



Basic Plumbing Principles

Inspection Theory & Practice

Great Lakes Chapter of ASHI - Oct. 2011

presented by

Roger Hankey, CAI

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Class demographics

- I'm not a plumber, but I study plumbing.
- I don't design or install. I observe.
- How many plumbers?
- How many plumbing inspectors?
- How many members of IAPMO?
- How many inspecting less than 5 yrs?
- Who routinely sees wells & septic systems?
- Typical water heater: Gas, Electric, other?

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Home Inspections – The task

- Your task is special and difficult.
- Your experience base can grow on nearly every case, if you are aware and mindful.
- Home inspection is pattern recognition.
- Does this installation fit the typical pattern?
- Confidence needed. – What is normal?
- Humility needed. Accept the challenge.
- Embrace the unfamiliar. Search further.
- Be curious. Do NOT guess. Ask for help.

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Why Plumbing? Why basics?

- What functions does the house perform?
- Why is plumbing important? Can you drink the water?
- Modern plumbing = Developed world
- Understand theory to understand application
- Fluid dynamics – Hydraulics – part of Building Science. Research at Univ. of Iowa
- Go beyond supply, drainage, and lack of leaks.

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23 Plumbing principles

- | | |
|------------------------|-------------------------------|
| • Potable water supply | • Drainage cleanouts |
| • Safe food storage | • Prevent backflow |
| • Required fixtures | • Vent terminals |
| • Connection to sewer | • Exclude damaging substances |
| • Air flow in pipes | • System durability |
| • Proper flow velocity | |

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23 Plumbing principles

- | | |
|--------------------------|--------------------------------------|
| • Tests & Inspections | • Accessible fixtures |
| • System Maintenance | • Water seal trap |
| • Building undamaged | • Light & ventilation |
| • No fouling surfaces | • On-site treatment |
| • Pressure and flow | • Avoid explosion & overheated water |
| • No excessive water use | • No untreated sewage discharge |
| • Supply hot water | |

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ASHI Standards of Practice

c. report:

1. those *systems and components inspected* that, in the professional judgment of the *inspector*, are not functioning properly, significantly deficient, *unsafe*, or are near the end of their service lives.
2. recommendations to correct, or monitor for future correction, the deficiencies *reported* in 2.2.C.1, or items needing *further evaluation*. (Per Exclusion 13.2.A.5 *inspectors* are NOT required to determine methods, materials, or costs of corrections.)
3. reasoning or explanation as to the nature of the deficiencies *reported* in 2.2.C.1, that are not self-evident.

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ASHI Standards of Practice

• 6.1 The *inspector* shall:

- A. *inspect*:
 - 1. the interior water supply and distribution *systems* including all fixtures and faucets.
 - 2. the drain, waste and vent *systems* including all fixtures.
 - 3. the water heating equipment.
 - 4. the vent *systems*, flues, and chimneys.
 - 5. the fuel storage and fuel distribution *systems*.
 - 6. the drainage sumps, sump pumps, and related piping.
- B. *describe*:
 - 1. the water supply, drain, waste, and vent piping materials.
 - 2. the water heating equipment including the energy source.
 - 3. the location of main water and main fuel shut-off valves.

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Environmental Sanitation

- MN Plumbing Code – Compare to your jurisdiction
- Home inspection is NOT code enforcement
- Basis for understanding good & established practices
- Necessary to protect health
- Applicable everywhere
- Helps interpret unforeseen situations
- Design, Installation, & Maintenance

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Where to be extra alert for adverse plumbing conditions?

- Remodeled kitchens & baths
- Relocated fixtures
- Fixtures not originally installed – basements finished later
- Unusual or atypical equipment
- Rural “no code enforcement area”
- Numerous DIY projects
- VACANT HOUSES - FORECLOSURES

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Where to be extra alert for adverse plumbing conditions?



Vacant house – bank owned. Faucet removed. No cap on drain. Potential sewer gas entry.

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Where to be extra alert for adverse plumbing conditions?



DIY plumbing is fun to inspect. It often reveals the installer's IQ or mindfulness.

