DAY Four – Week One

- Quiz – Review - Homework
- Mobile Homes
- Heating Systems
- Forensic Auditing

Today's Quiz

- What is a sacrificial rod? (think H2O)
- What is a casement window?
- Which formula is used to calculate surface heat loss through a wall?
- In a heating environment, where should the vapor & air retarders be located?
- What should be done before insulating ducts?
- Does condensation warm or cool surfaces?

Review !

R-Values & U-Values

"R" = the thermal resistance of a material or an assembly of materials

"U" = the heat flow through a material or assembly

"U" = the inverse of "R" (U=1/R as well as R=1/U)

WHY BOTH?

R-values can be added; U-values can not.

Review !

Assembly R values

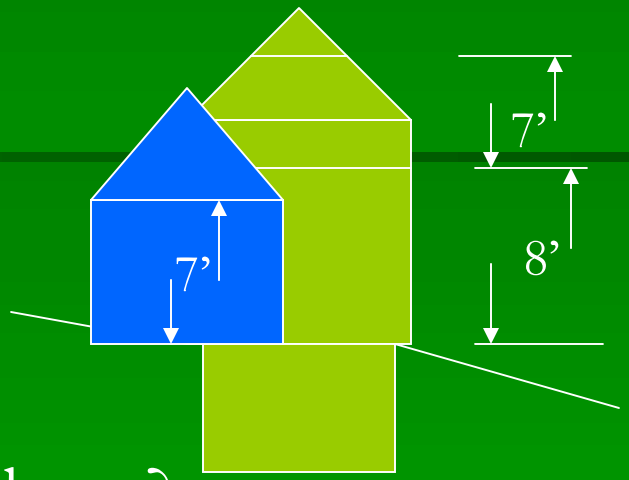
- For auditing purposes it's generally acceptable to assume an un-insulated wall is ≈ R-3 while a ceiling is R-2 if there is an attic floor & R-1 if there is none. An insulated wall or ceiling will have an overall R value ≈ equal to the manufacturer's rated value of any properly installed insulation minus 10% to 15%*.
- Most audit protocols reduce any calculated assembly R-value by some percentage – the well known fudge factor – to bring them more into line with real world & laboratory test results.

Guarded hot box testing (See Krigger pp 272)

* Unless it's exposed – no attic floor – fiberglass in a vented attic.

Review !

Volume



Attic flat = 8’

Slopes = 8’

Knee wall = 3’

Main house: 20’ x 26’

Ell: 12’ x 20’

What is the heated volume?

Main house (20’ x 26’ x 8’) + (20’ x 26’ x 3’) + (14’ x 26’ x 4’)

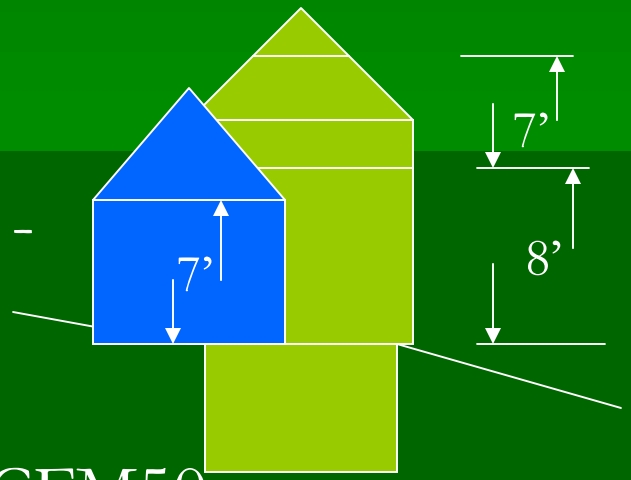
4160 + 1560 + 1456 = 7176

Ell (12’ x 20’ x 7’) = 1680

7176 + 1680 = 8856

Review !

Natural air change



Attic flat = 8’

Slopes = 8’

Knee wall = 3’

Main house: 20’ x 26’ -

Ell: 12’ x 20 – 1 story

Blower door = 2000 CFM50

What is the natural air change?

