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BUILDING MATERIAL PROBLEMS CAUSED BY CONDENSATION

by

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RCI Building Envelope Symposium
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Condensation within exterior walls and roof assemblies can severely impact the service life of building components. In extreme cases, condensation results in fungi attack, mold growth, decay of wood, and corrosion of metal. Condensation is typically the result of improper design or construction; however, it can also be related to occupant habits and building usage.

Condensation problems can be prevented by understanding sources of moisture. Sources of moisture, vapor retarders, air barriers, removing moisture, and the effects of moisture on building components will be discussed.

Case studies will be presented that include building envelope deterioration in an indoor swimming pool and an ice rink.

Deterioration mechanisms caused by condensation in various building envelope components will also be discussed.

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INTRODUCTION

Condensation within exterior walls and roof assemblies can severely impact the service life of building components. In extreme cases, condensation results in rotting of wood, corrosion of metal, and mold and mildew growth.

Condensation is typically the result of improper design or construction; however, it can also be related to occupant habits and building usage. Condensation problems can often be prevented by understanding sources of moisture.

SOURCES OF MOISTURE

Many sources of moisture exist within the building envelope. Five general sources include new construction materials, indoor activities, precipitation, outdoor air, and soil. Moisture within the building often leads to condensation problems because the moisture can infiltrate into wall and roof assemblies and condense on cool surfaces. Controlling indoor moisture can minimize condensation.

New Construction

Moisture from new construction is estimated to contribute an average of 10 or more pints of water per day. Note that 1 pint is approximately 1 lb of water. This may last for a period of 2 to 3 years after construction is completed, depending on the materials used. Moisture problems from new construction are most prevalent during the first year after completion. For this reason, the use of dehumidifiers during the first year is recommended, especially in concrete buildings and basements.

Interior Moisture Sources

Indoor activities also provide an abundance of moisture. The average person emits 2.6 pints of water per day through breathing and perspiration at rest. If strenuous activities are performed, the amount of water is increased substantially. Since the average working person spends the majority of at home time sleeping, moisture problems are prevalent in bedrooms. Moisture problems are also typically found in bathrooms. The average five-minute shower is estimated to emit 1.3 pints of water to the conditioned space. Other sources of moisture include standing water on floors, sinks, bathtubs, etc. Standing water in a toilet is estimated to contribute approximately 0.2 pints of water per day.

Kitchens are estimated to contribute approximately 5 pints of water per day for a family of four. The majority of this moisture is from cooking, however, washing of dishes also contributes significantly.

Exterior Moisture Sources

Precipitation can saturate exterior walls and roofs, leading to extremely large sources of indoor moisture. Modern houses and buildings are constructed with minimal eaves, if any. This results in precipitation saturating wood siding and masonry exterior walls. If leaks are present in roofs and vinyl sided walls, the sheathing can also become saturated. Resulting sources of moisture can be similar to that of new construction; on the order of 20 pints of water per day.

High outdoor summer relative humidities can significantly contribute to indoor moisture problems. From air leakage alone, high outdoor relative humidity is estimated to contribute between 60 to 130 pints of water per day to the conditioned indoor space. The specific amount of water depends on the tightness of construction, temperature difference between the indoor and outdoor air, and the relative humidity difference. Using hot humid outdoor air for ventilation will greatly increase the amount of moisture.

Moisture from Soil

Moisture from soil is typically due to improper design or construction. This type of moisture provides a constant supply of water that evaporates in to the living space through basement walls and floors. This type of moisture is estimated to contribute up to 50 pints of water per day in the conditioned space. Proper design and construction with the use of capillary breaks can virtually eliminate this source of indoor moisture.

Miscellaneous Moisture Sources

Other miscellaneous potentially large sources of moisture include indoor storage and drying of firewood, and combustion back drafting. Estimates for a 6-month period of firewood storage and drying range from 400 to 800 pints. Estimates of moisture from back drafting of gas furnaces and water heaters range up to 6,700 pints per year.

MOISTURE PROBLEMS

Excessive moisture in and around building materials leads to mold and mildew growth, rotting of wood, corrosion of metal, and can also lead to damage of concrete and masonry. Damage to concrete includes spalling from repetitive freezing and thawing of unprotected concrete. Damage to masonry includes freeze/thaw damage as well as efflorescence due to moisture migration from the interior to the exterior of the wall.

