Study Guide – Applied Structural Drying and Water Damage Restoration

This study guide is provided to you to complement the lecture and hands-on learning environment of the WRT / ASD courses. Please use this guide to become familiar prior to class with terms, formulas and basic information. When combining this pre-course study guide with classroom instruction and homework assignments, your exam should be easier with higher retention.

Category of Water: (the "source" of the water)

- **Category 1** (*previously known as "clean"*) - originates from a sanitary water source
- **Category 2** (*previously known as "gray"*) – contaminated; potentially causes discomfort or sickness
- **Category 3** (*previously known as "black"*) – grossly contaminated; includes toxins, pathogens
- **Special Situations** – regulated or hazardous materials (IEP recommended in most situations)

Class of Water: (quantity; anticipated evaporation rate; initial dehumidifier calculations)

- **Class 1** – least amount of water, absorption and evaporation
- **Class 2** - large amount of water, absorption and evaporation (carpet; cushion; base of walls)
- **Class 3** – greatest amount of water, absorption and evaporation (ceiling; walls; insulation; flooring)
- **Class 4** – specialty drying – (e.g., hardwood; lath and plaster; concrete) – deep pockets of saturation; requires controlled drying techniques, low vapor pressure, specialty equipment probable

Principles of Drying: **R**emove excess / **E**vaporation / **D**ehumidification (ventilation) / **T**emperature control

Extraction tools:

- Light wand – perimeter of water loss; extract glue-down carpets; follow-up extraction-stationary tool
- Stationary tool (e.g., Water claw; Flash Xtractor) – subsurface tool; extract carpet/cushion together
- Self-propelled tools (e.g., Rover; Xtreme Xtractor) –self-propelled riding tool; multi-speed; extract carpet and cushion
- Vacuum squeegee – concrete; hardwood; vinyl; laminate
- Submersion pumps - Formula – (ft^2 x inches deep) ÷ 12" = **ft^3 water x 7.48** = water volume

Evaporation tools:

- **Airmovers** – centrifugal (laminar); axial (high-amperage; low-amperage; focus ability)
  - placement – 1 for every 10-16 linear ft. of wall area; 5-45 degree focus; almost touching wall
  - safety screens – intake and output areas; clean with compressed air; do not block intake
  - electrical safety – lightweight extension cords; three-prong plugs; electrical cord safety
- **Structural Cavity Drying Systems** (SCDS)
  - Vented-ducted (e.g., Turbovents 18"-48" widths; Octi-dry; Air Wolf)
  - injected (e.g., Injectidry; Dri-Force; Omni-dry; Direct-it In)
- **Floor Drying Systems**
  - vented (e.g., Air Wolf)
  - injected – negative air mats/panels (e.g., Dri-Force; Injectidry)
  - air-blanket style
- **Air Filtration Devices** – AFDs (negative air machines - NAM; air scrubbers; HEPA filters)

Dehumidifier Ranges: Understanding where temperature, RH, and GPP ratings are out of working ranges

Type: **Reduced Performance if at or below:**

Type Dehumidifier	Relative Humidity	Humidity Ratio (gpp)
Conventional	40%	55
Low Grain Refrigerant (LGR)	30%	34
Desiccant (with silica gel)	10% - below	10-15 - below

- **Refrigerants** – Most efficient operating conditions **70º - 90º F.** (most energy efficient is an LGR)
- **Desiccants** – most efficient with incoming air from coolest/driest air possible; capable of creating greatest pressure differentials (air and vapor pressures); produces low humidity ratio (gpp) important to dry Class 4 materials, dense materials, and complex systems.
- **Uses** - closed-drying environments; multiple layers of materials; security limitations; high outside (*and inside*) humidity conditions; no ventilation ports; basement areas

Initial dehumidification recommendations (psychrometric readings dictate requirements after first day)

Type	Class 1	Class 2	Class 3	Class 4
Conventional	**100**	**40**	**30**	**N/A**
LGR	**100**	**50**	**40**	**50**
Desiccant	**1 ACH (÷ 60)**	**2 ACH (÷ 30)**	**3 ACH (÷ 20)**	**2 ACH (÷ 30)**

Electrical / Heat / Energy:

- **Amperes** (amperage or "amps") – the amount of electricity (current) flowing in a circuit
- **Voltage** – the force of electricity flow in a circuit
- **Watts –** the amount of electricity an electrical device uses when operating
- **British Thermal Units** (BTU) – heat generated by electrical device
  - **Formula** – amps x volts x 3.4 = British Thermal Units **(Btu) per hour**
  - **HVAC** – cooling ability to remove 12,000 Btu **per ton** per hour
- **Residential v. commercial** - generally, residential 15 amp / commercial 20 amp (consider never using over 80% of available amperage)
- **220 splitters** – use where there is limited amperage or fuses (typically, 30 amp-dryer/50 amp-range)
- **Light –weight extension cords** (shock/fire hazards)
- **Power consumption $** formula – ***volts x amps x 24 hours = watts ÷ 1000 = kW x cost per kW @ day***

Inspection equipment:

- **Moisture sensor –** senses moisture in materials over 17% MC; helps determine perimeter of water damage; unable to determine which layer is wet or when dry

- **Thermo-hygrometer** – determines temperature / RH in all required atmospheric areas of inspection; helps determine open or closed drying system; further determines dehumidifier recommendations after initial placement

- **Moisture meters –** invasive and non-invasive; determines moisture content; establish, monitor and determine when dry standards are met
- **Miscellaneous –** infrared camera and thermometer; manometer; borescope; data logger

Chemicals / biocides (antimicrobial biocides)
- Sterilizer; disinfectant; sanitizer
- Written informed consent to customer; advise occupants to leave during application; document
- HEPA – **H**igh **E**fficiency **P**articulate **A**ir (99.97% capture rate of particulates at .3 micron size)
- Government-registered disinfectants – document application details; apply only per label directions
- EPA – Environmental Protection Agency (U.S. federal agency with regulatory control over biocides)
- F.I.F.R.A. – Federal Insecticide, Fungicide and Rodenticide Act – U.S. federal regulations administered by EPA

Floorcovering carpet:
- **installation methods –** stretch-in, direct glue-down, double glue-down
- **drying methods** – in-place, full float, partial float
- **construction** – woven – Axminster, Wilton; usually natural fibers; tufted – primarily synthetic
- **delamination** – separation of primary from secondary backing; laminate strength loss up to 85% when wet (causes – over-aggressive extraction; "flapping" vs. floating; improper cushion; urine; folding; improper carpet stretch)
- **Category 3** – must remove and dispose; IEP possibly required for testing; if Category 2 – hot water extraction of carpet required if saved; ground surface water intrusion also known as Category 3

Floorcovering cushion (also known as padding, underlay)**:**
- **types –** foam (prime, bonded urethane); rubber; felt (hair/jute, synthetic); porous and non-porous
- **Category 2 and 3** - remove and properly dispose

Floorcovering wood (strip wood, plank wood, engineered – laminated wood, parquet)
- non-destructive (non-rotting) fungal growth - over **16%** MC
- destructive (wood-rotting) fungal growth – over **20%** MC
- fiber saturation ("wet rot") cell walls full / dimensional change stops– **28 – 30%** MC
- damages from moisture - (cupping – from wood edges and bottom; crowning; buckling; heaving)
- dry within 2-4 percentage points of EMC - **drying goal**

Floorcovering (laminate; resilient, ceramic tile)
- limitations (trapped water, potential asbestos, ceramic tile – sealed grout; trapped water)
- layers of floorcovering; dry flooring as a system

Microbiology (fungus; bacteria; virus)

- **conditions for growth**
  - organic food source (cellulose)
  - moisture (or high humidity)
  - temperature (most prolific 68-86º F. / 20-30º C.)
  - stagnant air
  - time (some 1-2 days; others up to 10-12 days in chronic conditions)
- **ANSI/IICRC S520** – Standard and Reference Guide for Professional Mold Remediation
- Indoor Environmental Professional (IEP) – specialized experts may be required
- Mycotoxin – a potentially harmful metabolite produced by some fungi, especially molds.
- Endotoxin – a portion of the outer cell wall of some gram-negative bacteria. When ingested or respired, endotoxins can cause fever, changes in white blood cell counts, increased airway resistance, shock and even death.

Psychrometry definitions:

- **Psychrometry** – study of the relationship between air, humidity and temperature and their effect on various materials and comfort levels
- **Psychrometric chart** – chart consisting of lines and curves that shows the relationship between air volume, temperature and relative humidity, and from which a variety of other information (humidity ratio-gpp, dew point, vapor pressure, etc.) relating to drying may be determined
- **Dew point** – the temperature at which humidity in air reaches saturation (**100% RH**) and will condense from that air to form condensation or "dew" on surfaces.
- **Infiltration** – migration of air into and area from outside area due to high VP differential
- **Equilibrium RH** – when air is in equilibrium with the built environment (i.e., the air is neither gaining moisture from, nor losing it to the material; or the point at which a hygroscopic material is neither gaining nor losing moisture).
- **Evaporation** – the process of changing a liquid to a vapor
- **Primary damage** – damage sustained as a result of direct exposure with water.
- **Secondary damage** – damage sustained from indirect or prolonged exposure to disaster contaminants
- **Relative Humidity (RH)** – the amount of moisture in a given volume of air, expressed as a percentage of the total moisture holding capacity of that volume of air, at a given temperature. As temperature increases, humidity 'relative' to the total air volume decreases; conversely, as temperature decreases, RH increases (inversely proportional).
- **Humidity ratio (***previously known as* ***specific humidity*****)** – the weight of suspended moisture in air expressed in grains per pound (gpp) of dry air (14 cubic feet of dry air equals one pound). 7000 grains of water vapor equals one pound of water. As humidity ratio (specific humidity) changes, there is a corresponding change in vapor pressure on the surrounding environment.
- **Grains of moisture per pound (gpp)** – unit to measure humidity ratio (specific humidity), or the weight of moisture in air, expressed in grains per pound (gpp) of dry air.
- **Balanced drying** – ideal drying situation in which the rate of evaporation is equal to or slightly less than the rate of dehumidification or ventilation.
- **Dehumidification / ventilation** – reducing (exchanging) moisture content of air
- **Dry bulb temperature** – temperature registered by a thermometer

- **Hygroscopic** – material that readily absorbs and retains moisture or water vapor from air in an attempt to reach equilibrium.
- **Moisture content (MC)** – weight or percentage of moisture in materials, as compared to the weight of oven-dried, like material. (Wood with 10% MC indicates that 100 pounds of that wood contains 10 pounds of water and 90 pounds of wood).
- **Permeance** – a measure of water flow through material(s) of specific thickness.
- **Moisture gradient** – different levels of moisture content within a wood material
- **Vapor pressure** – pressure on surfaces exerted by substances in a gaseous state; directly related to (reduced through) dehumidification.
- **Delta Vapor Pressure** – difference in VP between material/air (greater difference – evaporation)
- **Vapor barrier** – material through which moisture can't readily pass (perm factor of 1 or less).
- **Saturation** – point at which air or materials can absorb no more moisture; point at which drying stops; point at which air temperature has reached dew point (100% RH).
- **Grain depression** – reduction of humidity ratio (grains; gpp) as noted in difference from ambient air to output on dehumidifier, and as well noted in other area differentials (e.g., inside air – outside air; affected air – unaffected air; ambient air – HVAC register output) showing removal

Balanced drying characteristics:

- Humidity, airflow and temperature ***"HAT"*** work together and when managed, enable achieving target time for drying influences movement toward equilibrium - wet seeks dry; hot seeks cold; high vapor pressure seeks low vapor pressure
- Vapor pressure is directly related to humidity ratio/specific humidity) and dew point
- As heat is applied to a material, energy is added; raising the temperature of a wet material increases the rate of evaporation, further releasing moisture from the material, changing the material's vapor pressure
- The greater the difference between ambient temperature and dew point temperature, the greater the potential for faster and more efficient drying.
- Open drying – intentionally exchanging indoor with outdoor air without using dehumidifiers
    - requires constant monitoring; above 80ºF/ 27ºC – microbial growth highly probable
    - requires rapid exhausting of wet air; concerns of reaching dew point temperature
- Closed drying – use of mechanical dehumidification
- Heat drying systems – (directed heat and ambient heat applications) creates lower RH; requires rapid and massive ventilation of wet air to the exterior; increases rate of evaporation by increasing the surface temperature of wet materials

Common items to all drying jobs:

- Proper authorization (contract, payment terms, responsible parties)
- Protect contents from further damages; identify primary, secondary, and pre-existing damages
- Activation of site assets (ceiling fans, whole-house fans, exhaust vents, HVAC, open drying)
- Initiate extraction procedures (contain migrating water; remove excess moisture)
- Set up evaporation and dehumidification (ventilation) equipment to promote drying
- Customer communication; determine drying goals
- Project monitoring (frequency, activities, forms, documentation)
- Completion procedures (e.g., clean flooring; demolition; reconstruction, as required)
- Improper documentation (moisture map; daily atmospheric conditions – daily monitoring

Common numbers used in for definitions and calculations:

- **40%** - RH to attempt to achieve after 24-hours drying for "larger gas tank"
- **60% -** RH hygroscopic materials start to readily take on humidity; microbial activity ERH
- **14** – cubic feet in pound of dry air
- **7000** – grains in pound of dry air
- **55** – gpp where conventional dehumidifiers start to lose efficiency
- **34** – gpp where LGR dehumidifiers start to lose efficiency
- **70-90 F. (21-30 C.)** – temperature where refrigerant dehumidifiers have best performance
- **30%** - RH where LGR dehumidifiers start to lose efficiency
- **1.5** – Evaporation Potential number as minimum to use as goal with traditional drying equipment
- **12,000** – Btu removal action per ton of air conditioning per hour
- **80%** - available power to use per NEC per amperage in circuit
- **1200** – amount of times more effective of extraction to dehumidification in water removal
- **10-16** – distance recommended per l. ft. with most airmovers for potentially effective evaporation
- **50-60** – alternative recommended per sq. ft. for airmover placement
- **3 / 4"** thickness of most hardwood planks; distance of reading with non-invasive moisture meters
- **7.48** – gallons per cubic foot of water depth
- **3 feet** – distance of hardwood floor panels pulling from any direction as maximum distance set up
- **100%** - RH at saturation / dew point
- **20%** - rotting fungi growth ***IN*** wood (**16%** - non-rotting fungi growth ***ON*** wood)

25 DRYING TIPS

Drying – *Considerations*:

1. Humidity Ratio reduced **ASAP**, for more effective evaporation, especially with **Class 4** materials
2. In addition to reducing GPP, **consider augmenting process by applying heat**
3. Relative Humidity reduced to **40% after 24** hours to help create a **bigger "drying tank"** for ability to capture more evaporated moisture from materials
4. Every **20º F. rise in air temperature** approximates cutting ***RH % in half***
5. Sill plates or other "hidden" areas usually are the **last areas to dry**
6. High vapor pressure (high gpp) ***wants to move to*** low vapor pressure (low gpp)
7. For most efficient evaporation - get ***Hot…Dry…Airflow…to the Water!!!***
8. Material surface temperature **GREATER THAN** dew point temperature of air**!!!**
9. Greater difference in these temperature metrics creates **increased evaporation potential** for faster drying
10. Water seeks a **level of equilibrium**, especially into hygroscopic materials
11. Relative humidity **greater than 60%** - hygroscopic materials rapidly absorb humidity from ambient air
12. Open drying system - ***higher gpp inside*** compared to lower gpp outside
13. Closed drying system - ***higher gpp outside*** compared to lower gpp inside
14. Conventional refrigerant dehumidifiers have better efficiency **> 55 gpp** in air
15. LGRs have better efficiency **above 34 gpp** in air
16. Conventional refrigerant dehumidifiers have efficiency above **40% RH**
17. LGRs have efficiency above **30% RH**
18. Refrigerant dehumidifiers work best **70-90º** F range (generally, best around 85º - ***even when using high-temp LGRs***)
19. Desiccant dehumidifiers provide the **lowest Vapor Pressure** (*lowest gpp*)
20. Consider using desiccants if unable to raise temperature in colder environment when drying Class 4 environments or materials
21. Evaporation is the **BOTTLENECK** of drying ---- ***slows drying time***
22. Most effective extraction ----- ***most effective and expedient*** drying time
23. Maintain temperature control of both *ambient air **AND** material surface*
24. Dehumidification rate **EXCEEDS** evaporation rate - *balanced drying*
25. Adding energy (heat) to material **INCREASES** evaporation ability

S500 - Important Definitions

Throughout this document the terms "shall," should," and "recommend" are used to compare and contrast the different levels of importance attached to certain practices and procedures. It is impractical to prescribe procedures intended to apply to every water damage situation. In certain circumstances, deviation from portions of this Standard and Reference Guide may be appropriate. Carelessness is unacceptable and common sense and professional judgment are to be exercised in all cases.

shall: *when the term* **shall** *is used in this document, it means that the practice or procedure is mandatory due to natural law or regulatory requirement, including occupational, public health and other relevant laws, rules or regulations, and is therefore a component of the accepted "standard of care" to be followed.*

should: *when the term* **should** *is used in this document, they mean that the practice or procedure is a component of the accepted "standard of care" to be followed, while not mandatory by regulatory requirements.*

recommend(ed): *when the term* **recommend**(ed) *is used in this document, it means that the practice or procedure is advised or suggested, but is not a component of the accepted "standard of care" to be followed.*

In addition, the terms "may" and "can" are also available to describe referenced practices or procedures, and are defined as follows:

may: *when the term may is used in this document, it signifies permission expressed by the document, and means that a referenced practice or procedure is permissible within the limits of this document, but is not a component of the accepted "standard of care" to be followed.*

can: *when the term can is used in this document, it signifies an ability or possibility open to a user of the document, and it means that a referenced practice or procedure is possible or capable of application, but is not a component of the accepted "standard of care" to be followed*