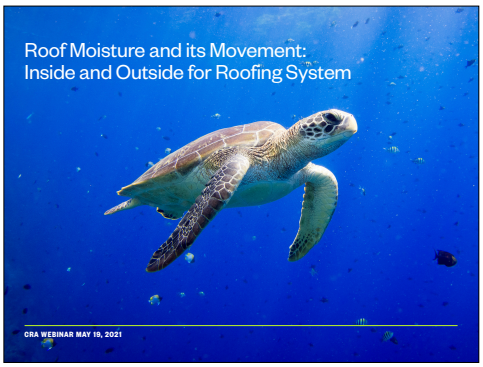
Your Instructor:

- Richard Boon, P.E.
  - 40 years in roofing
  - Former Director: The Roofing Industry Educational institute
  - Walked almost 200 million sq. ft. of roofing in career
  - Umpire for roofing-related disputes



Today's Agenda

- Moisture terminology and background
  - Terms
  - Movement
- Residential Control
  - Ventilation/Dilution
- Compact Roofing Assemblies
  - Low-Slope Roofing
- Rooftop drainage

This is a continuation of the webinars from last year plus some new stuff.

- Last Spring the CRA had webinars on:
  - Hail Damage investigation
  - Terminology, Investigating "leak" complaints, What causes problems in attics.
- Earlier this spring on:
  - Snow Retention
  - Wind Design
- Today we will:
  - Talk about problems with water in and on roofs

Basics: Terminology

Terminology

- Humidity
- Absolute Humidity
- Relative Humidity
- Condensation
- Condensate
- Permeability
- Perms
- Grains

Terms for moisture movement

- Permeance: the property of allowing the passage of moisture
- Permeability: the state or quality of a material or membrane that causes it to allow liquids or gases to pass through it.
- Perm Rating: a standard measure of the water vapor **permeability** of a material. The higher the number, the more readily water vapor (in the gaseous state) can diffuse through the material.
- Perm Unit: **perm** is defined as 1 grain* of water vapor per hour, per square foot, per inch of mercury**

* 7000 grains per pound **an inch of Hg is 0.4912 psi

Water is an enemy

- Water comes in three phases:
  - Solid as ice and snow (Where we sometimes want to retain it)
  - Vapor as steam
  - Liquid as water due to weight and leak potential
- Ice is not really a problem unless there is a "pool" of water that freezes and the expansion as water changes to ice causes problems.
- Vapor is only a problem as it condenses
- The weight of water can collapse roofs, if the water is allowed to pond deep enough

Water Vapor .....

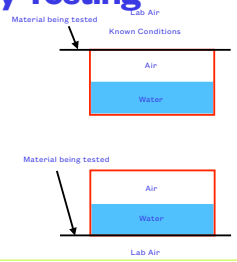
- Does nothing significant
- BUT
- It is a method to move moisture to places where water cannot "flow".

Vapor Movement

- From high pressure to lower pressure.
- It moves in the air stream when air moves
- The vapor can absorb into materials, move through them in molecular form and then reevaporate on the opposite side of the solid material.

Permeability Testing

- Testing can be done with the water directly against the material or with saturated air on the inside of a sealed vessel.
- By knowing the temperature and the humidity outside the sealed vessel the vapor drive can be calculated.
- The change in weight will allow the permeability to be calculated.



Permeability Range

• Class I, Impermeable (vapor-proof), ≤ 0.1 perm:

Built-up roofing membrane, perm rating 0.00-0.02

Single-ply membrane, perm rating 0.03-0.06

Polyethylene film, perm rating 0.06-0.08

• Class II, Semi-Impermeable, > 0.1 ≤ 1.0 perm:

Asphalt felt, perm rating 0.3-0.8

Polyiso roof insulation, perm rating 1.0

Extruded polystyrene, perm rating 1.0

• Class III, Semi-Permeable, > 1.0 ≤ 10.0 perm:

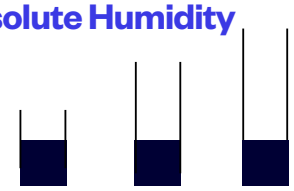
Expanded polystyrene, perm rating 1.2

Wood fiber, perm rating 3.0-5.0

Vapor information:

- Air always contains some percentage of moisture
- The capacity of air to hold or carry moisture is related to the temperature of the air
- The total amount of humidity in the air is called the “Absolute Humidity”
- The amount of humidity as a ratio against the capacity of the air is the “Relative Humidity”
- The temperature at which water vapor begins to condense on surfaces is called the “Dew Point”
- NOTE: The term is not “condensate” it is condense. Condensate is a noun not a verb.