Fungi Growth

Mold and mildew are fungi that grow on surfaces. These fungi grow rapidly in the presence of high humidity, nutrients, and water. Physical properties of building materials are not typically degraded by mold and mildew.

Optimal conditions for fungi growth are between 40 and 100°F with a relative humidity greater than 80%. Mold and mildew are easily removed from non-porous surfaces with bleach and easily prevented by removing the moisture source. Mold may permanently stain the material on which it is growing. Mold also typically increases the moisture content of the material on which it is growing.

Decay of Wood

Wood used in indoor construction normally contains between 6 and 11 percent moisture, depending on the location of the country. In the majority of the U.S., the average moisture content is approximately 8 percent. In the coastal regions of the southeast, the moisture content is typically about 11 percent, while in the desert regions of the southwest, the average moisture content is approximately 6 percent.

Wood products are sensitive to changes in the surrounding atmosphere. Changes in moisture contents cause wood products to swell and contract. Table 1 indicates the equilibrium moisture content of wood for different temperatures and relative humidities. It is important to note that even at high relative humidities and low temperatures, the average moisture content of wood is below 30 percent.

In general, wood decays (rots) when its average moisture content is above 30 percent. This is the level of fiber saturation. Different varieties of wood are more resistant to decay than others. Table 2 presents common varieties and their resistance to decay. Frequently wetted unprotected pine siding will begin to exhibit signs of decay in a matter of 12 months. It is important to understand that wood will not decay unless it is frequently wetted, to the point where its average moisture content is above 30 percent.

Corrosion of Metal

Unlike decay of wood, corrosion of metal is a continuous and naturally occurring process. Corrosion is simply the conversion of metal to its original form (a metal oxide). In the long-term, corrosion can not be prevented, it can only be delayed. In the short-term, corrosion can be delayed to the point that it appears to be prevented. Two basic means for corrosion delay in structures are available. The first method is to utilize the correct type and grade of metal for the exposure condition. The second method is the use of protective coatings such as paint or galvanization.

Corrosion occurs due to two basic mechanisms. The first mechanism is chemical attack. In general, acids readily attack steel, quickly corroding the metal. Steel, however, is protected in alkaline environments. This is why steel is used as reinforcing in concrete. The opposite is true of aluminum; it is readily attacked by alkaline environments, while it is not effected by mildly acidic environments.

The second corrosion mechanism is electrochemical attack. This is the most common means of corrosion. This type of corrosion requires air, moisture, and a small amount of electrical energy. Air surrounds us and carries moisture in the form of humidity. Small amounts of electrical energy are naturally occurring and are almost unpreventable in metals. For this reason, corrosion is a continuous and naturally occurring process. The use of protective coatings such as paint on metals reduces the amount of moisture and air that actually reach the metal, which slows the process of corrosion. Attaching two different (dissimilar) metals such as steel and aluminum increases the electrical energy, which speeds the process of corrosion.

Damage to Concrete and Masonry

Freeze/thaw damage to concrete and masonry occurs because water expands by almost 10 percent in volume as it freezes. Free water is almost always present in concrete. Repetitive freezing and thawing can cause large amounts of internal stress that can deteriorate concrete. Cracking, scaling, and crumbling are the visible forms of deterioration.

Concrete can be protected against freeze/thaw deterioration by adding an air-entraining agent to the concrete mix, before it is placed. The air-entraining agent forms small-interconnected bubbles of various sizes in the concrete for water to expand into as it freezes. Approximately 5 to 7 percent entrained air is required for adequate resistance to freeze/thaw damage. Concrete indented for exposure to freeze/thaw conditions is generally air entrained, while concrete for indoor use or in mild climates is generally not air-entrained.

Foamed (lightweight insulating) concrete for insulating applications in roof assemblies is not resistant to freeze/thaw damage. Although this type of concrete has little free moisture and is mostly trapped air, when saturated from a roof leak or large amount of condensation, this type of concrete deteriorates rapidly in freeze/thaw environments.

