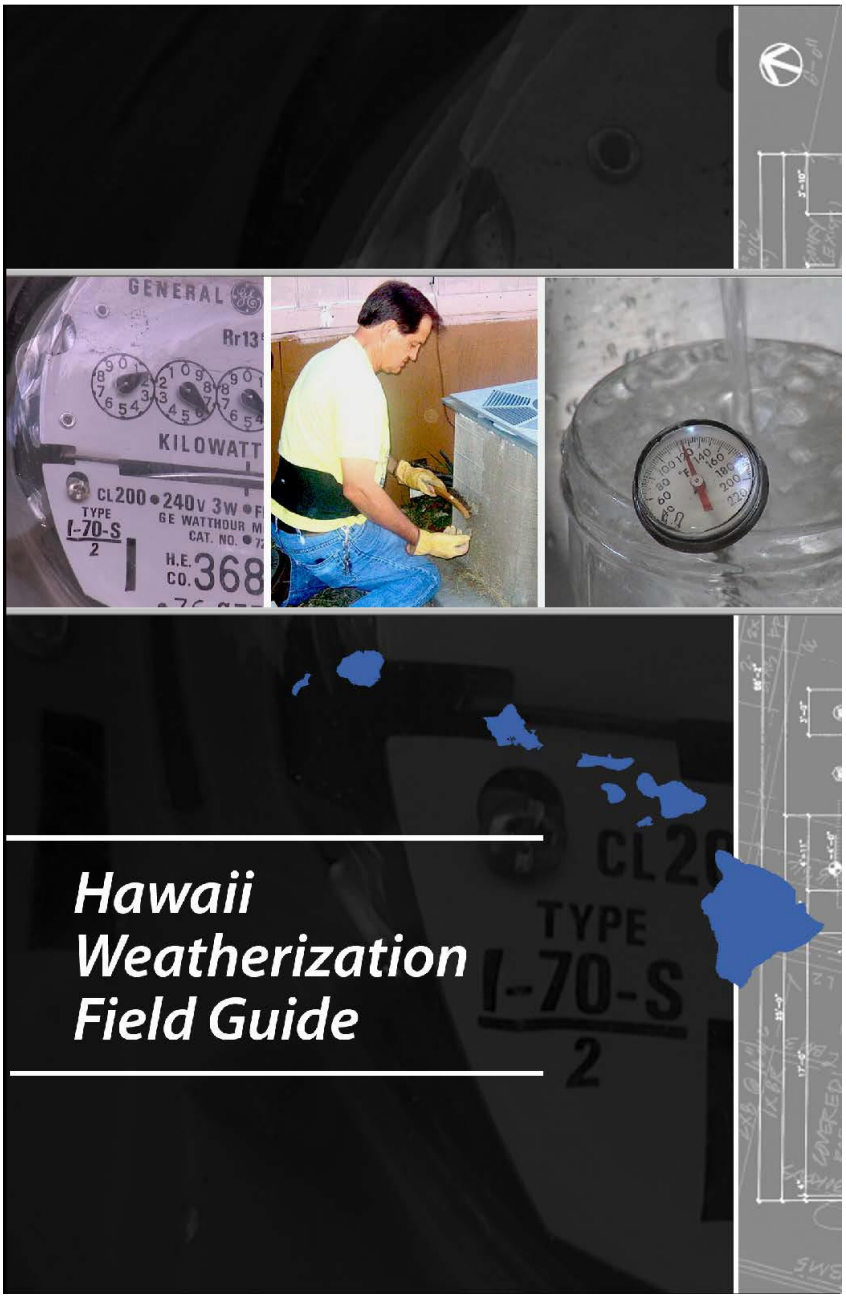

Hawaii Weatherization Field Guide

Hawaii
Weatherization
Field Guide
SWS-Aligned Edition

The *Hawaii Weatherization Field Guide* describes procedures used to analyze and improve the performance of existing homes retrofitted under the Department of Energy's (DOE) Weatherization Assistance Program (WAP). This field guide is cross referenced to the DOE's Standard Work Specifications (SWS) for Home Energy Upgrades.

Updated on February 24, 2022

Version 103115

State of Hawaii Department of Labor and Industrial Relations

Office of Community Services

Preface

In Hawaii, the State Department of Labor and Industrial Relations, Office of Community Services, (OCS), has administered WAP for approximately 30 years. This Weatherization Field Guide outlines a set of best practices.

Weatherization experts collaborating with the National Renewable Energy Lab (NREL) developed the SWS beginning in 2009. These new SWS standards reside online in *NREL's SWS Tool.*

The SWS presents details and outcomes for weatherization measures that are required when a weatherization agency selects a weatherization measure, based on its cost effectiveness. The technical content of this guide aligns with the SWS requirements. Hypertext references to the specific SWS details that our content aligns to are included. When you click on one of these references, the relevant detail appears in your browser.

Currently, there are seven approved weatherization measures in the DOE approved Hawaii Priority List that applies to single family homes and multi-family buildings with units of 4 or less. The following measures are listed in the order of most cost effective. When weatherizing a home, typically the measures are installed in order, as conditions and funding permit.

- Low-Flow Showerheads
- Low-Flow Faucet Aerators
- Compact Fluorescent Light Bulbs (CFL's)
- Small Room Air Conditioners
- Solar Water Heaters or Hybrid Heat Pumps
- Refrigerator Replacements
- Large Room Air Conditioners

The priority list criteria for these measures, along with their installation guidelines are covered in this field guide.

Like the SWS, this field guide is a living document and a work-in-progress. The field guide will change as the SWS changes. We hope you find this guide authoritative, easy to use, and well aligned to the SWS. We welcome all comments, suggestions and criticism. Thank you for your hard work and dedication in implementing the WAP.

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CHAPTER 1: HEALTH AND SAFETY

This chapter discusses some of the most important hazards that you find both in residential buildings and on weatherization jobs. The SWS contains many health and safety requirements that relate to various cost-effective energy-conservation measures (ECMs). These SWS requirements are referenced in this chapter.

The chapter begins with health, safety, and durability of the building. If health and safety problems affect the cost-effective ECMs you select, solve the problems before or during the weatherization work.

Workers are the most important asset of WAP. We discuss their health and safety at the end of this chapter.

Customer Health and Safety

House fires, moisture problems, carbon-monoxide poisoning, and lead-paint poisoning are the most common and serious health and safety problems found in homes.

Alert residents to any health and safety hazards that you find. Discuss known or suspected health concerns with occupants; take extra precautions based on occupant sensitivity to environmental hazards, such as chemicals and allergens.

- ✓ Inspect the home for fire hazards such as improperly installed electrical equipment, flammable materials stored near combustion appliances, or malfunctioning heating appliances. Discuss these hazards with occupants, and remove these hazards if possible, as allowed under Weatherization Program Notice (WPN)17-7.
- ✓ Understand and comply with the fire-containment code requirements of the International Residential Code (IRC).

- ✓ Find moisture problems and discuss them with the occupant. Solve moisture problems before or during weatherization work. *See page 13.*
- ✓ Obey the Environmental Protection Agency's (EPA) Repair, Renovation, and Painting (RRP) rules when working on homes built before 1978. Prevent dust during all weatherization projects. Explain the lead paint hazard and tell residents what you're doing to protect them. *See page 24.*

Worker Health and Safety

In the worker-safety section at the end of this chapter, we discuss the most dangerous hazards present during weatherization and how to avoid these hazards. Hazards include driving, falls, back injuries, cuts, chemical exposure, repetitive stress, and electrical shocks.

1.1 Fire Safety

The building codes focus on preventing the spread of fire within and between buildings. A fire barrier is a wall assembly that has been tested and certified to withstand and contain a fire for a particular time duration.

A fire partition is a fire barrier that prevents the spread of fire between the sections of a building. A firewall is a structural fire barrier between buildings that is designed to remain standing during and after a fire.

Flame spread is a tested value of how fast a material burns compared to red oak planks.

A thermal barrier is a sheeting material that protects the materials behind it from reaching a temperature of 250°F or breeching during a fire. One-half-inch drywall is the most commonly used thermal barrier and is rated for 15 minutes of protection. Fire partitions in multifamily buildings usually require a wall assembly with a 2-hour rating.

1.2 Smoke Alarms

SWS Details: 2.0101.1 Hardwired Smoke Alarm
SWS Details: 2.0101.2Battery- Operated Smoke Alarm

Every home should have at least one smoke alarm. Single-function alarms or combination alarms can interconnect electrically for whole-building protection. If one alarm sounds the other alarms sound too.

Educate occupants about the alarms and what to do if the alarm sounds. Discuss the low battery chirping sound and how to replace the battery. Tell residents that alarms last less than 10 years and that a different sound will alert them when the alarm fails.

1.3 Gas Range and Oven Safety

Gas ovens can release carbon monoxide (CO), natural gas, or propane into a kitchen. Oven burners are more likely to release CO compared to range-top burners.

Client Education about Ranges

Educate clients about the following safety practices in using their gas range.

- ✓ Never use a range burner or gas oven as a space heater.
- ✓ Open a window and turn on the kitchen exhaust fan when using the range or oven.
- ✓ Buy and install a CO alarm and discontinue use of the oven and range burners if the ambient CO level rises above 9 parts per million (ppm) as measured.
- ✓ Never install aluminum foil around a range burner or oven burner.

- ✓ Keep range burners and ovens clean.
- ✓ Burners should display hard blue flames. Call a service company if you notice yellow flames, white flames, wavering flames, or noisy flames.

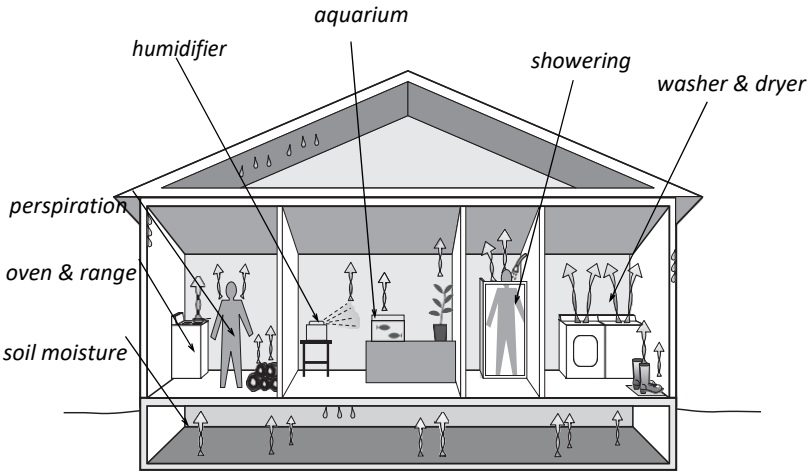
1.4 Reducing Moisture Problems

Moisture causes billions of dollars' worth of property damage, sickness, and high energy bills each year in American homes. Water damages building materials by dissolving glues and mortar, corroding metal, and nurturing pests like mold, dust mites, and insects. These pests, in turn, cause respiratory illness.

Water reduces the thermal resistance of insulation and other building materials. High humidity also increases air-conditioning costs because the air conditioner removes moisture from the air to provide comfort.

The most common sources of moisture are leaky roofs and damp foundations. Other critical moisture sources include clothes dryers venting indoors, showers, cooking appliances, and unvented gas appliances. Clients control many of these moisture sources, so educate them about how to reduce the moisture sources discussed here.

Climate is also a major contributor to moisture problems. The more rain, extreme temperatures, and humid weather a region experiences, the more of its homes are vulnerable to moisture problems.



Moisture sources: Household moisture can often be controlled at the source by informed and motivated occupants, who work to control moisture sources like these.

Reducing moisture sources is the first priority for solving moisture problems. Next most important are air and vapor barriers to prevent water vapor from migrating through building cavities. Relatively tight homes need mechanical ventilation to remove accumulating water vapor.

Table 1-1: Moisture Sources and Their Potential Contributions

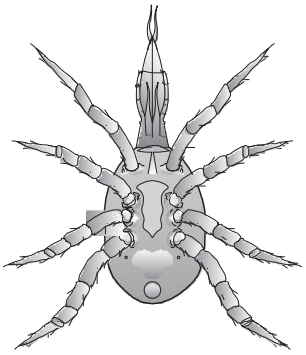
Moisture Source	Potential Amount Pints
Ground moisture	0–105 per day
Unvented combustion space heater	0.5–20 per hour
Seasonal evaporation from materials	6–19 per day
Dryers venting indoors	4–6 per load
Dish washing	1–2 per day
Cooking (meals for four persons)	2–4 per day
Showering	0.5 per shower

1.4.1 Symptoms of Moisture Problems

Condensation on windows, walls, and other cool surfaces signals high relative humidity and the need to reduce moisture sources. During air conditioning operation, condensation may occur on cold surfaces. This occasional condensation isn't a major problem. However, if condensation is a persistent problem, reduce moisture sources.

