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Controlling Mold Exposure During a Renovation Project of an Upscale Hotel in Singapore

January 14-16, 2019
Atlanta Marriott Marquis



Acknowledgements

- Saurabh Saini, CIH
Golder Associates (Singapore) Pte Ltd

Agenda

- Background and Site History
- Assessment Approach and Results
- Development of a Mold Remediation Strategy
- Contractor Prequalification and Bid Evaluation
- Post-Remediation Verification
- Conclusions

Background and Site History

- **Singapore:**
 - Island city-state off Malaysia
 - Global financial center
 - Tropical climate
 - One of the world's greenest cities
 - All land in Singapore is owned by gov.
 - 85% percent of housing is gov. supplied
 - Official languages are English, Chinese, Tamil, and Malay
 - You need to bid for the right to own/drive a car in Singapore (~ \$80,000)



Background and Site History

- 20-story, upscale hotel, located in downtown Singapore
- A total of 499 guest rooms on Floors 11 to 20
- Located above a busy shopping mall
- Both the mall and hotel have been in operation since 2014
- Floor 10 has the main hotel lobby, several restaurants, and meetings rooms
- Floor 19 has a more meetings rooms, a lounge, fitness studio, and more meetings rooms
- Infinity pool with roof deck and a Zen Garden on Floor 19

Background and Site History

- Due to chronic, long-term moisture intrusion related to infiltration of outside humid air through the building envelope and also directly into the rooms due to improper operation of room HVAC systems, extensive condensation and mold growth has occurred on both sides of exterior as well as interior walls within the guest rooms on all levels of the hotel.
- These conditions also resulted in musty odors throughout the hotel, with active mold growth identified on internally lined HVAC ductwork

Background and Site History

- **Initial Response:**
 - Only contaminated walls, insulation, and other structural building components that had to be removed as part of the building envelope repair work were removed and replaced
 - Several rooms remained closed and under construction until proper mold remediation work could be completed
 - Temporary repairs were completed in other rooms, where the extent of visible mold contamination was deemed as less severe,
 - Several rooms continued to have a musty odor

Background and Site History

- **Initial Response continued:**
 - Some rooms were “refurbished” by:
 - Removing wallpaper from the walls and painting them
 - Areas that were less impacted had wallpaper painted over
 - Cleaning and then covering veneer wood surfaces with a laminate
 - Removing the carpet, cleaning it, and then reinstalling it with a new under pad

Background and Site History

- **Golder's Involvement:**
 - Retained by both the owner/operator the builder of the hotel in September 2017, to conduct a comprehensive mold assessment:
 - Condition survey and determine extent of mold contamination of select hotel guestrooms
 - Recommendation for appropriate remedial approaches to return mold-impacted guest rooms and corridors back to uncontaminated conditions
 - Develop specifications for mold remediation of the guest rooms and corridors for Floors 11-18 and 20

Assessment Approach

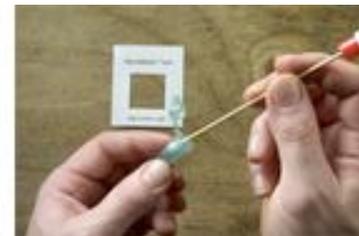
- American Society for Testing and Materials (ASTM) D7338-14 (2014) Standard Guide for Assessment of Fungal Growth in Buildings
 - Visual assessment
 - Limited destructive testing
 - Surface and air sampling using the Mycometer technology
- Assessment was conducted during a 7-day period by Golder staff from our Singapore office

Assessment Approach

- **Mycometer Sampling and Analysis:**
 - Method assesses the level of microbial activity by means of fluorometric detection of an enzyme (β -N-acetylhexosaminidase) present in all mold mycelium and spores
 - Can be used for surface (swab) or air sampling
 - Results are categorized into four categories: A, B C or below detection limits
 - Not legally enforceable or recognized standard limits but instead guidance limits for determining level of potential microbial contamination which may require further assessment or remediation

Assessment Approach

- Mycometer Sampling and Analysis:



Assessment Approach

- **Mycometer Air Sampling Interpretation Criteria:**

Category	Mycometer Air Value (MAV)	Suggested Interpretation
A	≤ 350	Typical environment; no contamination
B	> 350 but ≤ 450	Atypical environment; may not be contaminated
C	> 450	Contaminated environment

Note that this evaluation criteria is based on aggressive sampling for mechanically ventilated spaces but has not been validated.

