

### Oven Design



Several hours a week, men and women cook and prepare meals in their home kitchens. Cooking is a necessity and often a hobby for those who prepare home cooked meals for their families, entertain on holidays, and entertain friends. With the amount of time people spend in the kitchen cooking, it is crucial to have ergonomically designed appliances. More specifically, I'd like to focus on the oven. The oven is often used for baking, and roasting, which is a necessary step for cooking many meals. I will focus on the placement of the oven in the kitchen in terms of height and relation to the counter top. I will address the design of the oven handles, and design of the oven door and oven shelves in terms of how they can be modified to improve safety, productivity and comfort in the home. I will redesign the oven so that people can properly place things in to and remove things from the oven so that removing heavy items like a turkey will not cause back strain. I will design a way to open the oven to reduce strain on the wrists. I will improve the layout of where the oven should be located in the kitchen so that there is less unnecessary bending and reaching to reduce strain on the arms, and back, as well as reduce the risk of getting burned.

There are several problems with the design of many ovens in the market today. The first problem is the bar in which the oven is opened with. On most traditional ovens, it is a horizontal bar running across the top of the oven. This is used to pull the oven door open so that it opens towards the user. The bar forces taller people in to wrist flexion and smaller people in to wrist extension and does not allow for the wrist to be in normal posture. It also does not allow for maximum grip strength. The bar issue however, could be removed all together if the oven door was not intended to open towards the user. The door poses a problem for the user because now the person has to maneuver him/herself around the big hot door to place hot dishes in and out of the oven. This leads to improper bending and leaning with heavy and or objects in hand. The user is forced to stand far away from the area in which they are reaching towards because they are blocked by the oven door.

### **The Ergonomic Redesigning of the Oven:**

#### ***The Oven Door***

The design of the oven door is critical to allow for proper lifting which can reduce the risk of back injury. The current design of the oven door is one in which the door opens towards the user. This creates about a two foot barricade between the user and the inside of the oven where he or she must place food in to or remove food from. This bending over and around the oven door can create tension in the spine because there is an elongation of the inter-vertebral discs (Hedge, 2007). The design of the oven door can be improved to reduce the need to reach beyond a normal reach area, reduce bending and thus reduce back injury and strain by designing the oven door to open horizontally like a

microwave oven. The upper limb length can range from 25.8 inches in the 5<sup>th</sup> percentile of women, to 33 inches in the 95<sup>th</sup> percentile of men. Reaching over an oven door forces a person to reach beyond their arm length and over extend themselves to maneuver hot trays out of the oven. According to Sanders and McCormick any kind of barrier reduces reach distance, (1993). Not only can a person not easily reach the hot food they are removing from the oven, they will then have to lift it out of the oven improperly. According to table 6.5 in Introduction to Ergonomics, there are seven factors that “exacerbate postural stress in manual handling:

1. Having to grasp or hold the load at a distance from the trunk.
2. Having to twist the trunk while supporting or lifting a load.
3. Having to lift or lower objects placed below knee or above shoulder height.
4. Having to lift or move the load through large vertical or horizontal distances.
5. Having to hold or carry the load for long periods.
6. Having to lift or carry frequently.
7. Having to lift while seated.” (Bridger, p.172, 2003).

With these seven factors in mind, designing the oven door so that it opens like a door horizontally will help eliminate some of the risk factors that the pull down door creates. The door that opens towards the user vertically can create a substantial distance between the user and the object they are lifting out of the oven. Using the NIOSH equation developed in 1981, H, which is the distance of the load from the midpoint, will be much larger with the traditional oven design with a pull down door than with the new horizontally opened door design because there is no barrier between the load and the lifter, (Bridger, p. 173, 2003). This will lead to a safer lifting condition. A design like this

has been done by BONNET a company that manufactures industrial cooking units. They have a stand alone unit called the equator. This is what it looks like...



[http://www.bonnetcidelcem.com/static.php?op=01\\_equatorGB.html](http://www.bonnetcidelcem.com/static.php?op=01_equatorGB.html)

This is evidence that a horizontal door can be designed.

Once the door is open it will click in to place to minimize the potential for the hot door to close on the users arm. To release the door so it can be closed, the user will use a finger press on the handle.