Krigger pp 263: ACHn = CFM50 x 60/(LBL)n x V

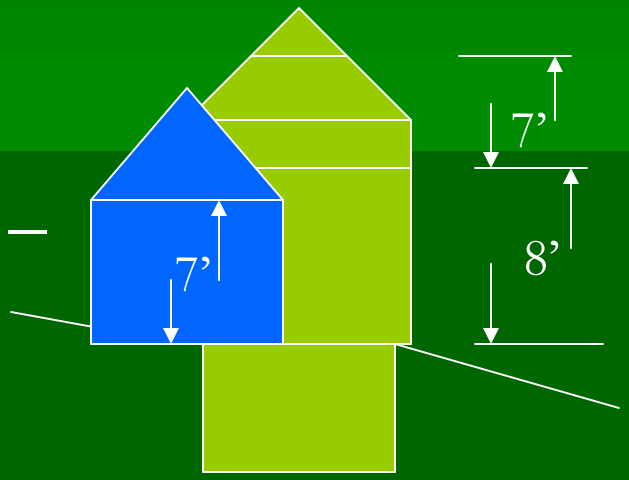
Apdx A-11: Zone 2; 1.5 stories; well shielded: n= 20

(2000 x 60)/(20 x 8856) = 120,000/177,120 =.678 ACH

How much extra is that? .68 - .35 = .33 ACH

Review !

Natural air change



Attic flat = 8’

Slopes = 8’

Knee wall = 3’

Main house: 20’ x 26’ –

Ell: 12’ x 20 – 1 story

Volume cu ft. 8856

<u>What does the unneeded .33ACH cost?</u>

Q= V x ACH x 0.0182BTU/Cu ft F° x HDD x 24 hr

Q = 8856 x .33 x 0.0182 x 7500 x 24 = 9,574,044 BTU

9,574,044 BTU @ 85% effic. & $4.25 gal oil = 9,574,044 / (.85 x 134,000) x $4.25 = (9,574,044/113,900) x $4.25 = 84 x $4.25 = $357/yr

Homework !

This is a 24' x 36' cement block home with 4 occupants – two adults & two grade school age children - located in a 7500 degree day area. It has a kitchen, utility room, living room, bath room & two bed rooms over a full basement. The CFM50 = 2647. The basement has a dirt floor. There is an electric water heater and warm-air furnace in the basement. The only access to the basement is from the exterior through a metal bulkhead door. The attic has 6" of unfaced fiberglass batts. There is no other insulation anywhere. The attic has one 12" X 16" gable vent. There is no other attic venting. There is a bath vent that dumps into the attic. There is no kitchen vent. The main floor ceiling is 1 foot sq. block fiberboard tile. The exterior walls are cement block, painted on the exterior, plastered directly on the block & wallpapered on the interior. There are two doors, two casement windows and seven double hung windows. The homeowner has just installed a direct vent condensing warm air furnace to replace the baseboard electric heat which cost them more than $4,000 to operate over the last heating season.

WHAT SHOULD BE DONE ?

So you think there aren't any cement block homes in Maine…..

Today's vocabulary !

- Window types
  - Double hung - single hung
  - Traverse/Slider
  - Casement/ Swing out, awning or hopper
- Framing styles
  - Post & Girt or Post & Beam
  - Balloon
  - Platform
  - Pier & post

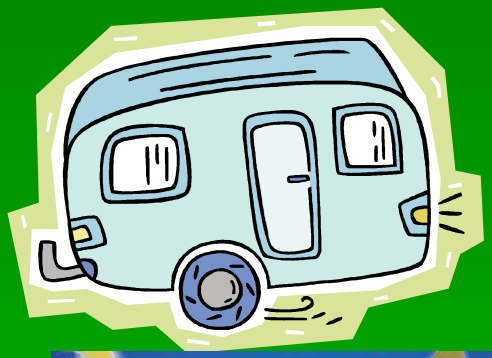
Mobile homes

- Mobile homes are unique unto themselves.
- There are several distinct styles, with the changes driven by the evolution from relatively portable vacation homes to basically stationary structures.
- The common trait has always been relatively low cost construction.
- Even newer mobile homes will often significantly benefit from properly installed added insulation & air sealing.

A little MH history…

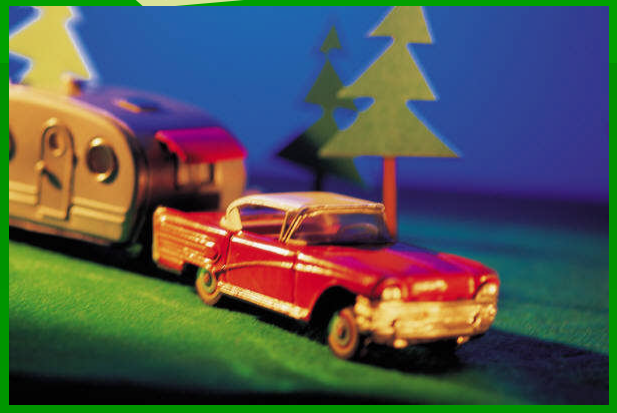
1920's: The first "mobile homes" were home made campers.