Efflorescence on older masonry is typically the result of a moisture problem. Although most masonry buildings normally exhibit efflorescence in the first year after construction, efflorescence should not otherwise occur. Efflorescence is typically calcium carbonate and is caused by a large amount of moisture migrating through the masonry.

MODELLING AND DESIGN

Moisture within the walls and roofs accumulates through condensation or leaks. Leaks consist of both precipitation penetrating through the exterior of the building, and moisture-laden air leaks penetrating the walls or roof, from either the interior or the exterior. Exterior air barriers and interior vapor retarders are designed to minimize air leaks into the walls and roof assemblies in appropriate climates, and are discussed in the next section.

Condensation is the result of interior moisture that migrates through building components and condenses on cold surfaces. The amount of moisture migration through a wall (with no air leakage) is dependent on the water vapor permeability of the materials used in construction. Table 3 provides water vapor permeabilities and thermal resistances of common building materials.

Several methods exist to calculate the potential for and/or the amount of condensation that might be expected to develop in a wall or roof assembly. Models range from simple to complex. The simple models consider only one-dimensional steady-state conditions, while the complex models consider two- and three-dimensional models that use actual hourly weather data and dynamic material properties.

For the purposes of determining whether condensation may be a problem, the simple models are adequate. The simple models, however, do not consider the dynamic effects of daily temperature changes, solar effects, air leakage, and material absorption. Condensation rates are rough approximations. The currently available complex models require very specific detailed information and are not very user friendly. However, the complex models can provide detailed information on the long-term moisture content and resulting thermal properties of materials.

Annex A1 of ASTM E755 presents a simple one-dimensional steady-state model. The model is easily incorporated into a spreadsheet. An example is presented in Figure 1. The model uses thermal resistance and water vapor permeability values of construction materials, and interior and exterior temperatures and relative humidities. The model presents the surface on which condensation may occur. The rate of condensation is estimated, but may be erroneous if condensation is predicted to occur on two or more surfaces. Additional calculations are required to determine where the condensation occurs and the rate of condensation. It is important to note that this model does not account for air leakage.

Average monthly temperatures or design temperatures should be used in the model. The use of design conditions may result in the over design of the building assembly; however, the use of average temperatures may result in some condensation during design conditions. Limited condensation during the winter months may be acceptable, provided it is not excessive, does not adversely affect building components, and is able to evaporate in the following months.

SOLUTIONS

In most cases, simple modifications to the design of the building assembly can mitigate most moisture problems. In cool climates such as the Midwest, a continuous interior vapor retarder is usually required. A continuous exterior air barrier, if not required, may be utilized to minimize airflow into the building envelope. Minimizing exterior air leaks reduces heating and cooling costs as well as reduces the potential for unexpected condensation.

Another commonsense method of eliminating moisture problems is to prevent exterior moisture from entering the building. This includes fixing air and water leaks, providing adequate drainage away from the building, moving landscaping away from the building, and not allowing sprinklers to wet the building. Removing indoor moisture will also help reduce moisture problems. Relative humidity should be controlled to a range of 45 to 60 percent. This is also the optimum range for human comfort and health. This can be accomplished through ventilation, humidifiers/dehumidifiers, air conditioning, and heat.

In many cases, generalized "rules-of-thumb" are not sufficient to prevent condensation within building assemblies. One specific example is reliance on the vapor retarder of batt insulation. This vapor retarder is not typically continuous and has a water vapor permeability slightly less than 1 perm. Although the definition of a vapor retarder is a material with a water vapor permeability of 1.0 or less, in many cases, this is not sufficient to stop moisture penetration. A continuous material is generally required, and a material such as polyethylene is a better and sometimes more appropriate vapor retarder.

Once moisture problems are addressed and the building envelope is repaired, moisture can generally be removed using dehumidification, heat, and/or ventilation.

CASE HISTORIES

Indoor swimming pools and ice rinks in winter climates have the potential for high indoor relative humidities and cold building materials. These elements can contribute to condensation and premature deterioration of building materials. Case histories are provided for an enclosed swimming pool and an enclosed ice rink with condensation problems.

Indoor Swimming Pool

An evaluation was performed after roof leaks were reported around skylights of a newly constructed indoor swimming pool in the Chicagoland area. After a preliminary inspection, it was evident that the reported leaks were related to building moisture problems. Exterior brick masonry exhibited heavy efflorescence and water streaks were visible on the exterior walls below the eaves. The evaluation included a visual inspection, field measurements, and analyses for condensation potential.