Absolute Humidity

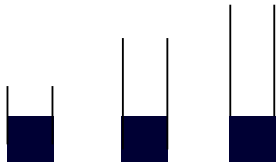


These have the same “Absolute Humidity”,

But

different “Relative Humidities”

Relative Humidity

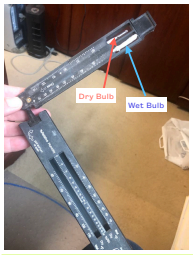


60%
32°F

30%
50°F

20%
60°F

Measurement: Psychrometor



- Originally 2 thermometers:
  - One with a wetted cotton "sock", a "Wet Bulb"
  - One just a "Dry Bulb"
- Using the temperature difference the Relative Humidity could be determined
- If you notice the silver color in the Dry Bulb, that is because Mercury thermometers are the most accurate. Needless to say I don't use this anymore.

Today's Psychrometer

- You can show the wet bulb, dry bulb and relative humidity
- Cost about $100
- Accuracy ±3%

REED Instruments 8706 Digital Psychrometer/ Thermo-Hygrometer, (Wet Bulb, Dew Point, Temperature, Humidity)

From where does the humidity come?

- Outside:
  - Open water
  - Plants
  - Evaporation from the ground
- Inside:
  - Bathing
  - Cooking
  - Living

Outside Sourced Humidity

- If the air is at 0°F, the Denver Design Temperature, and it is saturated (it is holding as much moisture as it possibly can) then when that air is heater to 70°F it would have a Relative Humidity of 5%.
- If the only source of humidity inside a structure is from outside air there cannot be a condensation problem.
- It is the inside activities that add humidity that create the problem.

What is done in the interior?

- Warehouse: likely dry
- Residential: If no humidification interior 30% Rh good value for interior Rh.
- Residential with Humidifiers: Possible problem, Measurements Required
- Factory: Check to see if there is live steam or open water
- Grow Operations: ALWAYS High Humidity

First Line of Control: Inside the Building

- If the moisture isn't in the air it can't move into the attic/roofing system.
- Things to check:
  - Mechanical Humidification
  - Lots of Cooking
  - Lots of washing
  - Steam Rooms or Steam Showers
- Direct vents to outside, are they working and are they used

More Things to Check:

- Concrete pour after roof install, new construction.
- Metal Buildings with old/torn bagged insulation
- Metal Building with high humidity occupancy
- Newly installed humidification systems

Moisture Source: Propane

Metal Building: holes/ gaps in vapor control layer led to water "filling" the space

Second Line of Defense: Direct Venting

- Are bath fans tied to light suites in bathrooms?
- Is there a vent hood used above cooking areas?
- If open water is used, is the area direct vented to the outside?
- If the house is "highly efficient" does the house have an air to air heat exchanger?
- Can venting be added?
- Can venting be tied to a humidistat?

Once the Moisture Sources are Controlled:

- If the general level of interior relative humidity is kept below 30%, then there is low probability of a moisture problem.
- Now you have an opportunity to prevent condensation above the conditioned living space.

Attic/Roofing Ventilation

The Building Code Requires it!

Don't Worry, Be Dry

Attic Ventilation: History

- Requirements date to 1942 FHA Property Standards Guide
- Building code adopted values from 1/150 to 1/600 over time.

- 2021 IRC Requirements Section R806
  - Minimum 1/150
    - Except where a Class I or II vapor retarder is installed on the warm side
    - Ventilation to be split 50:50 no worse than 60:40 with the high point 3-feet above the low point.

When the hail storm hits...

- And we are due.
- [Last year's webinars on hail damage are available from the CRA.]

- Ventilation is required, you need to add it. But how much?
- You are responsible to add ventilation if it is not already in place.
- This cost should be covered as a part of any Code upgrade coverage that the home owner has.