1930's: Manufactured campers & camper parks appear.



1940's: 8'x28'+ "house trailers" became homes to war workers & returning vets.

1950's: 10'x 50' to 60' "mobile homes" appear. Situated in large residential parks, they become the low income "home of choice".



MH History

'57 Olds?

By the 1970's mobile homes were getting bigger & more "housey" looking.

- Still mostly had rounded ends
- True glass to glass jalousie windows
- Generally no or 1" batt insulation
- Central heat with ducting – MOC 65

Intended market was retirees "following the sun" - Winter in the south; Summer wherever!

Mobile Home Regulation

- MH manufacturers tended toward high production and low cost.
- As with any self regulated industry, quality often suffered.
- Consumer complaints resulted in a bunch of Federal legislation between 1974 & 1976 when HUD officially adopted “Manufactured Home Construction & Safety Standards” as the national standard. (the HUD sticker)

HUD Zone II requirements

(Three E-W zones: NC North = Zone II)

- Min. of R-8 in all exterior surfaces.
- Ceiling vapor barrier.
- Rodent barrier.
- 2”x4” wall studs.
- Heating ducts inside envelope or insulated.
- Single hung or sliders with inside storms.

Units designated for a particular zone don’t necessarily remain there.

Lots of room for improvement!

SERI* study

Seven mobile homes Wx & studied under very controlled conditions

Results (best SIR first):

1. Blower door directed air sealing & duct repair
2. Furnace tune-up/repair
3. Belly blow
4. Interior storms (over awning windows)
5. Roof blow

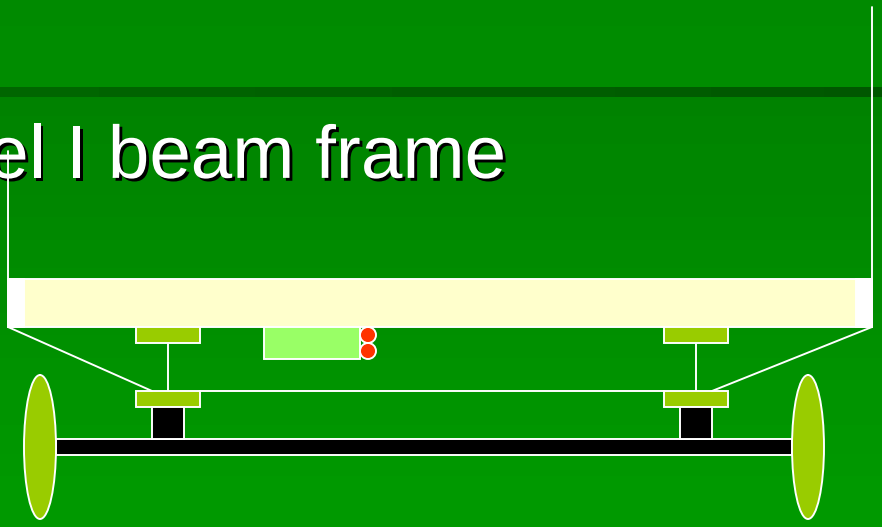
*Solar Energy Research Institute

Maine overview

- About 20% of Maine homes are mobile homes.
- Many are “pre HUD sticker” units
  - 2”x2” wall framing
  - ¼” plywood gusset trusses
  - (may have) Aluminum wiring
  - Miller CFM 65 furnaces
  - 1” batts in walls 2.5” batts in ceilings
- Newer units still under insulated & framed

