THE ROTUNDA

APPENDIX D

Mechanical, Electrical, Plumbing, and
Fire Protection Findings & Recommendations
2007
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UNIVERSITY OF VIRGINIA ROTUNDA

MEP/FP FINDINGS & RECOMMENDATIONS

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Prepared for

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1. INTRODUCTION

The University of Virginia – Rotunda

The Rotunda has three main floor levels: the Ground Floor (basement), the Main Floor (first floor), and the Dome Room (second floor). The Ground Floor and the Main Floor are subdivided into North, East, and West Oval Rooms with a central hourglass-shaped Stair Hall. A pair of stairways are located at the south end of the stair hall to interconnect the floor levels. The Dome Room is located at the second floor level and is open to the dome above. There are two gallery levels within the Dome Room: the Middle Gallery and the Upper Gallery.

The single-story terrace construction surrounding the Rotunda houses university administrative offices. The wings of the terrace construction are identified as the Northeast (NE), Northwest (NW), Southeast (SE), and the Southwest (SW) wings.

A major restoration and adaptation of the Rotunda was undertaken in 1974. This work included the reconstruction of the dome room. New building systems, including HVAC, fire protection, and electrical systems were introduced. The wings were not part of the restoration and adaptation project.

Plus Group has surveyed the Rotunda and surrounding terrace wings to assess the existing mechanical, electrical, and fire protection systems, to provide an overview of existing system conditions, and to formulate recommendations for improved building system performance.

In addition to a visual survey, information was obtained from the university's facilities management personnel, and from the 1974 restoration and adaptation plans of Ballou & Justice, Architects and Engineers.

2. MECHANICAL

A survey of the heating, ventilation, and air-conditioning (HVAC) equipment in the Rotunda and adjoining wings was carried out on October 17, 2006. The survey consisted of an inspection of equipment rooms with the university's facilities management staff. The intent of the inspection was to understand the existing HVAC system configuration, to note issues related to the existing system, and to assess the condition of equipment.

2.1 Summary – Observation

The key observations from the survey and analysis of the existing system may be summarized as follows:

- The existing HVAC system in the Rotunda is at the end of its useful service life; some of the equipment components are obsolete and are no longer available for replacement. With continuing maintenance the system can remain functional at reduced efficiency.
- The HVAC system in the wings dates to different periods; it has been added to and/or modified. Some of the equipment is in fair condition, and some of the equipment is nearing the end of its useful service life.
- The existing air conditioning system uses condensation on cold surfaces (i.e. a cooling coil in an AC unit) to remove moisture (dehumidification) from the air stream. The colder the cooling medium, the more effective the moisture removal, and the drier the air. However, the university's central chiller plant control strategies were developed to save energy, and the cooling medium runs warmer on mild days. Therefore, the current dehumidification process does not work well on mild and humid days; this results in poor humidity control.
- Prior to the December 2006, mold remediation project in the Dome Room (301), there was visible mold growth on the finished surfaces of the Upper Gallery. High relative humidity (>60%RH) and abundant vegetation on campus provide the necessary mold spores and nutrients for mold growth.
- Stable humidity control, not exceeding 50% RH in building spaces, is the most effective method of preventing mold growth.
- The buoyancy effect inherent in the Rotunda's design draws substantial amounts of untreated air into the building. This infiltration can add significantly to the humidity in the space. Proper sealing of entrance doors and windows, and the provision of a conditioned air supply in adequate amounts to maintain positive pressurization, must be achieved to offset infiltration.
- The air distribution ductwork installed during the 1974 renovation of the Rotunda was designed and installed to conform to the original building layout. The existing air distribution ductwork at the Ground Floor and Main Floor of the Rotunda can be reused.
- The air distribution at the perimeter of the Middle Gallery, high above the floor of the Dome Room (301), is unnecessary and may be promoting condensation and conditions for mold growth.

2.2 Summary – Recommendations

With the potential health risks of mold growth, and with the short life expectancy of the existing HVAC equipment, a new mechanical system should be designed for the Rotunda. Proven HVAC technologies, developed over the last thirty years, can be introduced to provide better comfort and indoor air quality, eliminating the health risks associated with the current system. The key recommendations are summarized below:

- High efficiency filtration should be incorporated in the air-conditioning (AC) system to filter out mold spores and nutrients. Ultra Violet (UV) light treatment should be incorporated to render mold spores ineffective.
- Modern desiccant (water absorbing) air-conditioning technology allows the process of moisture removal to be independent of the temperature cooling medium (i.e. central chiller plant control strategies). Desiccant technology can achieve stable humidity control; it should be incorporated in the design of a new HVAC system.
- The existing overhead air distribution in the Dome Room (301) counters the natural buoyancy of air flow. A low-level supply and high return will provide better comfort and air quality, and eliminate conditions for mold growth at the Upper Gallery level.

2.3 Existing System

The mechanical system configuration and survey observations for the Rotunda and wings have been separated for clarity of presentation.

2.3.1 HVAC System Utilities

Chilled water from a central campus plant enters the building at northwest corner of the basement mechanical room beneath the north portico stair. The 1974 restoration and adaptation plans show a chiller and cooling tower located in this space to generate chilled water for the building's air handlers. Subsequently the chiller and cooling tower were removed, and chilled water was supplied by a central campus chilled-water plant.

Steam from a central campus plant is supplied to the basement mechanical room. Steam-to-hot water converters are used to generate hot water for the heating system. The hot water for the heating system is distributed to the air-handling units.

The chilled water and medium-temperature hot water that are supplied to the building are not metered.