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Principle A: Potable Water Supply

- Pronounced with a long O, not POT.
- All premises intended for human habitation.
- Water to meet Health Dept. requirements
- **Potable Water:** Must not cause disease or harmful physiological effects. Must meet state or local public health authority
- Not connected to unsafe sources
- No backflow - No back-siphonage

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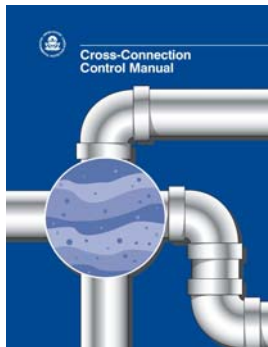
Principle A: Potable Water Supply

- Not connected to unsafe sources
- **Cross-connection:** Any connection between potable water system or fixture, through which contaminated water or any other substance can enter the water supply **"UNDER ANY CONDITION"**.
- Think "Worst Case Scenario"

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EPA Cross-Connection Manual



"Two factors are therefore essential for backflow.

First there must be a link between the two systems.

Second, the resultant force must be toward the potable supply."

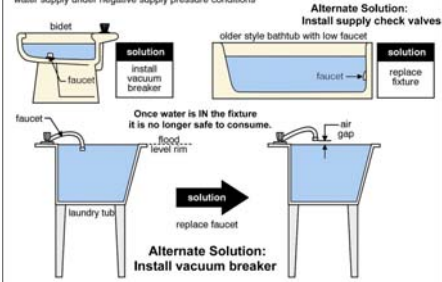
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Principle A: Potable Water Supply

Cross connections

cross connections can occur in fixtures where the faucet is below the high water level - an air gap is required to prevent contaminated water from being siphoned back into the potable water supply under negative supply pressure conditions



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Principle A: Potable Water Supply

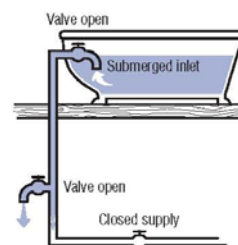
- **Backflow:** Flow of water or OTHER substances, INTO the potable water supply, from ANY source(s) other than the intended source.
- Separate city water from well water
- Disconnect or use backflow preventers

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Principle A: Potable Water Supply

FIGURE 7. Backsiphonage in a plumbing system.



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- **Back-siphonage:** Backflow due to Negative Pressure in a water supply pipe.
- Use vacuum breakers or air gaps.

Principle A: Potable Water Supply

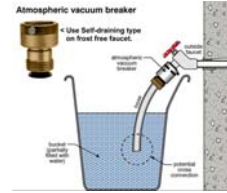
Air gap (water supply): An unobstructed vertical distance through free air between the lowest opening of the faucet, and the flood level rim of the receptacle.



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Principle A: Potable Water Supply



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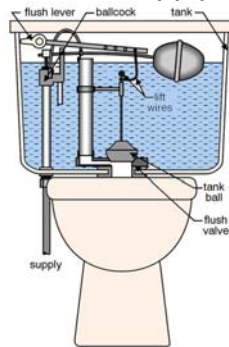
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Principle A: Potable Water Supply

Think - Worst Case Scenario
What is wrong with this toilet? >

What happens if the water supply pressure becomes NEGATIVE?

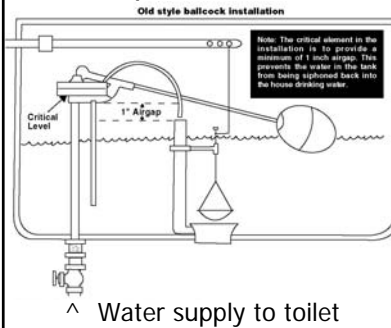
This is a Cross-Connection.



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Principle A: Potable Water Supply



A key part of the installation is to provide a 1" air gap. This prevents the water in the tank from being siphoned back into the potable water.