Building Description. The swimming pool structure has a steep roof and consists of masonry load-bearing walls supporting laminated wood trusses and laminated tongue and groove wood decking. The tongue and groove wood decking is exposed to the inside of the swimming pool area. A layer of asphalt felt and rigid insulation were placed over the tongue and groove wood decking. Prefabricated ventilated decking, consisting of two-oriented strand boards (OSB) with a ⅝-in. air gap, were attached on top of the rigid insulation. Roofing felt and asphalt shingles were installed over the ventilated deck boards. Several rectangular skylights were installed in the roof.

The walls consisted of cement plaster interior surfaces installed over concrete masonry units (CMU) with 2-in. of rigid insulation on the outer face of the CMU, and face brick. Exterior windows consisted of insulating glass panes in wood frames. Skylights were aluminum framed and reported to have argon-filled insulated glass panes. The building HVAC system is reportedly designed to provide negative interior pressure during the winter months and to maintain an indoor relative humidity of approximately 40%. Historical data indicated that, at times, the measured relative humidity was a high as 95%. Actual site measurements indicated little to no negative interior pressure.

Inspection and Review. Review of the design drawings indicated no effective vapor retarder was provided on the inner or warm surfaces of the roof and walls. Designers had attempted to prevent condensation by use of the ventilated deck boards; however, this ventilation was ineffective due to wood blocking specified at the eaves immediately above the eaves vents. In addition, the lower OSB of the ventilated deck became cold enough in winter conditions to cause condensation. Therefore, ventilating the upper deck panels would not eliminate condensation. Design drawings did not indicate asphalt felt above the tongue and groove wood deck. The design of exterior walls did not provide an effective vapor retarder within the wall system.

The visual inspection revealed heavy efflorescence, water dripping from the ceiling, water streaks visible on the exterior masonry walls, and deteriorated OSB roof decking.

Analyses. Condensation analyses were performed using the calculation procedure presented in Annex A1 of ASTM 755. Analyses confirmed that condensation readily formed in both the walls and the roof whenever the average daily temperature was below 45°F. Historically, this occurs during the period from November through March.

Results of the evaluation and analyses indicated the presence of condensed moisture as a direct cause of the observed water stains and masonry efflorescence.

Repair Plan. The recommended roof repair was the addition of a continuous warm side 6-mil polyethylene vapor retarder with a ventilated air space beneath the vapor retarder.

Condensation was predicted to occur at the interface between top of the insulation and the bottom of the OSB for winter design, the average January, and the average February conditions when 95% relative humidity was assumed for the indoor air. No condensation is predicted to occur with an indoor relative humidity below 53%.

The recommended wall repair was the installation of a continuous 6-mil polyethylene vapor retarder placed on the existing wall surface and a water-resistant wallboard placed over the vapor retarder. A vapor retarding paint was specified for application to the interior surfaces of the wallboard. This repair indicated a potential for condensation at the interface of the insulation and brick for the winter design and average January conditions when the relative humidity of the indoor air was in excess of 95%. No condensation is predicted when the relative humidity of the indoor air was below 88%.

The ASHRAE winter design condition is a severe case for condensation and is anticipated to be exceeded for a total of 54 continuous hours in the months of December, January, and February. Condensation predicted to occur only under these conditions is frequently able to evaporate during other periods and not cause damage. This repair is considered adequate for the conditions assumed.

No condensation was predicted for the summer conditions assumed for the recommended wall and roof repairs.

Indoor Ice Skating Rink

A 54-year-old enclosed ice rink in New England was investigated to determine the cause of a deteriorated wood roof deck. An elastomeric spray-applied membrane was placed on the exterior roof surface in 1987. The purpose of the analysis was to determine whether condensation caused significant deterioration of the wood deck prior to the application of the membrane.

Building Description. The building had an arched roof that consisted of steel girders spanning the entire width of the rink. The girders supported a roof that consisted of steel purlins, 2-in. of board insulation, 2-in. of tongue and groove wood decking, and a built-up roof membrane.

