Arrhenius Equation
For Every 10 Degree K Rise
Activation Energy Doubles

\[ k = A e^{-E_a/(RT)} \]
Damage Functions
Water
Heat
Ultra-violet Radiation
2\textsuperscript{nd} Law of Thermodynamics
Heat Flow Is From Warm To Cold
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less
Air Flow Is From A Higher Pressure to a Lower Pressure
Gravity Acts Down
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Diagram showing a roof structure with control layers.
Wind across the corner of a roof produces a vortex spreading along edges from the windward corner.
From Baker, M.; Roofs, 1980
Supply air into occupied zone returns to AHU by passing through deliberately porous dropped ceiling or through return grilles installed in dropped ceiling.

Air handling unit extracts air from dropped ceiling, conditions it and injects it into the occupied zones via supply ductwork.

Dropped ceiling depressurized by air handling units extracting air from dropped ceiling.
Air barrier system not present to prevent air from being extracted from roof assembly

- Corrugated metal roof deck
- Membrane roof
- Rigid insulation

Building paper

Interior gypsum should extend to underside of roof deck and be sealed

Exterior sheathing

Metal stud wall

Cavity insulation

Suspended ceiling

Top chord bearing roof truss

Interior gypsum
Parapet flashing

Fully-adhered water control membrane

Tapered rigid insulation

Grout and reinforce parapet CMU as per structural requirements

Backer rod

Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet

Fully adhered roof membrane

Two (2) layers insulation; joints staggered horizontally and vertically

Fully-adhered water, air and vapor control membrane

Peel and stick transition membrane; air and water control

Deflection space

Backer rod to fill deflection joint and debond water and air barrier
Fully-adhered roof membrane
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Protection
Two (2) layers insulation; joints staggered horizontally and vertically
Membrane closure strip
Sealant
Insulated metal panel
Metal deck
Gypsum sheathing
Air control membrane
Open web steel joist
It’s a Case of Black or White
It’s a Case of Black or White
Arrhenius
It’s a Case of Black or White
Arrhenius
Every 10 degrees C – double the “badness”
Roof membrane extends up back side of parapet

Gypsum protection board

Pressure bar

Roof membrane

One layer rigid insulation

"Fluted" metal deck
Absorbed rain water on exterior face of masonry parapet is driven inward and condenses on back side of roofing membrane protecting roof side of parapet.

Condensed water drains down back side of parapet into roof assembly and into building.

Solar radiation strikes wall.

Absorbed rain water.
Ballast
Filter fabric
Control layers
Roof structure
Ballast (rock, pavers, earth)

Filter fabric

Extruded polystyrene insulation

Sloped concrete topping; slope minimum 2% to drains

Concrete structural deck

Drainage gap, i.e., drainage mat or grooved insulation

Fully-adhered roof membrane
Concrete curb or paver

Planting medium

Gravel

Drainage space

Filter fabric

Root barrier

Water retention layer/vent and drainage layer

Insulation

Drainage space

Roof membrane (water control layer/drainage plane)
Plaza Decks
Open paving

Removable for drain cleaning

Closed paving with surface drainage

From Baker, M.; Roofs, 1980
Courtesy National Research Council of Canada
Install a light gauge metal angle at deck to wall interface.
Install deck waterproof membrane following the manufacturers recommendations.
Install a corner diverter gutter spaced out over the face of the balcony edge the thickness of the trim or cladding below. The gutter will direct water from the deck out from behind the adjacent wall cladding.
Metal edge angle spaced out over the face of the trim or cladding below. End of metal edge flashing fits into the diverter gutter.
Strip in the metal edge flashing with a strip of compatible self-adhered membrane flashing.
Drainage mat; compatible with waterproof membrane
Metal T-bar concrete stop installed over drainage mat. Shim as required at attachment locations.
Fold sheet WRB down over upper edge of deck waterproof membrane. Tape all cuts with compatible construction tape.
Shingles

Roofing paper

Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered

Nail base for shingles (plywood or OSB) screwed through rigid insulation to wood decking or timber rafters

Air barrier membrane

Wood decking

Timber rafter or exposed joist
Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered
Legend

- Green arrows: Upper level air flows
- Blue arrows: Lower level air flows
- Red arrows: Air flow at panel joints
Shingles

Roofing paper

Vent space of nailbase insulation panels

Acoustical perforations

Panel joint

Fluted metal deck
Building Science Corporation

New roofing system
Fully adhered membrane
Roof sheathing
Two layers of rigid insulation (joints staggered and offset)
Fully adhered membrane air barrier
Gypsum sheathing
Fluted metal deck
Fully-adhered roofing membrane

Coverboard and hygric buffer

Rigid insulation (min. two layers; joints offset)

Gypsum sheathing (paperless)

Fully-adhered air control layer/vapor control layer

Screw attachment

Metal deck
Steel angle with flat extension inserted under lap in membrane and fastened to plywood sheathing

Titanium cladding

Slip sheet

Paperless gypsum sheathing

Fully-adhered, single-ply EPDM membrane 36" (914 mm) wide with 6" (152 mm) lap

Metal purlins for cladding attachment at 24" (610 mm) o.c.

3/4" (19 mm) plywood fastened to purlins

2x4 purlins in two layers; lower purlins fastened to metal deck; upper purlins fastened to lower purlins

1 1/2" (38 mm) rigid insulation

Membrane air barrier

1 1/2" (38 mm) rigid insulation

Membrane

Gypsum sheathing

Metal deck