong>D. Dimensions</strong> |  |
| <strong>E. Materials</strong> | WOOD, MUD / PLASTER / CANE, NAILS / ADobe BRICK |
| <strong>F. Wood ID</strong> |  |
| <strong>G. Sketch</strong> | ![Sketch Image] |
| <strong>H. Notes</strong> | NEXT TO COLLAPSED AREA - 2nd Floor |</p>
<table>
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<td></td>
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<td>C. General Description</td>
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<tr>
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<tr>
<td>G. Sketch</td>
<td><img src="image" alt="Sketch" /></td>
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</tbody>
</table>
| H. Notes | 1ST FLOOR  
SECOR 2. |
First Floor Plan

Scale: 1 : 500
Second Floor Plan
Appendix E – Wood Samples from Hotel Comercio
Hotel Comercio Wood Identification
Lima, Peru

Sample: S1-II-a

Date Sampled: Jan. 14, 2011
Location: sector 1, second floor, room 243, SE wall
Element: post
Date Analyzed: Dec. 20, 2012
Prepared by: Rie Yamakawa

Camera: Canon Rebel T1i
Megapixels: 15.1
Lens: Canon EF-S 18-200mm 1:3.5-5.3 IS

Kodak Color Control Patches
Blue Cyan Green Yellow Red Magenta White 3/Color Black

232
Microscope: Olympus CX31RBSF
Lighting: Volpi Intralux 5000-1
           Halogen Reflector 20V/150W
Camera: Nikon DS-Fi1
Objective: 4x

ID:
A type of Cedar (exact species unknown)
Similar to Atlantic White Cedar (Chamaecyparis thyoides)

Class: Softwood
Features:
- non-resinous
- cedar like odor
- cupressoid cross field pitting

Tangential

Radial

Longitudinal
Date Sampled: Jan. 14, 2011
Location: sector 1, second floor, room 243, flooring
Element: joist
Date Analyzed: Dec. 11, 2012
Prepared by: Rie Yamakawa

Microscope: Leica MZ16
Lighting: Leica KL2500 LCD
Camera: Nikon DS-Fi1
Objective: 0.5x
### Microscope
- **Microscope:** Olympus CX31RBSF

### Lighting
- **Lighting:** Volpi Intralux 5000-1 Halogen Reflector 20V/150W

### Camera
- **Camera:** Nikon DS-Fi1

### Objective
- **Objective:** 4x

### ID:
- A type of **Cedar** (exact species unknown)
- Similar to Manio
- 

### Class:
- **Class:** Softwood

### Features:
- non-resinous
- cedar like odor
- cupressoid cross field pitting

### Images
- **Tangential**
- **Radial**
- **Longitudinal**
**Hotel Comercio Wood Identification**

Lima, Peru

Sample: **S1-III-a**

**Date Sampled:** Oct. 12, 2012  
**Location:** sector 1, third floor, room 344  
**Element:** uncertain  
**Date Analyzed:** Dec. 22, 2012  
**Prepared by:** Rie Yamakawa

**Microscope:** Leica MZ16  
**Lighting:** Leica KL2500 LCD  
**Camera:** Nikon DS-Fi1  
**Objective:** 0.5x
<table>
<thead>
<tr>
<th>ID:</th>
<th>Very similar to <strong>Douglas-fir</strong>, <em>(Pseudotsuga menziesii)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Class:</td>
<td>Softwood</td>
</tr>
<tr>
<td>Features:</td>
<td>- resinous</td>
</tr>
<tr>
<td></td>
<td>- abundant spiral thickening in tracheids</td>
</tr>
<tr>
<td></td>
<td>- piceoid crossfield pitting</td>
</tr>
<tr>
<td></td>
<td>- dark red heartwood</td>
</tr>
</tbody>
</table>

Microscope: Olympus CX31RBSF
Lighting: Volpi Intralux 5000-1 Halogen Reflector 20V/150W
Camera: Nikon DS-Fi1
Objective: 4x
Date Sampled: Oct. 12, 2012
Location: sector 2, first floor, 2nd patio
Element: post lying on ground (probably from collapsed area)
Date Analyzed: Dec. 21, 2012
Prepared by: Rie Yamakawa

Microscope: Leica MZ16
Lighting: Leica KL2500 LCD
Camera: Nikon DS-Fi1
Objective: 0.5x
<table>
<thead>
<tr>
<th>Microscope:</th>
<th>Olympus CX31RBSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting:</td>
<td>Volpi Intralux 5000-1 Halogen Reflector 20V/150W</td>
</tr>
<tr>
<td>Camera:</td>
<td>Nikon DS-Fi1</td>
</tr>
<tr>
<td>Objective:</td>
<td>4x</td>
</tr>
</tbody>
</table>

