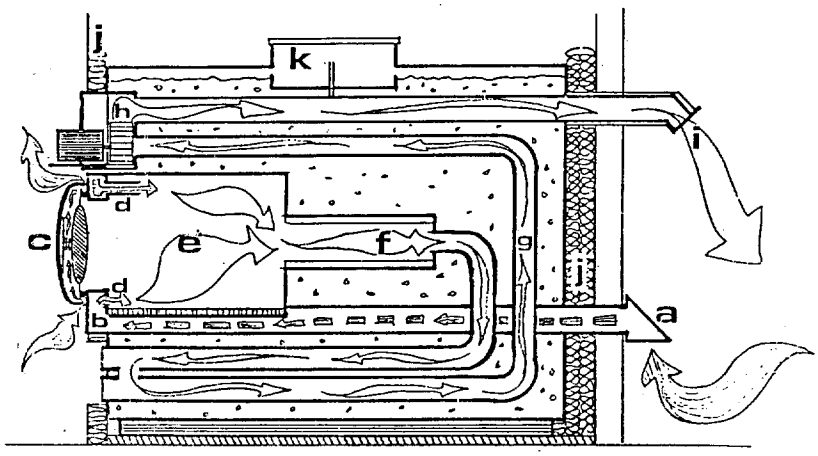
OPERATOR'S MANUAL

FOR

GARN® MODELS WHS 1450, 1500, 1900 and 2000



B. OPERATION

STARTING A FIRE

The first step in operating the unit is to read the water temperature. If you see a temperature or less, then you may proceed as follows.

1. Open the fuel-loading door.
2. Place small kindling or a small amount of newspaper near front of combustion c tuck the newspaper and/or kindling under the first few log. Paper can be sucke when the door is closed if not anchored down.

This step is eliminated when reloading the unit. In some cases a few remain bricks provide sufficient heat to ignite a fire even after sitting idle overnight

3. Place 50 to 85 lbs of one-year dry cordwood, 24" to 32" long and 3" to 1 the combustion chamber. Wood 10" in diameter and larger should be Place the fuel toward the rear of the combustion chamber. Load all wood the reaction chamber may occur.
4. DO NOT OVERLOAD THE FIREBOX. The wood fuel should not way line of the loading opening. Sufficient heat release volume must wood fuel for proper combustion.
5. Turn WHS Timer on to confirm that the draft inducer is operative
6. Light paper and watch for a few seconds to a minute to confirm
7. Turn the WHS TIMER past the 3-hour setting to activate the
8. Close door.

The above procedure should take about 5 minutes. Note that the used with any automatic fuel-loading device. MANUAL LOA

CAUTION: The exterior door and air collar surfaces m surfaces inside of the door and combustion chamber wi

If the water temperature is 175° F or greater, we do not rise from one firing of wood is 20 to 30 degrees witho water temperature is above 175° F, you will approach through the overflow. This is a nuisance, wastes energy an

The WHS Timer must be advanced beyond the 3 hour point whenev of your fuel takes longer to completely burn itself out). Failure to do this wi of the draft inducer, thereby creating a smoldering fire. A smoldering fire will dep exchanger tubes and require more frequent cleaning. Smoke and carbon monoxide may the unit.

Failure to seal ALL flue joints inside a building WILL result in harmful levels of carbon monoxide and carbon dioxide being introduced into the space. If strong smell of wood smoke is noticed— VENTILATE THE SPACE IMMEDIATELY! Failure to seal all flue joints outside the building may cause staining against the building.

Conversion to Other Wood Types

Wood Type	Air-Dry Weight+	Air-Dry MBTU's/Cord	x Diff From Red Oak*
Ash	3440	20.0	1.07
Aspen	2160	12.5	1.70
Beech	3760	21.8	0.98
Paper Birch	3040	16.2	1.17
Yellow Birch	3680	21.3	1.00
Elm	2900	17.2	1.24
Hickory	4240	24.6	0.87
Soft Maple	3200	18.6	1.15
Hard Maple	3680	21.3	1.00
Red Oak	3920	21.3	1.00
White Oak	2080	22.7	0.94
White Pine		13.3	1.60

+cord = 80 cubic feet of solid wood

Reference Notes:
1) Information on cord weight and BTU content taken from University of Wisconsin-Extension bulletin # G2874 Wood fur Home Heating: WOOD AS FUEL Jan 1978
2) BTU/lb of wet wood calculated using information from Jay Shelton's book entitled, Solid Fuels Encyclopedia-1983 and The Woodburners Encyclopedia-1976 by Vermont Crossroads Press

GARN®

Innovators in affordable energy systems.

WARNOCK HERSEY

LISTED

WARNOCK HERSEY

LISTED

GARN® WHS equipment has been tested and certified by ITS/Warnoch Hersey of Middleton, Wisconsin. Warnoch Hersey is recognized by The National Research Board, BOCA, ICBO and SBCCI.

TABLE OF CONTENTS

SAVE THIS MANUAL FOR FUTURE REFERENCE

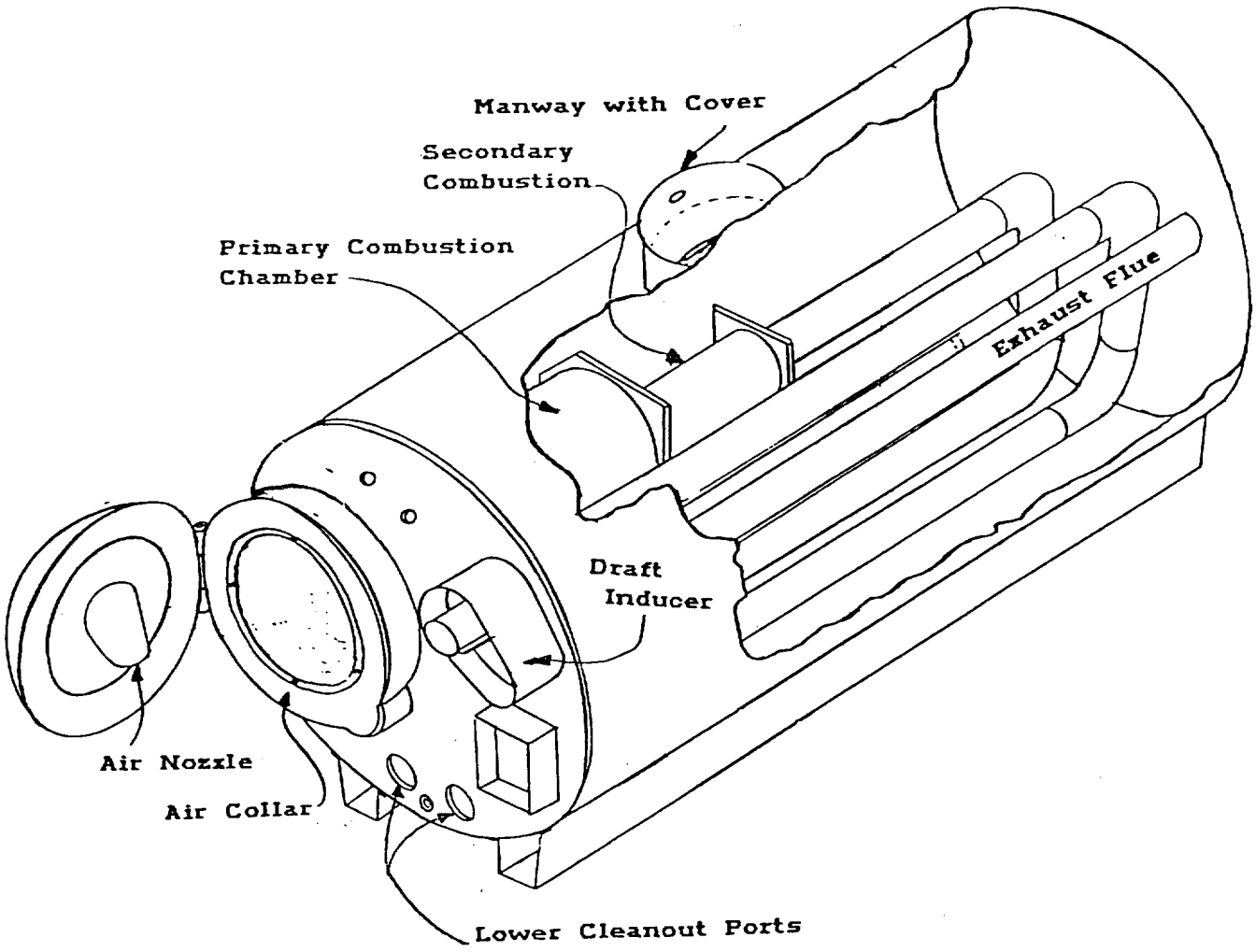
DECTRA CORPORATION @ 3425 33rd Avenue Northeast, St Anthony, Minnesota 55418
Phone: 612-781-3585 Fax: 612-781-4236 Web Site: www.garn.com