Assessment Approach

- **Mycometer Surface Sampling Interpretation Criteria:**

Category	Mycometer Surface Value (MSV)	Suggested Interpretation
A	≤ 25	Normal background level; no contamination
B	> 25 but ≤ 450	Settled spores or fungal fragments
C	> 450	Contaminated with active mold growth

Assessment Results

- Golder assessed a total of 153 guest rooms for mold contamination:
 - 40 Closed rooms (most impacted)
 - 55 Musty rooms
 - 21 Refurbished rooms
 - 37 Non-impacted rooms
- Approximately 30% of the total number of rooms were inspected
- Greater focus on upper floors which were more impacted
- Developed project-specific checklist

Overall Assessment Results

Assessment Classification (ASTM)	# of Rooms	% of Total Rooms Inspected
No apparent mold growth or water damage noted on building components but suspected or confirmed HVAC contamination	41	27%
Evidence of water damage noted on building components without suspected/confirmed mold growth but suspected or confirmed HVAC contamination	5	3%
Evidence of visual suspected/confirmed mold growth on building components, including HVAC, without apparent water damage	62	41%
Evidence of water damage with suspected/confirmed mold growth, including HVAC	45	29%

Summary of Mold Remediation Recommendations

Type	Extent of Remediation Required*	# of Rooms	% of Total Rooms
1	No physical removal of building components but cleaning of all surfaces and removal of internal HVAC insulation	143	28%
2	Removal of all wallpaper and partial removal of walls/ceilings; removal of internal HVAC insulation; cleaning and reinstalling carpet; and cleaning of all surfaces	319	64%
3	Complete demolition; removal of all wall finishes, carpet, and some ceilings; removal of internal HVAC; and reinstatement of new materials only.	37	8%

*Includes results of 30 air and 60 surface samples collected.

Veneer Discoloration

- The dark (black) staining is a result of long-term water damage, where water has penetrated the finish completely and a reaction with the tannins in the wood have resulted in the dark staining
- These stains are not mold growth!
- Some surfaces also had evidence of white spots, confirmed to be active surficial mold growth that can easily be cleaned using a detergent or disinfectant
- The dark staining cannot be easily removed without damage to the finish
- May be able to remove with bleach or oxalic acid but surfaces likely have to be stripped by scraping or sanding

Development of a Mold Remediation Strategy

- The primary objective of the remediation program was to physically remove mold contamination from affected areas of the site and to return these areas to “Uncontaminated Condition”
- Attempts to just kill, encapsulate, or inhibit mold growth instead of proper source removal was not deemed adequate

Development of a Mold Remediation Strategy

- General contractor to sub out demolition and remediation work
- Golder to “prequalify” remediation contractor
- Hotel to stay operational while work is being done on a floor-by-floor basis
- Specified environmental and engineering controls to prevent cross contamination of occupied areas
- Remediation and reinstatement works to be completed within a 6 week time frame for Floors 14 to 18 and within 4 weeks for others
- This includes achieving project-specific Post-Remediation Verification (PRV) criteria
- All rooms to be re-assessed by Golder prior to start of remediation work
- Singapore Ministry of Manpower (MOM) involvement?

Development of a Mold Remediation Strategy

- **Remediation Contractor Prequalification:**
 - Interviewed 6 different contractors who expressed interest in bidding
 - Developed an evaluation and scoring criteria based on contractor experience, resources, qualifications, training of key staff, etc.
 - Conducted in-person interviews with all contractors
 - Did not disqualify anyone although two contractors were rated significantly higher than the others
- All general contractors bidding on the job ended up choosing the same remediation contractor

Development of a Mold Remediation Strategy

- **Type 1 Mold Remediation:**
 - Physical removal of building components was not anticipated
 - Cleaning of all surfaces within room
 - Removal of internal HVAC liner and insulation was required
 - HEPA vacuuming of carpet and curtains only
 - PRV inspection required; PRV testing as needed
 - Final review and sign off by contractor, owner, and consultant

Development of a Mold Remediation Strategy

- **Type 2 Mold Remediation:**
 - Minimum respiratory equipment: half-face air-purifying respirator with HEPA cartridges (P-100) and additional organic vapor or other cartridges as required for sanitizing or biocide/fungicide use
 - Isolate work area and provide minimum negative pressure of 5 Pascals (0.02" w.g.)
 - Clean or remove any movable items as appropriate and put in storage
 - HEPA vacuum carpet and curtains; remove and clean professionally if appropriate; reinstall after mold remediation work has been completed