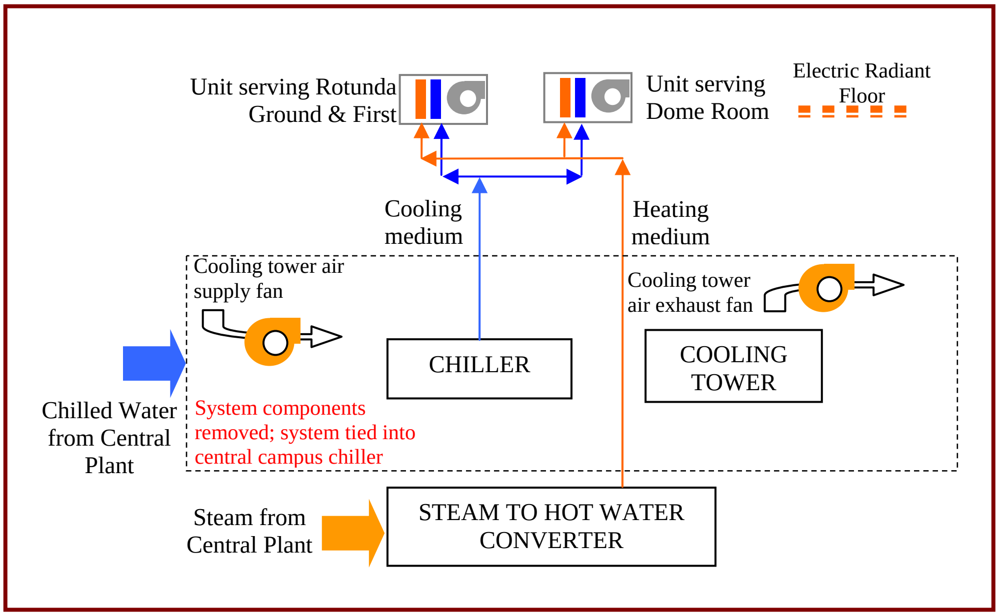
2.3.2 Rotunda HVAC System Configuration

The existing heating, ventilation, and air-conditioning (HVAC) system for the Rotunda was installed during the 1974 building renovation. The system included the following major components:

- An electric chiller and cooling tower were installed in the basement mechanical room beneath the north portico steps to generate the system's cooling medium. The chiller and cooling tower, and the cooling tower supply and exhaust fans, were later removed (components in dashed box in figure below); and the cooling medium (i.e. chilled water) was supplied from a central campus chiller plant. Chilled water is circulated to the air-handling units for cooling.

- Steam supplied from the central campus heating plant was converted to hot water for heating the building; this system remains in use. Hot water is circulated to the air-handling units and hot water coils for heating.
- Air-handling units were installed to supply cooled air in summer and warmed air in winter. Air handler AC-2, located in Mechanical Room (108), serves the ground floor and main floor of the Rotunda. A separate air handler, AC-1, is located in the South Portico Attic (402) and serves the Dome Room (301).
- Electric radiant floor heat was provided at the perimeter of the Dome Room (301).

The 1974 HVAC system configuration and later modifications are illustrated below.



The Rotunda spaces are served by two built-up air-handling units, AC-1 and AC-2. AC-1 serves the Dome Room (301) and AC-2 serves all the spaces at Ground Floor and Main Floor levels.

Air handler AC-1 is located in the South Portico Attic (402); this air handler serves the Dome Room (301). The unit consists of filters, a hot-water heating coil, and a chilled-water coil. The chilled-water coil removes moisture from the air stream through condensation on the cold coil surfaces in the same manner as moisture in ambient air condenses on the cold outside surface of a glass filled with ice. This process of removing moisture (dehumidification) is dependent on the temperature of the cooling medium. The colder the medium, the better the moisture removal, or dehumidification process.

Air handler AC-1 was configured for an economizer cycle during moderate months to meet energy code conservation requirements. During normal operation, a minimum amount of outdoor air is admitted to the system for ventilation, typically about 25%, as mandated by building codes. During moderate weather, an increased volume of outdoor air is admitted, reducing the load on the chiller plant (central or local), and thereby reducing energy consumption. In free cooling mode, when the outdoor temperature is about 55ºF, 100% of supply air is drawn from outdoors and the chiller is shut down.

One of the drawbacks of free cooling on mild but humid days is the large amount of moisture that is drawn in with the outdoor air. Also, on mild days the chilled-water plant controls are normally set to generate a warmer cooling medium than on hot days. The warmer medium is not capable of removing moisture effectively from a humid air stream; this results in increased humidity in the conditioned space.

As a larger percentage of outdoor air is drawn into the system, it must be relieved. The excess amount of outdoor air is exhausted through the relief-air grille. Both the outdoor-air intake and relief-air grille are located in the ceiling of the south portico. It appears that one of the remedial measures instituted to address mold growth was to forego free cooling, and limit outdoor air to the minimum ventilation air required by code. Thus the relief-air grille has been shut, and the relief-air duct capped.

A separate return-air fan, RAF#1, returns air from the Dome Room (301). Both the supply-air and return-air fans were equipped with vortex dampers. Vortex dampers were installed to regulate the amount of air supply for partial load and full load conditions. While this was an appropriate technology during the 1970s, the vortex dampers are inefficient devices; therefore, they were subsequently replaced with variable speed drives (VSD) which are both more efficient and provide more stable control.

The perimeter duct and sprinkler piping chase at the Upper Gallery (C501) of the Dome Room (301) houses the supply and return ductwork. Air is distributed through a slotted opening in the cornice beneath the Upper Gallery, and through grilles located on top of the duct chase. The air from the grilles is directed upward over the surface of the dome. Return-air ducts are run in vertical chases housed in bookcases at four locations in the Dome Room (301). The return-air grilles are located at the base of the bookcases, near floor level.

Air handler AC-2 is located in the ground floor Mechanical Room (108); this air handler serves the all the oval rooms and the hallways at the Ground Floor level and at the First Floor level. The unit consists of filters, electric preheat coils, and a chilled-water dehumidification coil. The air supply and return ductwork is located in the sub-basement. The air supply ductwork is divided to serve ten zones. The air-supply main to each zone is equipped with a hot-water reheat coil to control zone temperatures.

2.3.3 Rotunda HVAC System Assessment

The mechanical system selection for the 1974 renovation was appropriate. The equipment layout and air distribution were developed to conform to the building design. The cooling tower was installed indoors to keep it out of sight. However, it was not prudent to discharge air saturated with cooling tower chemicals close to the building. Cooling tower discharge air that infiltrates the building and the building mechanical systems can create a health risk for building occupants, increase the potential for mold growth, and contribute to the deterioration of building materials. The chiller and cooling tower were later removed when chilled water from a central campus plant was introduced.

The existing air-conditioning system design assumes the cooling process will remove any moisture needed to control humidity. However, when fresh air is both cool and humid, the cooling process may not operate as intended because the air-conditioning load is low or the cooling medium from the central plant is not cold enough. This allows moisture to build up, and indoor humidity rises when outside temperatures drop. We propose incorporation of desiccant (hygroscopic substance that absorbs moisture) wheel technology in the new HVAC system to achieve consistent removal of moisture from the air supply. The desiccant wheel technology is explained later in this report. However, it must be noted that no HVAC system can cope with large external sources of moisture, such as those introduced by leaks in the building envelope.