Typical floor details

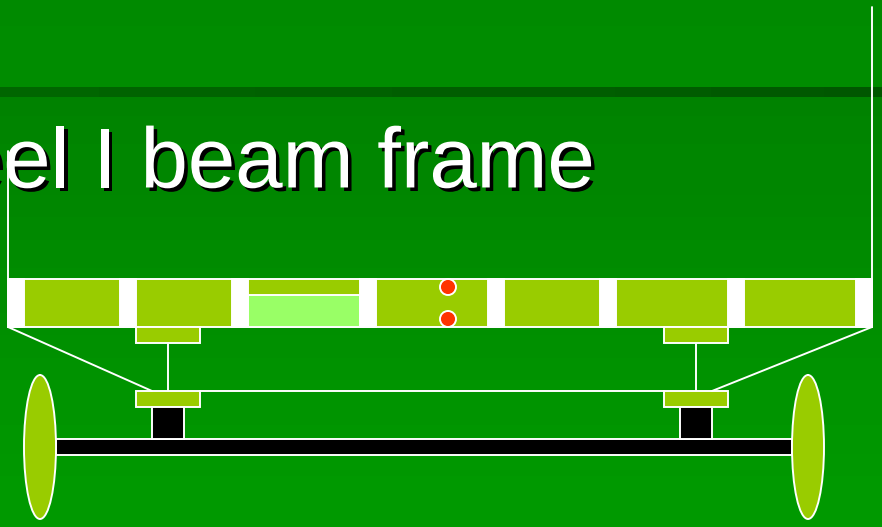
- Steel I beam frame



- Side to side floor stringers
- Heat duct fastened to under side of floor stringers
- Water pipes beside heat duct

Typical floor details

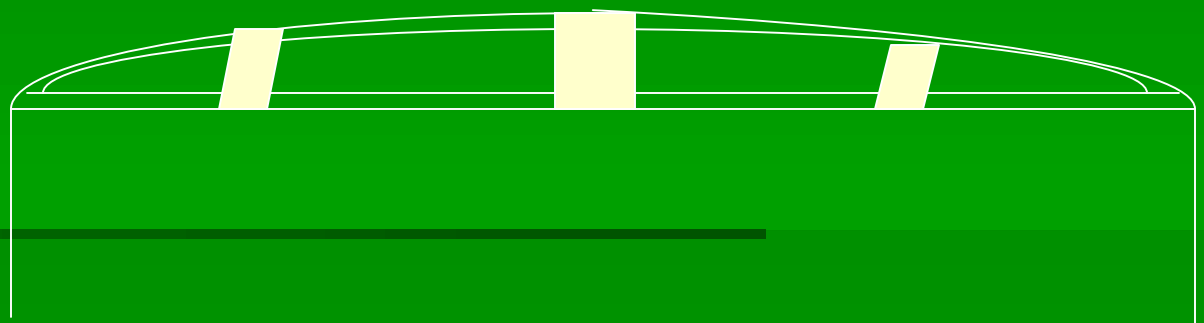
- Steel I beam frame



- Front to rear floor stringers
- Heat duct between floor stringers
- Water pipes between floor stringers

Typical older roof details

- Minimal strength bow trusses, usually constructed of scrap material.
- One piece insulation blanket laid on ceiling before trusses installed.



- Trusses typically 12” – 16” OC
- Ceiling usually has poly vapor retarder.

Typical newer roof details

- Pitched roof with “real” trusses
- Still often no or minimal edge overhang
- Usually R-18 one piece F’glas blanket
- May or may not have poly vapor retarder

Weak points (Opportunities)

- As in site built, often have air sealing issues at pipes, wires & chimney.
- Typically all surfaces underinsulated.

Precautions

- Generally, use fiberglass as opposed to cellulose
  - Weight
  - “Galvanic” reaction with aluminum
- Cellulose ok in pitched roof situation
- If insulating over factory roof, be sure to block off roof vents
- Be careful of wiring when stuffing walls
- Don’t overfill bellies
- Be sure belly insulation is kept below heat duct & pipes.

Mobile Home Weatherization

- Air seal
- Seal ducts
- Insulate ceilings
- Insulate walls
- Typical savings 30%