Moisture problems arise when parts of the building become wet often and stay wet for periods of time. Moisture in organic or porous building materials reaches a threshold that allows pests like mold, dust mites, and insects to thrive. These pests can cause or aggravate asthma, bronchitis, and other respiratory ailments because they produce potent biological allergens.

Rot and wood decay indicate advanced moisture damage. Unlike surface mold and mildew, wood decay fungi penetrate, soften, and weaken wood.



Dust mites: Biological pests create bioaerosols that can cause allergies and asthma.

Peeling, blistering, or cracking paint may indicate that moisture is moving through a wall, damaging the paint and possibly also the building materials underneath.

Corrosion, oxidation, and rust on metal are unmistakable signs of moisture problems. Deformed wooden surfaces may appear as the damp wood swells, and later warps and cracks as it dries.

Efflorescence is a white, powdery deposit left by water that moves through masonry and leaves minerals from mortar or the soil behind as it evaporates from the masonry surface. Concrete and masonry efflorescence indicates water movement through the home's foundation.

1.4.2 Solutions for Moisture Problems

SWS Details: 2.0203.1a Stand-Alone Dehumidifiers,

Preventing moisture problems is the best way to guarantee a building's durability and its occupant's respiratory health. However, the solutions get progressively more expensive if simple solutions don't solve the problems.

Inexpensive Moisture Solutions

If moisture source reduction isn't adequate to prevent moisture problems, try these solutions after preventive measures are in place.

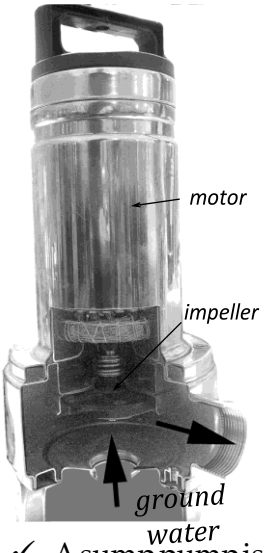
- ✓ Install a ground moisture barrier, which is a piece of heavy plastic sheeting (6 mil minimum) laid on the ground. Black heavy plastic film works well, but tough cross-linked polyethylene is even more durable. Secure the edges to the foundation walls 6-inches above the ground with polyurethane adhesive and/or mechanical fasteners.
- ✓ Overlap the ground moisture barrier seams by 12-inches and seal with polyurethane adhesive.
- ✓ Verify that clothes dryers and exhaust fans vent to the outdoors and not into crawl spaces or attics.
- ✓ Seal water leaks in the foundation.
- ✓ Seal water leaks in the roof.

- ✓ Educate clients about ways of reducing home moisture that are under their control.
- ✓ Educate customers to avoid excessive watering around the home's perimeter. Watering lawns and plants close to the house can dampen its foundation. In moist climates, keep shrubbery away from the foundation, to allow air circulation near the foundation.
- ✓ Insulate air conditioning ducts to prevent summer condensation.

More Costly Moisture Solutions

Follow these preventive measures before trying any of the solutions in the next section.

- ✓ Install or improve air barriers and vapor barriers to prevent air leakage and vapor diffusion from transporting moisture into building cavities.



Sump pump: Pumps water out of a sump or basin where water collects in a basement or crawl space.

- ✓ A sump pump is the most effective remedy when ground water continually seeps into a basement or crawl space and collects there as standing water. Persistent ground water seepage may only be solved by connecting an interior

perimeter drains to the sump. The sump cover must be openable, rigid, and must not interfere with drainage.

- ✓ Ventilate the home with drier outdoor air to dilute the more humid indoor air. Ventilation is only effective when the outdoor air is drier than the inside air, such as in win- ter. In summer, outdoor air may be more or less humid than indoor air depending on climate and whether the home is air conditioned.

Dehumidifiers and Air Conditioners for Drying

As a last resort, remove moisture from indoor air by cooling the air to below its dew point with dehumidifiers or air conditioners in summer. Using air conditioners and dehumidifiers for drying a home is the most expensive solution. Try all the moisture solutions discussed previously before resorting to a dehumidifier.

1.5 Electrical Safety

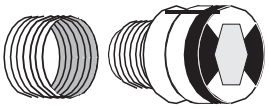
Electrical fires and shocks are common and serious safety problems. Electrical safety is a basic housing need requiring attention during home weatherization and repair.

Observe the following specifications for electrical safety in weatherizing existing homes.

- ✓ Whenever working around wiring, use a non-contact voltage tester to determine whether circuits are live. Turn circuits off at circuit breakers as appropriate.
- ✓ Inspect wiring, fuses, and circuit breakers to verify that wiring isn't overloaded. Install S-type fuses where appropriate to prevent circuit overloading. Maximum ampacity for 14-gauge wire is 15 amps and for 12-gauge wire is 20 amps.

- ✓ Confirm that all wire splices are enclosed in electrical junction boxes. If you plan to cover a junction box with insulation, attach a flag to mark its location.
- ✓ Verify that the electrical system is grounded to either a ground rod or to a metallic water pipe with an uninterrupted electrical connection to the ground.
- ✓ Install S-type fuses where appropriate to prevent occupants from installing oversized fuses if installing insulation.
- ✓ Perform a voltage-drop test to evaluate the size and condition of hidden wiring on older homes if installing insulation.

Non contact voltage tester: Test voltage wires near your work area and take action to turn off the circuit if appropriate.

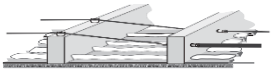


S-type fuse: An S-type fuse prohibits residents from oversizing the fuse and overloading an electrical circuit.

1.5.1 Decommissioning Knob-and-Tube Wiring

SWS Detail: 2.0301.2 Knob and Tube Wiring

Decommission knob-and-tube wiring before or during weatherization if possible. Try to convince your clients or their landlords to replace knob-and-tube wiring with their own funds.



Knob-and-tube wiring: Obsolete and worn wiring should be replaced during energy retrofit work so that building cavities can be sufficiently insulated.

Use a non-contact voltage tester to determine whether the knob-and-tube wiring is live. If you're unsure about whether the wiring is still live, schedule an inspection by a qualified and experienced electrician.

If the knob-and-tube wiring in an attic is live, ask an electrician or an electrical inspector to determine whether the attic wiring can be decommissioned and replaced with non-metallic (NM) sheathed electrical cable. Depending on the situation, the electrician may choose one of these two options.

1. Terminate the existing attic knob-and-tube wiring and connect the new NM circuit directly to the main service box.
2. Install a flagged junction box in the attic to connect the knob-and-tube riser to new NM cable in the attic.

Consider installing a hard-wired smoke detector in a common area near the bedrooms on the new circuit.

1.6 Pollutant Source Control

Radon, asbestos, and lead are also notable hazards to both occupants and workers.

1.6.1 Radon

SWS Detail: 2.04 Radon

Radon is a dangerous indoor air pollutant that comes from the ground through rocky soil. Studies predict about 20,000 lung cancer deaths per year are caused by radon exposure. Weatherization workers should be aware of the radon hazard, radon testing procedures, and radon mitigation strategies.

The EPA believes that any home with a radon concentration above 4 pico-Curies per liter (pC/l) of air should be modified to reduce the radon concentration. There are several common and reliable tests for radon, which are performed by health departments and private consultants throughout the U.S.

Energy conservation work usually has little effect on radon concentrations. However, ground-moisture barriers and foundation air sealing may reduce radon concentrations in addition to reducing air leakage.

DOE funds can't pay for fans or other measures specifically designed for radon mitigation. Radon mitigation must use non-DOE funds. Since radon comes through the soil, mitigation strategies include the following.

1. Installing a plastic ground barrier and carefully sealing the seams and edges.
2. Sealing the walls and floor of the basement or crawl space.
3. Ventilating the crawl space or basement with an exhaust fan to dilute radon.
4. Depressurizing the ground underneath the basement concrete slab.

Weatherization workers may install the first two mitigation strategies as prescribed by the weatherization work order for air-sealing.

1.6.2 Asbestos Containing Materials

Asbestos is classified as a "known carcinogen." Asbestos is found in the following materials: boiler and steam-pipe insulation, duct insulation, floor tile, siding, roofing, some types of vermiculite, and some adhesives. Weatherization workers must be trained to recognize asbestos and to avoid disturbing it. Penalties for mishandling asbestos-containing materials (ACM) can amount to $25,000 per day.

DOE weatherization policy requires weatherization agencies to observe the following safety precautions regarding asbestos.

- Asbestos siding comes in sheets approximately 16-inches by 24-inches. It is very weatherproof but very brittle.

Remove asbestos siding only if you can remove the siding without damaging it.

- Assume that asbestos is present in old gray-colored pipe insulation and duct insulation. Don't disturb asbestos-containing pipe or duct insulation; also caution occupants to avoid disturbing asbestos.
- Don't cut, drill, scrape, sand, or brush ACM.
- Don't remove vermiculite. Test vermiculite for asbestos and use air monitoring if asbestos is present in the vermiculite in a home you're weatherizing.

Contract with certified asbestos testers and abatement specialists to mitigate asbestos problems before or during weatherization, if necessary.

1.6.3 Lead-Safe Procedures

In 2010, the EPA's lead safe RRP rule became a legal mandate for weatherization work.

Lead dust is dangerous because it damages the neurological systems of people who ingest it. Children are often poisoned in pre-1978 homes because of paint disturbance during home improvement and because hand-to-mouth behavior is common. Workers are poisoned by dust containing lead.

Lead paint was commonly used in homes built before 1978. Contractors working on these older homes should either assume the presence of lead paint or perform tests to rule out its presence.

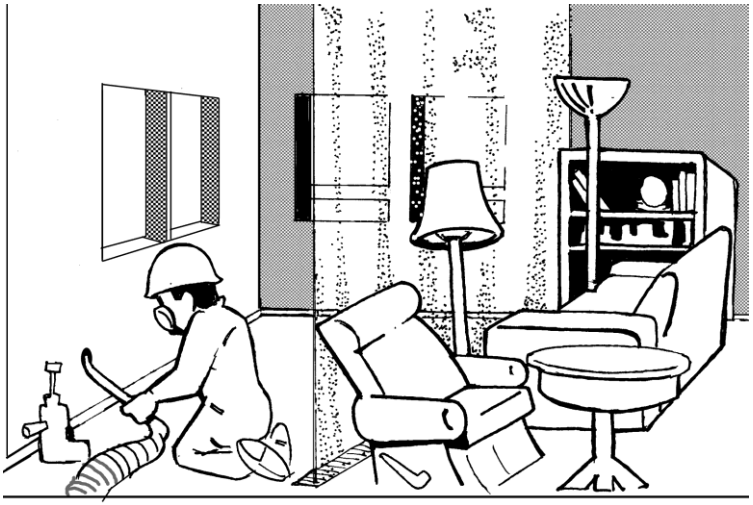
EPA RRP Requirements

The RRP rule requires lead-safe containment procedures whenever workers disturb painted surfaces of more than 6 square feet of interior surface per room or more than 20 square feet of exte-

rior surface per side by cutting, scraping, drilling, or other dust-creating activities in pre-1978 homes. Disturbing paint on windows and doors always requires containment.

The RRP requires certifications, warnings, dust-prevention, dust collection, and house cleaning as summarized here.

- ✓ With pre-1978 homes, either test for lead-based paint or assume that lead-based paint is present.
- ✓ Every pre-1978 weatherization or renovation job must be supervised by a certified renovator with 8 hours of EPA-approved training when workers will disturb more than the minimum paint area or when they will disturb paint on windows or doors.
- ✓ Renovation firms must be registered with the EPA and employ one or more certified renovators.
- ✓ Signs and barriers must warn occupants and passersby not to enter the work area.
- ✓ Floor-to-ceiling dust-tight barriers must prevent the spread of dust from the work area.



Protective sheeting: Dust-tight floor-to-ceiling barriers must separate work areas from living areas, according to EPA's RRP rule.

- ✓ Plastic sheeting must protect surfaces and fixtures within the work area.
- ✓ Workers must clean work surfaces sufficiently to pass an EPA-approved dust-wipe test, conducted by the certified renovator.
- ✓ Workers must not track dust from the work area into the home.

Lead-Safe Work Practices

Lead-Safe Weatherization (LSW) is a set of procedures developed by the DOE prior to the enactment of the RRP rule. LSW requires the same basic procedures as RRP in pre-1978 homes. When engaging in the paint-disturbing weatherization activities, follow these lead-safe work practices that were established by weatherization experts.

- ✓ Wear a tight-fitting respirator to protect yourself from breathing dust or other pollutants.

- ✓ Confine your work area within the home to the smallest possible floor area. Seal this area off carefully with floor-to-ceiling barriers made of disposable plastic sheeting, sealed at floor and ceiling with tape.
- ✓ Don't use heat guns or power sanders in LSW work.
- ✓ Spray water on the painted surfaces to keep dust out of the air during drilling, cutting, or scraping painted surfaces.
- ✓ Erect an effective dust-containment system outdoors to prevent dust contamination to the soil around the home.
- ✓ Use a dust-containment system with a High Efficiency Particulate Air (HEPA) vacuum when drilling holes indoors.