Attic Ventilation requirements not based on testing, but on anecdotal information

- Cold air cannot hold much moisture
- The amount of moisture that air can hold goes up quickly as the air warms.
- If cold air is warmed it will hold lots more water vapor.
- Attics are warmed by the sun on the roof and heat escape from inside the building.
- If there is air movement the moisture is diluted and there is no problem.

In extreme cold

- Condensation is expected
- The longer the cold stays below freezing the more condensation builds up
- Frost (condensation) starts on the metal fasteners and spreads
- The north face is worse than the South due to solar heating even with some snow
- Does not happen often in the Denver Front range

How to Handle Excess Moisture

- Don't worry about it, this is Denver a high plains desert
- Dilution is the solution
  - Ventilate, Ventilate, Ventilate
- Absorb and then release
  - Some materials handle moisture better than others

Attic Ventilation

- It is simple,
  - Calculate the area (in sq. ft.) to the plan view of the house.
  - Divide by 150
  - Divide by two
  - Install that area of free vent area near the ridge and in the soffit
- If it is that simple, why are there so many problems getting it done?

Sometimes the vents aren't truly: Free-Vent Area

Problems:

- No air movement
  - The moisture comes from the warm moist environment to the cold
  - The movement is driven by differential vapor pressure
  - If the moisture "pools" in a cold attic at some point it exceeds the air's capacity to hold it and condensation occurs.
    - A cold night reduces the air's capacity
- Differential attic temperatures
  - North side with snow will be colder than South face that gets full sun

Some designs are difficult to ventilate

- Blind valleys, Slopes into walls, some long valleys all can create problems for intake air.
- Open attics can get you around these problems.
- Sectioned attics make things worse.

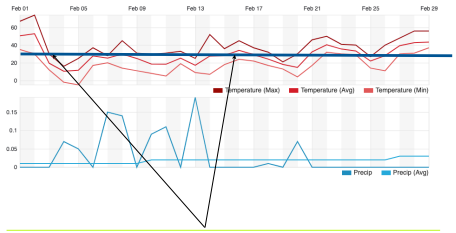
The problem is the impossible design

- Lots of ridge, right?

Interesting house

- Long valleys ridge placed skylights, likely cathedral ceiling, long North faces.

February 2020



12 days below freezing

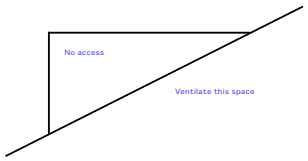
Ventilation solves the problem?

- This roof has a ridge vent, But not good eave venting.
- You need an inlet and outlet
- Ideally they are balanced.
- Excess in one is OK, but effective vent is balanced.

Dormers

- The large dormer on the left is built on after the roof slope was completed. This does not need to be ventilated.

Watch Dormers



"Free Vent Area"

- Screens limit air movement
- Non-wovens virtually stop air movement
- Excessive openings can allow snow entry.
- Baffles can allow air movement and stop snow
- Louvers on gable vents can be too open.

Free Vent Area

- For Example from available literature:

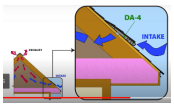
Features

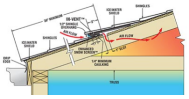
- Can be installed at edge of roof or on pitch
- Fits roof pitches from 3/12 to 6/12
- 9 square inches of net free area per foot
- Made with durable long lasting material
- 2 1/2" Ring shank nails included
- Integrated end plug every 2 inches
- Lifetime Limited Warranty

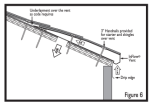
Quick Calculation

- 9 sq inches = 9/144 = 0.0625 sq. Ft
- 150 times 0.0625 = 9.375 square feet that this intake can vent.
- With a similar ridge vent (two sided one side having 9 sq. In per foot) this combination can vent an 18.7 ft length from eave to ridge.
- This is a house width of 37.5 feet.
- This does not work for complex geometries, but works great for simple ridge lines.
- If there is a vapor retarder, then the size/area vented can be doubled.

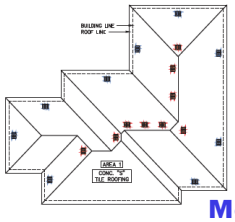
Field based Air Intakes







Some are intake and exhaust



Most are not!

Articles

- Lots of article on “best” way to ventilate roof
  - Ridge vents vs box vents
  - Gable vents and ridge vents
  - Mixed systems
- Individual companies generally have articles support the use of their products.
- How to Calculate Ventilation Requirements

Is Venting Required in a Reroofing Situation?