Development of a Mold Remediation Strategy

- **Type 2 Mold Remediation continued:**
 - Remove all wallpaper and mold-impacted drywall
 - Remove veneer paneling, furniture, bed headboard, and remove mold-impacted drywall
 - Assess ceiling and remove as required
 - Removal of internal HVAC liner and insulation
 - PRV inspection required; PRV testing as needed
 - Final review and sign off by contractor, owner, and consultant

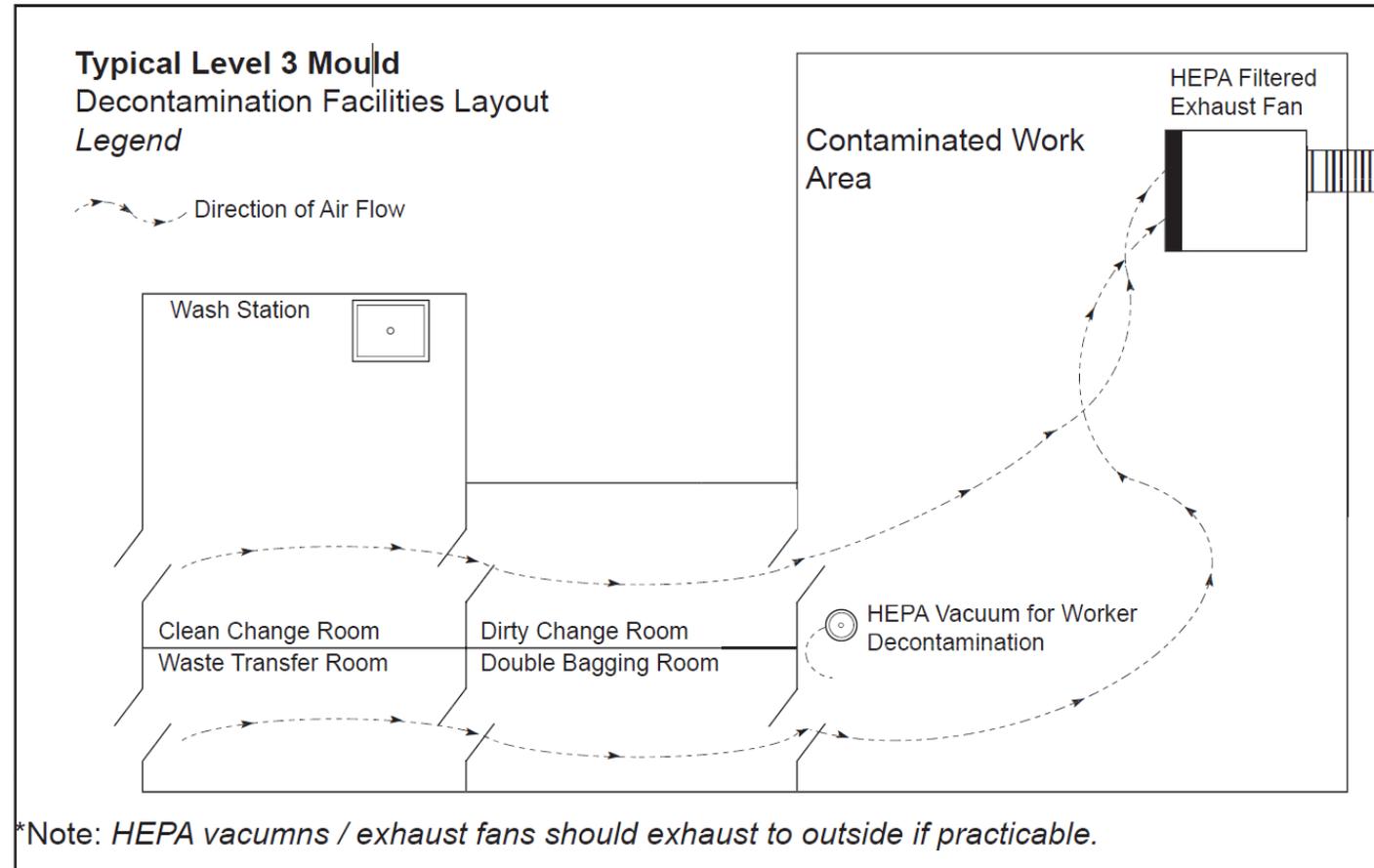
Development of a Mold Remediation Strategy

- **Type 3 Mold Remediation:**
 - Similar control measures as for Type 2
 - Complete demolition, including removal and disposal of all walls that are or were in the past covered with wallpaper, ceilings (including any drywall partition and box panels), carpet, furniture, and HVAC liner
 - Materials are considered contaminated beyond salvageability, requiring disposal as mold contaminated waste
 - Provide a minimum of 4 air changes per hour (ACH) and discharge filtered air directly to the outside the building

Development of a Mold Remediation Strategy

- **Type 3 Mold Remediation:**
 - Provide worker and waste decontamination facilities
 - PRV inspection and testing required
 - Final review and sign off by contractor, owner, and consultant

Development of a Mold Remediation Strategy



*Note: HEPA vacuumns / exhaust fans should exhaust to outside if practicable.