Drill shroud connected to HEPA vacuum: Collect dust where you're generating it.

- ✓ Avoid taking lead dust home on clothing, shoes, or tools. Wear boot covers while in the work area, and remove them to avoid tracking dirt from the work area to other parts of the house. Wear disposable coveralls or vacuum cloth coveralls with a HEPA vacuum before leaving the work area.
- ✓ Wash thoroughly before eating, drinking, or quitting for the day.

1.7 Worker Health and Safety

The personal health and safety of each employee is vitally important to every weatherization agency. Injuries are the fourth leading cause of death in the United States, while long-term exposure to toxic materials contributes to sickness, absenteeism, and death of workers. Both injury hazards and toxic substances are present during weatherization work.

The Occupational Safety and Health Administration (OSHA) establishes workplace safety standards. Weatherization staff and contractors must attend training on OSHA standards and observe these standards on the job. Safety always has priority over other factors affecting weatherization operations.

Some hazards deserve attention because of their statistical danger. Become aware of these most common workplace hazards.

- ✓ Vehicle accidents
- ✓ Falls
- ✓ Back injuries
- ✓ Exposure to hazardous materials
- ✓ Electrical hazards
- ✓ Repetitive stress injuries

1.7.1 Commitment to Safety

Workers may not remember safe work practices unless safety is periodically reinforced.

Safety education: Safety meetings are an essential part of a successful safety program.

- ✓ Arrange regular health and safety training.
- ✓ Conduct monthly safety meetings at headquarters and weekly safety meetings on the current jobsite.
- ✓ Provide well-equipped first-aid kits in the work vehicles and in the warehouse.
- ✓ Provide or require personal protective equipment for workers appropriate for their job duties.
- ✓ Provide a fire extinguisher in the warehouse and each work vehicle.
- ✓ Keep equipment in good condition.
- ✓ Observe all state and federal standards relating to worker health and safety.
- ✓ Keep lists of emergency-contact phone numbers for both employees and emergency services in the warehouse and in the work vehicles.
- ✓ Keep Safety Data Sheets (SDS) in the ware- house and in the work vehicles.

Safety requires communication and action. To protect yourself from injury and illness, learn to recognize hazards, communicate with co-workers and supervisors, and take action to reduce or eliminate hazards.

1.7.2 New Employees

New employees are several times more likely to injure themselves on the job compared to experienced workers. Before their first day on the job, new employees should learn about safety basics such as proper lifting, safe ladder usage, and safe operation of the power tools they will use on the job.

New hire: New hires are several times more likely to be injured than are experienced workers.

Be sure to inform new employees about hazardous materials they may encounter on the job. Show new hires the SDS required by OSHA for each material.

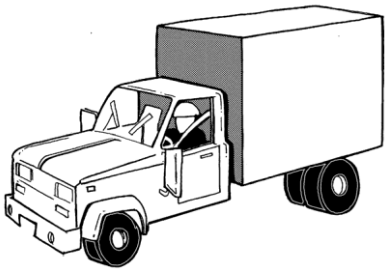
New employees should be required to use the following safety equipment.

- ✓ Proper clothing
- ✓ Leather gloves with cuffs
- ✓ Respirators
- ✓ Safety glasses
- ✓ Hearing protectors

Ban alcohol and drugs from agency headquarters and the job. Staff members should be encouraged to refrain from smoking and to stay physically fit.

1.7.3 Driving

According to the Bureau of Labor Statistics, one-third of all occupational fatalities in the United States occur in motor-vehicle accidents. Staff members should organize their errands and commuting to the job site so as to minimize vehicle travel.



Safe vehicles: Maintain vehicles in good repair. Drivers and passengers should always wear seat belts.

Vehicles should be regularly inspected and repaired if necessary. Verify that these safety features are present and functioning.

- ✓ Brake system
- ✓ Steering system
- ✓ Horn
- ✓ Headlights
- ✓ Rear-view and side-view mirrors
- ✓ Directional signals
- ✓ Backup lights
- ✓ A fire extinguisher

Always wear seat belts. Before traveling to the job, secure tools and materials in the vehicle's cargo area to prevent shifting.

1.7.4 Lifting and Back Injuries

Back injuries account for one out of every five workplace injuries. Most of these injuries are to the lower back and result from improper lifting, crawling in tight spaces, and using heavy tools.

Workers often injure their backs by lifting heavy or awkward loads improperly or without help. Use proper lifting techniques such as lifting with the legs and keeping a straight back whenever possible. To avoid back injury, get help before trying to lift heavy or awkward loads, stay in good physical condition, and control your weight through diet and exercise.

Awkward loads: Ask for help when moving heavy or awkward loads.

Workers with limited lifting abilities because of weakness or prior injury should avoid heavy lifting.

These policies help prevent jobsite injuries.

- ✓ Redesign work activities: adapt equipment to minimize awkward movements on the job site.
- ✓ Perform strength-testing of workers, set lifting limits, and provide training for all workers on the causes and prevention of back injuries.
- ✓ Encourage breaks to prevent workers from being in straining positions for long time periods.
- ✓ Share the most difficult work among all capable crew members.

1.7.5 Respiratory Health

Wear your respirator when working in a polluted environment. Common construction dust can contain toxins including lead, asbestos, and chemicals released by drilling, cutting, and scraping. Liquid foam, caulking, and solvents release toxic organic vapors that require either organic vapor cartridges or a fresh-air supply.

Test your respirators to be sure they have a good fit.

- ✓ Check the straps and face piece to be sure they are soft and free of cracks.
- ✓ Strap on the respirator and adjust the straps to be snug but comfortable.
- ✓ Close the exhalation valve with a hand.
- ✓ Exhale gently and check for leaks around the edges.
- ✓ If there are leaks, adjust or repair the respirator.

Workers with beards, facial scars, and thick temple bars on eyeglasses must use full-face respirators to achieve a good seal. OSHA requires a completed form documenting employees' fit tests each year.

Learn how to recognize asbestos insulation that may be installed around older furnaces and boilers. Avoid disturbing asbestos in any way.

Control dust in your client's homes by erecting temporary barriers when you are doing work that may release dust. Wear coveralls when entering attics or crawl spaces. Coveralls should be disposable or laundered professionally.

1.7.6 Hazardous Materials

Your health and safety can be threatened by hazardous materials used on the job. Workers often fail to protect themselves from hazardous materials because they don't recognize the hazards. Breathing hazardous materials, absorbing them through the skin, and coming into eye contact with hazardous materials are common ways workers are injured by chemicals.

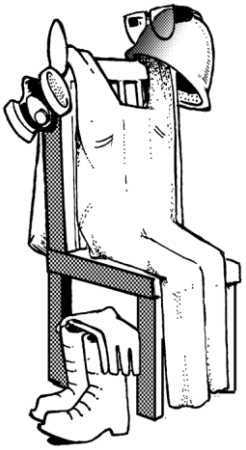
OSHA regulations require employers to notify and train employees about hazardous materials used on the job. An SDS for every workplace hazardous material should be readily available to employees. Obtain copies of SDSs from manufacturers or their distributors. OSHA requires that the SDSs be available at headquarters and at the jobsite for worker reference.

Learn how to handle hazardous materials used on the job. Use the personal protective equipment (PPE) that is recommended by the SDS.

1.7.7 Equipment for Personal and Crew Safety

Worker should have their own personal protective equipment.

- Respirators with dust and organic-vapor cannisters
- Clean cloth coveralls or disposable coveralls
- Gloves
- Safety glasses
- Hearing protection
- Hard hat for head-injury hazards



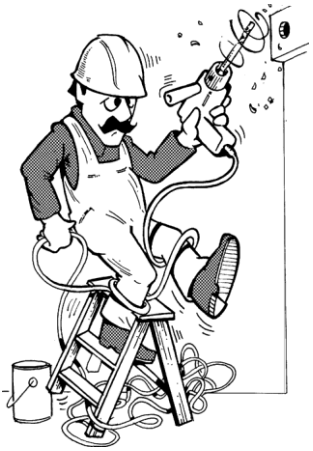
Personal protective equipment: Employees should own and maintain protective equipment to protect themselves from hazardous materials.

Crews should equip themselves with the safety equipment listed here.

- Ladder levelers and stabilizers
- Portable lights for work in dark areas
- A water jug
- Insect spray
- Safe, heavy electrical cords with ground fault circuit interrupter (GFCI) receptacles

1.7.8 Falls

Falls off ladders and stairs cause 13% of workplace injuries according to the National Safety Council. Other falls from heights account for approximately 7% of workplace injuries.



Ladders: Ladders are the most dangerous tools workers use.

Broken ladders and unstable ladders are both major causes of on-the-job falls. Step ladders, for instance, are often used for work that is too far off the ground, forcing workers to stand on the top step or to reach too far.

OSHA regulations include these important guidelines for ladder use.

- ✓ Maintain all ladders in good repair and replace ladders if they have missing or damaged steps, cracked side-rails, or damaged feet.
- ✓ Extend extension ladders at least three feet above the area they access.
- ✓ Ladders shouldn't have a pitch steeper than four feet of rise for each foot that the ladder's feet are away from the building.
- ✓ Block or tie ladders firmly in place at the top and bottom if you install the ladder at a steeper angle than suggested above or on windy days.
- ✓ Don't use metal ladders where they may accidentally touch electrical conductors.

- ✓ Maintain ladders free of oil, grease, and other slipping hazards. Inspect your shoes for slipping hazard before climbing a ladder.
- ✓ Don't over-reach. Instead, move the ladder.
- ✓ Avoid carrying heavy loads up ladders and operating power tools from ladders.

Build scaffolding when working above-ground for sustained time periods. Each scaffold leg should be stabilized so that it supports an equal weight as other legs. Secure planks to the structure and provide handrails on the sides and ends of the walkway.

Good housekeeping: Clear stairs and walkways are essential to protect workers and clients alike from falls.

Workers should inspect their workplaces regularly to notice and remove slipping and tripping hazards. Workers carrying loads should create and maintain debris-free walkways.

1.7.9 Tool Safety

The tools used in construction work are dangerous if used improperly. About 90,000 people hurt themselves with hand tools each year. The crew chief should conduct tool safety training as frequently as necessary to ensure safe tool use.

These basic safety rules can reduce the hazards of using hand and power tools.

- ✓ Use the right tool for the job.
- ✓ Keep all tools in good condition with regular maintenance.
- ✓ Inspect tools for damage before using them.
- ✓ Operate tools according to the manufacturer's instructions.
- ✓ Use appropriate personal protective equipment.
- ✓ Use double insulated power tools or GFCI outlets or extension cords to prevent electric shock.

Electrical safety: Maintain cords in good condition. Use GFCI cords for outlets in wet conditions.

- ✓ Use generators for electrical service on the jobsite and ground them.
- ✓ Verify that generator exhaust is directed away from the home, the vehicle, and the crew.

1.7.10 Repetitive Stress Injuries

Repetitive stress injuries are caused by over-working certain parts of your body. Poor body posture, such as reaching above your head when operating a power drill, can encourage these injuries. Good work habits prevent this type of injury.

- ✓ Use a comfortable arm and hand posture when operating tools for a long period of time.

- ✓ Change the angle and location of your work surface frequently.
- ✓ Mix your difficult tasks with easier ones.
- ✓ Carry smaller loads.
- ✓ Take short rest breaks periodically and stretch any tight muscles during this time.

When you purchase hand and power tools, look for models with ergonomic designs that place less stress on your body.

1.7.11 Safety for Extreme Weather

Extreme hot and humid weather is a common cause of job-related sickness and injury. You can avoid sickness and injury by awareness and preventive measures.

Know the signs of heat ailments and take action if you or a co-worker experiences the beginning of symptoms. Observe these hot-weather suggestions for staying cool and preventing heat ailments.

- ✓ Drink plenty of water and take salt tablets.
- ✓ Ventilate attics with fans.
- ✓ Rotate workers in attics to prevent heat exhaustion.
- ✓ Use water or ice to cool your skin.
- ✓ Rest when you feel fatigued.

1.8 SWS ALIGNMENT

Field Guide Topic	SWS Detail
Fire Safety Pg. 10	
Smoke Alarms Pg. 11	2.0101.1 Smoke Alarm 2.0101.2 Battery operated Smoke aLam

Field Guide Topic	SWS Detail
Gas Range and Oven Safety Pg. 11	
Reducing Moisture Problems Pg. 13	
Symptoms of Moisture Problems Pg. 15	
Solutions for Moisture Problems Pg. 16	2.0203.1a Stand-Alone Dehumidifiers,
Electrical Safety Pg. 18	
Decommissioning Knob-and-Tube Wiring Pg. 20	2.0301.2 Knob and Tube Wiring
Pollutant Source Control Pg. 21	
Radon Pg. 21	2.04 Radon
Asbestos Containing Materials Pg. 22	
Lead-Safe Procedures Pg. 23	
Worker Health and Safety Pg. 27	
Commitment to Safety Pg. 27	

CHAPTER 2: ENERGY AUDITS AND QUALITY CONTROL INSPECTIONS

This chapter outlines the operational process of energy audits, work orders, and final inspections as practiced by non-profit agencies and contractors working in the DOE WAP.