No dehumidification or air handling system was incorporated into the design of the building. The building was heated to 55°F only during periods when it was occupied. Fog routinely formed above the ice rink in the summer, and condensation was pervasive on the steel structural members of the roof. Pools of water formed on the ice in the winter months due to condensation dripping from the roof. This condition reduced skating quality and contributed to unsafe conditions. The ice provided a continual source of water vapor to the building air.

Evidence of fog in the building in the summertime, the dripping condensation in the wintertime, and the lack of dehumidification equipment indicated the building relative humidity was greater than 80% and probably close to 100%. For the purposes of analyses, indoor relative humidities were assumed to be 80% in the winter and 99% in the summer. Since the building was heated only when it was occupied, the winter indoor temperature was assumed to be 55°F or lower. The indoor summer temperature was assumed to be 70°F or lower. When analyzing moist wood decking and insulation, permeances and thermal conductivities were estimated to be twice that of dry materials.

Analyses

Steady-state water vapor diffusion analyses were performed in accordance with Annex A1 of ASTM C 755. Average winter and summer design conditions were used for the analyses. The analyses modeled the roof structure as constructed prior to the application of the membrane in 1987.

The results of the analyses showed that significant amounts of moisture from the indoor air condensed in the insulation and wood deck during average winter and winter design conditions. Analyses using average July and design summer conditions indicated that no condensation occurred, however, little to no drying occurred. The building relative humidity was at or near 100%, as evidenced by fog near the ice. The built-up roofing acted as a vapor retarder and prevented the wood decking and insulation from drying to the outside. The potential for drying to the indoor air was limited due to its high relative humidity.

The calculated condensation in the insulation and wood decking for the months of November through March was 0.27 quarts per sq ft. Assuming that no drying occurred during the remaining months of the year, this resulted in 2200 gallons per year of condensation in the entire roof assembly.

This rate of condensation and little to no drying potential, over an extended number of years, resulted in the accumulation of moisture in the insulation and wood decking. The high moisture content in the wood decking led to fungi attack and wood decay. Therefore, it is likely, that the roof deterioration was present well before the application of the elastomeric membrane.

SUMMARY

Condensation within building assemblies can severely impact the service life of building components. In extreme cases, condensation results in rotting of wood, corrosion of metal, and mold and mildew growth.

Condensation is typically the result of improper design or construction; however, it can also be related to occupant habits and building usage. Condensation problems can often be prevented by understanding sources of moisture.

Many sources of moisture exist within the building envelope. Moisture within the building often leads to condensation problems because the moisture can infiltrate into wall and roof assemblies and condense on cool surfaces. Controlling indoor moisture can minimize condensation.

Excessive moisture in and around building materials leads to mold and mildew growth, rotting of wood, corrosion of metal, and can also lead to damage of concrete and masonry. Damage to concrete includes spalling from repetitive freezing and thawing of unprotected concrete.

Several methods exist to calculate the potential for and/or the amount of condensation that might be expected to develop in a wall or roof assembly. Models range from simple to complex. Annex A1 of ASTM E755 presents a widely used simple one-dimensional steady-state analysis model.

Two case histories were presented which illustrate extreme examples of distress related to condensation. Analyses of the buildings presented as case histories used ASTM E755.

The swimming pool example showed how susceptible structures that enclose swimming pools are to condensation problems. After one year of service, the roof deck was saturated and showing signs of decay. An inspection revealed that a vapor retarder was not included in the design or construction. Condensation analyses were used to develop repair designs suitable for controlling condensation.

The ice rink example illustrated how significant condensation levels with little opportunities for drying can saturate and deteriorate a roof deck.

GENERAL REFERENCES

Moisture Control in Buildings, ASTM Publication No. 28-018094-10, American Society of Testing and Materials, Philadelphia, PA, 1994.

ASTM C755-85, "Selection of Vapor Retarders for Thermal Insulation", Volume 4.06, *Annual Book of ASTM Standards*, American Society of Testing and Materials (ASTM), West Conshohocken, PA, 1996.

Building Moisture Analyses Tutorial, Building Environment and Thermal Envelope Council (BETEC), Washington DC, September 17-18, 1997

1993 ASHRAE Handbook of Fundamentals, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta, GA 1993.

Corrosion Basics: an Introduction, National Association of Corrosion Engineers (NACE), Houston, TX, 1984.