Remediation

- **Main Challenges:**

- Consistent and proper use, and decontamination of PPE
- Maintaining minimum negative pressure and ACH requirements
- Not exhausting directly to the exterior
- Removal of contamination behind granite washroom/shower finishes
- Storage room for removed items did not have air conditioning
- Access to corridor Fan Coil Units (FCU) and ducts
- Providing adequate dust control during reconstruction and protecting new materials prior to installation
- Keeping percent relative humidity below 60% inside work areas
- A few isolated incidents of reoccurring "musty odors" and new staining on veneer for remediated rooms on Floors 20 and 18

Post-Remediation Verification

1. Contractor Competent Person performs visual assessment to verify mold control area is free of visible mold, debris and all waste has been removed, and requests a PRV assessment
2. Consultant and Contractor Competent Person conduct PRV and each will sign PRV form documenting acceptance or rejection of conditions within the mold work area
3. Following acceptable PRV, consultant may perform PRV sampling of surface areas or test the air within the mold work area
4. Consultant to notify contractor of the results of any PRV sampling conducted within 24 hours. If acceptable PRV criteria are met, application of a final bacteriostatic/fungistatic coating via use of an airless sprayer is approved
5. Following a 24-hour drying period after application of the final bacteriostatic/fungistatic coating, mold work area will be considered as returned to “Uncontaminated Condition” and ready for reinstatement of new building materials

Post-Remediation Verification Criteria

- **Myometer Air Sampling (aggressive):**
 - **PASS: $MAV = \leq 450$** which is indicative of normal background level and consistent with site-established “uncontaminated” level of < 400 MAV (n = 8)
 - **FAIL: $MAV = > 450$** which is indicative of an environment that is still contaminated with active mold growth or unacceptable dissemination of mold spores or fungal fragments, based on aggressive air sampling protocol for mechanically ventilated spaces.

Post-Remediation Verification Criteria

- **Myometer Surface Sampling:**
 - **PASS: $MSV = \leq 25$** which is indicative of normal background level and considered as “uncontaminated”
 - **FAIL: $MSV = > 450$** which is an indication of remaining contamination with active mold growth, requiring additional removal or cleaning
 - **$MSV = 25$ to ≤ 450** levels are subject to professional judgement but, at a minimum, require some level of additional cleaning but not necessarily additional removal of impacted material

Remediation Status

- Started with Floor 20 in April 2018
- Since then have completed Floors 18, 17, and 13
- Remediation work about to finish on Floor 11; reinstatement work has started on Floor 12
- FCU and duct liners in corridors of Floors 20, 18, 17, 13, and 11 have been found to be contaminated and replaced
- FCU and duct liners in corridors on Floor 12 were determined not to be contaminated and instead HEPA vacuumed, disinfected, and sealed
- PRV criteria for air is met at a rate of >91%, requiring only minimal additional cleaning (MAV average = 158 ; n = 85)

Conclusions

- Groundbreaking project for Singapore, raising awareness and expertise of mold remediation practice
- First major mold remediation project in Singapore to use North American best practices
- Challenge managing competing interest by two clients
- Using the on-site Mycometer sampling technique proved to be a highly practical, effective, and cost beneficial
- Overall both clients are happy with progress although significant delays have occurred almost entirely related to reinstatement work
- Local government is interested in developing mold assessment/remediation guidance document

References

- American Society for Testing and Materials (ASTM) *D7338-14 Standard Guide for Assessment of Fungal Growth in Buildings (2014)*
- ANSI/ASHRAE 62.1-2016 *Ventilation for Acceptable Indoor Air Quality*
- ANSI/ASHRAE 55-2017 *Thermal Environmental Conditions for Human Occupancy*
- ANSI/IICRC S500-2015 *Standard and Reference Guide for Professional Water Damage Restoration*
- ANSI/IIRC S520-2015 *Standard and Reference Guide for Mold Remediation*
- NADCA ACR 2013 *Assessment, Cleaning & Restoration of HVAC Systems*
- Singapore Standard SS554: 2009 *Code of Practice for Indoor Air Quality for Air-Conditioned Buildings*

Questions?

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