WELCOME TO THE WORLD OF GARN® WHS EQUIPMENT

GARN® WHS equipment is unlike all other "outdoor" wood heating equipment in that it incorporates clean, high efficiency combustion with thermal energy storage. As you use your **GARN® WHS unit**, you will come to appreciate its quality construction, unique features and many benefits. The following pages contain the unpacking and assembly instructions for the standard **GARN® WHS Heat Storage** unit without the electric heat back up option.

The **GARN® WHS** unit is non-pressurized. As such, the gasketed manway cover is simply set upon the top surface of the manway access ring. **DO NOT FASTEN OR OTHERWISE FASTEN** the cover to the tank or access ring; likewise, **DO NOT ADD WEIGHT** to the cover after the cover is in its final position.

An internal overflow/vent will prevent the development of internal pressure that could result from the gentle expansion and contraction associated with the varying temperature of water storage. In cases when accidental over firing results in rapid boiling, the manway cover is designed to raise slightly to relieve internal pressure and vent water vapor.



BACKGROUND TO THE GARN® WHS HEAT STORAGE SYSTEM

The **GARN® WHS** unit utilizes a non-pressurized, integral steel tank for water storage. The entire unit is insulated onsite to retain the heat and minimize loss. Water was selected for thermal energy storage because the storage of thermal energy (heat) in water is very efficient and very compact. There are several reasons for this:

- Water has the **highest specific heat** of any standard, non-harmful liquid.
- Water has a very **high heat transfer coefficient.**
- Water is readily **available,** is **inexpensive** and **conforms** to the shape of any storage container.
- Water (thus heat) is **easily moved** from the storage container to another point for use.

A sealed wood burning combustion chamber is **submerged** within a massive water storage tank. This chamber holds 50 to 80 lbs of wood fuel. A submerged draft inducer provides combustion air that is used to burn the wood fuel at an accelerated rate. Smoke and creosote (both normally wasted fuels) are drawn into a Secondary Reaction chamber with preheated secondary air where they burn at very high temperatures. The high temperature gases are then drawn through a 5-pass heat exchanger, also immersed within the massive water storage tank. During their travels through the heat exchanger the gases transfer their heat to the water. The resultant cool gases are then exhausted from the unit through a sidewall flue (much like a high efficiency gas furnace flue).

Because of the above process, the overall seasonal efficiency of the **GARN® WHS** unit is about 75%. Due to the high temperatures (1400F to 1800F) created in the primary combustion chamber followed by the very high temperatures (1800F to 2000F) encountered in the Secondary Reaction Chamber, smoke and creosote are consumed as fuel (rather than being waste and creating fire hazards). As a result, there are no chimney fires and pollution levels are very low when used with proper wood fuel.

Because water is the storage and heat transfer medium, the **GARN® WHS** unit interfaces easily with most conventional heating equipment. Heat water is simply pumped from the unit through piping to:

- A water to air coil (similar to a automotive radiator) installed in a forced air furnace.
- A hot water baseboard system.
- A radiant floor heating system.
- An older style hot water cast iron radiator system.
- A ceiling hung, wall mounted or under cabinet fan/coil unit.

Therefore, heat is delivered in a conventional manner familiar to you. In addition, a single **GARN® WHS** unit can be used to heat multiple buildings, such as: house, garage, shop, machine shed, wood shop, etc.

As you can see, the **GARN® WHS** provides comfort, convenience, safety, efficiency and low pollution when heating with wood. **Be sure to visit the GARN® web site at: www.GARN.com.**

B. OPERATION

STARTING A FIRE

The first step in operating the unit is to read the water temperature. If you see a temperature that is 150° F or less, then you may proceed as follows.

1. Open the fuel-loading door.

2. Place small kindling or a small amount of newspaper near front of combustion chamber. Securely tuck the newspaper and/or kindling under the first few log. Paper can be sucked into the flues when the door is closed if not anchored down. This step is **eliminated** when reloading the unit. In some cases a few remaining coals provide sufficient heat to ignite a fire.

3. Place 50 to 95 lbs of one-year dry cordwood, 24" to 32" long and 3" to 7" in diameter, into the combustion chamber. **Wood 8"to 12" in diameter should be split once, larger than 12" split twice.** Place the fuel toward the **rear** of the combustion chamber. Load all wood carefully or damage to the reaction chamber may occur. Maintain 8" to 16" between the lower nozzle and the front of the wood pile.

4. **DO NOT OVERLOAD THE FIREBOX.** The wood fuel should not extend significantly above the half way line of the fuel door. Sufficient heat release volume must be maintained above the wood fuel for proper combustion.

5. Turn **WHS Timer** on to confirm that the draft inducer is operative. Shut Timer off.

6. Light paper and watch for a 10 seconds or so to confirm that the paper has ignited.

7. Turn the **WHS TIMER** past the 3-hour setting to activate the draft inducer.

8. Close door.

The above procedure should take about 5 minutes. Note that the **GARN® WHS** equipment is not to be used with any automatic fuel-loading device. **MANUAL LOADING ONLY!**

CAUTION: The exterior door and air collar surfaces may be sufficiently hot to cause burns. The hot surfaces inside of the door and combustion chamber will cause burns.

If the water temperature is 185° F or greater, we do not recommend firing the unit. The normal temperature rise from one firing of wood is 20 to 25 degrees F without a load on the unit. If you fire the unit when the water temperature is above 185° F, you will approach the boiling point of water and the water will boil out through the overflow. This is a nuisance, wastes energy and evaporates water from the tank.