### ***The Handle***

The design of the handle on the oven door can be improved to remove the need for an over hand grip which forces the wrist in to flexion or extension depending on the height of the user with the horizontal rectangular bar. The handle should run vertically to allow for a power grip, which is a stronger grip, requiring less work of the person. According to Alan Hedge professor of Ergonomics at Cornell University the power grip is the most powerful (Hedge, 2007). The traditional horizontal bar design forces the wrist out of normal position but the new design resolves this issue by having the axis of the vertical handle positioned at an angle of 100-110 degrees in relation to the forearm. This is done because inline grip at this angle will keep the hand in a neutral position when the oven door is pulled open (Bridger, 2003). The handle will be 1 inch in diameter to utilize

optimal grip range which is between .875 to 1.25 inches, (Tilley, p.74, 2002). There will be no finger grooves in the handle to eliminate the possibility of “pressure ‘hot spots’” which arise for the users whose hand does not align properly with the handle (Bridger, 2003). The handle will be made out of heat resistant silicone to ensure the safety of the user. The handle will have a button on the interior of the side of the handle which can be pressed by the fingers while gripping the handle to release the door from its locked in position when opened. It will be 3.9 inches long to accommodate up to the 99<sup>th</sup> percentile of men’s grip width from the index finger to the pinky (Tilley, p.75, 2002). The width of the button will cover half of the cylindrical handle. The recessed finger strip will be included in the design in place of a thumb press because the fingers can share the load more equally (Sanders and McCormick, p. 392, 1993).

### ***Oven Location***

Traditionally, most ovens are at knee level because they are situated on the floor and function as a stove top as well. This is not ergonomically practical because it requires unnecessary bending. A person has to transfer a load from the knee level oven to an elbow level counter top and exert lots of energy. To remove this bending element from oven use, the new oven design will have the oven be elevated to slightly below standing elbow height. This has been recommended in a study by Grandjean in 1988. Light assembly work for men standing should be done between 34.5 and 42 inches and for women should be between 32 and 38 inches (Sanders and McCormick, p.436-437, 1993). Since there are many different variations of standing elbow height where the 5<sup>th</sup> Percentile of women is 36.9 inches, and the top 95<sup>th</sup> percentile of men is 46.9 inches, the

stove top must be able to accommodate a wide variety of people. This will be accomplished by designing a system that can be raised and lowered electrically. This technique was recommended by McCormick and Sander (1993). An adjustable oven has been created by Charvet, a family owned company that manufactures industrial cooking units. Their rise and fall induction suite unit can be electrically lifted and lowered by a



foot pedal. This is what it looks like...

<http://www.charvet.co.uk/rise.asp?page=2>

The oven I designed will have an up and down arrow that can be used to raise or lower the oven height to the users comfort level. The button will provide feedback to the user by emitting a beep for each time it is pressed. There will also be a digital reading of the height in inches of the bottom of the oven from the floor that is represented on a scale from 1 to 9 (1 being 32 inches, and 9 being 41 inches). There will be an “enter” button so that once the user determines the height they want the oven at they press enter and the oven adjusts itself. This is to prevent the oven from moving as the user is still pressing the arrows. The circular arrow buttons and enter button will be .85 inches in diameter to accommodate the finger tip of the index finger up to the 95<sup>th</sup> percentile of men (Tilley, p.79, 2002). The buttons will require the resistance of 2.8N which is the minimum force recommendation (Tilley, p.76, 2002). The range of the bottom oven shelf can be adjusted to a height between 32 and 41 inches to allow for a 5 inches below the standing elbow height of the 5<sup>th</sup> percentile of women and 95<sup>th</sup> percentile of men. By increasing the height

of the oven from traditional height at the knees, to elbow height, D which represents the distance which the load is lifted, from the NIOSH equation will decrease, thus reducing lifting hazards (Bridger, p.175, 2003).

Since the new oven design eliminated the issue of bending and leaning, it also will further eliminate the element of reaching that is a problem with the traditional oven design. The oven shelves will be able to be electrically protruded from the oven unit by pressing a button that is also .85 inches in diameter so that there is no reaching involved. All movements will take place in the user's normal area. "A person's normal area can be conveniently reached with the sweep of a forearm"(Sanders & McCormick, p.432, 1993). "A person in their zone of convenient reach would not have to bend at the waist and can assume full grip at reach point" (Sanders and McCormick, p.432). This is important so that a user can achieve the strongest grip when they are carrying a hot tray. By including the element of tray extension in the new design the tray is in convenient reach zone of the users so they are not leaning in to the hot oven and using a potentially weaker grip. The depth of the oven tray will fit the upper limb length of the 5<sup>th</sup> percentile of women, which is 25.8 so that when the tray is extruded, all parts of the tray can be comfortably reached if needed. Therefore the oven depth will be 2 feet in depth so that if a woman is baking cookies, when she ejects the tray she does not have to lean or reach an inch to reach the back row of cookies. The oven shelves will then be closed with the use of a foot switch to free the user from the need to use his or her hands which may be carrying a hot dish. The pedal will be at a 20 degree angle from the vertical because forces from a neutral leg position are greatest between 15 and 35 degrees from vertical (Sanders and McCormick, p.475, 1993). According to Measures of Man and Woman, 20 degrees is the maximum