**ID:**  
A type of **Cedar** (exact species unknown)  
Similar to Eastern Red Cedar (*Juniperus virginiana*)

**Class:**  
Softwood

**Features:**  
- non-resinous  
- cupressoid-taxodioid  
- cross field pitting  
- dark red heartwood  
- sweet odor
Date Sampled: Oct. 12, 2012
Location: sector 2, first floor, room 120
Element: beam lying on ground (probably from collapsed area)
Date Analyzed: Dec. 08, 2012
Prepared by: Rie Yamakawa
Microscope: Olympus CX31RBSF
Lighting: Volpi Intralux 5000-1
          Halogen Reflector 20V/150W
Camera:   Nikon DS-Fi1
Objective: 4x

ID:  Walnut genus
     Very similar to black walnut (*Juglans nigra*)
     Possibly Peruvian walnut
     (*Juglans neotropica, J. olanchana, etc*)

Class:  Hardwood
Features: - semi-diffuse porous
Date Sampled: Oct. 12, 2012
Location: sector 3, second floor, room 228
Element: joist
Date Analyzed: Dec. 08, 2012
Prepared by: Rie Yamakawa

Camera: Canon Rebel T1i
Megapixels: 15.1
Lens: Canon EF-S 18-200mm 1:3.5-5.3 IS
Microscope: Olympus CX31RBSF
Lighting: Volpi Intralux 5000-1 Halogen Reflector 20V/150W
Camera: Nikon DS-Fi1
Objective: 4x

ID: Walnut genius
Very similar to black walnut (*Juglans nigra*)
Possibly Peruvian walnut (*Juglans neotropica, J. olanchnana, etc*)
Similar to Keruing (*Dipterocarpus sp.*)

Class: Hardwood
Features: - diffuse porous
Hotel Comercio Wood Identification
Lima, Peru

Sample: S2-III-a

Date Sampled: Oct. 12, 2012
Location: sector 2, third floor, hallway (next to room 336)
Element: joist
Date Analyzed: Dec. 08, 2012
Prepared by: Rie Yamakawa

Microscope: Leica MZ16
Lighting: Leica KL2500 LCD
Camera: Nikon DS-Fi1
Objective: 0.5x
ID: Very similar to Douglas-fir, *Pseudotsuga menziesii*

Class: Softwood

Features: - resinous abundant spiral thickening in tracheids - piceoid crossfield pitting - dark red heartwood
Sample: S3-II-a

Date Sampled: Oct. 12, 2012
Location: sector 3, second floor, room 327
Element: post
Date Analyzed: Dec. 11, 2012
Prepared by: Rie Yamakawa
| Microscope: | Olympus CX31RBSF |
| Lightin: | Volpi Intralux 5000-1 Halogen Reflector 20V/150W |
| Camera: | Nikon DS-Fi1 |
| Objective: | 4x |

**ID:** Very similar to **Douglas-fir** (*Pseudotsuga menziesii*)

**Class:** Softwood

**Features:**
- resinous
- abundant spiral thickening in tracheids
- piceoid crossfield pitting
- dark red heartwood
Appendix F – Wood Analyses Reports from Hotel Comercio
Mr. Rie S. Yamakawa  
32 North 40th Street  #3F  
Philadelphia, PA  19104

Dear Rie,

Thank you for sending the 1 sample (Structural Wood from Lima, Peru) to us for identification. It is as follows:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Podocarpus</td>
<td>Podocarpus sp.</td>
</tr>
</tbody>
</table>

Podocarpus (Podocarpus spp. /Podocarpaceae) is a primitive conifer genus that contains about 103 species native to the southern temperate regions through the tropical highlands of the globe including temperate South America, South Africa, Japan and the West Indies. When the super continent Gondwana broke apart around 100 million years ago, the ancestors of Podocarpus were separated, resulting in species on most of the present day continents. They are all evergreen shrubs and trees that can reach heights of 75 to 120 feet. Many species are large enough to produce beautiful lumber. The timber has a light yellow or straw yellow color with a clear, fine straight grain. It weighs between 25 and 35 pounds per cubic foot. The microscopic wood anatomy of most species is identical.

South African Yellowwood (Podocarpus elongata & P. thunbergii) appears in colonial furniture of the Cape Colony (Dutch & English).