The **WHS Timer must** be advanced beyond the 3 hour point whenever loading the unit (or longer if a load of your fuel takes longer to completely burn itself out). Failure to do this will result in a premature shutoff of the draft inducer, thereby creating a smoldering fire. A smoldering fire **will deposit** creosote in the heat exchanger tubes and require more frequent cleaning. Smoke and carbon monoxide may also escape from the unit.

Failure to seal ALL flue joints inside a building WILL result in harmful levels of carbon monoxide and carbon dioxide being introduced into the space. If strong smell of wood smoke is noticed—VENTILATE THE SPACE IMMEDIATELY! Failure to seal all flue joints outside the building may cause staining against the building wall.

From experience, you will determine that dry wood burns completely in about 1 to 2 hours. You can load the second fuel charge (generally 30 to 85 lbs) before the fire is out, and continue to burn without having to start completely over. Watch the tank temperature, being careful not to continue adding wood if the temperature approaches 185° F.

Door Seal Adjustment

The door consists of an inner insulated disk on a threaded shaft and an outer heat shield. The heat shield is designed to function as a spring. It maintains a constant pressure on the gasket mounted on the insulated disk. The disk should be rotated until there is a good seal all the way around the air collar. The outer heat shield should flex when the door latch is secured. It is this flexing which maintains the door seal. If too much pressure is required to close the latch, rotate the disk clockwise to relieve the stress. The door **latch** may be rotated on its screw to adjust its position right or left.

WHS Primary Air Control Brick

Moisture content, wood type, size and surface area will all affect the combustion characteristics of your system. If you are experiencing smoke after ten to fifteen minutes, and your fuel is not overly large, there are a couple of things you can try to minimize the formation of smoke and pollution (which can result due to the wide variability of wood fuels).

Using a Primary Air Control Brick

A primary air control brick is simply an extra brick (2" x 4.5" x 9" – a spare bottom brick from the combustion chamber). It can be used to "disrupt or spread" the flow of high velocity combustion air entering from the primary nozzle to attain better combustion with certain types of fuels. The brick is positioned across the primary nozzle, about 3" **out from** the primary nozzle.

No brick:	This position is to be used when burning wetter woods or if the fuel requires a very long burn to fully consume "tail coals." Also, good for one year dry fuel of normal to larger size.
Full brick:	Brick set to stand 4.5" high x 9" wide. This position should be used when most of the fuel is dry or has a large surface area. This position may minimize puffing with high surface area fuels. Brick is positioned so that it does not fully close off the primary nozzle; primary airflow is required in order to cool the air collar.
Half Brick:	Brick is set to lie on its side standing 2" tall x 9" wide. This position is utilized when either of the above two positions do not seem to work sufficiently for the particular wood fuel that is being burned.
Experiment:	Determine the best position for your fuel or if you even need to use a brick. Remember your fuel will change every year, so you must relearn every year.

The Primary Air Control Brick should be positioned before lighting the fire! It will be VERY HOT once the fire has been ignited. Use EXTREME CAUTION if trying to adjust brick during firing or burns will occur!

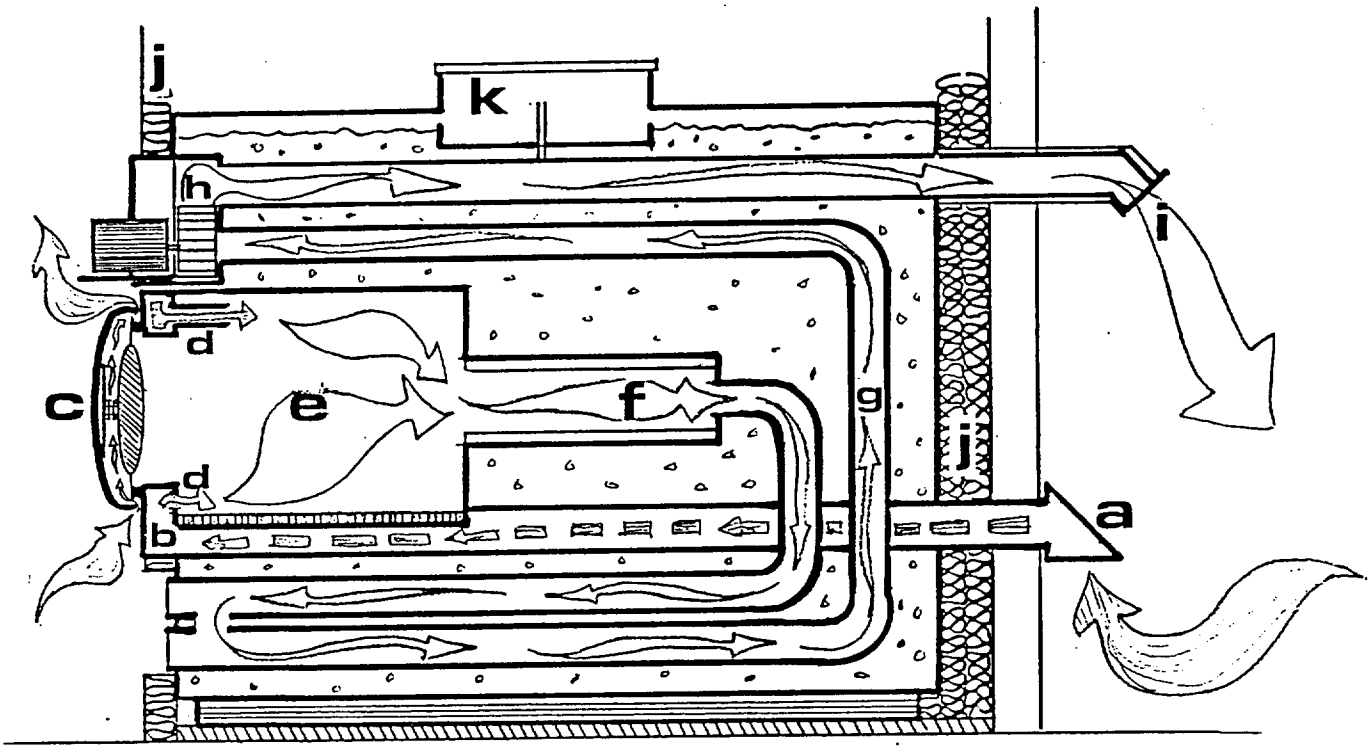
Puffing indicates that the fire requires additional combustion air. If puffing should occur, push the burning fuel toward the back of the combustion chamber and away from the primary air nozzle. Placing the Primary Air Control Brick in front of the primary air inlet nozzle should help.

During a fire or burn, the door may be opened; you may want to add more wood. If the draft inducer is operating, it will pull room air through the combustion chamber. As a result, no flames and little smoke will exit the combustion chamber. (If a large fire is burning, a small amount of hot gas may enter the room.)

In spring and fall when the outdoor temperatures are milder, less firings will be required. This is the convenience and comfort that the **GARN®** unit provides. In all cases, the **WHS Timer** will shut off automatically after the pre-set time has expired.

If you experience any difficulty with the above, please refer to Section D of this manual, Trouble Shooting and/or contact your GARN dealer..