WAP's Mission

The mission of DOE WAP is **"To reduce energy costs for low-income families, particularly for the elderly, people with disabilities, and children, by improving the energy efficiency of their homes while ensuring their health and safety."**

This chapter also discusses ethics, customer relations, and customer education.

Why We Care about Health and Safety

The health and safety of customers must never be compromised by weatherization. Harm caused by our work would hurt our clients, ourselves, and our profession. Weatherization work can change the operation of heating and cooling systems, alter the moisture balance within the home, and reduce a home's natural ventilation rate. Weatherization workers must take all necessary precautions to avoid harm from these changes.

2.1 PURPOSES OF AN ENERGY AUDIT

An energy audit evaluates a home's existing condition and outlines improvements to the energy efficiency, health, safety, and durability of the home.

Depending on the level of the audit, an energy audit may include some or all of the following tasks.

- Evaluate the current energy consumption along with the existing condition of the building.
- Diagnose areas of energy waste, health and safety, and durability problems related to energy conservation.
- Recommend Energy Conservation Measures (ECMs).
- Diagnose health and safety problems and how they may be affected by the proposed ECMs.
- Predict savings expected from ECMs.
- Estimate labor and material costs for ECMs.
- Encourage behavioral changes that reduce energy waste.
- Educate residents about their energy usage and your proposed energy retrofits.
- Provide written documentation of the energy audit and the recommendations offered.

2.1.1 Energy-Auditing Judgment and Ethics

The auditor's good decisions are essential to the success of a weatherization program. Good decisions depend on judgment and ethics.

- ✓ Understand the requirements of the WAP program.
- ✓ Treat every client with the same high level of respect.
- ✓ Communicate honestly with clients, coworkers, contractors, and supervisors.
- ✓ Know the limits of your authority and ask for guidance when you need it.
- ✓ Develop and maintain the inspection and diagnosis skills necessary for WAP energy auditing.
- ✓ Choose ECMs according to their cost-effectiveness along with DOE and State policy and not according to personal preference or customer preference.

- ✓ Don't manipulate the priority list to select or avoid particular ECMs.
- ✓ Avoid personal bias in your influence on purchasing, hiring, and contracting.

2.1.2 Energy-Auditing Record-keeping

The client file is the record of a weatherization completion. The client file may contain all of the following items, depending on Hawaii WAP policy.

1. Customer intake document
2. Income verification
3. Owner agreement form
4. Client health-notification documents
5. Energy Survey and Inspection form
6. Workplan
7. Energy-education documentation
8. Hawaii solar and heat pump water heater savings calculator
9. Moisture and mold findings
10. Hold harmless statement
11. Solid fuel inspection report
12. Refrigerator replacement analysis
13. Photo documentation
14. EPA lead-safe RRP final-inspection report, if applicable

2.2 Customer Relations

Customer satisfaction depends on the energy auditor's reputation, professional courtesy, and ability to communicate.

2.2.1 Communication Best Practices

Making a good first impression is important for customer relations. Friendly, honest, and straightforward communication creates an atmosphere where the auditor and clients can discuss problems and solutions openly.

Setting priorities for customer communication is important for the efficient use of your time. Auditors must communicate clearly and directly. Limit your communication with the customer to the most important energy, health, safety, and durability issues.

- ✓ Introduce yourself, identify your agency, and explain the purpose of your visit.
- ✓ Make sure that the customer understands the goals of the WAP program.
- ✓ Listen carefully to your client's reports, complaints, questions, and ideas about their home's energy efficiency.
- ✓ Ask questions to clarify your understanding of your client's concerns.
- ✓ Before you leave, give the client a quick summary of what you found.
- ✓ Avoid making promises until you have time to finish the audit, produce a work order, and schedule the work.
- ✓ Make arrangements for additional visits by crews and contractors as appropriate.

2.2.2 Customer Interview

The customer interview is an important part of the energy audit. Even if customers have little understanding of energy and buildings, they can provide useful observations that can save you time and help you choose the right ECMs.

- ✓ Ask the customer about comfort problems, including zones that are too hot.

- ✓ Ask the customer to see their energy bills if you haven't already evaluated them.
- ✓ Ask about family health, especially respiratory problems afflicting one or more family members.
- ✓ Discuss drainage issues, wet basements or crawl spaces, leaky plumbing, and mold infestations.
- ✓ Discuss the home's existing condition and how the home may change after the proposed retrofits.
- ✓ Ask the client to sign the necessary permissions.

2.2.3 Deferral of Weatherization Services

When you find major health, safety, or durability problems in a home, sometimes it's necessary to postpone weatherization services until those problems are solved. The problems that are cause for deferral of services include, but are not limited to, the following.

- Major roof leakage.
- Major foundation damage.
- Major moisture problem including mold infestation.
- Major plumbing problems.
- Human or animal waste in the home.
- Major electrical problems or fire hazards.
- The home is vacant or the client is moving.
- The home is for sale.

Behavioral problems may also be a reason to defer services to a customer, including but not limited to the following.

- Illegal activity on the premises.
- Occupant's hoarding makes difficult or impossible to perform a complete audit.

- Lack of cooperation by the customer.

Matching Funds to Avoid Deferrals

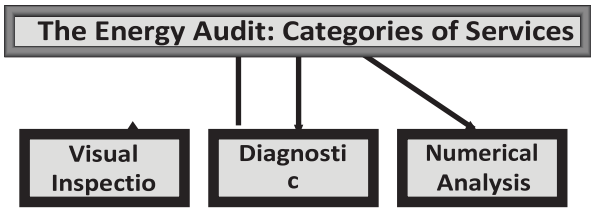
Auditors should assist customers in obtaining repair funds from the following sources whenever possible:

- Department of Housing and Urban Development (HUD) Emergency Repair Funds
- HUD Healthy Homes Initiative Funds
- Department of Agriculture (USDA) Rural Development Funds
- State and local repair funds
- Church, charity, and foundation funds

2.3 Parts of an Energy Audit

Visual inspection, diagnostic testing, and numerical analysis are three types of energy auditing procedures we discuss in this section. Hawaii uses a priority list for weatherization measures that should be installed in qualifying single-family homes.

The energy audit must also propose solutions to health and safety problems related to the energy conservation measures.



2.3.1 Visual Inspection

Visual inspection orients the energy auditor to the physical realities of the home and home site. Among the areas of inspection are these.

- Health and safety issues
- Building air leakage
- Baseload energy uses

2.3.2 Diagnostic Testing

Measurement instruments provide important information about a building's unknowns, such as air leakage and combustion efficiency. Use diagnostic tests as appropriate during the energy audit.

2.3.3 Numerical Analysis

The DOE approves priority lists based on the results of Weatherization Assistant or other DOE-approved software on typical homes. The priority list is then used instead of the software, which saves time for evaluating common home types. Energy auditors still use software to evaluate ECMs for uncommon home types.

DOE WAP requires that ECMs have a Savings to Investment Ratio (SIR) greater than 1. ECMs with higher SIRs should be installed before or instead of ECMs with lower SIRs.

SIR = Lifetime savings / Initial investment.

Whether a weatherization provider uses software or a priority list, the auditor must collect information to make an informed decision about which ECMs to choose.

Evaluate energy bills and adjust the job's budget within limits to reflect the potential energy savings.

2.4 The Work Order

The work order is a list of materials and tasks that are recommended as a result of an energy audit. Consider these steps in developing the work order.

- ✓ Evaluate which ECMs have an acceptable SIR using the priority list.
- ✓ Select the most important health and safety problems to correct, as these problems are directly related to the cost-effective ECMs.
- ✓ Provide detailed specifications so that crews or contractors clearly understand the materials and procedures necessary to complete the job.
- ✓ Estimate the cost of the materials and labor.
- ✓ Verify that the materials needed are in stock at the agency or a vendor.
- ✓ Inform crews or contractors of any hazards, pending repairs, and important procedures related to their part of the work order.
- ✓ Obtain required permits from the local building jurisdiction, if necessary.
- ✓ Consider in-progress inspections and schedule the final inspection for the job's final day if possible.

2.5 Work Inspections

The inspector is responsible for the quality control of the weatherization process. Good inspections provide an incentive for auditors to produce good energy audits and work orders and for workers to do quality work. There are two common opportunities for inspections: in-progress inspections and final inspections.

2.5.1 In-Progress Inspections

Many ECMs are best inspected while the job is in progress. Visiting while the job is in progress demonstrates your commitment to getting the job done correctly. Either the energy auditor or the inspector may conduct an in-progress inspection.

In-progress inspections are also an excellent way to provide training and technical assistance.

2.5.2 Final Inspections

A certified inspector completes a final inspection before the weatherization job is reported to DOE as a completion. The inspector is ideally a different person than the auditor.

Final inspections ensure that weatherization services were provided as specified in the work order and that the home is left in a safe condition. The weatherization agency does the final inspection for quality control, which is a term for in-house self evaluation of jobs.

Completing the final inspection with the crew or contractor on site allows the inspector and workers to review the work scope and correct deficiencies without requiring a return to the home. Verify the following during the final inspection.

- ✓ Review and verify the initial field data collected and energy audits performed to ensure the SIR calculation called for the correct measures.
- ✓ Review all completed work with the client. Confirm that the client is satisfied.
- ✓ Specify corrective actions whenever the work doesn't meet standards.
- ✓ Verify that all required paperwork, with required signatures is in the client file. *See "Energy-Auditing Record-keeping" on page 43.*

2.5.3 Questions about the Audit and Work Order

The inspector should ask these questions during the inspections.

- Did the auditor find all the opportunities and identify all the hazards?
- Did the work order specify the labor and materials required by the energy audit adequately?
- Did the workers follow the work order?
- What changes did the crew leader make to the work order?
- Did these changes benefit the client and the WAP program?
- Is the completed weatherization job, the energy audit, and the work order aligned with State policy and the SWS?

2.5.4 Quality Control Versus Quality Assurance

Quality control is an internal process of a weatherization agency focusing on the final inspection. Quality assurance is a third-party inspection performed by an inspector employed by either the State or the DOE.

Certified quality-control inspectors (QCI) may perform both quality-control inspections and quality-assurance inspections. The following are important elements of these inspections.

- Verify compliance with specifications, job order, and energy audit.
- Provide feedback on material quality and worker performance, both good and bad.
- Issue instructions for correcting errors and omissions.
- Survey clients for level of satisfaction.
- Report to the weatherization agency, the State, or the DOE about the quality of the weatherization work.

The State WAP must justify to the DOE the percentage of homes that State inspectors inspect for quality assurance. The required percentage depends on the independence of the local agency's quality control inspectors from the agency's energy auditors.

2.6 Field Monitoring

Field monitoring is the quality assurance visits conducted by the State weatherization program. The State monitor's job is similar to the agency's inspector. However, the State monitor is independent of the local weatherization agency and reports his or her inspection results to the State. The monitor describes these inspection results in these ways.

1. Strengths or areas where the agency performs well.
2. Concerns are minor problems with paperwork or job quality that the agency can easily correct.
3. Major findings, including contract violations, safety violations, or omissions of required procedures.

The monitor issues a report and the agency must respond in writing. Major findings require the agency to tell the State how the agency will correct the problems and how corrections will be paid for. Major findings from the DOE may require the State to propose a correction plan.

2.7 SWS Alignment

Field Guide Topic	SWS Detail
Purposes of an Energy Audit Pg. 41	
Energy-Auditing Judgment and Ethics Pg. 42	
Energy-Auditing Record-keeping Pg. 43	

CHAPTER 3: BASELOAD MEASURES

Baseload energy consumption accounts for a large part of home energy use. This chapter discusses energy savings for lighting, refrigeration, entertainment, and laundry.

Table 3-1: Levels of Household Electric Baseload Consumption

Indicator	Low	Medium	High
kWh per Year	<4500	4500–8500	>8500
kWh per Month	<375	375–700	>700
kWh per Day	<12	12–23	>23
kWh per Person (Annual)	<1900	1900–3500	>3500

Doesn't include heating, cooling, or water heating. Assumes 2.4 persons per household and average annual consumption of 6500 kWh per household.