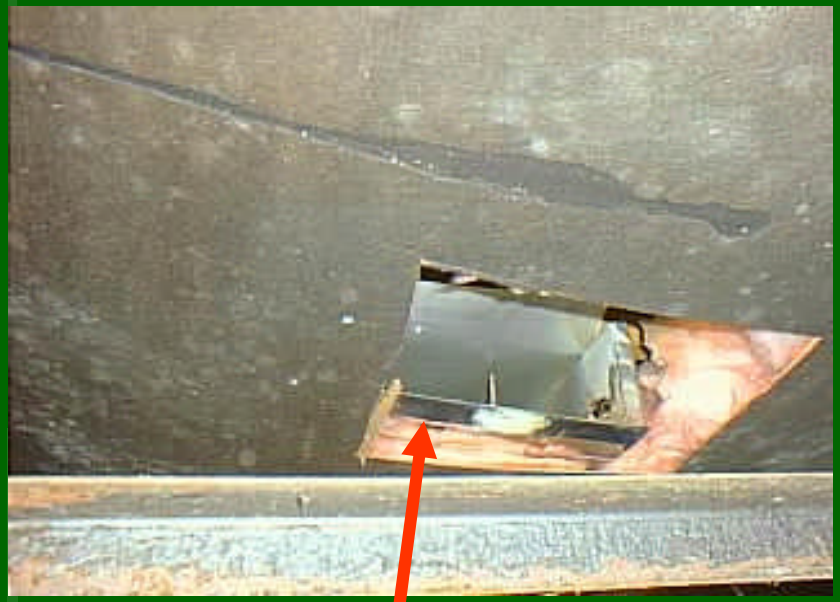
Typical savings

- Duct sealing & eliminating floor return systems ≈ 25% - 30%
- Insulating attics, walls & floors ≈ 7-8% each measure
- Air sealing alone ≈ 10% (plus roof “leaks” go away)
- When done as a package, typical savings can approach 40%

Mobile Home Weatherization

Mobile Home Weatherization

Duct sealing



End of duct left open at the factory

Repairing rodent barrier

Blowing belly

Opening roof edge to tube blow

Tube blowing roof from edge

Blowing roof from the top

Ceiling drilled to blow from inside

Blowing roof cavity from inside

Done !

Mobile Home Weatherization

Bending Lexan™ for wall stuffer

Wall opened to stuff

Stuffing walls

Not stuffed

Closing up

Using Lexan™ wall stuffer

Stuffing wall

Done !

Roof too heavy?....

Wood heat with wood back-up !

Some things defy belief !

(a little about) Domestic hot water

- Immersion coil
- Free standing tank on separate zone
- Free standing tank with oil or gas burner
- Electric free standing tank
  - “Sacrificial” rods
- Instantaneous
- Stone or glass lined
- Tank location

Domestic H2O energy use

- Dependent on:
  - Tank location
  - Tank insulation
  - Temp of incoming water
  - Temp set (outgoing water temp & standby)
  - Usage
- BTU use = (Temp out – Temp in) x # pounds of water
  - 125° out - 55°F in = 70° ΔT
  - 80 gallons = 10 lbs (“a pint’s a lb the world around.”)
- Immersion coil ≈ 15 gallon #2/month
- Free standing tank ≈ 10 gallon #2/month

Solar !

Heating Systems

- Heating systems consist of:
  - A combustion appliance
  - A vent system
  - A heat distribution system
- Heating systems are categorized by:
  - Fuel type
  - Appliance type
  - Heat delivery type

Efficiency rating

- There are two important efficiency ratings:
  - Steady state – the % of heat staying in the appliance
  - AFUE – the % provided to the delivery system.
    - ramping up
    - cooling off
    - Standby
  - AFUE is sometimes called seasonal efficiency
- Neither rating considers delivery system inefficiencies.

Efficiency testing

- Done at steady state
- Ambient air temp
- Flue gas temp
- % of CO_2 or oxygen in flue gas
- Smoke rating (0 -10)

Heating appliance Designations

- Boilers vs. furnaces
- Steam vs. hot water
- Updraft vs. downdraft (furnace)
- Condensing vs. non-condensing
- Hi-mass vs. low-mass (boiler)
- Cold start vs. temp maintaining
- Atmospheric vs. sealed combustion

Delivery systems

- Steam – one pipe or two pipe
- Hartford Loop
- Pipe “hammer”
- Steam valves
- Furnace - single or multiple return
- Duct sizing & design
- Heat rise
- Circulators & zone valves

Vent systems

- Direct vent vs. chimney
- Power vents
- Draft diverters
- “Vent-free” apliances

Other important “stuff”

- Thermostat anticipator
- Thermostat location
- Pressure relief valves
- TC-1 location & direction
- Required switches
- Required oil shut off valves
- Propane vs. natural gas

Sizing & Distribution

- Design Temp = The temperature low which is not exceeded 97.5% of the time during the three coldest months of the year subtracted from 65ºF
- Central Maine = - 5ºF
- Heating systems in central Maine are sized to deliver adequate heat with a ΔT of 70ºF.
- Distribution is sized room by room
- Heating plants are sized by the total of the installed distribution
- Manual J

What's important

- BTU/hr heat load = U x A x ΔT where U = 1/R, A = surface area and ΔT = °F design temperature in to out.
- Design temperature is the temperature exceeded 97.5% of the time for the three coldest months of the year. The mid-Maine design temp is -5°F.
- Daily degree days are determined by dividing the difference between the day's high & low temperatures in two and then subtracting the result from 65°F.
- Annual degree days are the total of all the degree days in one heating season.