- **P. dacydioides** – New Zealand White Pine [New Zealand] — general construction
- **P. elongata** – Common Yellow-wood [South Africa] – beams, planks & general construction work
- **P. falcatus** – False Yellowwood [South Africa] – furniture, roof beams, floorboards, door and window frames and boat building (topmasts of ships).
- **P. ferruginea** – Miro [New Zealand] – heavy construction and cabinetry
- **P. latifolius** – Real Yellowwood [South Africa] – flooring, furniture, sleepers, wagon beds, coffins
- **P. nubigenus** – Manio [Chile]
- **P. salignus** – Manio [Chile]
- **P. spicata** – New Zealand Black Pine [New Zealand] – durable & dense wood for outdoors and cabinetry
- **P. totara** – Totara [New Zealand] – durable for outside work and furniture
- **P. urbani** – Yacca [Jamaica]
Podocarp or Manio (Podocarpus spp. /Podocarpaceae) is also known as: Cipres (Guatemala, Honduras), Cipricillo, Cipresillo lorito (Costa Rica), Pino chaquiro (Colombia), Pino castaneto (Venezuela), and Pinho bravo (Brazil). It is native to the mountainous areas from the West Indies and southern Mexico to southern Chile. The tree varies considerably with species, ranging from heights of 60 ft and diameters 10 to 16 in. to heights of 100 ft and diameters up to 40 in. Clear straight boles often somewhat fluted but without buttresses. The heartwood is pale yellow to yellowish brown; not distinct from sapwood. The wood has a fine and uniform texture without conspicuous zones of latewood. It is somewhat lustrous with the grain usually straight but may be slightly interlocked. Specific gravity (ovendry weight/green volume) varies with species from 0.37 to 0.55 and the air-dry density is 28 to 42 pounds per cubic foot. The timber works easily with hand and power tools; nails easily and takes stain, varnish, and paint satisfactorily. Heartwood from trees grown in Belize reported to be moderately durable ground contact under tropical exposure. Durability of other species from other are reported as low. It is used for joinery, millwork, furniture components, boxes and crates, general construction, veneer and plywood, pulp and paper, pattern making.

References:

Chudnoff Tropical Timbers of The World

We appreciate your business!

Best Regards!

Harry A. Alden
Alden Identification Service

3560 Brookside Drive, Chesapeake Beach, MD 20732  410-286-8722
http://woodid.homestead.com/ais.html  aldenid@comcast.net

12/5/12  Invoice #: 4386

Mr. Rie Silvana Yamakawa
4360 Spruce Street
Philadelphia, PA 19139

Dear Rie,

Thank you for sending the 4 samples (Historic Building) to us for identification. They are as follows:

1 – I-A2-a-post  Eastern Red Cedar  *Juniperus virginiana*
2 – II-A1-a-post  Atlantic White Cedar  *Chamaecyparis thyoides*
3 – III-A1-a-joist  Douglas Fir  *Pseudotsuga menziesii*

**Eastern Redcedar/Juniper, etc.** (*Juniperus* spp./Cupressaceae). The Junipers are composed of about 50 species, native to North America [13], Mexico and Central America [11], West Indies [5], Bermuda [1], and the Old World [25]. The word *juniperus* is the classical Latin name. The wood of all species in this genus looks alike microscopically.

<table>
<thead>
<tr>
<th>Eastern North America</th>
<th>Europe/Middle East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Redcedar</td>
<td><em>Juniperus virginiana</em></td>
</tr>
<tr>
<td>Southern Redcedar</td>
<td><em>Juniperus silicicola</em></td>
</tr>
<tr>
<td>Common Juniper</td>
<td><em>Juniperus communis</em></td>
</tr>
<tr>
<td>Grecian Juniper</td>
<td><em>Juniperus excelsa</em></td>
</tr>
<tr>
<td>Stinking Juniper</td>
<td><em>Juniperus foetidissima</em></td>
</tr>
<tr>
<td>Syrian Juniper</td>
<td><em>Juniperus drupacea</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Western North America</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashe Juniper</td>
<td><em>Juniperus ashei</em></td>
</tr>
<tr>
<td>California Juniper</td>
<td><em>Juniperus californica</em></td>
</tr>
<tr>
<td>Common Juniper</td>
<td><em>Juniperus communis</em></td>
</tr>
<tr>
<td>Alligator Juniper</td>
<td><em>Juniperus deppeana</em></td>
</tr>
<tr>
<td>Redberry Juniper</td>
<td><em>Juniperus erythrocarpa</em></td>
</tr>
<tr>
<td>Drooping Juniper</td>
<td><em>Juniperus flaccid</em></td>
</tr>
<tr>
<td>Onesseed Juniper</td>
<td><em>Juniperus monspelma</em></td>
</tr>
<tr>
<td>Western Juniper</td>
<td><em>Juniperus osteosperma</em></td>
</tr>
<tr>
<td>Utah Juniper</td>
<td><em>Juniperus pinetorum</em></td>
</tr>
<tr>
<td>Pinchot Juniper</td>
<td><em>Juniperus pinchoti</em></td>
</tr>
<tr>
<td>Rocky Mountain Juniper</td>
<td><em>Juniperus scopularum</em></td>
</tr>
</tbody>
</table>
Cedar*, Atlantic White [Chamaecyparis thyoides (L.) B.S.P. Cupressaceae] The genus Chamaecyparis is composed of 6 or 7 species, with 4 in Japan/Formosa and 3 in North America. The North American species are:

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. lawsoniana</td>
<td>Port Orford Cedar</td>
</tr>
<tr>
<td>C. nootkatensis</td>
<td>Alaska Cedar</td>
</tr>
<tr>
<td>C. thyoides</td>
<td>Atlantic White Cedar</td>
</tr>
</tbody>
</table>


The word chamaecyparis is derived from the Greek chamai (dwarf) and kuparissos (cypress). The term thyoides means “like Thuja,” a related genus containing northern white-cedar. The other two North American species are Port-Orford-cedar (Chamaecyparis lawsoniana) and Alaska-cedar (Chamaecyparis nootkatensis). The wood of each of the three species in this genus is anatomically distinct.

**Other Common Names:** Amerikansk vit-ceder, cedar, cedre blanc d’Amerique, cedro bianco, cedro bianco Americano, cedro blanco Americano, cipres blanco, cipresso bianco, coast white ced, juniper, kogelcypress, post ced, retinospora, southern white-cedar, swamp-cedar, swano white ced, vit-cypress, white-cedar, white chamaecyparis, white cypress, witte Amerikaanse ceder, zeder-zypresse.

**Distribution:** Atlantic white-cedar currently is native to the Coastal Plain of the eastern United States from central Maine south to northern Florida and west to southern Mississippi. It is an obligate wetland species, i.e. it can only grow in very wet areas, usually lowlands.

**The Tree:** Trees of Atlantic white-cedar reach heights of 60 ft (18.29 m), with diameters of 1 ft (0.30 m). Under optimal growth conditions, this tree can reach heights of 120 ft (36.58 m), with diameters of 5 ft (1.52 m).

**General Wood Characteristics:** The sapwood of Atlantic white-cedar is narrow and white, and the heartwood is light brown with a reddish or pinkish tinge. The wood has a characteristic aromatic odor when freshly cut and has a faint bitter taste. It is light weight, has a fine texture, and is straight grained. It is moderately soft, low in shock resistance, and weak in bending and endwise compression.

**Working Properties:** It works easily with tools, finishes smoothly, holds paint well, and splits easily.

**Durability:** Atlantic white-cedar heartwood is resistant to very resistant to decay (56).

**Modern Use:** Cooperage, wooden household furniture, boat building, fencing, and industrial millwork.
**Alden Identification Service Report**

**Historic Use:** Atlantic White Cedars ability to withstand both water and fungi (damp-rot) made it a premier wood choice for boats and house clapboard and shingles in the American colonies. By the end of the 18th Century, almost all of the living Atlantic White Cedar trees were removed from the swamps of Jersey [The Pine Barrens, The Hackensack Meadowlands and Sandy Hook]. This area had the highest concentration of the trees along the Atlantic Seaboard – 500,000 acres then, 115,000 today. Some tree loss was due to habitat destruction (agriculture, peat & cranberry bogs). Dead trees had fallen into the swamp and been preserved by the anaerobic environment to the cellular and molecular levels. They were subsequently hauled out of the swamps and mined in the mud flats to satisfy the demand, prior to the Civil War. It was also used for cooperage, wooden household furniture, fencing, buckets, decoys and channel-marking posts.


http://www.nj.gov/dep/parksandforests/forest/njfs_awc_initiative.html


Modified from Elbert Little Jr. USDA Forest Service.
Keruing or Apitong (*Dipterocarpus* spp./ *Dipterocarpaceae*) is composed of over 70 species, which are marketed collectively. They occur throughout Indo-Malaysia and those from Malaysia are the most variable in physical and mechanical properties. Other common names include; Eng, In (Burma), Yang, Heng (Thailand), Lagan, Keroeing (Indonesia), Dau (Vietnam, Cambodia) and Gurjun (India). The tree characteristics are variable within this genus, but they commonly reach heights of 100 to 200 ft with clear, cylindrical boles 70 ft long; trunk diameters 3 to 6 ft, commonly with a small buttressed base.