OPERATIONAL SCHEMATIC



Outside air is drawn into the air inlet tube (a) through the water to the air distribution collar (b). The door (c) prevents air from being drawn from the room. It consists of an inner insulated disk and an outer heat shield. Room air cools the heat shield as it passes between it and the insulated disk. The air from the collar is directed by an upper and lower nozzle (d) into the combustion chamber (e). Any remaining free air is mixed with hot gases just before they enter the ceramic fiber lined secondary combustion chamber (f). In this ceramic fiber tube, smoke and creosote are burned at temperatures reaching 2000° F. These hot gases release their heat as they move through the heat exchanger tubes (g) within the water storage. The cooled gases are then pulled into the Draft Inducer housing (h) and then pushed out of the exhaust pipe (i) at temperatures between 200° and 500° F. The entire unit is insulated on site (j). An access opening on the top of the unit (k) is used for manufacturing and for the adding of water treatment chemicals when initially filled.

OPERATION OF GARN® WHS EQUIPMENT

GARN® WHS equipment is inherently very safe. **However, safe equipment is no match for human error or carelessness.** Please review and carefully follow the procedures listed below **every time** you use your **GARN® WHS** unit.

WHS TIMER: **TURN PAST THE 3-HOUR SETTING WHEN LOADING.** If the draft inducing blower does not operate, check the power supply or call your **GARN®** dealer. If the low water light and/or horn are on, the motor will not operate until water is added to the system.

NOTICE: **DO NOT OVERFIRE!** If the tank temperature exceeds 200 F or steam is visibly discharging from the overflow pipe or the manhole cover – you are **overfiring.** There is no danger of explosion. However, higher temperatures significantly increase water loss from the unit.

CAUTION: **DO NOT OPEN** the loading door if the draft inducing blower stops operating during a burn. Opening the loading door allows smoke to enter the room. Ventilate the space if the smell of wood smoke is strong.

DO NOT TOUCH loading door or air collar surfaces as they may be sufficiently hot to cause burns. The hot surfaces inside of the door and combustion chamber **will** cause burns.

DANGER: **RISK OF FIRE OR EXPLOSION** – Do **not** burn garbage, gasoline, oil in any form or other flammable liquid.

DO NOT BURN trash, plastics, pressure treated wood, railroad ties, particle board, etc

DO NOT USE lighter fluids, gasoline, oil, or any other liquid fuel to **start** a fire.

DO NOT OPERATE with the fuel loading door open.

DO NOT OPEN the fuel-loading door if a flammable gas is present.

ALWAYS VENTILATE – before removing ash or repairing the unit, ventilate the area to remove any unwanted gas (flammable, CO2, CO, etc.).

INSPECT AND CLEAN – the internal flue passages and the chimney on a regular basis.

DO NOT STORE COMBUSTIBLE MATERIALS near, around, above or in front of the unit. Maintain a clear and clean **5-foot minimum** distance the full width of the unit in front of the unit. Combustible materials include (but are **not** limited to): matches, kindling, paper, wood, oil, gasoline, rags, clothing, foam insulation, solvent-based paints, plastics, etc

DO NOT ALLOW the accumulation of bark, sawdust, shavings, kindling, hand or power tools, rakes, shovels, brooms, etc. within the area defined above.

SIMPLY STATED: **KEEP YOUR AREA CLEAN AND AS RISK FREE AS POSSIBLE.**

APPROVED FUELS

The following fuels may be used. Remember, **DO NOT OVERLOAD!** The wood fuel should **not** extend above the half way line of the loading opening. Sufficient heat release volume must be maintained **above the wood fuel** for proper combustion.

Seasoned Cord Wood: Firewood that has been cut, split and dried for one year is best. Wood cut 24" to 32" long x 6" diameter is considered best. Longer lengths should be cut and larger diameter logs should be split. Load the woodpile toward the rear of the combustion chamber to allow airflow. Any type of stick woods; i.e. oak, birch, poplar, pine, etc. is very acceptable. Dry wood at 15 to 20% moisture content contains 6880 BTU's per pound.

Briquettes: Briquettes consist of wood scrap that has been **highly densified** (without adhesives) into small 3" diameter "logs" that are 3" to 8" long. Because of the high cost to set up a facility, briquettes are usually the by-product of a large wood products company (furniture, door and window trim, etc). Usually sold in 70 lb paper bags, like dog food. Load the bag **and** contents into the combustion chamber, ignite the bag and shut the door.

Corn on the Cob: The whole ear of corn; i.e. cob and kernel is ideal for the **GARN®** unit. Air dried corn-on-the-cob has a high BTU content. Several acres of corn will supply a season's heating requirements. It burns best if mixed with seasoned wood.

Clean Scrap Wood: Waste from: construction sites, truss manufacturing facilities, pallet recycling facilities, etc. This fuel is usually very dry and bark free. Cut it to 24" to 32" lengths and stack it neatly in the combustion chamber.

Because this fuel has a high surface to volume ratio and is dry, puffing may occur. Therefore, stack the wood tight (to reduce exposed surface area) and use a primary air control brick.

Estimated GARN® WHS Performance Based on Moisture Content

% Water by weight	BTU/lb	MBTU's/ Cord Oak	Estimated Efficiency	MBTU yield w/5% Loss	x More* Wood Needed
5%	6438	21.3	70%	13.8	1.16
10%	6225	21.3	75%	14.9	1.07
15%	5906	21.3	80%	16.0	1.00
20%	5588	21.2	80%	++15.9	1.00
25%	5269	20.9	70%	13.6	1.18
30%	4844	20.4	60%	11.2	1.42
35%	4313	19.5	55%	9.7	1.64
40%	3888	18.5	55%	9.3	1.73
50%	2400	13.5	50%	6.1	2.64

One cord air-dried red oak weighs 3680 pounds and is *approximately* 4'x4'x8' in size, but size can vary considerably. All performance calculations based on weight. NOTE: Using wet wood significantly decreases performance and increases wood use* and maintenance.

*subtract 1 for % more

++ GARN® WHS uses 15 million BTU's (per cord of oak) as the estimate of heat delivered to the point of end use. The chart below can be used to convert that figure to the specific wood type being burned.