Tags & paperwork

- Heating system required paperwork:
  - Installers name & address
  - Installation manual
  - Efficiency test result

Categories

Fuel type	Appliance	Delivery method
#2 fuel oil	Boiler	Baseboard
Kerosene	Wet base	Convectors
Natural gas	Dry base	Radiators
Propane	Steam	sngl/dbl loop
Wood/coal	Low mass	
Electric	Furnace	Registers

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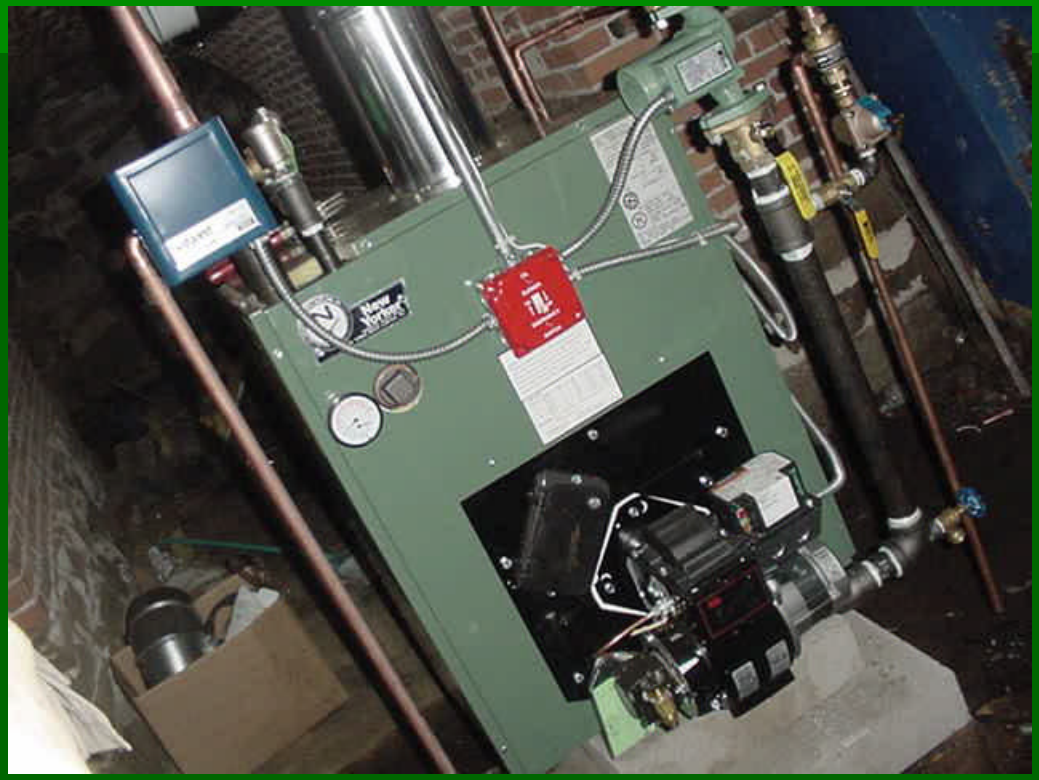
639
883
KEMPORT


Low mass wet
base boiler.