The heartwood varies from light to dark red brown or brown to dark brown, sometimes with a purple tint; usually well defined from the gray or buff sapwood. The texture is moderately coarse. The grain is straight or shallowly interlocked. It has a low luster and a strong resinous odor when freshly cut. The resin exudation may be troublesome and its silica content is variable, generally less than 0.5%.

Its basic specific gravity (ovendry weight/green volume) is generally 0.57 to 0.65 and its air-dry density is 45 to 50 pounds per cubic foot (0.64 – 0.94 g/cc), but both can vary widely.

It dries slowly often with considerable degrade due to checking and warp and sometimes collapse. Resin exudation is common, particularly at high temperatures. Kiln schedule T3-D2 is suggested for 4/4 stock and T3-D1 for 8/4. Shrinkage green to air dry: radial 2.5 to 5.5%; tangential 7.5 to 11.5%. Movement in service is medium to large.

Keruing generally saws and machines well, particularly when green. Blunting of cutters is moderate to severe due to silica content and it is sometimes difficult to glue. Resin adhering to machinery and tools may be troublesome and also interfere with finishes. Its durability varies with species, generally classified as moderately durable, but the heartwood is susceptible to termite attack. However, silica content may be high and resistance to marine borers is erratic. The sapwood and heartwood are both rated as moderately resistant to preservative treatments using either open tank or pressure systems.

Keruing is used for general construction work, framework for boats, flooring, pallets, chemical processing equipment, veneer and plywood. It is suggested for railroad crossties if treated with preservatives.

### Mechanical Properties: (2-in. standard)

<table>
<thead>
<tr>
<th>Moisture content</th>
<th>Bending strength</th>
<th>Modulus of elasticity</th>
<th>Maximum crushing strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Psi</td>
<td>1,000 psi</td>
<td>Psi</td>
</tr>
<tr>
<td>Green (3)</td>
<td>8,500</td>
<td>1,750</td>
<td>4,050</td>
</tr>
<tr>
<td>12%</td>
<td>2,510</td>
<td>8,600</td>
<td>16,700</td>
</tr>
<tr>
<td>Green (1)</td>
<td>1,710</td>
<td>5,690</td>
<td>11,900</td>
</tr>
<tr>
<td>12%</td>
<td>2,080</td>
<td>19,900</td>
<td>10,500</td>
</tr>
</tbody>
</table>

The Janka side hardness about 1,520 lb for dry material, while the Forest Products Laboratory toughness factor is 240 in.-lb for green material (2-cm specimen).

Additional Reading:

We appreciate your business!

Best Regards!

Harry A. Alden
November 30, 2012

Hi Rie,

I have examined the eight wood samples you sent to me. Below are my results including a description of the anatomical features I observed and my best bet for the species. I used the labels that are on the baggies I received to id the samples. I do not have species that are native to Peru for comparison. I found several species that are identical to those of north America (such as Douglas-fir and black walnut). I do not know if that makes sense in the context:

1) I-A2-a post — Features: Softwood, non-resinous, cupressoid-taxodioid cross field pitting, dark red heartwood, sweet odor. Species: A type of cedar (different from # 3 & 4 below) (exact species unknown)

2) I-A2-b beam — Features: Hardwood, semi-diffuse porous, (very small sample). Species: Walnut genius — very similar to black walnut (Juglans nigra)

3) II-A2-a post — Features: Softwood, non-resinous, cedar like odor, cupressoid cross field pitting. Species: A type of Cedar (exact species unknown) (same species as #4 below)

4) II-A2-b Joist — Features: Softwood, non-resinous, cedar like odor, cupressoid cross field pitting. Species: A type of Cedar (exact species unknown) (same species as #3 above)

5) II-A3-a post — Features: Softwood, resinous, abundant spiral thickening in tracheids, piceoid crossfield pitting, dark red heartwood. Species: Douglas-fir, (Pseudotsuga menziesii)


7) III-A1-b-? — Features: Hardwood, diffuse porous. Species: Walnut genius — very similar to black walnut (Juglans nigra)