Conversion to Other Wood Types

Wood Type	Air-Dry Weight+	Air-Dry MBTU's/Cord	x Diff From Red Oak*
Ash	3440	20.0	1.07
Aspen	2160	12.5	1.70
Beech	3760	21.8	0.98
Paper Birch	3040	18.2	1.17
Yellow Birch	3680	21.3	1.00
Elm	2900	17.2	1.24
Hickory	4240	24.6	0.87
Soft Maple	3200	18.6	1.15
Hard Maple	3680	21.3	1.00
Red Oak	3680	21.3	1.00
White Oak	3920	22.7	0.94
White Pine	2080	13.3	1.60

+cord = 80 cubic feet of solid wood

Reference Notes:

1) Information on cord weight and BTU content taken from University of Wisconsin-Extension bulletin # G2874 Wood for Home Heating: WOOD AS FUEL Jan 1978

2) BTU/lb of wet wood calculated using information from Jay Shelton's book entitled, Solid Fuels Encyclopedia-1983 and The Woodburners Encyclopedia-1976 by Vermont Crossroads Press

Dectra CORPORATION

COMPARATIVE SPACE HEATING COSTS FOR VARIOUS FUELS AND EQUIPMENT EFFICIENCIES

Electric	Fuel Oil	Fuel Oil	Propane	Propane	Propane	Nat. Gas	Nat. Gas	Nat. Gas	Wood	Wood	Wood	Cob Corn	
3,413	138,690	138,690	91,500	91,500	91,500	100,000	100,000	100,000	20.5	20.5	20.5	464,100	
btu/kwh	btu/gal	btu/gal	btu/gal	btu/gal	btu/gal	btu/ccf	btu/ccf	btu/ccf	mbtu/cd	mbtu/cd	mbtu/cd	btu/bu	
100%	60%	75%	60%	75%	90%	60%	75%	90%	30%	50%	75%	75%	$/MBTU
Cents/kwh													
1.00	0.24	0.30	0.16	0.20	0.24	0.18	0.22	0.26	18.02	30.03	45.05	1.02	2.93
1.50	0.37	0.46	0.24	0.30	0.36	0.26	0.33	0.40	27.03	45.05	67.57	1.53	4.39
2.00	0.49	0.61	0.32	0.40	0.48	0.35	0.44	0.53	36.04	60.06	90.10	2.04	5.86
2.50	0.61	0.76	0.40	0.50	0.60	0.44	0.55	0.66	45.05	75.08	112.62	2.55	7.32
2.75	0.67	0.84	0.44	0.55	0.66	0.48	0.60	0.73	49.55	82.59	123.88	2.80	8.06
3.00	0.73	0.91	0.48	0.60	0.72	0.53	0.66	0.79	54.06	90.10	135.15	3.06	8.79
3.25	0.79	0.99	0.52	0.65	0.78	0.57	0.71	0.86	58.56	97.60	146.41	3.31	9.52
3.50	0.85	1.07	0.56	0.70	0.84	0.62	0.77	0.92	63.07	105.11	157.67	3.57	10.25
3.75	0.91	1.14	0.60	0.75	0.90	0.66	0.82	0.99	67.57	112.62	168.93	3.82	10.99
4.00	0.98	1.22	0.64	0.80	0.97	0.70	0.88	1.05	72.08	120.13	180.19	4.08	11.72
4.25	1.04	1.30	0.68	0.85	1.03	0.75	0.93	1.12	76.58	127.64	191.46	4.33	12.45
4.50	1.10	1.37	0.72	0.90	1.09	0.79	0.99	1.19	81.09	135.15	202.72	4.59	13.18
4.75	1.16	1.45	0.76	0.96	1.15	0.84	1.04	1.25	85.59	142.65	213.98	4.84	13.92
5.00	1.22	1.52	0.80	1.01	1.21	0.88	1.10	1.32	90.10	150.16	225.24	5.10	14.65
5.25	1.28	1.60	0.84	1.06	1.27	0.92	1.15	1.38	94.60	157.67	236.50	5.35	15.38
5.50	1.34	1.68	0.88	1.11	1.33	0.97	1.21	1.45	99.11	165.18	247.77	5.61	16.11
5.75	1.40	1.75	0.92	1.16	1.39	1.01	1.26	1.52	103.61	172.69	259.03	5.86	16.85
6.00	1.46	1.83	0.97	1.21	1.45	1.05	1.32	1.58	108.12	180.19	270.29	6.12	17.58
6.25	1.52	1.90	1.01	1.26	1.51	1.10	1.37	1.65	112.62	187.70	281.55	6.37	18.31
6.50	1.58	1.98	1.05	1.31	1.57	1.14	1.43	1.71	117.13	195.21	292.81	6.63	19.04
6.75	1.65	2.06	1.09	1.36	1.63	1.19	1.48	1.78	121.63	202.72	304.08	6.88	19.78
7.00	1.71	2.13	1.13	1.41	1.69	1.23	1.54	1.85	126.14	210.23	315.34	7.14	20.51
7.25	1.77	2.21	1.17	1.46	1.75	1.27	1.59	1.91	130.64	217.73	326.60	7.39	21.24
7.50	1.83	2.29	1.21	1.51	1.81	1.32	1.65	1.98	135.15	225.24	337.86	7.65	21.97
7.75	1.89	2.36	1.25	1.56	1.87	1.36	1.70	2.04	139.65	232.75	349.12	7.90	22.71
8.00	1.95	2.44	1.29	1.61	1.93	1.41	1.76	2.11	144.15	240.26	360.39	8.16	23.44
9.00	2.19	2.74	1.45	1.81	2.17	1.58	1.98	2.37	162.17	270.29	405.44	9.18	26.37
10.00	2.44	3.05	1.61	2.01	2.41	1.76	2.20	2.64	180.19	300.32	450.48	10.20	29.38

All fuel BTU figures taken from the Minnesota Department of Energy and Economic Development's 1984 Energy Data Book.

Corn figures are taken from their 1980 Bienneial Report. Corn is 6630 BTU/pound with the cob. The cost of a bushel of corn is priced only by the kernal's weight at 56 pounds/bushel.

The cobs add 14 pounds to the bushel's wieght, i.e. 70 pounds/bushel for 15% moisture corn-on-the-cob.

Wood BTU content is based on a 4x4x8 foot cord of logs at 20% moisture content.

C. MAINTENANCE

Periodic inspection and maintenance is required on all mechanical and electrical equipment in order to keep machinery operating safely and efficiently. For instance, cars require periodic: oil changes; replacement brake pads, radiator flushes; tire replacements; spark plug replacements; etc. The same is true for **GARN WHS** equipment. This section describes the periodic maintenance that is required to keep your unit in top shape, operating safely and efficiently.

Periodic Ash Removal

Remove excess ash from the combustion chamber as needed. A small bed of ash is allowed and preferred. The correct quantity of ash helps to prevent heat loss from the firebox during combustion yet does not inhibit combustion. Ash should never be allowed to cover the primary air inlet nozzle located at the **lower front** of the combustion chamber under the loading door. Nor should the ash slope up to the level of the bottom edge of the reaction chamber. Maintain about a 2" ash bed on top of the firebrick.

You can expect to remove approximately 2 to 3 cubic feet of ash per full cord (4' x 4' x 8') of hard wood that you burn. However, the quantity of ash varies widely. Ashes are removed using a small shovel through the loading door of the unit. **DO NOT** rake ashes forward into the lower nozzle!!

VENTILATE THE AREA BEFORE REMOVING ASHES FROM THE UNIT.

DISPOSE OF ASHES IN A SAFE MANNER. Ashes should be placed in a metal container with a tight fitting lid. Place the ash container on non-combustible surfaces only, safely away from all combustible items such as wood, cardboard boxes, paper, walls, vehicles, paints, chemicals, etc. until the ashes and container have thoroughly cooled.

Periodic Flue Tube Cleaning

Periodically inspect all flue tubes. Look for accumulated ash and debris. If one year dry, seasoned wood (15% to 20% moisture content) is burned the flue tubes and chimney may only have to be inspected every 12 to 24 months. Flue tubes will require more frequent cleaning if wet wood is burned.