Table 3-2: Electrical Consumption of Typical Appliances

Appliance	Annual usage (kWh)	Annual cost
Ten-year-old refrigerator or freezer	1250	$188
New ENERGY STAR refrigerator or freezer	500	$75
Television	100–1000	$15–$150
Clothes dryer	1200	$180
Well pump	500	$75
Furnace fan	500	$75
Computer	50–400	$8–$60
Hot tub, spa	2300	$345
Water bed	1000	$150

Data from Lawrence Berkeley Laboratory and others. Based on 15¢ per kilowatt-hour for electricity.

3.1 Lighting-Efficiency Improvements

Lighting-efficiency improvements include bulb (lamp) replacement, fixture replacement, energy-efficient lighting controls and daylighting.

CFL and LED lamps: These advanced lamps use about one-third of the electricity of the incandescent lamps they usually replace and last about ten times as long.

3.1.1 Lighting Retrofit Equipment

SWS Detail: 7.0103.1 Lighting Replacement

Consider the following requirements when retrofitting lighting equipment.

- ✓ Ask the customer about their lighting usage and explain the electrical savings potential for switching to compact fluorescent lamps (CFLs) or light-emitting diodes (LEDs).
- ✓ Demonstrate a CFL or LED bulb to the customer if they're hesitant about replacing their incandescent light bulbs.
- ✓ Select the type of CFL or LED and its wattage, according to its use and the customer's accustomed light level.
- ✓ Examine fixture for exposed wiring and other safety issues. Do not install fixture if either exist.
- ✓ Turn on each CFL or LED after installation to ensure that it operates. Make sure that the customer is satisfied with the light level.

LED bulb

LED recessed-light replacement

LED lamps and fixtures: LEDs are rapidly gaining market share because of their superior energy efficiency and long life.

- ✓ Replace a halogen-torchiere lamp holder with an LED conversion kit for the torchiere.
- ✓ Replace incandescent bulbs in candelabra fixtures with LEDs designed for this purpose.
- ✓ All bulbs, fixtures, and controls must be appropriate for the intended application (for example: enclosed, dimmable, indoor, outdoor).
- ✓ Select bulbs, fixtures, and controls to provide the brightness and light quality required in that application (for example: task lighting, walkway lighting, night lights).
- ✓ All bulbs, fixtures, and controls must be ENERGY STAR® rated where applicable.
- ✓ Bulb wattage must not exceed rated wattage of the light fixture.
- ✓ Select bulb replacements based on expected life span, light quality, and lifetime energy use.
- ✓ Install occupancy sensing controls where appropriate.
- ✓ All bulbs, fixtures, and controls will be Underwriters Lab- oratories (UL)-approved and installed according to local codes and *National Fire Protection Agency (NFPA) 70 National Electric Code.*
- ✓ Inform customers about proper recycling of fluorescent bulbs by stores, municipal waste departments, or other recycling organizations.
- ✓ Replace fluorescent light ballasts containing polychlorinated biphenyls (PCBs) according to the EPA's *Healthy Indoor Environment Protocols for Home Energy Upgrades.*

3.1.2 Daylighting

SWS Detail: 7.0103.1 Lighting Replacement

Use daylighting as appropriate to save electricity.

- ✓ Replace, adjust, or repair window coverings to maximize useful daylight where appropriate.
- ✓ Design and use active and passive day lighting where appropriate.

3.2 Refrigerator Replacement and Maintenance

Refrigerators built after 1993 use less electricity than refrigerators built before that year. Another efficiency increase occurred in 1999 in the refrigerator industry.

3.2.1 Refrigerator Replacement

SWS Detail: 7.0101.1 Refrigerator and Freezer Replacement

Comply with the following requirements when replacing refrigerators.

- ✓ The new refrigerator must fit the existing space.
- ✓ The new refrigerator must be 40% more efficient than the minimum federal standards or be labeled ENERGY STAR.
- ✓ The new refrigerator must have a minimum one-year warranty.
- ✓ Take refrigerators that are replaced to a facility that is licensed to reclaim their refrigerant and recycle the refrigerator's parts.

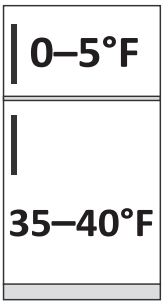
- ✓ No refrigerator, taken out of service, may be returned to service by sale, barter, or for free.
- ✓ Instruct the client about location and operation of energy controls such as the thermostats for the refrigerator and freezer.

Some clients use two or more refrigerators in their homes and this practice results in high electricity usage. Suggest to these clients to consolidate food storage into a large single refrigerator.

3.2.2 Refrigerator Cleaning and Tuning

SWS Detail: 7.0101.2 Refrigerator/Freezer Clean and Tune

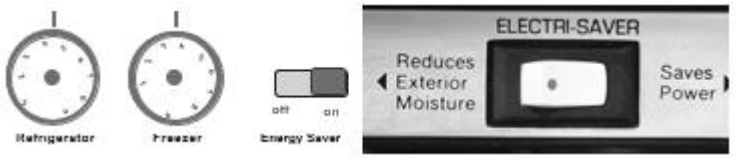
Cleaning and tuning an existing refrigerator can increase its efficiency. Follow these procedures.



Refrigerator clean and tune: Clean coils and check temperatures. Adjust temperatures that are out of range.

- ✓ Clean dirt off clogged coils.
- ✓ Move objects that block airflow around the refrigerator and ask the client to store the objects elsewhere.
- ✓ Measure refrigerator temperature and verify that it is between 35° and 40° F. Otherwise reset the thermostat to this temperature range.

- ✓ Measure the freezer temperature and verify that it is more than or equal to 0° F. If it is colder than 0°, reset the freezer's thermostat to 0° F.
- ✓ Check the condensation-control switch. If the condensation control is on, the refrigerator door or door frame is being heated. Try turning the switch to "energy saver" which turns the heating elements off. If frost forms on the door, turn the control back on.
- ✓ Explain the function of the condensation control to clients. If the energy-saver setting isn't adequate for very humid weather, the occupants could toggle setting.

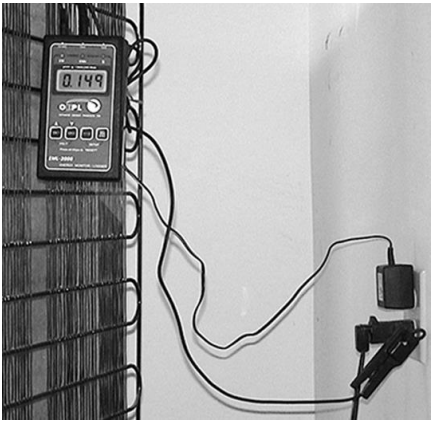


Refrigerator energy controls: Refrigerator and freezer temperatures aren't typically labeled in degrees, so there might be some trial and error in getting the setting within range. The condensation control is either on and heating the door perimeter or off and not heating the door perimeter.

3.2.2 Refrigerator Metering Protocol

Older refrigerators use from 1000 to 2000 kilowatt-hours per year. Newer ENERGY STAR refrigerators use less than 400 kilowatt-hours per year. You need a minimum of two hours to accurately measure refrigerator energy consumption using a recording watt-hour meter.

Recording watt-hour meter: Measures energy consumption over time. The better units can also calculate monthly consumption, or record maximum current draw to help identify the defrost cycle.



There are two common options for evaluating refrigerator energy consumption for replacement.

1. The first option is to find the age of the refrigerator that is listed on the nameplate. If it's not listed, find the serial number, model number and the manufacturer information. Enter this information into the manufacturer's website to learn the energy usage. Or use the manufacturer's customer service phone number or computer-chat option.
2. The second option is to follow the metering procedure presented here.

Refrigerator Metering Procedure

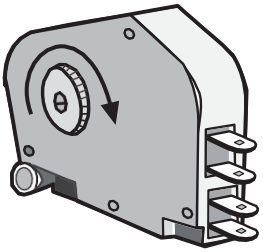
If the refrigerator is an automatic-defrost model, you could measure an inaccurate reading if the unit goes into the electric defrost mode during the test period. The following test protocol includes provisions to prevent the defrost mode from activating.

1. Determine if the refrigerator is equipped with automatic defrost. This is usually stated on the manufacturer's data plate or on the outside of the unit. If the refrigerator is equipped with a manual

defrost, proceed to step 3.

2. If the unit is equipped with automatic defrost, follow this sub-procedure.

   a. Locate the defrost timer. This small electrical-control box is located in the refrigerator or behind the front kick-plate. The defrost timer may also be located on the rear of the unit.



Defrost timer

Defrost Timer: The defrost timer initiates the defrost cycle to melt ice at regular intervals.

   b. Open the defrost timer and locate the advance pinion. This shaft usually has a screwdriver slot to allow you to manually advance the timer.

   c. Turn the timer clockwise (you can break the timer if you turn it counter-clockwise) until you hear a loud click. This turns the defrost heaters on. Turn it further until it clicks loudly again, turning the defrost heaters off.

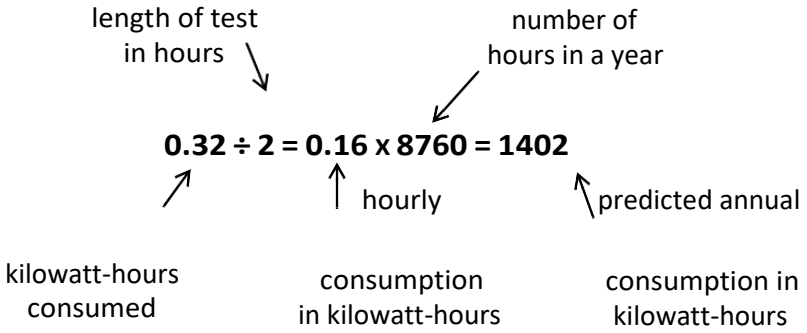
   d. You can now perform your measurement since the timer won't call for defrost heat again for several hours.

3. Connect the refrigerator to a recording watt-hour meter. Run the test for at least two hours. You don't need to stop at two hours and a longer measurement is

better. During the test, avoid opening the refrigerator, or do so briefly.

4. At the end of the test read the kilowatt-hours of consumption measured by the meter. Divide this number by the number of hours in the test. This gives you the number of kilowatt-hours consumed each hour. Multiply this number by 8760 (the total number of hours in a year). The product of this calculation is the annual kilowatt-hours of electrical usage.

5. **Remove the meter and plug the refrigerator back into its outlet.**



Refrigerator consumption example: In this example, a 2-hour measurement was performed. During this time, the appliance consumed 0.32 kilowatt-hours of electricity, or 0.16 kilowatt-hours per hour. The annual total of 1402 kilowatt-hours, calculated above, is well beyond the 450 kilowatt-hours per year consumed by today's most efficient refrigerators.

Table 3-3: Kilowatt-Hours per Hour & Kilowatt-Hours per Year

kWh/hour	kWh/year	kWh/hour	kWh/year
0.23	2000	0.16	1400
0.22	1900	0.15	1300
0.21	1800	0.14	1200
0.19	1700	0.13	1100
0.18	1600	0.11	1000
0.17	1500	0.10	900

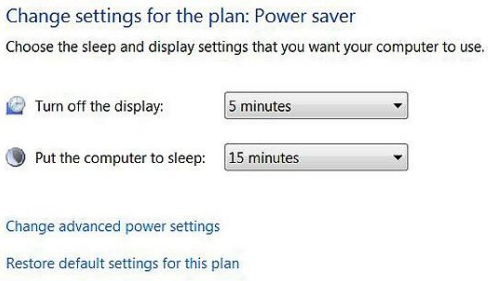
Metering Accuracy Issues

A number of unusual circumstances could reduce the accuracy of the metering, including the following.

- A quantity of warm food recently placed in the refrigerator.
- Abnormally high or low ambient temperature. For example: refrigerators in garages during the summer or winter; or refrigerators in vacant homes where heating or cooling systems aren't operating.

3.3 Entertainment and Computer Systems

SWS Detail: 7.0102.1 Consumer Electronics Replacement



Computer power settings: Go to your computer's control panels and set the *power-saver control* to rest the display and sleep the computer after some chosen time of inactivity.

The purpose of this section is to help clients conserve electricity that they use for entertainment and computing.

- ✓ Advise clients to buy equipment labeled ENERGY STAR.
- ✓ Advise clients to buy electronic equipment that doesn't need to be left on when not being used.
- ✓ Standby losses for electronic equipment must be one watt or less.
- ✓ Patch all holes, made for installation of electronic equipment, in an airtight and weather-tight manner.
- ✓ Read the operating manual and enable all energy-saving features of an appliance. Explain the energy-saving features to the client.
- ✓ Verify that clients have operating instructions for their electronic equipment or that they know how to access instructions using the Internet.
- ✓ Recycle or dispose of equipment using principles of the EPA Responsible Recycling (R2) Initiative.

Smart plug strips: A variety of plug strips with built-in controls are now available. The plug strips interrupts power to appliances by remote control, on a time schedule, or by sensing occupancy.