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Principle A: Potable Water Supply

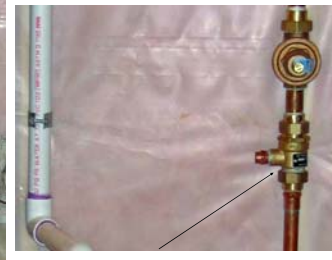


Look for these valves on boiler water supply. (often Watts 9D)
Dual Check Valve with Intermediate Atmospheric Vent

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Principle A: Potable Water Supply



Also installed on water powered backup sump pumps

Dual Check Valve with Intermediate Atmospheric Vent

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Other potential cross connections?



Hose to tube, up to connect to drain.

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Track softener discharge hoses to their terminal. This one was a direct cross connection to a drain.

Pause for Watts Video

- Backflow Prevention video
- We are NOT enforcing a “plumbing code”.
- Not all jurisdictions require all the devices shown in the video.
- Different devices for different situations.
- State your findings. Recommend a course of action. Do NOT design the fix.
- Typical recommendation: **Have this condition corrected by a qualified plumber.**

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Principle B: Safe Food Storage

- Protect food, water, sterile goods, etc. from backflow of sewage.
- Use indirect connection for refrigerator, freezer drains.
- **Air Gap:** The unobstructed vertical distance in air between the outlet of a waste pipe and the flood level rim of the fixture into which it discharges.
- Walk in coolers, etc., drain to floor drains, etc.
- History: Ice box drains. Receptacle will overflow before sewage reaches protected device.

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Principle C: Four Required Fixtures

- What are the 4 plumbing fixtures each family dwelling unit must have?

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Principle C: Four Required Fixtures

- Each family dwelling unit shall have at least:
- 1 water closet = **Toilet**
- 1 **bathtub** or shower
- 1 lavatory = **hand sink**
- 1 **kitchen sink**
- Other habitable structures shall have **sufficient** sanitary facilities.



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Principle D: Public Sewer Connection

- If plumbing fixtures are installed, if public sewer is “available within a reasonable distance”, they **shall be connected** to the sewer.
- If no public sewer available, see Principle U. (On-site waste treatment required)
- Be aware of jurisdictions you serve where public sewers are being installed.

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Principle E: Proper air flow

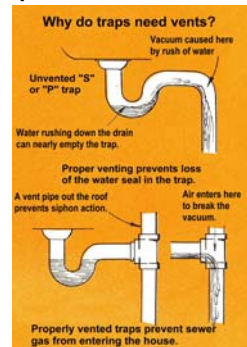
- Drainage system shall be designed to circulate air in all pipes to prevent:
 - Siphonage
 - Aspiration
 - Forcing of trap seals
 under conditions of ordinary use. This is the **VENTING** requirement.

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Principle E: Proper air flow

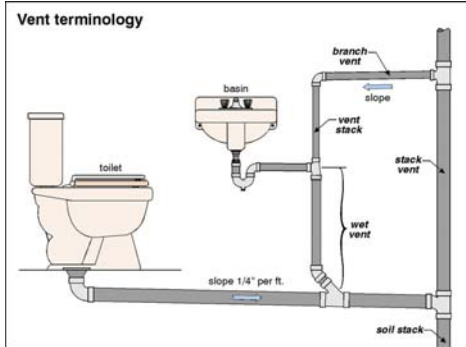
- This is the **venting** requirement.
- Each fixture needs a water seal **trap**.
- Each trap needs a vent to replace the air displaced by the water flowing down the drain.
- Plumbing vents also vent the sewer.



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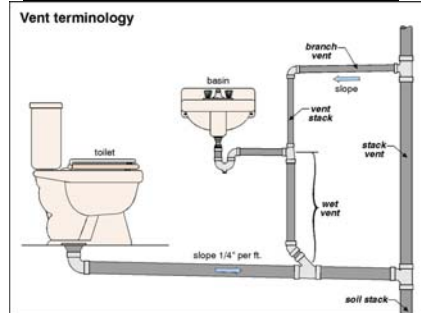
Principle E: Proper air flow



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Principle E: Proper air flow



How would a plumber eliminate the wet vent?

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Principle E: Proper air flow



The original waste & vent in the wall is not in use.