The current air distribution system in the Rotunda uses overhead air supply. This method of air distribution, and the existing ductwork, can be reused at the ground floor and main floor levels. However, we suspect that the flow pattern resulting from overhead supply in the Dome Room (301) is contributing to the development condensation and promoting the growth of mold. We recommend reversing the air distribution in the Dome Room, providing a low-level air supply and high-level air return, and completely shut off the air supply at the base of the dome. The cool air supply will spread along the floor and rise as a plume around the occupant (heat source) to provide comfort and improved air quality.

Inherent in the design of the building is the buoyancy effect of natural ventilation. The warm air mass directly under the dome was vented through the skylight, creating buoyant forces that drew significant amounts of unconditioned outdoor air from the lower levels and openings. Untreated outdoor air mixing with the cold air stream produced by a modern air-conditioning system, or coming into contact with surfaces cooled by an air-conditioning system, can cause condensation and create the potential for mold growth. An adequate amount of treated air must be introduced in the building to positively pressurize the building envelope and counter the infiltration of untreated air.

Most of the existing mechanical equipment can be considered near the end of its useful service life, and in some instances replacement parts are no longer available. However, the existing equipment can continue to function at reduced efficiency with an increasing level of maintenance.

2.3.4 Terrace Wings HVAC System Configuration

The terrace wings were not part of the 1974 restoration and adaptation campaign. The original system consisted of steam radiators and operable windows for ventilation and no provisions for cooling. The original steam piping has failed in some instances, and cooling has been introduced. The heating, air conditioning, and ventilation systems in the terrace wings vary, and appear to be retrofitted in response to the condition or state of the original systems. The systems for each wing are described below:

2.3.4.1 Existing System - Southwest (SW) Wing

It appears that the piping buried in the floor for the perimeter radiation heating of this wing had failed. The radiators were removed and the piping has been abandoned. A 3 ton heat pump unit with an auxiliary electric coil serves this wing. Supply air is ducted to the various offices with plenum return. There is no provision for mechanical outdoor air ventilation.

2.3.4.2 Existing System - Southeast (SE) Wing

The perimeter radiation heating is still active in this wing. The original cast-iron radiators have been have been retained and supplied with low temperature hot water. A 3 ton cooling only unit provides comfort cooling. Supply air is ducted to the various offices with plenum return. There is no provision for mechanical outdoor air ventilation.

2.3.4.3 Existing System - Northeast (NE) Wing

The perimeter radiation heating was removed. Two-pipe fan-coil units are provided under the windows. Low temperature hot water is supplied for heating and chilled water for cooling. A stand-alone dehumidifier is located in the northeast corner room. This room has direct access to the exterior, so the dehumidifier augments the dehumidification provided by the fan-coil units.

Dedicated run/standby circulators are used to distribute hot water for heating to the northeast and northwest wings.

2.3.4.4 Existing System - Northwest (NW) Wing

This wing is similar to the northeast wing. The perimeter radiation heating was removed. Two-pipe fan-coil units are provided under the windows. Low temperature hot water is supplied for heating and chilled water for cooling. A stand-alone dehumidifier is located in the southwest corner room. This room has direct access to the exterior, so the dehumidifier augments the dehumidification provided by the fan-coil units.

2.3.5 Other Systems

All of the exhaust air from the building is ducted down to the sub-basement level, and an exhaust fan, EAF#1, in the sub-basement relieves the exhaust air into the mechanical room beneath the north portico stair.

Toilet Room (T101), Toilet Room (T102A), and Catering Servery (106) are served by dedicated fan-coil units.

Unit heaters are provided in the mechanical rooms to temper the mechanical spaces.

There are no smoke purge systems. Smoke/fire dampers and smoke detector shutdown interlocks are undetermined.

2.3.6 Controls

The 1974 controls were all pneumatic. It appears that they have been changed to electronic sensors with pneumatic actuators. The compressor and refrigerant air dryer for control air is located in Mechanical Room (108) and provides compressed air for valve actuation.

2.4 Condition Overview of Existing Equipment

All of the equipment that was surveyed appears to be approximately 20-30 years old. Based on visual observation they are in fair to poor condition, and should provide few more years of useful service life. Given the age of these units, a coherent system that encompasses both the Rotunda and the Wings should be considered in the near future.

Service / System	**General Condition**	**Overall Condition Rating** **Good / Fair / Poor**
Chilled Water pumps	> 15 years	Fair. Replacement recommended
Heating Hot Water Pumps	> 15 years	Fair. Replacement recommended
AC#1	~ 30 years	Built up unit. Extremely limited access for service and maintenance. Two stages of the electric pre-heat

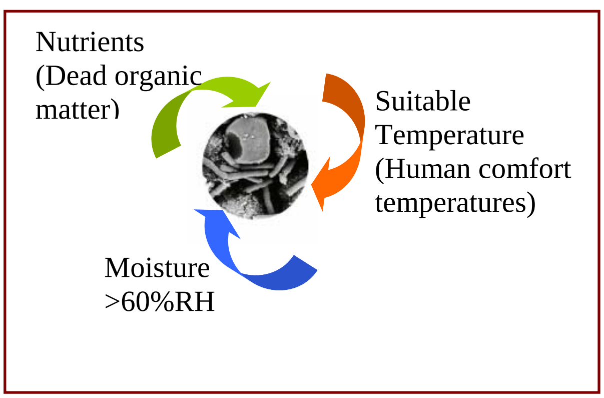
Service / System	General Condition	Overall Condition Rating Good / Fair / Poor
		coils are inactive. Obsolete, parts are unavailable. Moving components can be expected to be past their useful life.
AC#2	~ 30 years	Built up unit. Fair access for service and maintenance. Vortex dampers subsequently retrofitted with variable speed drives Moving components can be expected to be past their useful service life.
Exhaust Fan	> 15 years	Moving components can be expected to be past their useful service life.
SW Wing Heat Pump	> 15 years	Fair. Can be considered close to end of its useful service life.
SE Wing AC unit	> 15 years	Fair. Can be considered close to end of its useful service life.
NE & NW Wing Fan Coil Units	> 15 years	Fair. Can be considered close to end of its useful service life.