angle at which a small woman can be comfortable (Tilley, p.77, 2002). The width of the foot switch will be 3 inches which is considered the optimal width (Tilley, p.77, 2002).

Along side of the oven will be a 24 inch by 24 inch counter top to rest any item on before or after it is in the oven. It will be a heat resistant surface situated at standing elbow height. The fixed height recommended for a work surface is 42 inches for males and 38 inches for females (Sanders and McCormick, p. 437, 1993). The counter will therefore be 38 inches because then the counter will either be slightly below or equal to standing elbow height, which is recommended (Sanders and McCormick, 1993). This will eliminate any twisting with a heavy load in hand to transfer food in to the oven which is considered to exacerbate the risk of injury (Bridger, 2007). The user will now only have to take a lateral step and place the food on the tray which is adjusted to his or her height of comfort. This now reduces A, which represents the Angle of Asymmetry of Lift used in the NIOSH equation which reduces the risk of injury (Bridger, p.175, 2003).

The final design of the oven will remove the need for bending, reaching, and lifting for extended distances and allow the user to lift a hot tray safely. According to Alan Hedge safe lifting requires a person to

- “Stand as close to the load as possible (*this is addressed by the removal of the traditional oven door.*)
- Bend at your knees NOT your waist (*there is no need to bend what so ever because the height of the oven can be adjusted to accommodate the user and the trays extend outward to eliminate the need for leaning.*)



- Hug the load close to your body, don't hold it away from you (*also resolved with the new door design*)
- Raise yourself up with the strong thigh muscles” (Hedge, 2007).

It is a shame that after decades of using common kitchen appliances, no one has standardized a more practical oven design, or recognized the need for ergonomic ovens. People should not have to move themselves to accommodate technology and or appliances, the design should fit the form of the person. Until people realize the importance of ergonomics we will continue to strain our backs, and burn ourselves on traditional ovens.