The present trap drains through the floor and is not vented.

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Principle E: Proper air flow



Breather vents or **Air Admittance Valves** are not legal in Minnesota and some other jurisdictions.

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Principle E: Proper air flow



This kitchen was remodeled and the sink relocated.
Is the sink vented?
If yes, how?
If no, why not?

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Principle E: Proper air flow



The kitchen sink drain is NOT vented.
The looped pipe above the sanitary tee reconnects to the drain. It is no different than a capped vent pipe.
RECOMMENDATION:
Have a qualified plumber correctly vent the kitchen sink.

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Principle E: Proper air flow



This basement bar sink looks fine, but check further.

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Principle E: Proper air flow



The bar sink drain wraps around the utility room to the main stack (white PVC). No vent was found.

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Principle E: Proper air flow

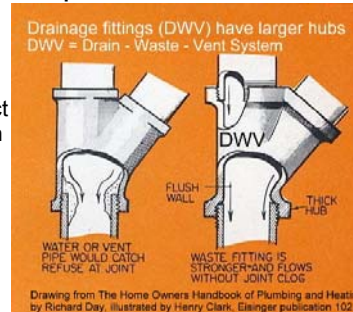
- Check all suspected unvented fixtures
- Track the drain looking for the vent
- Conduct the GURGLE test.
- Fill fixture nearly full of water.
- Release drain stopper.
- Listen as the water leaves the fixture.
- Loud gurgle = Unvented fixture.

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Principle F: Proper drain flow velocity

- Designed, constructed & maintained to conduct waste water with velocities which prevent:
 - Fouling
 - Deposition of solids
 - Clogging



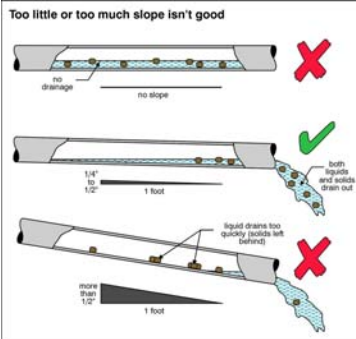
Drawing from The Home Owners Handbook of Plumbing and Heating by Richard Day, illustrated by Henry Clark, Eisinger publication 102

Use Drain-Waste-Vent fittings

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Principle F: Proper drain flow velocity



INSPECT:
 Supports, Slope, Connections
 Check in crawl spaces.
 Lead, ABS, PVC, and cast iron need more supports than steel or copper.

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Principle F: Proper drain flow velocity



Discuss this bathtub drain. List any adverse conditions. Make a recommendation.

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Principle F: Proper drain flow velocity



- The bathtub trap is made up of elbows rather than an approved water seal trap. The drain has an excessive slope. The drain is not connected to a vent. **RECOMMENDATION:** Have a qualified plumber correct the bathtub drain.

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Principle F: Proper drain flow velocity



- T-Y creates steep slope, use sanitary tee.
- Dishwasher discharge has high velocity.
- The "vent" is horizontal below fixture.

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Principle F: Proper drain flow velocity



Discuss this installation. List any adverse conditions. Make a recommendation.

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Principle F: Proper drain flow velocity



The kitchen sink drain slopes uphill from the trap to the tee fitting. (Trap is too low.) The drain has two unapproved ribbed flexible connectors which increase the potential for clogging & leaks. **RECOMMENDATION:** Have a qualified plumber correct the kitchen sink drain.

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Principle G: Drain Cleanouts

- System must have an “adequate number” of cleanouts arranged so that in case of stoppage the pipes may be readily cleaned.
- Inspect cleanouts for loose, missing & damaged covers, and signs of prior clogging. Look in pits for loose or missing cleanouts. Do NOT enter pits with missing cleanout covers due to sewer gas risk.

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Principle G: Drain Cleanouts

- Sewer gas can contain: Hydrogen Sulfide, Ammonia, Carbon Dioxide, Sulfur Dioxide, Methane, Nitrous Oxides, bleach, household chemicals and industrial wastes.