- The current ventilation requirements for ventilation are based on new construction.
- There is a push to have the ventilation added specifically to the codes for reroofing.
- If you are interested in helping to push through a code change to add the ventilation requirement, go to: www.roofventilation.org.

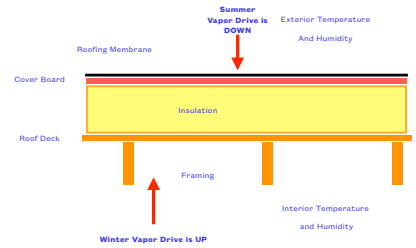
Compact Roofing Assemblies

- Moisture movement is slow
- Drive is from warm and moist to cold and dry.
- If the moisture hits a surface that is below the dew point temperature, then it will condense.

Moisture Movement in Compact Roofing

- The layers of the roofing assembly are laid out and a thermal profile is run
  - The thermal profile will provide information about the location of the temperature at which condensation will occur.
- The layers of the roofing can be checked and a determination can be made about the possibility of moisture movement.
- If a layer that has a low perm rating is on the "warm" side of the assembly, then that layer will slow the movement of moisture into and through the roofing assembly.

What is happening?



When the drive is down in Denver,

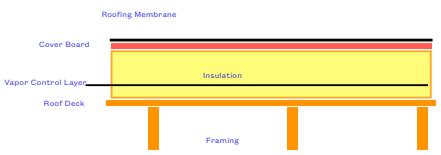
- The moisture is being driven out of the assembly into the interior of the building
- The temperature of the roofing membrane is high:
  - Black membrane 180° F
  - White membrane 120°F
- The air is relatively dry, both inside and outside of the building
- This is not a condition that creates a concern.

Winter is the problem

- We have a low Design Temperature, 0°F (1% design)
  - This means that the temperature of 0°F happens approx. 1% of the time in a year.
- Our air is very dry. If the outside air is only heated and no moisture is added, the absolute humidity does not change so there is no problem.
- If the amount of humidity that is added due to interior operations is low, then there is no problem.
- If the amount of humidity that is added is too high then condensation can be a problem.

Vapor Control Layer

- Slows moisture movement



Thermal Profile

- Needed to identify the dew point location in the assembly.
- A temperature check at the interface is the easiest way to do this. The temperature in a slab of insulation is a linear relationship with location between the temperature at the top and the bottom.

Thermal Profile	Thickness	Outside Temperature °F	0	Relative Humidity	80%
		Thickness	R-Value	Temp at bottom of layer	R-value to this point
Air Film		Outside Film Cold	0.17	0.5	0.17
Membrane Surfacing		No Surfacing	0	0.5	0.17
Membrane		TPO	0.24	1.1	0.41
Coverboard	.25	Gypsum	0.775	3.2	1.125
Insulation Layer #1	2.5	Poly Isocyanurate	13.75	41.7	14.875
Insulation Layer 2	1.5	Poly Isocyanurate	8.25	64.8	23.125
Layer		Choose Product	0	64.8	23.125
Layer		Choose Product	0	64.8	23.125
Roof Deck		Wood	1.25	68.3	24.375
Interior Air Film		Indoor Heat Up	0.61	70.0	24.986

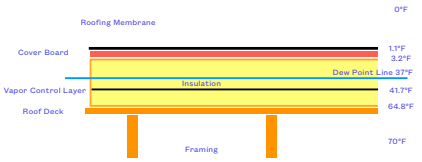
Vapor Condensation occurs at the Dew Point Temperature

- The Dew Point is the temperature at which the air is saturated
- This can be calculated by multiplying the Relative Humidity at the interior temperature by the saturation vapor pressure.
- Compare this value with the saturation pressure table and then look at the temperature at which this occurs.
- This is the Dew Point temperature

Calculation

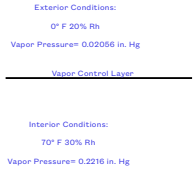
- Interior 70°F 30% Rh
  - Saturation Vapor Pressure =0.7387
  - Actual Vapor Pressure= 0.3 x 0.7387 = 0.2216 in. Hg
- The saturation vapor pressure of 0.2206 occurs at 37°F
- Exterior 0°F
- Therefore, there is a dew point within the assembly.
- The question is does the vapor get to that point in the assembly.