2.4.1 Mold Growth in Dome Room

One of the issues with the Dome Room (301) is mold growth; this was particularly evident on the painted wood railings of the upper gallery.

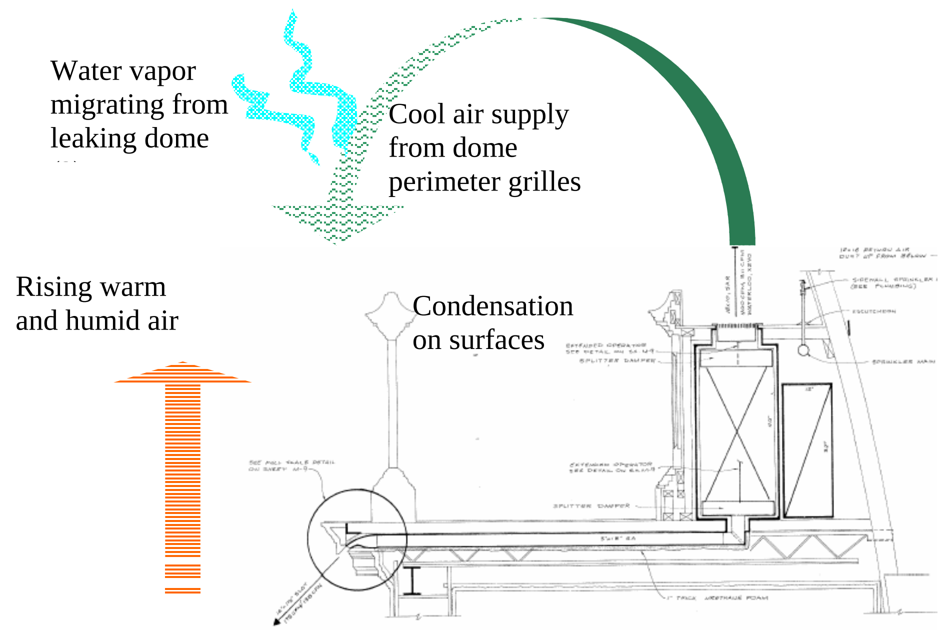
2.4.1.1 Mold Growth - Analysis

The following analysis is not a result of exhaustive research and testing. It attempts to outline the potential factors contributing to the mold problem based on a review of existing conditions and existing HVAC system design and operation.



Mold growth generally results from a combination of mold spores, food sources in the form of organics and dust, temperatures between 65ºF and 90ºF, and relative humidity above 65%. Since mold spores, favourable temperatures, and food sources exist in most buildings, controlling relative humidity is the only means available to avoid microbial growth problems. The potential factors contributing to mold problems are outlined below:

- The air-handling unit, AC#1, serving the Dome Room has a chilled-water cooling coil for dehumidification and cooling. It is likely that the chilled water supply temperature during moderate outdoor conditions is not low enough to provide adequate dehumidification. Relative humidity levels in the Dome Room (301) may exceed 60%~70% for extended periods.
- Mold spores are in relative abundance during mild seasons.
- Any source of water leakage and infiltration of moisture must be investigated.
- Abundant vegetation on the campus provides the necessary mold spores. This combined with relatively high humidity levels can result in microbial growth problems.



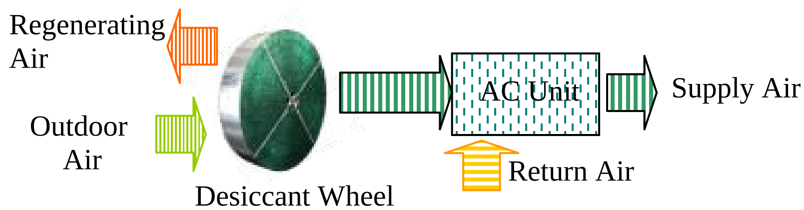
EXISTING AIR DISTRIBUTION IN DOME ROOM

- It is also likely that the current air distribution is suspect. The cold air supply at the dome perimeter mixes with the rising warm and humid air in the upper gallery zone leading to surface condensation on railing surfaces. This promotes conditions conducive to microbial growth. This may be checked by measuring the temperature and humidity profile three feet on either side of the upper gallery railing.
- Infiltration of untreated air due to the buoyancy effect inherent in the Rotunda's design must also be investigated. Untreated air with high moisture content will raise the relative humidity in the space. When untreated outdoor air comes in

contact with cold surfaces (cold air from perimeter dome supply) it can cause condensation, promoting conditions for mold growth.

2.4.1.2 Mold Growth Remediation- Recommendations

As noted in the analysis above, stable and low relative humidity is the most effective means available to control microbial growth in buildings. The proposed desiccant technology utilizes a wheel coated with a hygroscopic substance that absorbs water to remove moisture. The desiccant, which can be silica gel, lithium chloride or a molecular sieve, is infused into an inorganic composite material that resembles the honeycombs of a beehive, and this is formed into a wheel. The wheel rotates slowly between the outdoor air and the reactivation or regenerating air stream. Moisture extracted from the outdoor air is removed from the desiccant by the heated regenerating air stream. The function of drying the air is totally separated from cooling the air with the cooling medium to meet the space cooling load.