Table 1. Equilibrium Moisture Contents of Wood, percent of dry weight

Temperature, °F	Relative Humidity of Surrounding Air, percent			
	25	50	75	100
30	5.5%	9.5%	15%	27%
50	5.5%	9.5%	14.8%	27%
70	5.4%	9.2%	14.4%	26.7%
90	5.1%	8.9%	13.9%	26%

Table 2. Decay Resistance of Select Wood Species

Highly Resistant	Moderately Resistant	Not Resistant
Cedar Oak (Most) Redwood Walnut	Douglas Fir Pine (select varieties)	Ash Fir (Most) Hemlock Oak (Red) Pine (Most) Spruce

Table 3. Thermal and Moisture Properties of Select Building Materials

Material	Thickness, in.	Thermal Resistance, $hr\cdot ft^2\cdot °F/Btu$	Water Vapor Permeance, perms
Drywall	½	0.45	34
Tyvek™ (air barrier)	1 layer	0	58
Housewrap™ (air barrier)	1 layer	0	15
Fiberglass	5¼	19	30
Air Space (Still)	1	Varies	120
Concrete	4	0.25	0.8
Extruded Polystyrene	2	10	0.6
Expanded Polystyrene	2	8	2
Polyethylene	0.006	0	0.06
Plywood (exterior)	¼	0.31	0.7
Paint (vapor retarding)	0.0031	0	0.45
Exterior Acrylic Paint	0.0017	0	5.47
Wood (Pine)	3.5	4.4	0.84

Figure 1. Example Condensation Analysis from ASTM C755

CONDENSATION AND MOISTURE
IN THE BUILDING ENVELOPE

CTL INC.

				Corresponding Saturation Vapor Pressure
Indoor Relative Humidity	40	%		
Indoor Temperature	75	°F		0.8756
Outdoor Relative Humidity	70	%		
Outdoor Temperature	40	°F		0.2478

	Indoor	Air Film		Wood Deck		15-lb Asphalt Felt		Rigid Polyisocyan Insulation		Plywood		45° Air Gap		Plywood		15-lb Asphalt Felt		Asphalt Shingles		Air Film	Outdoor	Total
Thickness, n, in.				2				2.5625		0.4375		0.8125		0.4375								
Permeance, M, perm		160				5.6		1.25		0.35				0.35		5.6		5.6		1000		
Permeability, u, perm•in.				2.9								120										
Vapor resistance, 1/M or n/u, 1/perm		0.006		0.690		0.179		0.800		2.857		0.007		2.857		0.179		0.179		0.001		7.754
Vapor pressure drop for continuity		0.000		0.016		0.004		0.018		0.065		0.000		0.065		0.004		0.004		0.000		0.177
Vapor pressure for continuity, pc, in. Hg	0.350		0.350		0.335		0.330		0.312		0.247		0.247		0.182		0.178		0.174		0.173	
Thermal conductance, C		1.6				16.7				1.07		0.9709		1.07		16.7		2.27		6		
Thermal conductivity, k				1.06				0.1667														
Thermal resistance, n/k		0.625		1.887		0.060		15.375		0.935		1.030		0.935		0.060		0.441		0.167		21.513
Temperature drop, °F		1.0		3.1		0.1		25.0		1.5		1.7		1.5		0.1		0.7		0.3		35.0
Temperature, °F	75		74.0		70.9		70.8		45.8		44.3		42.6		41.1		41.0		40.3		40.0	35
Saturation vapor pressure, in. Hg	0.876		0.846		0.763		0.760		0.310		0.292		0.274		0.258		0.258		0.250		0.248	
Actual vapor pressure, in. Hg	0.350		0.350		0.335		0.330		0.310		0.247		0.247		0.182		0.178		0.174		0.173	
CONDENSATION (Yes or blank)									YES													
Maximum Condensation									MAX.													
Vapor Flow from outside					0.023		0.023		0.022		0.023		0.023		0.023		0.024		0.165			
Vapor Flow from inside					0.023		0.023		0.024		0.023		0.023		0.023		0.023		0.023			
Condensation Rate*, grams / week / sq ft									0.020													

*Condensation rate only valid for the location of the maximum condensation