If inspection indicates that cleaning is required, use a stiff round wire brush coupled to standard flexible rod extenders. Correctly sized wire brushes (4.5" and 6" diameter) are available from your **GARN** dealer; flexible rod extenders are available from most hardware stores. The flue tubes may be accessed through the secondary reaction chamber, the lower two cleanout ports, the upper cleanout port and by removal of the draft inducer housing.

Care should be taken when removing the cleanout port covers so that gasket materials are not damaged. Upon reassembly, be sure the gasket material is in proper position and the covers are securely fastened.

Replace all damaged gaskets and install missing gaskets with new gaskets manufactured specifically for GARN WHS equipment obtained from a GARN dealer.

DO NOT INSTALL CLEANOUT COVERS WITHOUT GASKETS OR WITH DAMAGED GASKETS BECAUSE OF POSSIBLE CARBON MONOXIDE AND FIRE HAZARDS.

Periodic Chimney Cleaning

GARN WHS units may be installed with either a short horizontal Class A flue or a more traditional vertical Class A flue. Both chimney styles require periodic inspection and cleaning, similar to the flue tubes. Again use a correctly sized wire brush coupled to flexible rod extenders. Be careful not to damage the inside surface of the Class A flue. All Class A flue used with **GARN** equipment is Security brand.

An insulated Class A tee is required at the base of vertical chimney. This tee is supported by a tee bracket hung from the exterior wall of the building in which the **GARN** unit is located. The chimney tee may be cleaned by removing the insulated bottom access cover that is supplied with the tee. **Be sure to reinstall the cover before firing the unit.**

Cleanout Cover Gaskets

High heat resistant, insulating semi-rigid ½" thick gaskets are used at the following locations on the **GARN WHS** unit: induced draft blower assembly; the upper cleanout port; and two lower cleanout ports. The gaskets serve **two very important functions:**

1. To **provide a seal** so that unwanted particulates and gases do not exit or enter the unit.

2. To **provide thermal insulation** so that the high temperature exhaust gases do not create a fire hazard and do not destroy the induced draft motor's bearings or windings.

In general, the gaskets are sandwiched between a steel cover plate and the tank or blower housing. Gaskets require periodic inspection as they may wear over time or fail. Two primary modes of failure exist:

Erosion Damage — This is caused by the impact abrasion of high velocity fine ash particles carried within the exhaust gases. The lower cleanout cover gaskets and the gasket for the draft inducer motor may occasionally experience this condition. To minimize this abrasion at the lower cleanouts, a thin disk of sheet metal is installed within the stud circle, sandwiched between the gasket and the tank wall. The disk will resist the abrasion while the perimeter of the gasket provides a seal

Physical Damage — This may occur during the removal of an inspection port in order to clean the flues of a unit. If the clean out cover has not been removed for an extended period of time, the gasket will stick to both the tank and cover, tearing upon removal.

Replace all damaged gaskets and install missing gaskets with new gaskets manufactured specifically for GARN WHS equipment obtained from a GARN dealer.

DO NOT INSTALL CLEANOUT COVERS WITHOUT GASKETS OR WITH DAMAGED GASKETS BECAUSE OF POSSIBLE CARBON MONOXIDE AND FIRE HAZARDS.

Review the attached multiple page MATERIAL SAFETY DATA SHEET (MSDS) regarding the safe handling of the gasket material. Be sure to utilize the specified 3M or equivalent air purifying respirator while handling and fabricating this material.

When replacing the draft inducer motor gasket, use only the "full-face style" of gasket provided by your **GARN** dealer. **DO NOT INSTALL a "donut"** style gasket as this provides no thermal protection to the motor. Without thermal protection the motor will "burn out" (bearings and/or windings) very quickly. **Use only the full-face style of gasket.**

Draft Inducer Motor

At least once a year use compressed air and a high velocity nozzle to remove accumulated dust from the windings of the draft inducer motor. Excessive dust accumulation will block airflow around motor windings creating hot spots that may terminate motor operation via a thermal safety switch. In extreme cases, hot spots may start a fire. In all cases, hot windings shorten motor life.

The bearings of the motor are factory sealed to prevent the entrance of dust, dirt and moisture. Therefore, the bearings do not require periodic lubrication.

Combustion Air Intake Hood

Periodically inspect the combustion air intake hood and screen located at the rear of the **GARN** unit on the outside wall of the building in which the **GARN** unit is located. Remove all leaves, paper, etc – anything that may reduce or prevent the intake of combustion air to the unit. During winter months periodically remove snow from the area near the hood.

A restricted air intake yields inefficient smokey combustion. This in turn allows creosote to condense on the inside surfaces of flue tubes creating a fire hazard. A restricted air intake is usually (but not always) accompanied by "puffing" during combustion.

Fuel Loading Door Gasket

Periodically examine the fuel loading door tadpole gasket for tears, permanent compression set, "burn outs," or other degradation. **Replace the entire gasket** when such damage is found. Replacement gaskets can be obtained from your **GARN** dealer.

Use only tadpole door gasket that is manufacture specifically for GARN WHS equipment obtained from a GARN dealer.

DO NOT SUBSTITUTE A GASKET OF LESSER QUALITY OR "PIECE TOGETHER" A GASKET FROM SHORT LENGTHS.

Gaps formed when piecing together short lengths of gasket may create significant carbon monoxide and fire hazards.

If the fuel loading door does not tightly seal against the front face of the air collar, simply open the door and rotate the inner door assembly counter clockwise one half turn **to increase** the seal pressure. Shut and latch the door to check. Repeat this process until the seal is "snug." Only adjust the door when the door is cool; **DO NOT ADJUST THE DOOR WHEN IT IS HOT.** The door will seal tighter when in use.

Low Water Indicator Light

If the low water indicator light is on, water needs to be added to the system. Add the water using a garden hose and the water filter supplied with the unit through the manway opening. Fill the unit to a level that is approximately 8" below the top of the overflow tube located in the manway collar when the water temperature is 120 degrees F. Review the Water Treatment Chemical section below.

Contact your dealer or the **GARN** factory if water needs to be added more than twice per year. In general and assuming correct use and firing, very little water is evaporated over the course of a typical year.

Anode Rods

Once per year unscrew one of the anode rods, remove it and examine it for degradation (anode rods are consumed while providing corrosion protection). If the anode rod is "in poor condition" contact **DECTRA** to order replacement rods. Install four (4) new **magnesium** anode rods **without** thread compound or Teflon tape. The rod **must** develop a good electrical contact with the tank fitting. **Do not install aluminum anode rods.**

Accelerated anode rod degradation may be a sign of electrolysis. It may also indicate the presence of either a poor ground connection or a "floating ground condition" within the building wiring or electrical service. Installation of a proper ground will help to minimize this condition.

Manway Cover Gasket

Occasionally the manway cover gasket may require replacement. Carefully and fully remove the old gasket. Use a solvent such as lacquer thinner to remove all traces of the old adhesive. Carefully follow all safety precautions when using any solvent; dispose of cleaning materials such as rags so as not to create a fire hazard. **USE ONLY METAL CONTAINERS WITH LIDS FOR THE DISPOSAL OF RAGS, ETC.**

After the flat of the manway cover is cleaned of all old gasket and adhesive, remove the paper backing for a distance of about 2" from one end of the new gasket. Align the end of the new gasket and firmly press it into position. Carefully install the remainder of the gasket around the flat while simultaneously removing the paper backing. As the gasket is slightly longer than required, cut the free end after all but the last 2" of the gasket is in position. Be sure that both ends of the gasket meet **without a gap** (a gap will leak moisture and air, significantly increasing evaporation).