GM



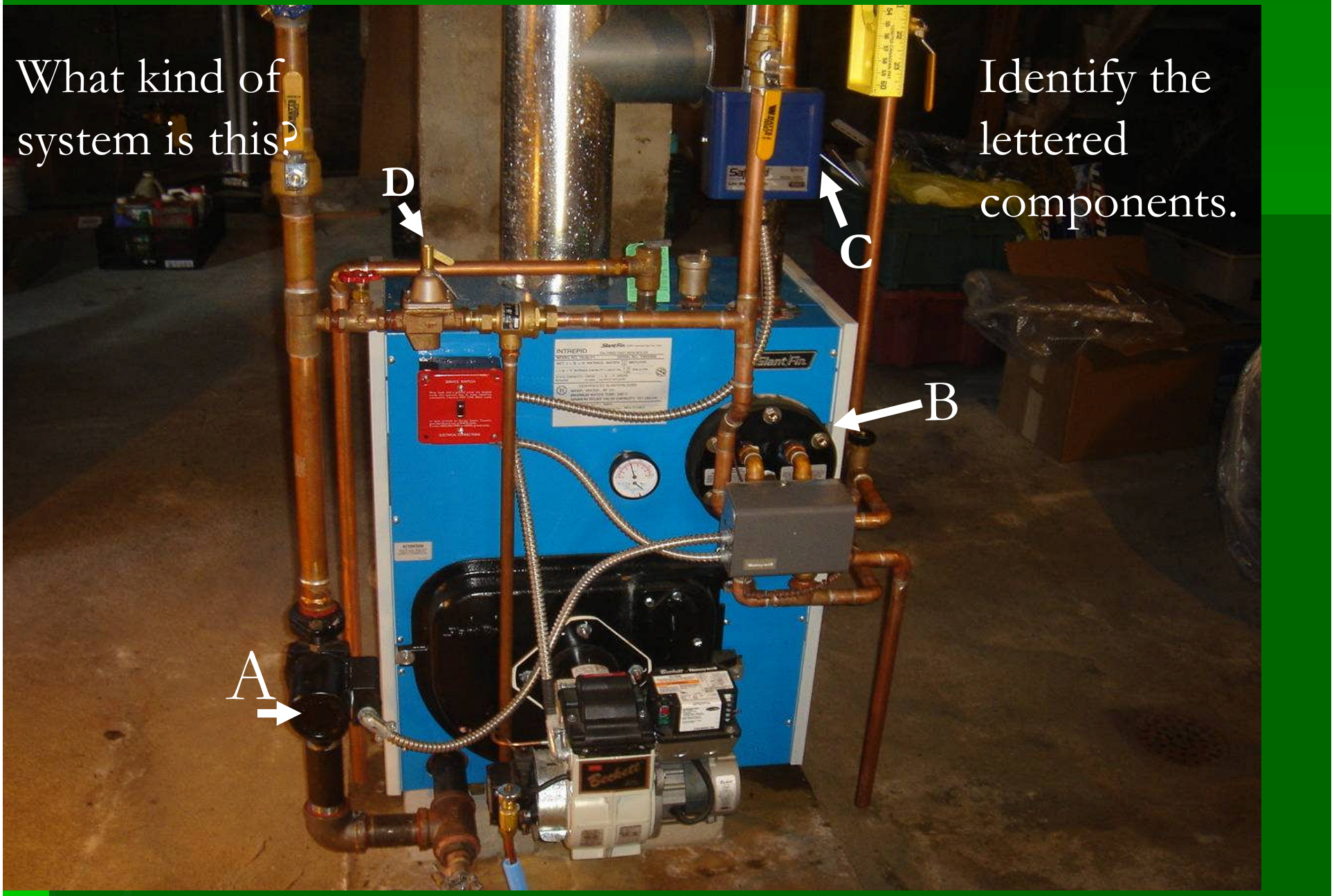

HERCULES


What's wrong with this picture?


WINKLER

Disadvantages of over sizing:

1. Higher initial cost
2. Uses more fuel
3. Lower seasonal efficiency


What kind of system is this?
Identify the lettered components.
A
B
C
D


OIL
BURNER
ON
OFF
EMERGENCY
SWITCH


DANGER
NOTICE
ANTI-FREEZE COOLANT


DAUGHTERS
CAPTAIN COOK


Honeywell


attention
Tree !!!