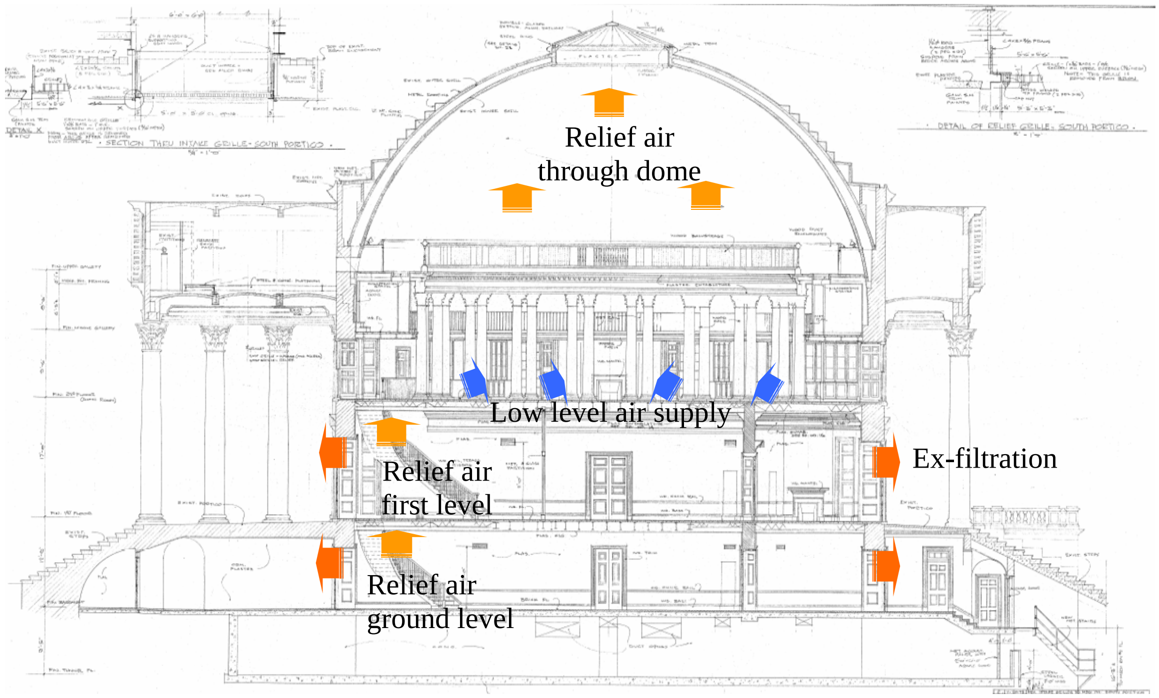
DE-COUPLED MOISTURE REMOVAL SYSTEM

2.5 HVAC System Recommendations

2.5.1 Dome Room AC System

The Dome Room air-conditioning system should be replaced with a new system that incorporates desiccant dehumidification technology. The air distribution in the Dome Room should be reversed. The existing perimeter supply at the base of the dome is not necessary. More effective air distribution, known as displacement ventilation, would provide low-level supply air and relief-air in the same direction as the buoyant forces (see illustration below). This will provide better comfort both in summer and winter. It will also provide improved indoor air quality, natural rise of warm air for relief through the dome skylight, and warmer air temperatures which results in lower relative humidity.

We also anticipate a lower volume of air supply with the implementation of a displacement ventilation system. This will need to be confirmed during the design phase.



PROPOSED AIR DISTRIBUTION AND INFILTRATION CONTROL

2.5.2 Rotunda Ground Floor and Main Floor AC system

We recommend that the air-conditioning system for the Ground Floor and Main Floor levels of the Rotunda also incorporate desiccant dehumidification technology. This will insure dryer air in the building and provide stable humidity control throughout the Rotunda.

The current air distribution system for the Ground Floor and Main Floor levels can be maintained. Air distribution terminal types may be changed and air flow quantities adjusted to meet new programmatic requirements.

2.5.3 Terrace Wings – HVAC System

Considering the historic context of the building a more compact system type is proposed for the terrace wings. It consists of a dedicated outdoor air unit to supply pre-conditioned ventilation air. The ventilation air is supplied at a neutral temperature of about 70ºF.

A separate parallel system, in the form of a ceiling induction unit, a floor-mounted displacement induction unit, or a floor or ceiling-hung fan-coil unit is proposed. The parallel system is a four pipe system that is used to satisfy the loads independently in each of the thermal zones.

The ventilation air supply is decoupled and is distributed independently of the parallel system. The air can be supplied either at floor level or at ceiling level, and the ductwork can be located as required.

The system configuration described above has the following advantages over a conventional all-air system:

- It keeps the ductwork to a minimum in comparison to an all-air system because only the ventilation air is distributed.
- It allows flexibility in the location of ductwork.
- The compactness of ductwork and the choice of a parallel system makes integration with the architectural demands of a historic structure more manageable.
- Improved zoning and improved air quality.

3. ELECTRICAL

The electrical system survey of the Rotunda and adjoining terrace wings was carried out on October 17, 2006. The survey was made in the presence of the architect and the university's facilities management staff. The intent of the survey was to provide an overview of existing conditions for the electrical, lighting, and life-safety systems.

3.1 Summary and Recommendations

An overview of the survey and summary recommendations are provided below:

- The existing electric service capacity appears adequate unless new program requirements impose significant additional loads.
- The power distribution equipment is at least 30 years old, and the reliability of some of the components is questionable. The original equipment manufacturer is no longer in business. Major pieces of equipment can be retrofitted; however, a new distribution system with new panels and conductors is recommended.
- The existing electrical system power quality may not meet current industry standards. Transient voltage surge suppression devices should be incorporated.
- The electrical panels in the terrace wings are generally full; they have little or no spare capacity. New distribution panels with adequate space and new electric feeds commensurate with program requirements are recommended.
- Some of the lighting fixtures in the Rotunda are old, and the wiring to these fixtures is suspect. With no replacement parts available, the fixtures are rendered obsolete. New or historic replica lighting fixtures, meeting UL standards, with new wiring are recommended.
- Building life-safety lighting and exit signs are not connected to an emergency power source. An emergency power source such as a central uninterruptible power supply (UPS) or individual battery back-up supplies, should be used for life-safety lighting.
- Emergency lighting levels appear inadequate. Layout and lighting levels must be reviewed to meet code requirements.
- Currently there is no fire alarm system in the building. As a place of assembly, the Rotunda is required to have a fire alarm system.
- An air terminal on the dome skylight is provided for lightning protection. A more comprehensive lightning protection system should be considered for the building.

3.2 Overview of Existing Systems

3.2.1 Power

The Rotunda and terrace construction may be divided into three areas for the purpose of electrical system description: the Rotunda, the north wing, and the south wing.

The building derives electrical power from a 1600Amp, 120/208Volt switchboard located in the mechanical room beneath the north portico stair. Much of the power distribution system equipment is manufactured by Kinney, a company that is no longer in the business. Some panels are retrofitted with Westinghouse circuit breakers. The power distribution system equipment was upgraded approximately 30 years ago, and it appears to be in fair working condition. However, the reliability of these components (over-current devices, wiring, wiring devices, and lighting fixtures) and overall system performance becomes questionable.