3.4 CLOTHES WASHER SELECTION/REPLACEMENT

SWS Detail: 7.0105.1 Washing Machine

Observe the following standards to minimize the energy consumption of clothes washers.

3.4.1 Clothes Washer Selection

SWS Detail: 7.0105.1b Washing Machine Selection

Comply with these requirements when selecting a new clothes washer.

- ✓ Select clothes washers that meet or exceed ENERGY STAR® and Water Sense® specifications.
- ✓ Maintain adequate clearance around appliance when fit into the available space, so access to cabinets and light switches aren't blocked.
- ✓ Appliance must be covered by a minimum one-year warranty.
- ✓ Standby losses for clothes washers must be one watt or less.

3.4.2 Clothes Washer Installation

SWS Detail: 7.0105.1c Clothes Washer Installation

Comply with these requirements when installing a new clothes washer.

- ✓ Install clothes washers in accordance with manufacturer specifications, (including leveling, plumbing connections, electrical connections) and meet all applicable codes.
- ✓ Install shut-off valves on hot and cold supply water if not already present.
- ✓ If located in conditioned or finished area, install an overflow pan and drain the pan to a safe location.
- ✓ Air seal any penetrations to the exterior of the home created by the washer's installation.
- ✓ Demonstrate energy-related appliance controls to the occupant.

- ✓ Provide specific information about proper maintenance of the washer to the occupant.
- ✓ Provide warranty information, operation manuals, and installer to the owner.

3.5 Clothes Dryer Selection/Replacement

The following standards minimize the energy consumption of clothes dryers.

3.5.1 Clothes Dryer Selection

SWS Detail: 7.0105.2b Clothes Dryer Selection

Comply with these requirements when selecting a new clothes dryer.

- ✓ Maintain adequate clearance around appliances to avoid blocking cabinets and light switches.
- ✓ Verify that appliances have a minimum one-year warranty.
- ✓ Select equipment with features that reduce peak electric demand and energy use.
- ✓ Standby losses for clothes washers must be one watt or less.

3.5.2 Clothes Dryer Installation

SWS Detail: 7.0105.2c Clothes Dryer Installation

Install the appliance in accordance with manufacturer specifications and all applicable codes.

Consider these requirements when replacing clothes dryers.

- ✓ Demonstrate energy-related dryer controls to the occupant.

- ✓ Provide specific information of the proper maintenance of the equipment to the occupant.
- ✓ Provide warranty information, operation manuals, and installer contact information to the occupant.
- ✓ Recycle or remove and dispose of replaced appliances in accordance with local regulations, including older equipment switches containing mercury.

If existing venting doesn't meet manufacturer specifications, code, or the following criteria, install new venting using these specifications.

- ✓ Vent all dryers, other than condensing dryers to the outdoors.
- ✓ 28-gauage metal duct is required for all primary dryer ducting with exception of transition duct, which relate to the connection of the dryer to the duct, where space limitations impede the use of hard metal ducting.
- ✓ When a UL 2158A-approved ducting material is used as a transition, it should be less than 8 feet in total length and with no joints.
- ✓ Use only metal clamps on semi-rigid metal and UL listed foil-type vent pipes.
- ✓ Termination fitting manufactured for use with dryers must have a backdraft damper.
- ✓ Any dryer duct installed outside of the thermal boundary will be insulated to a minimum of R8 to prevent condensation.
- ✓ Seal penetrations to the outdoors created by the appliance installation to an airtight condition.

3.5.3 Clothes Dryers Service and Venting

SWS Detail: 7.0105.2d Clothes Dryer Venting

Clogged clothes-dryer vents are a leading cause of house fires. The drying time of a load of laundry depends first on the dryer installation. The original installation can also cause excessive drying time when flexible vents are excessively long, kinked, or restricted in some other way. The amount of lint in the dryer, vent, piping, and vent termination also affects dryer safety and efficiency. Lint builds up over time and slows drying time and increases the fire hazard.

Vinyl flexible dryer vent isn't an approved dryer vent material. To reduce energy cost and improve safety, replace vinyl flex duct with metal flexible dryer vent.

Service Procedures

Observe the following suggestions when servicing clothes dryers to prevent fires, reduce drying time, improve energy efficiency, and reduce lint build-up.

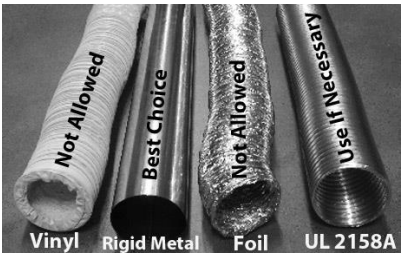
- ✓ Unplug the clothes dryer before making any improvements.
- ✓ Remove the vent pipe and vent termination and clean all lint out of them.
- ✓ Clean lint out of the electric heating elements and the airway around them.
- ✓ Inspect the airway at the dryer's vent connection and clean the lint out of it.

Dryer Exhaust Venting Requirements

Follow these venting requirements for clothes dryers when servicing dryers.

- ✓ Dryer vents should be piped in 4-inch diameter rigid aluminum or galvanized pipe whenever and wherever possible.

- ✓ Don't use screws or rivets to join rigid pipe sections because they collect lint. Join and seal the sections with clamps or other specialized duct fittings in accordance with manufacturer specifications and sealed with UL181B or UL181B-M tapes or mastics.
- ✓ Exhaust venting duct must be supported at maximum 4-foot intervals.
- ✓ Use short, stretched pieces of flexible metal dryer vent, labeled UL 2158A, to connect the dryer to the rigid vent through difficult framing or to allow dryer to be moved in and out. Make connections using rigid fittings installed male-to-female in the direction of exhaust flow to prevent lint build-up.
- ✓ Fasten UL listed foil-type vent or semi-rigid sheet metal to rigid metal with a clamp.
- ✓ Fasten other specialized duct fittings according to manufacturer's specifications.
- ✓ Seal duct connection with foil tape labeled UL 181B or 181B-M.
- ✓ Install a booster fan for dryer ducts exceeding 35-feet in duct equivalent length. When calculating duct length, add 5-feet for each 90º bend and 2.5-feet for each 45º bend.
- ✓ Provide make-up air if you measure excessive depressurization or if the dryer moves 200 cubic feet per minute (CFM) or more.



Dryer vent types: Clothes dryer energy-efficiency depends on the type of vent material and the equivalent length of the vent.

3.6 SWS ALIGNMENT

Field Guide Topic	SWS Detail
Lighting-Efficiency Improvements Pg. 54	
Lighting Retrofit Equipment Pg. 55	7.0103.1 Lighting Replacement
Daylighting Pg. 57	7.0103.1 Lighting Replacement
Refrigerator Replacement and Maintenance Pg. 57	7.0101.1 Refrigerator and Freezer Replacement

Field Guide Topic	SWS Detail
Refrigerator Replacement Pg. 57	7.0101.1 Refrigerator and Freezer Replacement
Refrigerator Cleaning and Tuning Pg. 58	7.0101.2 Refrigerator/Freezer Clean and Tune
Refrigerator Metering Protocol Pg. 59	
Entertainment and Computer Systems Pg. 63	7.0102.1 Consumer Electronics Replacement
Clothes Washer Selection/ Replacement Pg. 64	7.0105.1 Washing Machine
Clothes Washer Selection Pg. 65	7.0105.1b Washing Machine
Clothes Washer Installation Pg. 65	7.0105.1c Washing Machine
Clothes Dryer Selection/ Replacement Pg. 66	
Clothes Dryer Selection Pg. 66	7.0105.2b Clothes Dryer Selection
Clothes Dryer Installation Pg. 66	7.0105.2c Clothes Dryer Installation
Clothes Dryers Service and Venting Pg. 68	7.0105.2d Clothes Dryer Venting

CHAPTER 4: WATER HEATING

4.1 WATER-HEATING ENERGY SAVINGS

The most important tasks in evaluating hot water energy savings are measuring the shower's flow rate, determining the water heater's insulation level, and measuring the water temperature.

Table 4-1: Water Heating Consumption According to Family Size

Number of Residents	Annual kWh	Annual Therms	Gallons Per Day
1	2700	180	25
2	3500	230	40
3	4900	320	50
4	5400	350	65
5	6300	410	75
6	7000	750	85

Author's interpretation of data from single-family homes with existing water heaters from Energy Information Administration, Lawrence Berkeley Laboratory, *Home Energy Magazine*, and others.

4.1.1 Water-Saving Shower Heads and Faucet Aerators

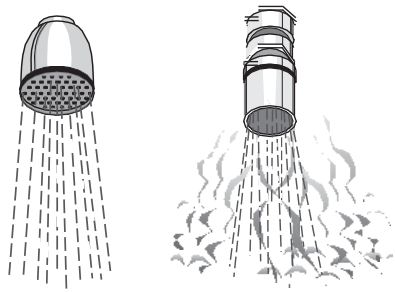
SWS Detail: 7.0201.1 Low-flow Devices

Most families use more hot water in the shower than for any other use. A low-flow shower head reduces this consumption.

- ✓ Water-saving shower heads must be rated for a flow of 1.75 gallons per minute or less.

- ✓ Water-saving aerators must be rated for a flow of 1.2 gallons per minute or less.
- ✓ Use caution in removing the existing showerhead or aerator from old, fragile plumbing fixtures. Use a plumbing wrench when removing the shower head and a small wrench for the aerator.
- ✓ Run the faucet and shower with aerator or showerhead off for 10 seconds to remove any remaining grit and sediment.
- ✓ Use caution when installing new shower head or aerator, being sure not to damage with wrench. DO NOT over tighten.
- ✓ Check the water quality for debris that may clog the equipment.
- ✓ The shower or faucet flow rate must be satisfactory to the occupants and be documented.
- ✓ Features must meet any special needs of the occupant (shut off, swivel, handheld showers).
- ✓ Once installed, test the fixtures to determine if tightened adequately to prevent leakage at the point of connection.
- ✓ Recycle replaced shower heads and aerators.

Water-saving shower heads: Two styles of water-saving shower heads give consumers a choice between steamy showers and less steamy ones.



Measuring Shower or Faucet Flow Rate

You can determine flow rate by measuring the time needed to fill a one-gallon plastic container. If the one-gallon container

fills in less than 20 seconds, your flow rate is more than 3 gallons per minute.

1. Start the shower and set it to the maximum showering rate.
2. Start a stopwatch at the same time you move the container underneath the shower, capturing its entire flow.
3. Record the number of seconds and divide 60 by that number to find gallons per minute.

Measuring shower flow rate: If you divide 60 by the number of seconds needed to fill a gallon container, you will calculate flow in gallons per minute.

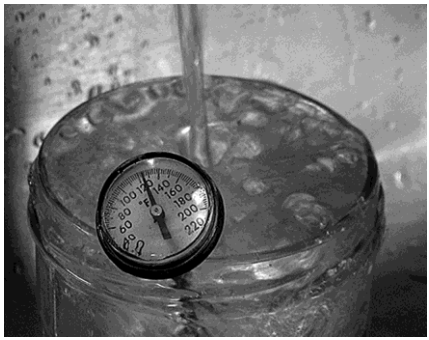
$$\frac{1\ \text{gal}}{15\ \text{sec}} \times \frac{60\ \text{sec}}{1\ \text{min}} = 4\ \frac{\text{gal}}{\text{min}}$$

4.1.2 Measuring and Adjusting Hot Water Temperature

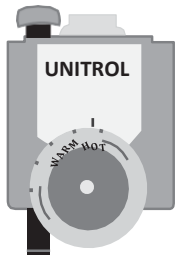
SWS Detail: 7.0302.1 Electric Storage Tank Water Heater

Use the following instructions to adjust water temperature.

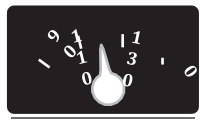
- ✓ Shut off power to an electric water heater before opening thermostat access panels.
- ✓ Measure the water temperature at the nearest faucet to the water heater. Reduce the temperature to 120° F with the customer's permission.
- ✓ On electric water heaters, set both upper and lower thermostats to the same temperature.



Setting hot-water temperature: Getting the temperature correct can take a few measurements and re-adjustments.



Gas water heater control



Electric water heater control

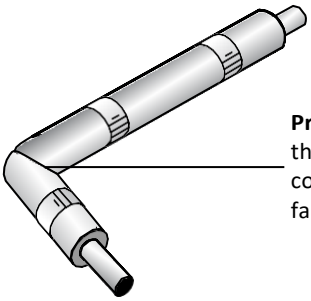
4.1.3 Heat Traps and Water-Heater Pipe Insulation

SWS Detail: 7.0302.1 Electric Storage Tank Water Heater

Heat traps are piping loops or valves that prevent thermo-siphoning of water in and out of the piping near the water heater. Install heat traps if the water heater has no built-in heat traps. Install pipe insulation to slow convection of hot water into the water lines near the tank.