Water Treatment Chemicals

Once a **GARN** unit is delivered, the manufacturer is **not** able to control the quality of the fill water, the quantity or type of treatment chemicals, nor the level or frequency of ongoing chemical testing and maintenance. Thus, corrosion protection is the **sole responsibility** of the owner. There is **no warrantee** regarding corrosion or corrosion induced failures of any component of **GARN WHS** equipment or any components attached to the **GARN** equipment.

In addition to using a chemical treatment program that addresses **both** oxygen and bacteriological corrosion, every **GARN** owner should become a **proactive participant** in the protection of their investment. A number of common sense procedures exist to help reduce the potential of corrosion. The items listed below are suggested, minimum baseline maintenance procedures.

Water treatment chemicals, anode rods and biocide are **consumed** while providing protection. Treatment chemicals incorporate a semi-transparent tracer dye that changes color as the chemicals are depleted or the pH drops below a critical level (<8.3). Note the original color of the **treated** water shortly after filling the **GARN** unit. The bottom of the **GARN** unit should be easily visible through the full water depth in the tank.

1. If possible, examine the water in the **GARN** unit twice per year. If a color change has occurred, immediately take a sample and forward it to the water treatment company. Upon receipt of the test results, adjust the chemical concentration as advised by the water treatment company.

2. Whenever water is added to the unit, utilize the water filter provided so that sediment is **not** carried into the system. Add water treatment chemicals (based upon the volume of water added) and biocide **every time** water is added.

3. Add biocide: whenever makeup water is added to the unit; a few days before the end of the heating season; and at the beginning or middle of the heating season. Depending upon the location of the **GARN** unit and quality of the make up water biocide may have to be added bi-monthly. Dusty or dirty locations require more frequent biocide additions to minimize sludge build-up and under-deposit corrosion potential.

4. Raise the water temperature to +180 degrees F or more once per month, whenever the **GARN** unit stands unused for a period of time (i.e. during the summer months). 180 degrees F will kill most bacteria living **within** the tank (it will **not** kill the bacteria in the piping system). High temperature heating will reduce **(but not eliminate)** the requirement for biocide.

5. Draw **two samples** of the treated water **per year** and send them to the water treatment company for analysis. Upon receipt of the test results, adjust the chemical concentration as advised by the water treatment company.

6. Every three (3) to five (5) years drain you **GARN** unit. Check with local officials to ascertain the safety of draining the treated water onto the ground or into a city sewer system. **DO NOT DRAIN:** hot water (allow it to cool to 75 F or lower); water recently treated with biocide (wait 2 to 4 months); **GARN** water into a septic system (it will overload the system and possibly destroy it). Prevent animals from drinking the water; simply allow it to be absorbed by the soil (most corrosion treatment chemicals are a form of mild fertilizers). Before draining the unit, draw a treated water sample and set it aside (for testing if required).

   Flush the tank with clean water. Like the cooling system of a car, all chemical suppliers recommend a periodic flushing of the system. Hose down the entire inside of the tank. All dirt and sludge that has accumulated in the bottom of the tank **must** be removed.

   Inspect the cleaned tank. This simple visual inspection is more informative than hundreds of lab tests. Look for and identify any type of corrosion. Forward a water sample to your water treatment company. Upon receipt of the test results, adjust the chemical concentration as advised during refilling. Depending upon the type of corrosion found, check the tank ground, building electrical ground and anode rods. Clean all corrosion spots thoroughly by wire brushing and flushing with clean water.

7. Refill the **GARN** unit in compliance with **Initial Water Treatment Installation Procedures** (refer to the Installation Manual). Send a treated water sample to the water treatment company for an initial analysis. Use standard sampling procedures in obtaining the sample. Upon receipt of the test results, adjust the chemical concentration as advised.

D. TROUBLE SHOOTING

Lack of Heat in Building

1. Check and confirm thermostat function.

2. Check and confirm power supply, circuit breaker position, etc

3. Check and confirm pump operation.

4. Check and confirm supply water flow by determining if the pipes are hot when the pump activated. Check the pipes in the house, not at the **GARN** unit. If pipes are not hot and the pump is activated, the pipes may be "air bound', a manual valve is set in the shut position or a solenoid valve is inoperable. Call your dealer and shut off thermostat.

5. Check and confirm the supply water temperature. The minimum supply water temperature: for forced air systems should be 120° F; for radiant floor systems approximately 90°-120° F; for baseboard radiation systems 130°-145° F and for radiator systems 110°-140° F. If the supply water temperature is inadequate, heat will not be delivered even though supply water flow is adequate.

6. If all of the above checks OK and heat is still not flowing to the building call your dealer.

Draft Inducer Fails to Operate

1. If the draft inducer motor does not activate when the timer is turned past the 3 hour position, check and confirm:

    - Status of the power supply, circuit breaker, etc of the circuit feeding the **GARN** controls.

    - That the electrical plug for the motor is pushed all the way into the electrical socket.

2. If the above checks OK and the motor stills does not activate pull the electrical plug and insert another electric device in the same outlet and turn the timer past the 3-hour position. If this device operates properly, then the motor is defective. If this device does not operate, then either the Intermatic timer or the Honeywell control relay is defective. Call your dealer.

3. If everything above checks OK, then visually check the water level in the **GARN** unit. If the water level appears low and adding water corrects the condition (motor operates), then Low Water Indicator light is burned out. If the water is not low or if adding water does not correct the condition, then the float switch is defective. Call your dealer.

Noisy Draft Inducer

If the draft inducer operates noisily, check and confirm that all of the mounting bolts are not loose and that the gasket is in good condition. If the bolts are loose tighten until snug (**do not** over tighten). If this does not solve the problem, the noise may be the result of:

1. Ash, wood debris or paper kindling that has been pulled through the heater exchanger and is stuck in the blades of the blower wheel creating an imbalance. Ash will normally disintegrate, debris and paper will not. Disconnect the motor from the **GARN** controls and **CAREFULLY** remove the draft inducer assembly from the its housing. Clean the motor, blower wheel, etc, install a new full-face gasket and reassemble.

2. A defective bearing, generally due to overheating as a result of using a "donut gasket" in lieu of a **GARN** full face gasket. Disconnect the motor from the **GARN** controls and **CAREFULLY**

remove the draft inducer assembly from the its housing. Replace the motor, reinstall the blower wheel with anti-seize compound, install a new full-face gasket and reassemble.

Puffing During Operation

Puffing or pulsation during operation is a condition that you will surely notice when it occurs. It is the result of a grossly **incorrect** fuel air mixture. This condition occasionally develops in all wood equipment. **Excessive or long term puffing will damage the unit and may create hazardous conditions.** Reasons for this effect are:

1. **Excessively dry wood fuel** such as: wood that is more than 2 years dry; construction or furniture scrap; wood without bark; wood that has been stored for an extended period of time indoors, etc. Fuel with a moisture content of 15 % to 20% (one year dry) is best for a **GARN** unit.