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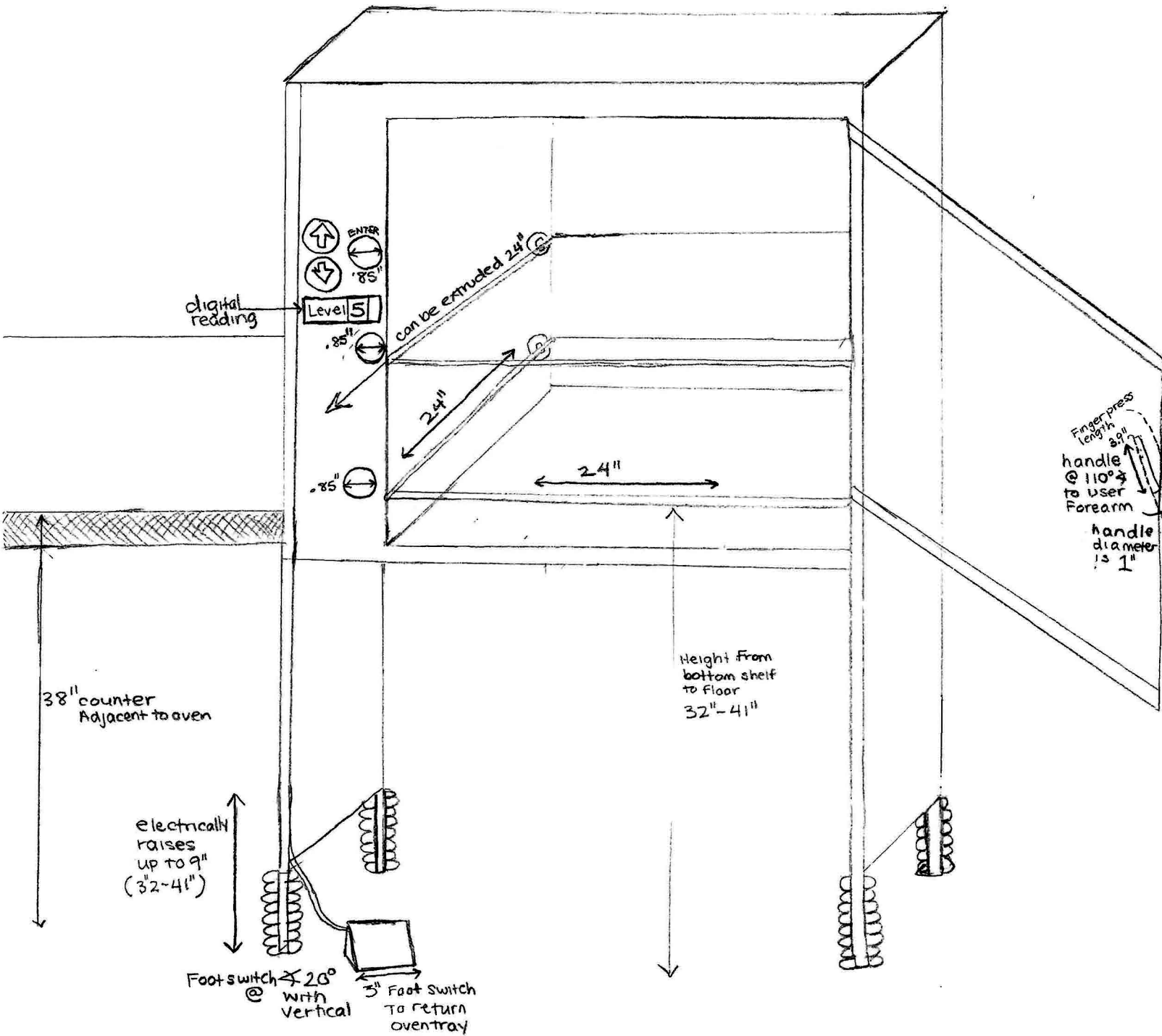
Charvet Oven Image: <http://www.charvet.co.uk/rise.asp?page=2>

BONNET Oven Image: [http://www.bonnetcidelcem.com/static.php?op=01\\_equatorGB.html](http://www.bonnetcidelcem.com/static.php?op=01_equatorGB.html)

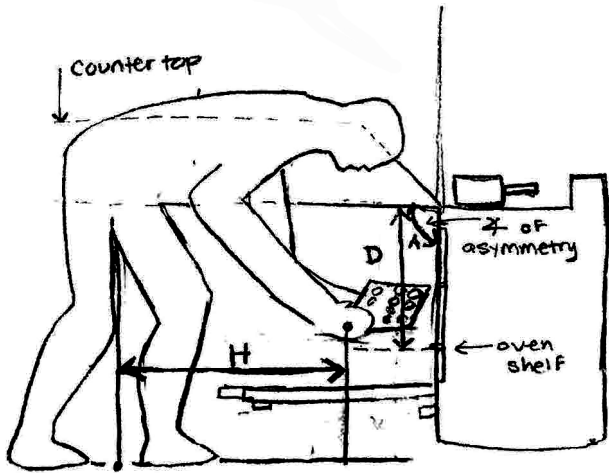
Traditional Oven Image:

[http://www.sears.com/shc/s/p\\_10153\\_12605\\_02294038000P?vName=Appliances&cName=Cooktops,+Ranges+&+Ovens](http://www.sears.com/shc/s/p_10153_12605_02294038000P?vName=Appliances&cName=Cooktops,+Ranges+&+Ovens)