- ✓ Interior diameter of pipe sleeve must match exterior diameter of pipe.
- ✓ Insulate the first 6-feet of hot and cold water pipe from the water heater.
- ✓ Use pipe wrap with a minimum thickness of 1-inch and a minimum R-value of 3. Cover elbows, unions, and other fittings with the same insulation thickness as the pipe.
- ✓ Corners must be mitered, tight fitting, sealed, and secured with appropriate material to prevent failure.

- ✓ Keep pipe insulation 6-inches away from single-wall vent pipe and 1-inch away from Type B vent.
- ✓ Fasten pipe insulation with zip ties, tape, or other approved method.



Properly installed pipe insulation: Will be the right size for the pipe, will completely cover the pipe, including bends, and will be fastened tightly to the pipe.

4.2 Selecting Storage Water Heaters

Storage water heaters are the most common water heaters found in homes.

4.2.1 Determining a Storage Water Heater's Insulation Level

SWS Detail: 7.0302.1 Electric Storage Tank Water Heater

Common storage water heaters consist of a tank, insulation surrounding the tank, and an outer shell. There is typically either 1 or 2-inches of insulation surrounding the tank. The insulation is either fiberglass or polyisocyanurate.

Follow this procedure to determine the water heater's insulation level.

- ✓ Look for a listing of R-value on a label on the water heater.

- ✓ Find a hole in the outer shell where the flue pipe emerges or where plumbing connects. Look around the hole for either fiberglass or polyisocyanurate insulation.
- ✓ If the hole isn't large enough to see the insulation level on an electric water heater, try removing the access panel for the heating element after disconnecting power from the unit.
- ✓ You may just be able to see the gap between the tank and outer shell. If you can't see this gap, use a ruler or probe to push through the insulation along side of a pipe connecting to the tank until the probe hits the steel tank to determine thickness. Make sure that the probe is against the tank and not against a nut welded to the tank.
- ✓

Identifying Tank Insulation

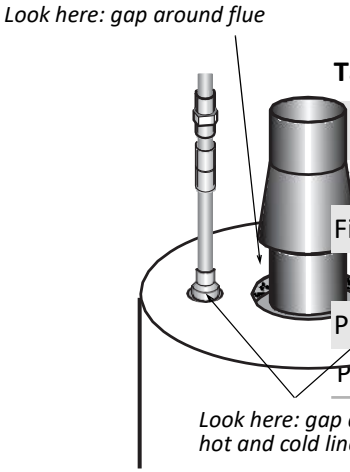


Table 4.2: Insulation R-Values

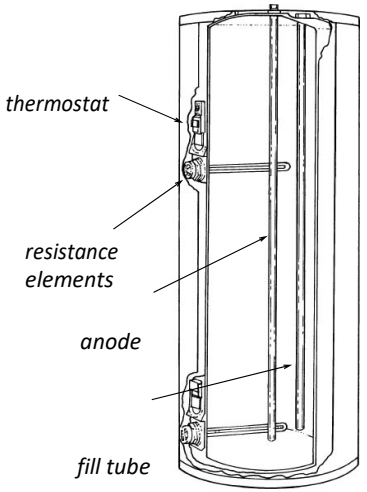
Insulation/thickness	R
Fiberglass 1-inch	3
Fiberglass 2-inches	6
	6.5
PIC 2-inches	13
PIC 3 -inches	19.5

4.2.2 Storage Water Heater Selection

SWS Detail: 7.0302 Water Heater Installation,

Existing gas water heaters, including propane, typically use 200 to 400 therms per year. New gas water heaters use as little as 175 therms per year, resulting in a savings of between 25 and 225 therms per year. Similar savings are possible by replacing electric water heaters. Consider the following recommendations for specifying water heaters.

- A replacement gas or oil storage water heater will be either direct vented or power vented, and ENERGY STAR qualified or have an Energy Factor (EF) of 0.67 for water heaters 55 gallons or less.
- A replacement electric water heater should have an EF of at least 0.93 and be insulated with at least 2.5-inches of foam insulation.



Standard electric storage water heater: Electric water heating is more expensive than gas or oil but safer. Electric water heaters should have at least 2-inches of foam insulation.

4.3 Alternative Water Heaters

Weatherization programs sometimes choose alternative water-heating products to improve efficiency and safety.

Table 4-3: Comparison of Advanced Water Heaters

Advanced Water Heater Type	$ Savings*	Expected Lifespan	Major Advantages
High efficiency storage tank (Oil, gas, electric)	≤$500	8–15 years	Lowest first cost
Instantaneous Tankless (direct fired)	≤$1800	5-15 years	Unlimited hot water
Heat pump	≤$3000	5-15 years	Most efficient

From information supplied by ENERGYSTAR.gov by the Environmental Protection Agency. * Lifetime savings compared to conventional water-heater models and same fuel.

4.3.1 Solar and Hybrid Heat Pump Water Heaters

Water heaters use more electricity than other appliances in most homes, averaging 40% of the client's energy consumption. A solar water heater can save a typical home $80 to $100 a month on their electric bill.

Both solar and heat pump water heaters cost much more than conventional electric water heaters but are far less costly to operate. Heat pump and solar water heaters can heat water at up to 2.3 times more efficiently than electric-resistance storage water heaters.

Hawaii WAP uses information from the client intake form to determine if the client qualifies for a solar or heat pump water heater. The Solar Water Heating Savings Calculator calculates how much money the client will save on their utility bills once they make the switch. In order for the client to be eligible for a solar

install their existing hot water system must be electric and functioning.

4.3.2 Solar Water Heaters

SWS Detail: 7.0302.6 Solar Water Heater

Installing solar water heaters is a complex process and the State of Hawaii advises to refer to local agency program guidelines for direction and specifications.

Example Agency Program Guidelines

Priority List Criteria

- Use the DOE-approved Water Heater Savings Calculator to determine allowable cost and the SIR for replacing the existing system with either a solar water or hybrid heat pump water heater. The replacement system showing the highest SIR must be installed.
- The auditor must print the calculated comparison and save a copy in the client file.
- Cost must include all necessary incidental construction (sheds or platforms), delivery, and disposal.
- If the Water Heater Savings Calculator indicates fuel switching as the most cost-effective for a household, fuel switching is allowed.

Installation of solar water heaters must be electric or propane and follow these specifications.

- Installations must be sized according to the "Residential Solar System Sizing Verification," which uses a 20 gal/person standard.
- Installations must pass the equivalent of the "Hawaii Energy Efficiency Program's Water Heater System Inspection Check List."

Specifications

Solar water heater systems must be able to service a family of up to six people that use 6,000 kilowatt hours or more per year. Bigger households will be dealt with on a case by case basis.

There are 2 types of solar water heaters installed.

1. 80 gallon tank, two 4-feet x 8-feet solar panels, tank location same as existing heater, readily available electrical service (both 110V and 220V service within 5-feet) flush mounted on single story roof oriented between 135 T-225 T. **Note: Appropriate materials may be required for households of more than six members to comply with Hawaiian Electric Company (HECO) requirements.**
2. 120 gallon tank, two 4-feet by 8-feet solar panels, tank location same as existing heater, readily available electrical service (both 110V and 220V service within 5-feet), flush mounted on single story roof oriented between 135 T-225 T. **Note: Appropriate materials may be required for households of more than six members to comply with HECO requirements.**

Vendors must include the materials used and the size and brand of water heater in their cost proposal. All materials must be new and not reconditioned, with materials manufactured in the U.S. as much as possible.

Vendors are also responsible of pre and post installation inspections.

Vendor Bid Process

Contractor bids require the following information.

- An itemized listing of the equipment to be installed.
- A listing of the various warranties of the equipment.
- A building permit.

- An outline of the labor and other related costs.
- A site inspection of the home and property.
- The Residential Solar Sizing Verification form.
- Total cost, including equipment, labor, insurance and tax.

Most programs require a minimum of three bids for installation. The selection is based on these five criteria.

1. Lowest bid or cost of installation
2. Product availability
3. Delivery and installation availability
4. Ease of ordering the equipment
5. Additional features of the product that are included at no cost

4.3.3 Hybrid Heat Pump Water Heaters

Heat pump water heaters use heat from surrounding air to heat water. The specifications and installation guidelines listed below are based on the installation of the GE GeoSpring Hybrid Water Heater and are common to most models. If installing a different model, be sure to consult that model's installation instructions. Install water heaters in accordance with local codes. If no local codes exist, consult the National Electrical Code.

Specifications

- ✓ Install the water heater in locations that remain in the 40°-90°F range year-round (4.4° - 32°C).
- ✓ Provide the minimum amount of air space around the water heater for the unit to be effective.
- ✓ Set appropriate temperature controls for proper operation.
- ✓ Instruct clients on proper hybrid heat pump water heater use and maintenance and give them the operating manuals and warranties at the time of installation.

Heat pump water heater: This heat pump water heater has the heating coil (condenser) surrounded by the domestic water.

Location

Follow these guidelines when deciding where to install the water heater.

- ✓ Find a clean dry area as close as possible to the room that uses the most water, usually a bathroom or kitchen.
- ✓ For GE models the water heater can be installed in a room that is smaller than 700 cubic feet, but there must be a louvered door that covers 240 square inches or greater.
- ✓ Allow enough room for maintenance and service. There must be at least a 7-inch clearance around and 8-inches above the water heater.
- ✓ Do not install the water heater outdoors.

Thermal Expansion

When water is heated it increases in volume, which over time can affect the proper operation of the water heater. It is preferred to have an open-water system that allows the excess water to

flow back into the water main. In a closed-water system, thermal expansion can cause a failure in the safety settings of the relief valve. If a closed-water system exists, an expansion tank will need to be installed in the cold-water line.

Consult a knowledgeable contractor for information on installing expansion tanks.

Water Supply Connections

Use 3/4-inch female national pipe thread fittings (NPT), along with thread sealant when connecting the inlet and outlet ports of the water supply. Install a shut-off valve in the cold-water line near the water heater.

Do not apply heat to the water connections. Heat will permanently damage the internal plastic lining in both cold and hot water ports. If using sweat connections, sweat the tubing to the adapter before fitting it to the cold -water connections on the heater.

Condensation Drain

Follow these guidelines for proper water heater drainage.

- ✓ Install the water heater within close proximity to a floor drain or a drain that is no higher than 36-inches above the ground.
- ✓ If a drain is not available, install a one gallon minimum condensate pump.
- ✓ Install the proper fitting to the primary port on the water heater, suitable for a rigid or flexible drain line.
- ✓ Maintain a downward slope in the drain line to allow for proper drainage, routing it to ensure water doesn't contact live electrical equipment or cause water damage.

- ✓ Install an emergency drain pan under each replacement water heater, with sides that extend a minimum of 4-inches above floor, if leakage would cause damage to the home.

Relief Valve

Follow these guidelines when installing the relief valve.

- ✓ Install the relief valve in the opening specifically provided and marked on the water heater. Do not install any other type of valve between the relief valve and the water heater tank.
- ✓ Refer to the rating label located on the front of the water heater for direction on the pressure rating and the British Thermal Units per Hour (BTUh) rating. The pressure rating can't exceed the maximum working pressure of the water heater and the BTUh rating can't be less than the input rating of the water heater.
- ✓ Position the tubing so any discharge from the valve does not come in contact with electrical equipment or cause structural water damage.

Electrical Connections

Both voltage requirement and wattage load are specified on the rating label and the specific manufacturer's instructions. Use 10 gauge wire for connections.

A proper ground connection is important. If using metallic conduit or metallic sheathed cable, install with fittings specified for the purpose of grounding.

If using cable that is not approved for use as a ground conductor, you must include a separate conductor for grounding. Attach this to the ground terminals of the water heater and the electrical distribution box.

Powering the Water Heater

Before turning the water heater on, it must be filled with water. Use these specifications to properly fill the water heater.

- ✓ Confirm that the drain valve is closed.
- ✓ Open at least one hot water faucet in the home so air can escape from the water heater as it fills.
- ✓ Open the shut-off valve in the cold-water supply line.
- ✓ Check the flow from the open hot water faucet. A steady flow indicates that the water heater is full.
- ✓ Turn on the water heater and refer to manufacturer's instructions for directions on water heater startup.

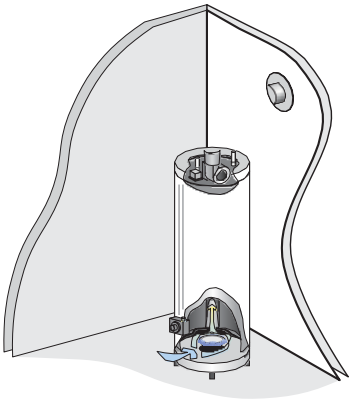
Operation

Most hybrid electric water heaters have five modes of operation. The modes have various names, but the function is the same.