SUPERIOR

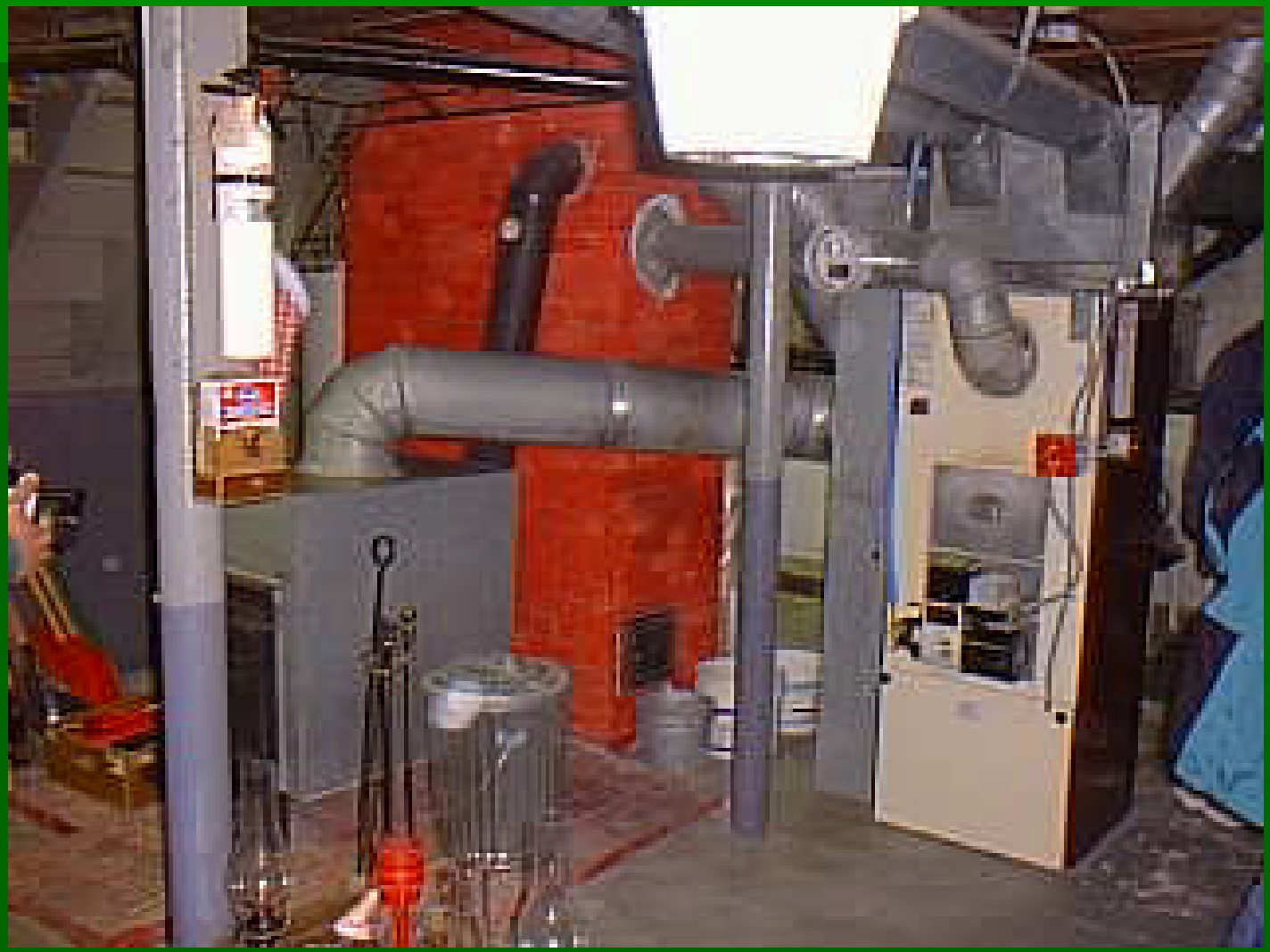

BOSCH

Venting

Why should exterior chimneys be discouraged?

Tanks*

* But, no thanks !

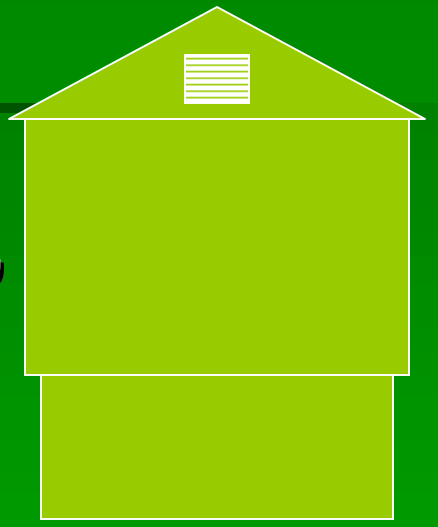


Mars Hill !

Forensic Auditing !

Homework !

- 20’ x 30’ (average 8”) log cabin
- Two 6’- 8” x 3’ x 2” wood doors
- Heated 7’ 6” concrete basement,
- Sill 18” above grade,
- 6” fiberglass in attic
- Five 3’ x 4’ single pane windows with storms
- 1”styrofoam under cedar shakes on exterior
- exposed log interior
- CFM50 = 1800
- HO reports 4 fill-ups/yr ≈ 200-250 gal. each
- H^2O = immersion coil
- 7500HDD



Homework !

- BTU/yr through:
  - Ceiling
  - Walls
  - Windows
  - Doors
  - Basement
  - Air transported
- Convert to Therms/yr?
- Treat in what order?

Day Over !

Reading: Krigger – Finish !