Where is this point?



Vapor Control Layer

- The vapor control layer is below the Dew Point so there is not a problem.
- How do we know this?
  - The maximum drive is the bulk air conditions on both the inside and the outside.



- The drive is the difference in pressure = 0.2216-0.02056 = 0.2010 in. Hg
- 4 mil poly has a perm rating of 0.08 grains/hour/square foot/ inch of Mercury delta Pressure
- 0.08 x 0.201 grains/hr/sq ft
- =0.0161grains per hour.

Exterior Conditions:

0° F 20% Rh

Vapor Pressure= 0.02056 in. Hg

Vapor Control Layer

Interior Conditions:

70° F 30% Rh

Vapor Pressure= 0.2216 in. Hg

- In 87.6 hours a total of 1.4 grains will get through
- That is 1/5,000th of a pond total.

Is that a problem?

- Roofing materials can absorb and release moisture
- The amount that they can absorb and release depends on the chemistry of the product.
- For example, gypsum inherently contains a lot of moisture and it can absorb and release a lot of moisture without harming the material.
- Wood is also good at absorbing and releasing moisture.
- For example, Iso Insulation has an equilibrium moisture content of 1.4% at 45% Rh and 3.0% at 80% Rh.

ISO Roof Insulation

- 1.4% of dry weight at 45% Rh
- 3.0% at 80% Rh
- A 1" thick section -ft square of Iso with 2.7 lbs/cu. ft density weighs 0.23 pounds.
- The difference in weight due to moisture is 1.6% of 0.23 = 0.0036 lbs.
- 0.0036 lbs = 25.2 grains

- Remember in 1% of a year only 1.4 grains will get through. Lots of safety.

What are the issues?

- The model assumes perfect sheets with no holes.
- There needs to be an effort made to overlap sheets and tape joints.
- Holes need to be patched.

- What about putting fasteners through the sheet?
  - The fastener is in the hole.
  - The compression reduces/prevents air movement

Moisture Movement: Compact Roof Assemblies

- Moisture moves as a vapor when space allows
- Moves through contact between elements in the assembly.
- For the purpose of our discussion we will use vapor pressure as the driving force

Model

Moisture movement

Assembly Profile			R-value			Grains /hr	^/V	% RH at Bottom of layer	Sat. Vapor press	∆ vapor Press	Perm rating of layer
Thermal Profile	Thickness	Outside Temperature °F	0	Relative Humidity	80%						
		Thickness	R-Value	Temp at bottom of layer	R-value to this point						
Air Film		Outside Film Cold	0.17	0.6	0.17	0.0000	^	390.5%	0.0378	0.0000	100.00
Membrane Surfacing		No Surfacing	0	0.6	0.17	0.0000		390.5%	0.0378	0.0032	
Membrane		TPO	0.24	1.5	0.41	0.0000	^	339.6%	0.0411	0.0335	0.00
Coverboard	.5	High Density ISO	2.75	11.3	3.16	0.0000	^	200.8%	0.0736	0.0000	0.25
Insulation #1		Choose Product	0	11.3	3.16	938.9663	^	200.8%	0.0736	0.0939	100000.00
Insulation # 2	1	Poly Isocyanurate	5.5	32.9	8.66	0.0154	^	88.2%	0.1675	0.0616	0.25
Layer	.75	Wood Fiber	2.085	38.4	10.745	10.3242	^	64.4%	0.2260	0.3538	30.00
Layer	2	Fiberglass Batts	7	60.4	17.745	2.6029	^	25.9%	0.5801	0.0847	30.00
Roof Deck		Wood	1.25	67.8	18.995	0.0193	^	22.2%	0.6668	0.0719	0.25
Interior Air Film		Indoor Heat Up	0.61	70.0	19.605			20.0%	0.7267		
Total R-Value			19.605								
Inside Temperature		Inside Temperature	70								
Interior Relative Humidity		Relative Humidity	30					Partial Pressure in Hg	0.1477		

New Amenity: Rooftop Skating Rinks

Roof Drainage

- Get the water off the roof
  - If the water is not on the roof, then the roof won't leak.
  - The weight can become an issue 5 psf per inch of depth
- Drainage needs to be sized for both high and low slope
  - High slope drainage problems related to water sheeting from roof
  - Low-Slope drainage needs to have a back-up to prevent overloading roof structure

We all know what Liquid Water does to buildings...