8) III-A2-a joist — Features: Softwood, resinous, abundant spiral thickening in tracheids, piceoid crossfield pitting, dark red heartwood. Species: Douglas-fir, (Pseudotsuga menziesii)

Regards,
Joe Loferski, Professor
Index

A
adobe, 6, 7, 8, 17, 19, 20, 23, 26, 27, 28, 29, 61, 67, 80, 82, 88, 104, 106
ant, 19

B
bacteria, 34
bamboo, 24, 25
biodeterioration, 30, 33, 34, 42, 57, 58, 59, 64, 90, 111
brown-rot, 36, 111

celloose, 36

C
cane, 19, 20, 24, 29, 88
cellar, 36
channels, 41
climate, 10, 19
colonial, 3, 17, 18, 21, 105
Colonial, 1, 6
colonia architecture, 18
Colonial architecture, 1
Cordano, 67, 71, 72, 73, 74, 79, 80, 82, 83, 89, 90

crack, 31, 45
deflection, 53
detachment, 90, 91, 92

earthquakes, 4, 15, 21, 22, 45, 46, 47
exit hole, 34, 39, 40, 41, 55, 65, 111

F
fracture, 42
fragmentation, 44
frass, 32, 34, 39, 40, 41, 55, 65, 91, 111
fruit body, 35
fungous, 36
fungi, 31, 34, 35, 36, 37, 43, 60, 62, 63, 64, 111
fungus, 36, 61, 62, 64, 112
galleries, 40, 41
grain, 36, 96
growth test, 61
heartwood, 41, 43, 97
hemicellulose, 36
Historic Centre, 1, 6, 19, 26, 67, 83, 105, 109
holography, 59
Hotel Comercio, 5, 6, 8, 38, 53, 67, 70, 72, 75, 77, 80, 81, 82, 83, 84, 85, 86, 87, 93, 94, 97, 98, 99, 100, 101, 102, 105, 106, 108, 109, 110, 111
huasca, 26
huascas, 20, 28, 89
hypha, 35
hyphae, 36

I
infrared thermography, 59
insect, 43, 55, 60, 64, 66, 94, 109, 110, 111
insect identification, 94, 110

L
larvae, 39, 40, 41, 65, 66, 112
lignin, 36
Lima, 1, 2, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 16, 17, 19, 21, 22, 24, 26, 29, 34, 36, 42, 45, 46, 47, 48, 51, 67, 72, 77, 80, 81, 82, 83, 86, 105, 106, 109, 110, 111

M
microscopy, 59, 111
Ministry of Culture, 7, 8, 77, 82, 83
Modified Mercalli Intensity Scale, 47
moisture, 34, 36, 37, 39, 40, 41, 42, 43, 52, 56, 109
moisture content, 34, 37, 39, 40, 41, 42, 43, 56, 109
mud, 19, 20, 23, 25, 29, 88, 89, 90, 91
mycelium, 33, 35, 61, 62
natural durability, 107
organism, 32, 34, 35
oxygen, 34

P
pilodyn, 56, 57
plaster, 22, 25, 29, 88, 90, 91, 92
preservatives, 35, 45, 107, 112
punta, 28
quincha, 4, 6, 7, 8, 9, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 67, 82, 88, 90, 91, 92, 106, 108

R
radiography, 59
reed, 19
Republican architecture, 6
resistograph, 56, 57

S
sapwood, 34, 40
seismic activity, 27, 28, 29, 46, 106
seismic movement, 20, 45
spore, 36
spores, 35, 62
stain, 37, 62
strands, 33
surface mold, 36
tectonic plates, 9, 45
temperature, 35, 39, 43
termites, 39, 41, 65, 110
tomography, 59, 60

V
Vallejo, 67, 72, 74, 80, 82, 89
Viceroyalty, 1, 14, 15, 16, 17, 29, 78, 84

W
warp, 27, 44
water infiltration, 109
weathering, 33, 35
white-rot, 36, 37, 62, 111
wood, 6, 7, 8, 9, 19, 20, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 39, 40, 41,
42, 43, 44, 45, 51, 53, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 72, 73, 88, 90, 91,
92, 93, 95, 96, 97, 101, 103, 105, 107, 108, 109, 110, 111, 112
wood decay, 30, 109
wood destroying insect, 110, 112
wood destroying organisms, 34, 111
wood deterioration, 30, 34
wood identification, 93, 94, 96, 103, 107
wood samples, 6, 64, 93, 95, 110
wood surface, 34, 37