The Rotunda power distribution system consists of panels located in electric closets at the Ground Floor and Main Floor levels and panels located in the attic spaces above the north and south porticos. All of the panels in the Rotunda are fed from the main switchboard in the mechanical room beneath the north portico stair. Power distribution system feeders are installed in conduits.

The following electric distribution panels are located in the Rotunda:

a. Ground Floor: Two panels are located in the northwest hallway closet (101A). One panel is serving receptacle, appliance, and miscellaneous small power loads. The second panel is serving lighting loads.

b. Main Floor: Two panels are located in the northwest hallway closet (203). One panel is serving receptacle, appliance, and miscellaneous small power loads. The second panel is serving lighting loads.

c. North Portico Attic: Two panels are located in the attic. One panel is serving appliance and miscellaneous small power loads. The second panel is serving lighting and receptacle loads.

d. South Portico Attic: One panel is located in the mechanical space. The panel is serving receptacle, appliance, and miscellaneous mechanical system loads.

The north wing office spaces are served by three (3) lighting and appliance panels located on the ground floor at various locations. The mechanical room beneath the north portico stair is served by two panels. One panel serves mechanical system loads; the second panel is sub-fed from the first panel and serves lighting and receptacle loads. These panels are fed from the main switchboard.

The south wing office spaces are served by four (4) lighting and appliance panels. Two of these panels are located in Mechanical Room (108) and the other two (2) panels are located in the southwest and southeast office spaces. One additional panel is provided for exterior events. These panels are served from a distribution panel located in Mechanical Room (108). The distribution panel is fed from the main switchboard located in the mechanical room beneath the north portico stair. The distribution panel feeder is installed in the sub-basement tunnel beneath the Rotunda, connecting the north and south wings.

The installation of some of the existing power distribution system equipment is not in compliance with working clearances imposed by code. These conditions pose safety risks to the service personnel.

The university's facilities management staff expressed concerns about the lack of adequate capacity in the existing panel boards to serve increased loads in the office spaces.

3.2.2 Grounding

The effectiveness of electrical grounding of the buildings was not determined at the time of the survey. Testing of grounding is recommended.

3.2.3 Lighting

The lighting fixtures in the Rotunda are old, and it appears that replacement parts are no longer available. Concerns have been expressed about the fixtures meeting current UL standards, and the wiring is suspect. The fixtures and wiring may pose safety risks for the university's facilities management personnel. New or historic replica lighting fixtures, meeting UL standards, with new wiring are recommended.

Lighting illumination levels in the Rotunda appear to be adequate. Generally, lighting in the public spaces of the Rotunda is controlled by dimmers. There are wall dimmers, as well as dimming panels in various locations. The dimming equipment is manufactured by Parlights, Inc.; and it appears to be in a good working condition.

Manual switches are used to control lighting in the north and south wings.

The building life-safety lighting and exit lights are not emergency lighting units with integral batteries and inverters. The life-safety lighting fixtures and exit signs derive power from a disconnect switch connected to the line side of the main switchboard service switch.

3.2.4 Emergency Power System

The building is currently not provided with an emergency, or standby, generator or uninterruptible power supply (UPS).

3.2.5 Fire Alarm

The building is not provided with a fire alarm system.

3.3 Electrical Recommendations

3.3.1 General

The overview of the building electrical system and deficiencies is based on a visual inspection. The major components of the system are in good working order. Some parts of the distribution system are fully loaded, and there is no room for expansion. Replacement of the existing power distribution system should be considered. A new system will provide improved operational reliability and additional capacity for future expansion.

3.3.2 Power

The existing electric service feeder size and capacity appear adequate, unless new program requirements impose significant additional loads.

The existing electrical system components are at least 30 years old. The reliability of these components (over-current devices, wiring, wiring devices, and lighting fixtures) is questionable. Major equipment, such as the main switchboard, can be retained and upgraded if necessary; however, the electrical panels, over current devices, and wiring should be replaced.

The existing system power quality may not meet current industry standards required for modern office equipment. The new switchboard and panelboards serving data equipment should incorporate transient voltage surge suppression (TVSS) devices.

The existing panels in the terrace wings have little or no capacity for expansion. All new power distribution system equipment and feeders should be sized with 20% spare capacity for future use.

Currently, there is no metering of the building's electric use. This should be incorporated, in accordance with university standards.

An emergency power source in the form of a generator or central uninterruptible power supply (UPS) should be considered for life-safety systems. Alternatively, battery ballast type fixtures may be used for life-safety systems.

3.3.3 Grounding System

The main switchboard should be provided with a new grounding bar connected to ground electrodes. Effective grounding is required to enable protective devices to operate within a specified time period during fault conditions. A dedicated technical ground system should be provided for telecommunication system equipment.

All extraneous conducting metalwork within the building should be bonded with a ground conductor. All feeders and branch circuit wiring systems should be provided with equipment grounding conductors. Additional isolated ground conductors should be provided for select equipment and devices as required.

3.3.4 Lighting

The university's facilities management staff is concerned about the availability of replacement parts and the safety compliance of existing lighting fixtures and wiring in the Rotunda.

Historically significant light fixtures should be replicated, and the existing light fixtures should be replaced or upgraded, making them compliant with current UL standards. The wiring should be upgraded as well.

The lighting systems should be reviewed for compliance with the latest applicable energy conservation code.

3.3.5 Lightning Protection System

Though not mandated by applicable codes, a comprehensive lightning protection system can reduce the risk of personal injury and property damage from lightning. Provision of a modern lightning protection system should be considered in the context of building preservation.

3.3.6 Emergency Lighting and Exit Signs

Based on visual inspection, it appears that the emergency egress lighting and signage is not sufficient and is not code compliant.

A new emergency lighting system and exit signs should be provided in compliance with applicable codes. Emergency lighting fixtures and exit signs should be provided with integral batteries / ballasts, or connected to a central emergency lighting inverter or other source of emergency power.

3.3.7 Fire Alarm and Smoke Detection System

A new addressable fire alarm system is required in accordance with applicable codes. The system should consist of a main Fire Alarm Control Panel (FACP), remote annunciators, audible and visual devices, manual pull stations, smoke and heat detectors, and an interconnecting wiring system installed in conduit. The system can be interfaced with building management, security, elevator recall, and sprinkler systems as required.

The system may be connected to the Facilities Management Systems Control Center (FMSCC) as required by university standards.