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Principle G: Drain Cleanouts



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Principle H: Prevent sewage backflow

- Where the building drainage system may be subjected to backflow of sewage, suitable provision shall be made to prevent its overflow in the building.
- Equipment rarely installed. Old styles fail.
- Modern automatic equipment expensive.
- Backups less frequent where storm and sanitary sewers have been separated

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Principle I: Vent Terminals

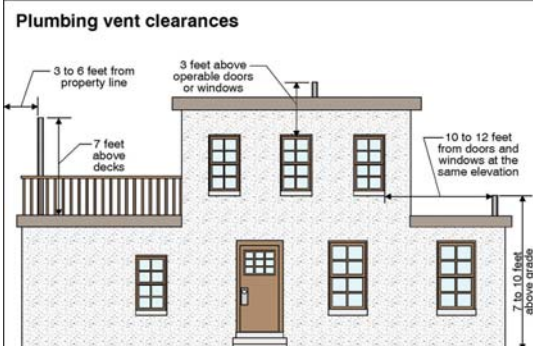
- Each vent terminal shall extend to outdoor air and be installed to minimize the possibilities of clogging and the return of foul air to the building.
- Inspect height, test caps distance from windows. (check flashings as part of roof inspection)
- Protect from freeze-up.



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Principle I: Vent Terminals



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Principle I: Vent Terminals

Vent too tall
if the plumbing vent extends too far above the roof, frost closure can become a problem

plumbing vent should extend no more than 12' above the roof

note
on flat roofs, the vent should extend at least 6' above the high water level

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Principle I: Vent Terminals

Check vents in all readily accessible areas. Sewer gas can be very corrosive.

Two of the pipe nipples in this vent are gone.

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Principle J: Exclude damaging substances from drains

- “No substance which will clog or accentuate clogging of pipes, produce explosive mixtures, destroy the pipes or their joints, or interfere unduly with the sewage disposal process shall be allowed to enter the drainage system.”
- Rarely an issue in residential piping, EXCEPT do not use lye based drain cleaners on lead drains.

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Principle J: Exclude damaging substances from drains

Drain cleaner destroyed lead pipe. Not found until ceiling below drain collapsed.

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Principle K: Piping Durability

- “The piping of the plumbing system shall be of durable material, free from defective construction and so designed and constructed as to give satisfactory service for its reasonable expected life.”
- Watch out for lead drains, old galvanized steel water piping, old steel vents in multiple dwellings, and PB water tubing.
- Inspect for damage, deterioration, & workmanship in design & installation. Look for pipe supports.

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Principle K: Piping Durability

Galvanized steel pipe
Galvanized steel pipes have a limited life since they are vulnerable to a buildup of mineral deposits on the inside of the pipes. These deposits slowly reduce the flow rate of water. Pipe replacement is the only practical remedy when the flow rate is no longer acceptable.

Leaks are also likely to develop at connections between steel pipe and copper tubing, unless special fittings (di-electric unions) are installed.

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Principle K: Piping Durability



Copper tubing is not compatible with galvanized steel pipe, unless di-electric unions are installed between the two pipes.

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Principle K: Piping Durability



CPVC supported with twine
Check supports for piping & tubing. (not loose or sagging)

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Principle L: Tests & Inspections

- “The plumbing system shall be subjected to adequate tests and to inspections in a manner that will disclose all leaks and defects in the work or material.”
- **Air pressure test on drain-waste-vent system.**
- Work done without permits is not inspected, often incorrectly designed, functions poorly, and creates adverse conditions which can become unsanitary or unsafe.

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Principle L: Tests & Inspections

Watch for left-over test caps.



Test caps are to be removed after the test.

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Principle M: Maintenance

- “Plumbing systems shall be maintained in a safe and serviceable condition from the standpoint of both mechanics and health”
- Frequent maintenance tags may indicate a significant problem.



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Principle N: Don't damage structures

- “Plumbing shall be installed with due regard to preservation of the strength of structural members and prevention of damage to the walls and other surfaces through fixture use.”