- Promotes rot
- Reduces R-values
- Promotes mold growth
- Stains paint
- Swells wood products
- Corrodes fasteners

Liquid water can also collapse buildings

- Drain and scupper sizing is crucial to the performance of the roof.

Roof Drainage Elements

- Size of the Deluge (rainfall intensity)
- Duration of the intense rain
- Roof Area being drained
- Slope of the roof

Roof Drainage

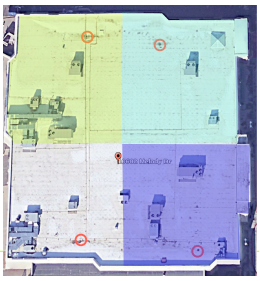
- Key points:
  - Rainfall intensity
  - Duration
  - Roof Area to drain
  - Slope of roof

Low-Slope Roofing Steps:

- Calculate the area per drain
- Determine the drain size
- Determine the leader size
- Determine the leader slope
- Determine the water load on the drain
- If the capacity of the drain is greater than the amount of water, Great!
- If not a provision for more drainage is required.

Look at Satellite or Eagle View

- Locate drainage and divide the area based on drainage locations.
- Determine the area drained by each drain



City of Denver Rainfall

- We design for the 100-year rain

Table 5.1. One-hour Point Rainfall Depths

Return Period	One-hour Point Rainfall (inches)
2-Year	0.95
5-Year	1.34
10-Year	1.55
50-Year	2.25
100-Year	2.57
Date: July, 1992 Revised:	Reference: Wastewater Management Division, 1987, as determined based on NOAA Atlas 2, Volume IIII.

Fomula:

- Gallons Per Minute = 0.0104 x Rainfall Intensity (in./hr) x Roof Area (sq. ft.)
- Denver Rainfall Intensity = 2.57 inches in one hour [Deluge is higher]
- 5,000 square feet (measured)
- GPM = 0.0104 x 2.57 x 5,000 = 133.64 gallons per minute

IPC Section 1105 Roof Drains

- Sized to meet sizing in Section 1106

TABLE 1106.2
STORM DRAIN PIPE SIZING

PIPE SIZE (inches)	CAPACITY (gpm)				
	VERTICAL DRAIN	SLOPE OF HORIZONTAL DRAIN			
		1/16 inch per foot	1/8 inch per foot	1/4 inch per foot	1/2 inch per foot
2	34	15	22	31	44
3	87	39	55	78	111
4	180	81	115	163	231
5	311	117	165	234	331
6	538	243	344	487	689
8	1,117	505	714	1,010	1,429
10	2,050	927	1,311	1,855	2,623
12	3,272	1,480	2,093	2,960	4,187
15	5,543	2,508	3,546	5,016	7,093

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gallon per minute = 3.785 L/m.

Short term intensity

- A different look: 5 minute deluge

AREA		A Storms which should be exceeded only once in 10 years		B Storms which should be exceeded only once in 100 years	
		1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)	1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)
Colorado	Denver	5.7	210	9.1	130
	Boulder	6.4	190	9.4	130

Now the tricky part:

- The drain that exists on the roof can be measured.
- If doing a reproofing, make sure to use the diameter of the insert not the original
- You have to check the slope of the drain leader inside the building.
- Make sure the drain is cleared…..

Low-Slope Drain Capacity

- Locally 2.5-3.0 inches / hour is commonly used
- Check with local code authority.

CALCULATE AREA DRAINAGE BY ROOF DRAIN SIZE AT VARIOUS RAINFALL RATES

DRAIN OUTLET SIZE		HOURLY RAINFALL (in inches)									
PIPE SIZE (inches)	OPEN AREA (sq. inches)	ROOF AREA SQUARE FOOTAGE									
		1	1.5	2	2.5	3	4	5	6	7	8
2	3.14	2,880	1,920	1,440	1,150	960	720	575	480	410	360
3	7.06	8,880	5,860	4,440	3,520	2,930	2,200	1,760	1,470	1,260	1,100
4	12.56	18,400	12,700	9,200	7,360	6,130	4,600	3,680	3,070	2,630	2,300
5	19.60	34,600	23,050	17,300	13,840	11,530	8,650	6,920	5,765	4,945	4,325
6	28.30	54,000	36,000	27,000	21,600	18,000	13,500	10,800	9,000	7,715	6,750
8	50.25	116,000	77,400	58,000	46,400	38,660	29,000	23,200	19,315	16,570	14,500