2. **"Punky wood"** – wood that has been drying for so long that it is beginning to decompose internally (usually very light to handle). Fuel with a moisture content of 15% to 20% (one year dry) is best for a **GARN** unit.

3. Wood fuel that has an **excessively large surface area** in relationship to its volume (i.e. – small sticks, leaves, small furniture scraps, etc). Because all wood burners are surface burners, the surface to volume ratio of the fuel is critical for any specific burner. For the **GARN** unit wood cut 24" to 32" long x 6" diameter is considered best. Longer lengths should be cut and larger diameter logs should be split.

4. **Lack of sufficient combustion air** – normally caused by a partially blocked air inlet hood or flue tubes. Sometimes cause by the installation of an improper air inlet hood (too small) or no inlet air hood. Generally easily corrected by clearing blocked passages or installing the correct hood.

5. **Wood fuel positioned too close to the primary air nozzle**. A hot fire in this position excessively preheats the primary combustion air, yielding a flash then no-flash combustion condition. To reduce this sensation, push the fire further back into the combustion chamber with a hoe or rake. This also allows the combustion air to disperse more widely at a lower velocity over the woodpile.

6. Starting the fire with an **overabundance of kindling.**

In Case of Electrical Power Failure

If during operation the electrical power to the GARN WHS unit fails, **DO NOT OPEN THE DOOR and DO NOT ATTEMPT TO RELOAD THE UNIT.** Fire in the combustion chamber will safely snuff itself out within a few minutes. When power returns the unit will automatically purge itself and the fire will generally restart. Do not open the door until 5 minutes after power has been restored.

If power has been off long enough to allow the mechanical timer to run down to 0, the fire may not automatically restart when power is restored. **DO NOT OPEN THE DOOR and DO NOT ATTEMPT TO RELOAD THE UNIT.** When power returns, activate the draft inducer by turning the timer to the 3-hour position. Allow the GARN WHS unit 5 minutes to purge itself before opening the door to re-establish the fire or reload. Occasionally, the unit will restart during this 5-minute purge period.

Formation of Smoke or Creosote

If you observe excessive smoke from the chimney or accumulations of creosote within the combustion chamber and cleanout ports, it is generally the result of: insufficient combustion air; excessively wet wood fuel; too much fuel; or the burning of trash and plastic. Under normal operation, smoke and creosote are consumed by the high fire temperature in the Secondary Reaction Chamber. Smoke and

creosote should almost be non-existent after 10 to 20 minutes of initial operation; hence, are a sign of a serious problem.

1. Check and confirm that the moisture content of your wood is 15% to 20% (1 year dry).

2. Reduce the volume of wood fuel loaded into the combustion chamber. The wood fuel should **not** extend above the half way line of the loading opening. Sufficient heat release volume must be maintained **above the wood fuel** for proper combustion.

3. **DO NOT BURN TRASH, PLASTIC, PRESSURE TREATED WOOD, ETC**

4. Check and confirm that all of the flue passages and the chimney are not blocked.

5. Check and confirm that the air inlet hood is not blocked.

6. Check and confirm that the primary and secondary air nozzles are clear.

7. Check and confirm that the induced draft blower is operating properly.

8. Check and confirm that the loading door seals tight to the air collar face.

9. If all of the above check as OK, then call your dealer.

Smell of Smoke

If you observe a strong smoke smell, **IMMEDIATELY VENTILATE AND EXIT THE AREA.** A strong smoke smell is usually caused by the following. Investigate and repair as required.

1. Defective or worn cleanout cover gaskets.

2. Defective or worn loading door gasket.

3. Incorrectly adjusted loading door (door does not seal tight to the air collar face).

4. Defective induced draft blower motor or wheel.

5. Blocked chimney.

6. Excessive depressurization of the building in which the **GARN** unit is located. This may be due to high levels of exhaust as a result of operating equipment not related to the **GARN** unit. Solution is to provide make up air in a volume that is equal to the exhaust air volume. Contact a Consulting Mechanical Engineer to help solve this condition.

Excessive Water Consumption

Excessive water consumption is caused by the following. Investigate and correct or repair.

1. High evaporation rates due to consistent over-firing so as to yield storage water temperatures above 205 degrees F.

2. Leak in a supply or return pipe (generally underground because leaks within a building are readily noticed).

Corrosion of the Storage Tank

Corrosion is almost universally caused by **not following** a defined water treatment and maintenance program. Please refer to the Water Treatment Section of the Installation Manual and other sections of this manual. Remember that the water in a **GARN** unit must be **tested at least twice per year.**

Excessive Wood Use

Excessive wood use is generally caused by the following. Investigate and correct.

1. Consistent over-firing so as to yield storage water temperatures above 205 degrees F

2. Wood fuel moisture content too high (15% to 20% moisture content is best and most efficient). Refer to Estimated Performance Chart on the next page to understand the **massive effect** that wood moisture content has on fuel consumption.

If you have additional questions please contact your GARN dealer or visit the GARN website at: www.GARN.com.

Estimated GARN® WHS Performance Based on Moisture Content

% Water by weight	BTU/lb	MBTU's/ Cord Oak	Estimated Efficiency	MBTU yield w/5% Loss	x More* Wood Needed
5%	6438	21.3	70%	13.8	1.16
10%	6225	21.3	75%	14.9	1.07
15%	5906	21.3	80%	16.0	1.00
20%	5588	21.2	80%	++15.9	1.00
25%	5269	20.9	70%	13.6	1.18
30%	4844	20.4	60%	11.2	1.42
35%	4313	19.5	55%	9.7	1.64
40%	3888	18.5	55%	9.3	1.73
50%	2400	13.5	50%	6.1	2.64

One cord air-dried red oak weighs 3680 pounds and is *approximately* 4'x4'x8' in size, but size can vary considerably. All performance calculations based on weight. NOTE: Using wet wood significantly decreases performance and increases wood use* and maintenance.

*subtract 1 for % more

++ GARN® WHS uses 15 million BTU's (per cord of oak) as the estimate of heat delivered to the point of end use. The chart below can be used to convert that figure to the specific wood type being burned.

Conversion to Other Wood Types

Wood Type	Air-Dry Weight+	Air-Dry MBTU's/Cord	x Diff From Red Oak*
Ash	3440	20.0	1.07
Aspen	2160	12.5	1.70
Beech	3760	21.8	0.98
Paper Birch	3040	18.2	1.17
Yellow Birch	3680	21.3	1.00
Elm	2900	17.2	1.24
Hickory	4240	24.6	0.87
Soft Maple	3200	18.6	1.15
Hard Maple	3680	21.3	1.00
Red Oak	3680	21.3	1.00
White Oak	3920	22.7	0.94
White Pine	2080	13.3	1.60

+cord = 80 cubic feet of solid wood

Reference Notes:

1) Information on cord weight and BTU content taken from University of Wisconsin-Extension bulletin # G2874 Wood for Home Heating: WOOD AS FUEL Jan 1978

2) BTU/lb of wet wood calculated using information from Jay Shelton's book entitled, Solid Fuels Encyclopedia-1983 and The Woodburners Encyclopedia-1976 by Vermont Crossroads Press