Sawzall School of Plumbing

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Principle N: Don't damage structures

- "Plumbing shall be installed with due regard to preservation of the strength of structural members *and prevention of damage to the walls and other surfaces through fixture use.*"



This means plumbing should not leak.

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Principle N: Don't damage structures



Check out unusual holes in walls and ceilings.



This makeshift patch was above the hole. This is not a long term repair.

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Principle N: Don't damage structures

Pause to watch Watts Regulator video on preventing water damage.

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Principle O: Durable Smooth Fixtures

- "Plumbing fixtures shall be made of durable, smooth, nonabsorbent, and corrosion-resistant material and shall be free of concealed fouling surfaces."



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Principle P: Adequate water flow & pressure

- "Plumbing fixtures, devices, and appurtenances shall be supplied with water in sufficient volume and at pressures adequate to enable them to function properly and without undue noise under normal conditions of use."



Saddle tee fittings rarely provide proper flow rates to typical fixtures.

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Principle P: Adequate water flow & pressure

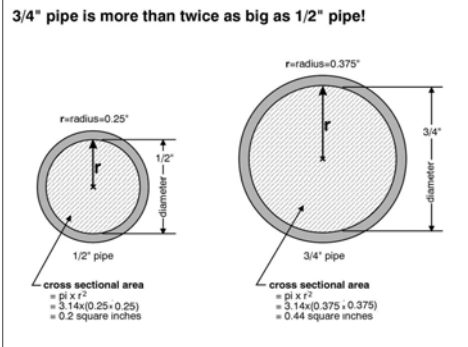


Half inch steel water service. Circa 1909. Very limited flow. Replacement recommended.

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Principle P: Adequate water flow & pressure



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Principle Q: Don't waste water Provide hot water

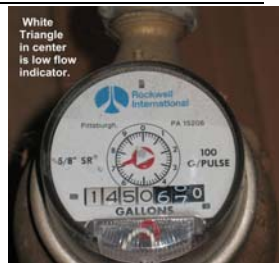
- "Plumbing fixtures shall be designed **and adjusted** to use the minimum quantity of water consistent with proper performance and cleaning.
- Hot water shall be supplied to all plumbing fixtures which normally need or require hot water for their proper use and function."
- All showerheads sold in the United States may only deliver a maximum of 2.5 Gallons/Minute. (not an inspection issue) Current law on new toilets sold in the US requires 1.6 gal./flush.

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Principle Q: Don't waste water

- You may check for slow leaks by watching the water meter low flow indicator.
- Observe the meter when all fixtures are OFF.



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Principle R: Accessible fixtures

- "All plumbing fixtures shall be so installed with regard to spacing as to be accessible for their intended use and cleaning."

30 inch wide space for toilet is typical. (15" o.c.)

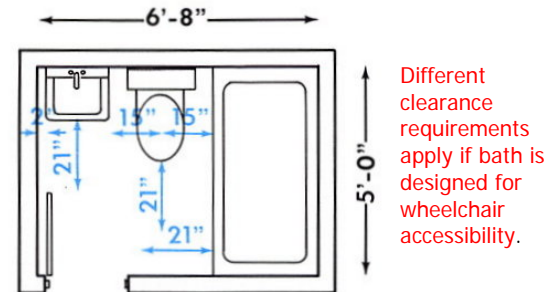


Different space requirements if designed for wheelchair accessibility.

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Principle R: Accessible fixtures



MINIMUM FIXTURE CLEARANCES

Council Notes vol. 3 #2, Univ. of Ill. SHC 1976

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Principle S: Water-seal Traps

- "Each fixture shall be provided with a separate, accessible, self-scouring, reliable water-seal trap placed as near to the fixture as possible."
- No true trap here, > a very shallow water seal may exist.



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Principle S: Water-seal Traps

- "Each fixture shall be provided with a separate, accessible, self-scouring, reliable water-seal trap placed as near to the fixture as possible."



Dishwashers, disposers, and their kitchen sink traps seem to be confusing to the do-it-yourself plumber.

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Principle S: Water-seal Traps



Discuss this installation.

Report any adverse conditions.

Write a recommendation.