 *BASED ON ZURN AND MARATHON DRAIN TABLE

Section 1106
Size of Conductors, Leaders and Storm Drains

- Rainfall Conversion
- GPM=R x A x 0.0104
- R = Rainfall intensity in inches per hour
- A = Roof Area in square feet

TABLE 1106.1
VERTICAL LEADER SIZING

SIZE OF LEADER (inches)	CAPACITY (gpm)
2	30
2 x 2	30
3 x 2	30
2	54
2 x 3	54
3	92
2 x 4	92
2 x 3	92
4	192
3 x 4	192
3	360
4 x 5	360
4 x 4	360
6	563

TABLE 1106.2
STORM DRAIN PIPE SIZING

PIPE SIZE (inches)	CAPACITY (gpm)				
	VERTICAL DRAIN	SLOPE OF HORIZONTAL DRAIN			
		1/16 inch per foot	1/8 inch per foot	1/4 inch per foot	1/2 inch per foot
2	34	15	22	31	44
3	87	39	55	79	111
4	180	81	115	163	231
5	311	117	165	234	331
6	538	243	344	487	689
8	1,117	505	714	1,010	1,429
10	2,850	927	1,311	1,855	2,623
12	3,272	1,480	2,093	2,960	4,187
15	5,543	2,508	3,546	5,016	7,093

Residential is similar

- For this roof 1st pass
- Total Roof area /number of downspouts= Area drained per downspout
- Identify Problems: drainage across low-slope roof

1106.6 Gutter Capacity

- 1106.6 Requires that the listed values not be exceeded.
- Two numbers are rectangular
- One number is a semi-circle

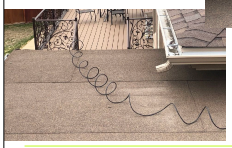
Gutter	Area (sq.in.)	Slope	GPM
1-1/2 x 2-1/2	3.75	1/4	26
1-1/2 x 2-1/2	3.75	1/2	40
4	6.28	1/8	39
2-1/4x3	6.75	1/4	55
2-1/4x3	6.75	1/2	87
5	9.82	1/8	74
4x2-1/2	10	1/4	106
3x3-1/2	10.5	1/2	156
6	14.14	1/8	110
3x5	15	1/4	157
3x5	15	1/2	225
8	25.13	1/16	172
4-1/2x6	27	1/4	348
4-1/2x6	27	1/2	494

Downspouts

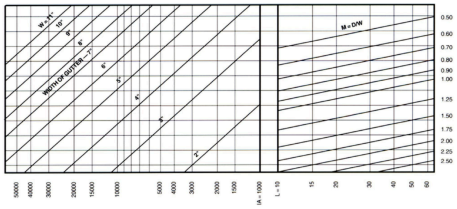
- Location, Location, Location
  - Where to intercept the water on the roof
  - Where to discharge the water to the ground
- Considerations:
  - North Side
  - Walkways/Driveways
  - Across lower roofs
- What about overflow?

High Roof to Low Roof

- Bad Practice
- Erodes lower roof
- Adds to the water load further downstream



Gutter Sizing



Gutter Topping Devices

- Will likely create icicles.
- Will likely be topped in a deluge.
- When cleaning is required it can be hard.

- Seem to be the number one pop-up on my computer

Gutter Sizing Summary

- Most follows standard tables.
- Never heard of too many downspouts.
- Every turn slow the movement of water
- Watch where you put the water on the ground
- At least if a gutter plugs the water just runs over the top.

Final comments:

CRA COLORADO ROOFING ASSOCIATION

- ☆Thank you Rich!
- ☆Presentation Handout & Wind Calculation Tools are available at: https://www.coloradoroofing.org/member/education
- ☆A survey will be sent after the seminar, please take the time to respond. Your feedback helps us plan future webinars and seminars.
- ☆Thank you for staying on the webinar the full time. **Please answer this final poll question to earn your CIUs.** Then, you are free to hop off and end your session.

Thank You for attending!