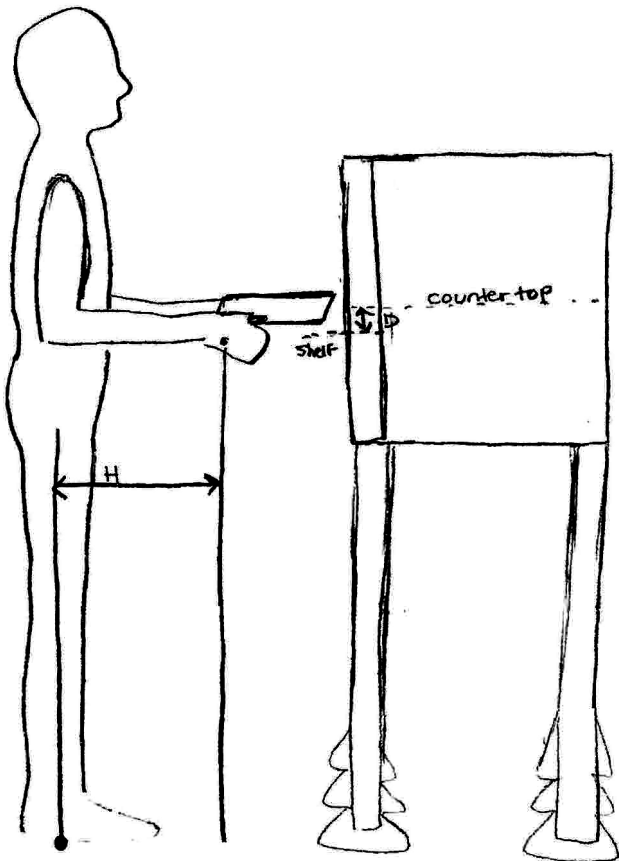
NOT TO SCALE



# NIOSH VARIABLE COMPARISON



Must twist to reach counter space

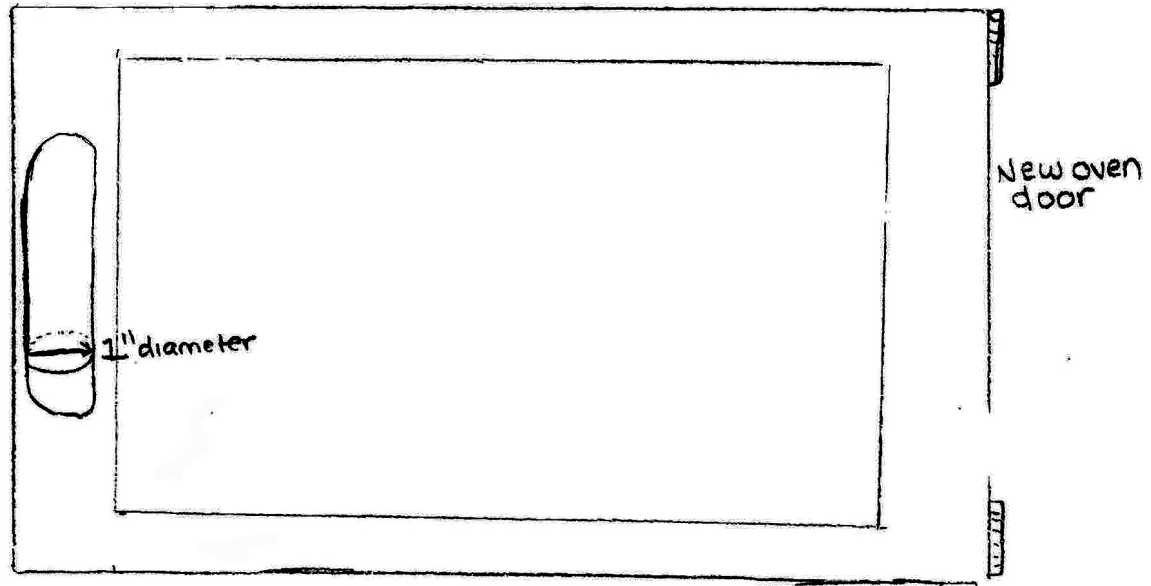
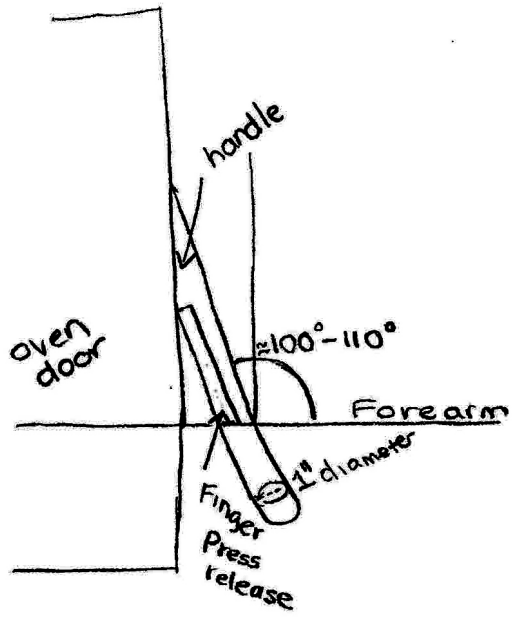


Counter space adjacent to oven  
No twisting needed  $\angle A$  is  $0^\circ$

Tray is closer to body

No bending required

D and H both decrease



door opens  
this way