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Principle S: Water-seal Traps

The clothes washer drain (standpipe) lacks a water seal trap, increasing the potential for sewer gas entry.



RECOMMENDATION:

Have a qualified plumber correct this condition. (Install a water seal trap.)

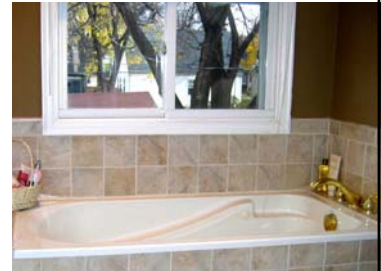


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Principle T: WC Light & Ventilation

- "No water closet or similar fixture shall be located in a room or compartment which is not properly lighted and ventilated."



- What type of window glass?
- Does the window open?
- How do you check vent fans?

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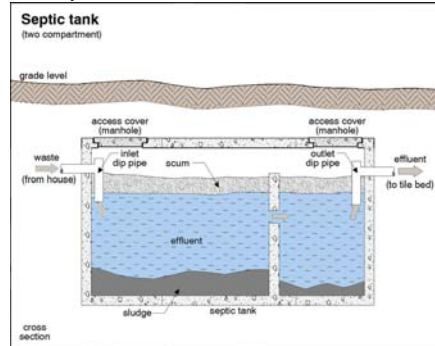
Principle U: On-site Waste Treatment

- If water closets or other plumbing fixtures are installed in a building where there is no sewer within a reasonable distance, suitable provision must be made for **treatment of the building sewage** by methods which meet the design criteria of the Minnesota Pollution Control Agency as prescribed in Chapter 7080.
- One-family and two-family dwellings must comply with local ordinances.

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Principle U: On-site Waste Treatment

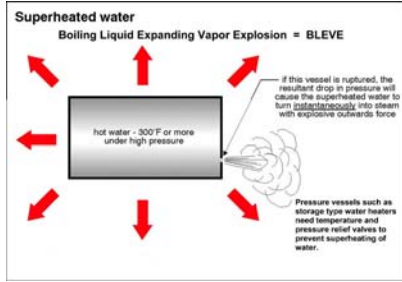


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Principle V: Prevent Overheated Water & Explosions

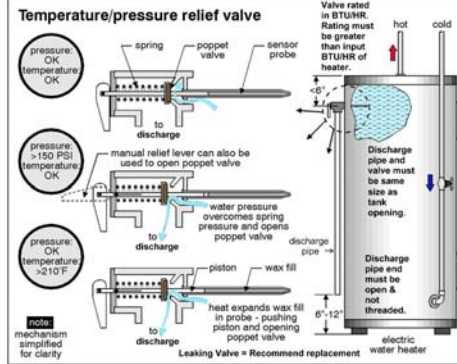
Devices for heating water and storing it shall be designed and installed to prevent all dangers from explosion and overheating.



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Principle V: Prevent Overheated Water & Explosions



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Principle V: Prevent Overheated Water & Explosions



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Discuss this installation.
List any adverse conditions.
Make a recommendation.

Principle V: Prevent Overheated Water & Explosions



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The water heater T & P relief valve lacks a drain tube and faces the front of the heater. This increases the potential for scalding injury.
RECOMMENDATION:
Have a qualified plumber correct this condition.

Principle V: Prevent Overheated Water & Explosions



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Discuss this installation.
List any adverse conditions.
Make a recommendation.

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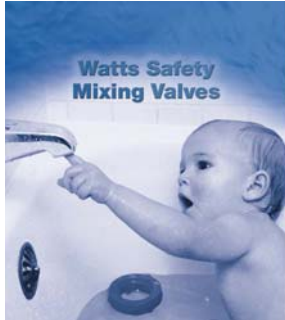
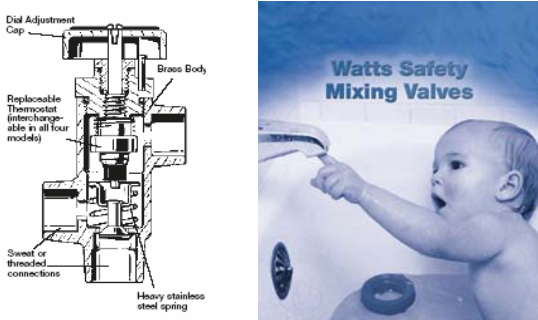
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The water heater relief valve drain tube has a threaded end, creating the potential to defeat the relief valve.
RECOMMENDATION:
Have a qualified plumber correct this condition.