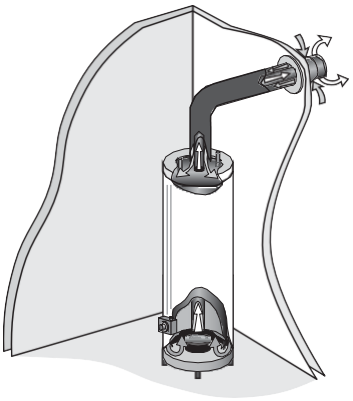
- *Heat Pump Mode* is the most energy efficient but takes longer to heat the water. This is not good for larger families or when company is visiting.
- *Hybrid Mode* provides the energy efficiency of the heat pump with the recovery of a standard electric water heater.
- *High Demand Boost* uses the electric heating elements when the water usage is high.
- *Electric Standard* heats the water quicker and is the least energy efficient.
- *Vacation Mode* keeps the water heater at a steady 50 degrees by using the most efficient heating mode.

4.3.4 Sidewall-Vented Gas Storage Water Heaters

When gas storage water heaters cause persistent venting problems, specify a sidewall-venting water heater. Two common types of these water heaters are shown here.



Fan-assisted water heater: The fan allows horizontal venting. The water heater may be open combustion or sealed combustion.



Direct-vent water heater: Moves combustion air and flue gases through a concentric pipe system without a draft fan.

- ✓ Choose a sealed-combustion sidewall-vented gas water heater, if possible. Next best is a fan-assisted unit.
- ✓ Install the replacement water heater in accordance with manufacturer specifications, 2012 IRC G2427.8.

4.3.5 On-Demand Water Heaters

On-demand electric water heaters are more efficient and cost less to operate compared to conventional gas storage water heaters. However, on-demand electric water heaters are more expensive to install and may have shorter lifespans compared to storage water heaters.

4.4 Storage Water Heater Installation

Follow these procedures when installing a storage water heater or an alternative water heater.

- ✓ Replacement water heater must have a pressure-and-temperature relief valve with a discharge line that terminates less than 6-inches from the floor into a floor drain or drain pan. The pipe must also terminate in an observable location.
- ✓ The discharge pipe should be made of rigid metal pipe or approved high-temperature plastic pipe.
- ✓ Install dielectric unions and a backflow preventer as part of a water heater replacement if any of these components are missing from the existing installation.
- ✓ Install an expansion tank for all storage water-heater replacements.
- ✓ Install an emergency drain pan under each replacement water heater, with sides that extend a minimum of 4-inches above floor, if leakage would cause damage to the home.
- ✓ Install a $^{3}/_{4}$-inch drain line to the tapping on drain pan. Terminate the drain line in a floor drain or outdoors at least 6-inches above grade.
- ✓ Install heat traps on the water heater's inlet and outlet piping if the manufacturer hasn't provided traps.
- ✓ Adjust water temperature not to exceed 120° F or as prescribed by the local code.

For a complete list of DOE installation requirements for water heaters, see *SWS Detail 7.0302 Water Heater Installation*.

4.5 Comparing Water Heaters

The choice of fuel and model for a storage water heater isn't easy and it involves many factors including safety, reliability, efficiency, and installed cost. See *Residential Energy Dynamics* free comparison tool.

4.5.1 Safety Comparison

Conventional direct-fired gas water heaters vent their combustion by-products to a gravity vented chimney. They can spill products of combustion into the living space, especially if the chimney isn't tall enough, warm enough, or sized properly.

Electric water heaters have no chimney and need no combustion air, which makes them safer for buildings with low natural air leakage, compared to gas storage water heaters.

Electric water heaters have no products of combustion. However, because their recovery capacity is generally much slower than gas water heaters of the same size, there is a greater chance of someone trying to compensate for a cold shower by setting the electric water heater to an unsafely high temperature where occupants could be scalded.

4.5.2 Reliability Comparison

Storage water heaters are popular because they are inexpensive and reliable. Both gas and electric storage water heaters are simpler and more reliable than more expensive and complex water heaters. The lifespan of storage water heaters depends on local water quality and the quality of the water heater's storage tank.

Most heaters have glass-lined steel tanks which are typically warranted for five years. All types of heaters are available with larger or additional sacrificial anodes, which are pieces of metal that corrode before the tank does, thereby extending the tank life and maybe the warranty. If you buy a ten-year guarantee heater instead of a five-year guarantee heater, this choice might

reduce the future cost of replacement and possible water damage from eventual storage-tank leaks.

4.5.3 Efficiency and Energy Cost Comparison

Conventional gas storage water heaters are rated at about 80% steady-state efficiency. However, whenever a storage water heater isn't firing, it's losing heat up the chimney. This happens when cold air, flowing through the heater, is warmed by the heater and escapes up the flue. This off-cycle heat loss reduces annual efficiency drastically and may result in the water heater's EF being less than 0.60.

The exact EF for a particular storage water heater is difficult to estimate because of many factors including: chimney height, chimney diameter, wind, the home's air-tightness, outdoor temperature, and water heater temperature setpoint. Considering these variables, the actual EF can vary from 0.60 to 0.40 or even lower.

As a heating fuel, electricity is approximately 2.5 times as expensive as natural gas. However, electric water heaters have no chimney and therefore no chimney losses. Electric water heaters do lose heat through the insulation jacket, which results in an EF of around 0.90. Heat-pump water heaters have an operating efficiency of over 200% (COP=2.3) because they heat water with heat from the surrounding air. However, because the electricity production and transmission system in the U.S. is about 31% efficient, the overall energy use and cost for heating water with electricity is still higher than with gas.

4.6 SWS Alignment

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Water-Heating Energy Savings Pg. 72	

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Water-Saving Shower Heads and Faucet Aerators Pg. 72	7.0201.1 Low-flow Devices
Measuring and Adjusting Hot Water Temperature Pg. 74	7.0302.1 Electric Storage Tank Water Heater
Heat Traps and Water-Heater Pipe Insulation Pg. 75	7.0302.1 Electric Storage Tank Water Heater
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CHAPTER 5: COOLING SYSTEMS

5.1 ROOM AIR CONDITIONERS

Room air conditioners are small packaged air conditioning units installed in windows or an exterior wall. All room air conditioners have an energy efficiency rating (EER), which is computed by dividing cooling capacity, measured in btu's per hour by the watts of power used. The federal government requires all air conditioners to carry a yellow energy label listing cost-of-operation, including the EER. The higher the EER, the more efficient the air conditioner and the lower its operating cost. Under Hawaii's WAP, existing units with a maximum EER of 9.7 are eligible for replacement.

5.1.1 Small Room Air Conditioner Replacement

Priority List Criteria

- Unit has 6,000 - 15,000 btu/h cooling capacity.
- New units should have a minimum EER of 10.5 to 11, depending on the BTU.
- If the existing unit is oversized for the space, use sizing guidelines on the next page to determine the proper size air conditioner. Do not replace with a larger unit than the existing.
- Minimum usage is 10 hours per day.
- Cost limits are different depending on the BTU. Check the approved Priority List for details.

Table 5-1: Room Air Conditioner Sizing Guidelines

Area to be Cooled (square feet)	Capacity Needed (BTUs per hour)
100 to 150	5,000
150 to 250	6,000
250 to 300	7,000
300 to 350	8,000
350 to 400	9,000
400 to 450	10,000
450 to 500	12,000
550 to 700	14,000
700 to 1,000	18,000
1,000 to 1,200	21,000

Source- https://www.energystar.gov/

5.1.2 Very Large Room Air Conditioners

Priority List Criteria

- Replacement units must be the same size, or smaller, as existing unit.
- Existing units with a maximum EER of 9.8 are eligible for replacement.
- New units must have a minimum EER of 12 or ENERGY STAR.
- Minimum usage must be at least 10 hours per day.
- Cost is limited to $3,500/unit.

Window Installation Guidelines

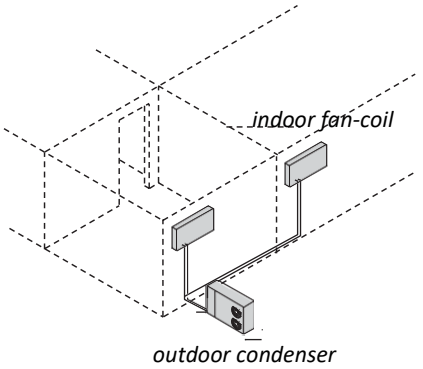
- Remove existing air conditioner, being careful not to spill any rainwater that may have accumulated inside the unit.
- Install the new mounting brackets and side extensions per manufacturer's instructions.
- Slide unit into window and attach to mounting brackets.
- Lower the window sash to top of unit and securely fasten the side extensions to the window frame. Seal with foam.
- Attach drainage hose, if supplied.
- Turn on the air conditioner, set the temperature controls and confirm the unit operates correctly.
- Educate the client on operation and maintenance. Leave the owner's manual and warranty information with client.
- Remove all packaging from client's house.
- If the old unit is infested with pests, seal prior to removal.
- Follow program requirements regarding proper disposal and removal certification that is needed for the job file.

Through the Wall Installation Guidelines

- Remove existing air conditioner, being careful not to spill any rain water that may have accumulated inside the unit.
- Remove existing chassis. Mount the chassis from the new air conditioner to the wall.
- Slope the chassis following manufacturer's specifications to ensure proper drainage to the outside. Fasten to the frame.
- Install mounting brackets if included with the new air conditioner.
- Slide the air conditioner inside the chassis and secure per manufacturer's instructions.
- Install flashing or drip rail for proper drainage away from

the house.

- Insulate gaps between framing members, reusing existing pieces if insulation when possible.
- Piece in the drywall, finish, and sand. Paint the wall with as close of a matching color as possible.
- Seal the seams between the chassis and the siding with silicone caulk around the exterior wall.
- Turn on the air conditioner, set the temperature controls, and confirm the unit operates correctly.
- Educate the client on operation and maintenance. Leave the owner's manual and warranty information with client.
- Remove all packaging from client's house.
- If the old unit is infested with pests, seal prior to removal.
- Follow program requirements regarding proper disposal and removal certification that is needed for the job file



Ductless mini-split heat pumps: These systems have very high efficiency: 200% to 400%.

5.2 Cool Roofs

Cool roof coatings reduce summer cooling costs and improve comfort by reflecting solar energy away from the home's roof and slowing the flow of heat into the home. They are shown to reduce overall cooling costs by 10-20%, and are a good choice for site-built homes with low slope or flat roofs. Cool roof coatings are usually bright white, and must have a reflectivity of at least 60% to meet the ENERGY STAR or equivalent requirement for cool roof coatings.

Cool roof coatings are usually water-based acrylic elastomers and are applied with a roller. They can be applied over most low-sloped roofing such as metal, built-up asphalt, bitumen, or single ply membranes. Some underlying materials require a primer to get proper adhesion. Check the manufacturer's recommendations for asphalt-shingle roofs.

Surface preparation is critical when applying any coating. The underlying roofing materials must be clean so the coating will stick. Repairs should be performed if the existing roofing is cracked or blistered. Roof coating won't stick to dirty or greasy surfaces and can't be used to repair roofs in poor conditions.

Observe the following specifications when installing cool roof coatings.

- ✓ Install the coating when dry weather is predicted. Rain, heavy dew, or freezing weather, if it happens within 24 hours of installation, will weaken the coating's bond to the underlying roofing.
- ✓ Protect any nearby windows, siding, or automobiles from splatters. For roller application, use a large brush for the edges, and a shaggy 1 to $1\,^1/_2$-inch roller on a 5 or 6-foot pole for the field. Run the coating up the roof jacks and other penetrations to help seal these areas. Install at least two coats, with second coat applied in the opposite direction to the first to get more complete coverage. Allow a day for drying between coats.
- ✓ Clean the roof of loose roofing material and other debris.
- ✓ Wash the roof with a water/tri-sodium phosphate (tsp) solution, or comparable mildew-cide, and scrub brush. Better yet, use a pressure washer.
- ✓ Buy the highest quality coatings and look for those that are specifically formulated as mobile home roof coatings.
- ✓ Reinforce any open joints around skylights, pipe flashing, roof drains, wall transitions, or HVAC equipment. For build-up asphalt or bitumen roofs, repair any cracks, blisters, or de-laminations. Use polyester fabric and roof coating for these reinforcements and repairs by dipping fabric patches in the roof coating and spreading them over the existing roofing, or by laying dry fabric into a layer of wet coating. Smooth the patches down with a broad-knife or squeegee to remove bubbles or wrinkles. Allow any repairs to cure for 1 to 2 days before applying the topcoat.
- ✓ For metal roofs, sand any rusted areas down to sound metal. Install metal patches over any areas that are rusted through, followed by polyester patches as described above.

5.3 SWS ALIGNMENT

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The Hawaii Weatherization Field Guide describes the procedures used to audit, inspect, and retrofit existing homes.

- Health and Safety
- Energy Audits and Quality Control Inspections
- Baseload Measures
- Water Heating
- Cooling Systems