Additionally, a voluntary early smoke detection system may be considered appropriate considering the historic value of the building.

3.3.8 Miscellaneous Low Voltage Systems

The existing low voltage wiring systems in the Rotunda and wings are visually obtrusive. New low voltage systems (telecommunications, security, audio/visual) should be incorporated in any planned building renovation.

4. PLUMBING

4.1 Summary and Recommendations

A visual survey was made of the plumbing systems in the Rotunda and terrace wings on October 17, 2006. A summary of observations and recommendations is made below:

- The existing domestic water service and water pressure appears to be adequate for its intended purpose. If no additional demand is made, the existing service may be sufficient.
- The service needs to be metered and protected from cross connection.
- The water service for the fire suppression system appears to be adequately sized; however, a hydrant flow test is recommended to ensure that sufficient pressure is available to protect the building.
- The existing plumbing fixtures are of various makes and models. The fixtures and faucets are in good working condition. ADA compliance must be reviewed. The installation of water conserving fixtures should be considered when the bathrooms are upgraded or renovated.
- The sanitary system is a gravity type, fully-vented system that appears to be functioning without problems. The piping is of different ages, and some of it may require replacement.
- The terrace storm water drainage system is susceptible to clogging. Sand from the setting bed beneath the terrace paving appears to be infiltrating the drains.

4.2 Existing Plumbing Systems

4.2.1 Utilities

The existing building has all of the basic utilities: domestic water, fire suppression sprinkler service, sanitary sewer, and storm water drains.

Combined sprinkler and domestic water service is brought to the building from a 10" water main located to the east of the Rotunda. The existing water service for the Rotunda is 5" diameter line that enters the mechanical room beneath the north portico stair.

The existing 6" diameter sanitary sewer pipe runs through the sub-basement utility tunnel and exits the building at the north end of the tunnel. Apparently it is connected to the street sewer beneath University Avenue.

The routing and the exact locations of the building storm water drains were not determined during the survey. The information is provided on the campus utility map.

There is no gas service to the building.

4.2.2 Existing Domestic Water System

The existing 5" diameter combined water service splits into a 2" diameter domestic water line and a 5" diameter sprinkler service line at the point of entry in Mechanical

Room (108). The domestic water service is provided with a shut-off valve; the service is not metered.

The domestic water service appears to have an adequate capacity for the current load. The university facilities management staff confirmed that water pressure is adequate.

Domestic water is distributed to the plumbing fixtures located throughout the building and to the mechanical equipment rooms. A reduced pressure zone backflow preventer is provided on the cold water branch supplying make-up water to the mechanical equipment.

The condition of the existing water distribution piping could not be observed due to the presence of pipe insulation. The water service and the majority of the distribution piping are approximately 30 years old. The age of the piping supplying plumbing fixtures in Toilet Rooms (T112) and (T113) is not known. Toilet Room (T112) was recently renovated; therefore, the water piping for this bathroom is relatively new and expected to be in good condition. The piping for Toilet Room (T113) is assumed to be at least 30 years old.

The existing domestic hot water supply is generated by electric storage type water heaters. A 30 gallon, 4.5 KW electric water heater serving Toilet Rooms (T101) and (T102A) is located in Closet (T102B) at the entrance to the women's toilet room (T102A). A 20 gallon water heater is located in Storage/Janitor's Closet (110).

Apparently, there is no hot water recirculation system. As a result, hot water to the lavatory faucets on the upper floors appears with delay, after all of the standing cold water in the piping is discharged.

4.2.3 Existing Sanitary System

The existing sanitary system is a fully-vented system, provided for all toilet rooms, pantries and mechanical rooms.

The 4" diameter sanitary building drain line runs under the slab in the utility tunnel, than drops down beneath the slab in the mechanical room beneath the north portico stair. Prior to exiting the building the 4" diameter drain line transitions to a 6" diameter line. No house trap was found.

It appears that the sanitary system is gravity type throughout the building. No sewage ejector or sump pumps were located during the survey.

It is our understanding that the majority of the sanitary pipe was installed during 1974 restoration. The sanitary pipe for recently renovated Toilet Room (T112) is new; the sanitary piping for Toilet Room (T113) appears to be at least 30 years old. It appears that the 4" diameter sanitary pipe for Toilet Room (T112) is plastic, while the rest of the system is cast iron.

Floor drains are installed in Toilet Room (T102A), in rooms with hot water heaters, and in the mechanical rooms. There are no floor drains in Toilet Room (T101), Catering Servery (106), Toilet Room (T112), Toilet Room (T113) and the toilet rooms on the upper floors of the Rotunda.

There is no grease trap for the double-compartment sink in Catering Servery (106).

4.2.4 Existing Storm Water System

The storm water from the Rotunda roof is being collected into the perimeter gutter and discharged via external downspouts to the campus drainage system.

The storm water from the terraces above the wings is collected at promenade type roof drains. The terrace drains are susceptible to clogging; sand from the setting bed beneath the terrace paving appears to be infiltrating the drains.

Area drains are provided at ground level in the cryptoporticus.

4.2.5 Existing Plumbing Fixtures

The type, model, and make of the plumbing fixtures vary throughout the system and reflect upgrades through the years.

All of the existing toilet rooms are located in the Rotunda. One drinking fountain and a pantry sink are located in the northwest wing. No plumbing fixtures are located in the other wings.

The water closets in Toilet Room (T112), Toilet Room (T101), and Toilet Room (T102A) are floor-mounted and equipped with flush-o-meters. The flush-o-meters in Toilet Room (T102A) are the automatic sensor type; manual types are used in all other locations. The water closets in Toilet Room (T113) and in the toilet rooms on the upper floors of the Rotunda are the floor-mounted, tank type.

All lavatory faucets are manual.

Toilet Rooms (T102A) and (T112) appear to be ADA compliant. Toilet Room (T113) does not comply with ADA standards. The toilets rooms on the upper floors of the Rotunda are not ADA compliant.

All plumbing fixtures and faucets are in good condition and operational.

4.3 Plumbing System Recommendations

4.3.1 Utilities

The capacities of existing utilities are adequate for the current loads. If the domestic, fire, or sanitary building loads are increased the capacities of the existing utilities will need to be re-evaluated.