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Basic Construction



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- Pause for Watts video on anti-scalding devices.
- Because you are an ASHI Inspector you will also be checking other aspects of the water heater: combustion venting, wiring, etc.
- These topics are outside the Plumbing Principles.

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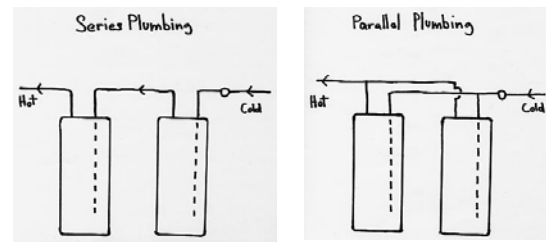
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Discuss this installation. Describe it.

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Series heaters - Parallel heaters

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As I recall, this is a series installation with extra valves to permit single heater use, or to reverse the pre-heat & final heat roles.

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How would a qualified installer improve the venting of this water heater?

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An improved vent configuration would use stacked tees, with the water heater into the upper tee.

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Gas water heater vents can become orphans in the chimney, when the larger BTU input of the furnace is disconnected from the chimney.

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Melted rings at the water pipes indicate backspillage of combustion products.

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The backspilling heater was also making 65 ppm CO.

"If you don't test you don't know."

(exceeds ASHI Standard)

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ASHI Standard -**The inspector shall:**

A. *inspect:* the fuel storage and fuel distribution systems.

Describe the **actions** you take when encountering this condition.

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- **REQUIRED actions** with real & potential gas leaks:
- List in your report (with optional marked photo)
- Report remark to recommend immediate correction.

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Principle V: Prevent Overheated Water & Explosions



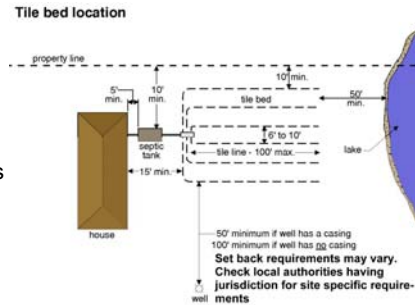
- Suggested additional actions with real or potential gas leaks to reduce your liability exposure: (discuss these suggestions with your attorney)
- Leave a note at or on the pipe.
- Tape the valve handle closed
- Discuss with customer & agent.

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Principle W: Prevent discharge of untreated sewage

- Sewage or other waste shall not be discharged into surface or sub-surface water unless it first has been subjected to an acceptable form of treatment.



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Resources & References

Minnesota Plumbing Code, Chapter 4715
 Plumber's Installation Handbook, Plastic Pipe and Fitting Assoc. www.toolbase.org
 HUD Rehab Guide Vol. 8 HVAC/Plumbing www.toolbase.org
 Drawings in the presentation provided by:
 "Illustrated Home" by Carson Dunlop, www.carsondunlop.com/Inspectors/illhome.htm
 US EPA Cross Connection manual www.epa.gov/safewater/crossconnection.html
 JLC Magazine: www.jlconline.com
 Healthy Housing Reference Manual, US CDC National Center for Environmental Health (aka Basic Housing Inspection) www.cdc.gov/nceh/publications/books/housing/housing.htm
 PATH Rehab Guide HVAC / Plumbing US Dept. of HUD www.huduser.org/Publications/PDF/hvac.pdf

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THANKS for your participation

- Questions welcomed. Group or individual training available.
- Roger Hankey, Member of ASHI®
- Hankey & Brown Inspections
- 952 829-0044
- www.hankeyandbrown.com
- rhankey@hankeyandbrown.com



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