The age of the domestic and sanitary piping varies. We recommend that a video survey of all existing sanitary and storm water building drain lines be undertaken to evaluate the condition of the existing piping. If the existing pipes are found to be deteriorated, they may have to be replaced.

A hydrant flow test should be performed to confirm that the pressure in the water main supplying the Rotunda is adequate for the automatic sprinkler system.

4.3.2 Domestic Water System

Domestic water has to be metered and protected from cross-connection. A metering and cross-connection arrangement should be provided in accordance with local water department requirements. The typical arrangement consists of providing a meter and backflow preventer on the combined sprinkler/domestic water service (inside or outside of the building), or providing a meter and backflow preventer on the domestic water service and a double check detector (with meter on by-pass) on fire protection service.

The 2” diameter domestic water service appears to be adequate for the current load only. If the current load is increased, the service and water main should be replaced with larger service.

The domestic water piping installed as part of the 1974 renovations should be replaced.

The hot water delay in the toilet rooms is a concern. To improve this condition we propose providing water circulation for the hot water branch for the lavatories. This will also allow the use of water efficient metering valves in the toilet rooms.

We recommend replacing water heaters that have been in service for more than 10 years.

We also recommend providing wall hydrants at the perimeter of the building for exterior water use.

4.3.3 Sanitary System

The existing sanitary system, installed as part of the 1974 and later renovations, is sufficient for the current building configuration. If a major renovation of the building is undertaken, this piping should be completely replaced.

All new plumbing fixtures should be the water-conserving type.

4.3.4 Storm Water System

With the proposed restoration of the dome roof a new storm water drainage system should provided.

The storm water drainage system for the terrace requires attention. The drains should be replaced with new ones that prevent the permeation of sand. Additionally, the terrace paving tiles may need to be re-laid on a new setting bed that is not susceptible to decomposition.

4.3.4 Plumbing Fixtures

All new plumbing fixtures should be the water conserving type.

ADA compliance for existing and future toilet rooms should be reviewed as part of the overall strategy of ADA compliance for the building.

5. FIRE PROTECTION

5.1 Summary

The fire protection survey of the Rotunda and terrace wings was carried out on October 17, 2006. The intent was to review the existing fire protection system, to assess the condition of the existing equipment, and to provide an overview of issues related to the existing system design and equipment. A summary of our observations is provided below:

- A combined water service provides water for both domestic use and for the fire suppression system.
- The building has partial, automatic sprinkler system protection. An automatic deluge water system, activated by a smoke detection system, is provided along the south stairs. Previously, a false smoke alarm activated the deluge system and flooded the ground floor of the Rotunda. The deluge valve has been disabled.
- Based on current configuration and use, sprinkler protection is required for the Dome Room (301).
- No fire department connection was found during the survey. A fire standpipe system is required by code.
- The introduction of a fire protection system, based on prescriptive code requirements, is not always effective and practical in a historic structure. A performance based, comprehensive fire protection approach is recommended.

5.2 Existing Fire Protection System

The Rotunda is provided with a partial automatic sprinkler system. There is no fire standpipe system in the building.

The existing sprinkler service is combined with domestic water. Upon entering the building in Mechanical Room (108), the 5” diameter combined service splits into a 2” diameter domestic water service and a 5” diameter sprinkler service. Sprinkler service is not metered, and no backflow preventer device is provided.

A building control valve and an alarm check valve are installed on the sprinkler service. The alarm check valve serves the entire building; there are no floor control valves or floor water switches elsewhere in the building.

The sprinkler system is installed in the hallways and oval rooms on the ground floor and main floor, in Mechanical Room (108), Toilet Rooms (T101) and (T102A), beneath the Middle and Upper Galleries of the Dome Room (301), and at the base of the dome on the Upper Gallery. There are no sprinklers in the toilet rooms, corridors, storage rooms, or mechanical room of the north terrace wing.

In areas where sprinklers are provided the sprinkler coverage appears to be adequate for the occupancy hazard levels.

An automatic deluge system is provided along the south stairs at the ground floor level, apparently to create a fire separation between the main floor and ground floor so that the stair can be used for fire egress. According to the university facilities management staff, the deluge system is activated by the building smoke detection system (i.e. activation of any smoke detector in the building triggers the deluge valve and allows water to flow into the system). Previously, a false smoke alarm activated the deluge system and flooded the ground floor. After this incident, the deluge valve was disabled.

Sprinkler heads in most of the areas are the pendent, concealed type. The sprinkler heads at the base of the dome are the vertical, sidewall type. The deluge sprinklers are the open type. All sprinklers appear to be in good condition.

No fire department connection was found at the building during the survey.

5.3 Fire Protection System Recommendation

5.3.1 Fire Standpipe System

Based on the International Building Code, all buildings with floor levels located more that 30 feet above the fire department access should be provided with an Automatic Wet Fire Standpipe System. The Rotunda appears to fall under this category and may be required have a Fire Standpipe System.

Introducing a new Fire Standpipe System into a historic building is not always practical. A variance, based on a comprehensive fire protection strategy developed by Fire Engineer in consultation with the local Fire Department, is recommended at an early stage of design.

5.3.2 Sprinkler System

The requirements for the Automatic Sprinkler System depend on the Building Use and Occupancy. It is our understanding that the Rotunda occupancy can be considered as Assembly Group A-3, while the terrace wings occupancy may be classified as Business Group B.

According to the International Building Code, Group B occupancies do not require sprinkler protection unless space does not have required openings or the building is of high-rise type; Group A-3 Occupancies must be protected with sprinklers if one of the following conditions exists:

- The fire area exceeds 12,000 square feet
- The fire area has an occupant load of 100 or more
- The fire area is located on a floor other that the level of exit discharge

The second and third conditions apply for the Rotunda; it has to be fully protected by an automatic sprinkler system.

The terrace wings do not have to be sprinklered if full fire separation is provided between the wings and Rotunda. Currently there is no full fire separation between the Rotunda and the wings.

To fully comply with prescriptive requirements of the Code, the following upgrades may have to be provided:

- Fire separation between the Rotunda and the wings
- Sprinkler protection for the entire Dome Room in the Rotunda
- A Fire Standpipe System

These measures are not always practical in the context of a historic building. A fire protection scheme should be developed based on a comprehensive fire protection strategy developed by a Fire Engineer, in consultation with the local Fire Department. It is recommended that this occur at an early stage of design.