
Preface

On August 8, 1996, a Special Interest Forum (SIF) was held in Washington DC, on the topic of “Accessible Appliances and Universal Design.” Its purpose was to promote innovation in major appliance design and to help make kitchens and laundries more accessible and usable by a diverse population, including people with disabilities. This report is based on the presentations made during the Forum. It captures the main points raised by the presenters and elaborates on many of the issues. Credit is given to presenters where appropriate.

The SIF was organized by the Association of Safe and Accessible Products (ASAP). Funding was provided by the Center for Inclusive Design and Environmental Access (IDEA Center), State University of New York at Buffalo as part of a grant from the US Department of Housing and Urban Development entitled *Fair Housing Means Universal Design*.

Introduction

The technological development of home appliances has its starting point in the Feminist Movement of the mid 1800s. In an era where new factories attracted single women away from domestic work and the women’s rights movement began, “Material Feminist” philosophers and activists sought to improve the working condition for women in the home. One movement leader, Catherine Beecher, condemned the social condition of women; she proclaimed, “a democracy can suffer no disenfranchised class, no privileged sex” and called for a social change through design of housing (Hayden, 1982). Many Material Feminists viewed mechanization of household chores as one means to free women from the drudgery and burden of domestic work. Mechanization of cooking, cleaning, ironing, dishwashing and carpet sweeping became the impetus for appliance design.

Today’s appliances have simplified domestic work. They helped enfranchise women and brought the social and democratic goals of Material Feminism closer to reality. Many of today’s appliances have gone far beyond the imagination of Catherine Beecher. For example, could she have imagined microwave

ovens, frozen food and garbage disposals? These inventions decreased drudgery and increased efficiency of domestic work substantially, enabling women to pursue occupational roles in the community at large.

A careful examination of home appliance design, however, demonstrates that while many people have benefited from the astounding technological developments in mechanizing housework, there are others who are still disenfranchised. These people find it difficult to use the appliances upon which we now depend to perform household activities. People are living longer with more functional limitations and less family assistance than during the early feminist period. More and more people are facing discrimination by poor design. Civil rights laws such as the Fair Housing Act of 1988 and the Americans with Disability Act (ADA) of 1990 were designed to prevent this sort of discrimination by ensuring equal access to the built environment. During the short period in which these laws have been in effect, it has become clear that greater accessibility and usability benefit all people, not only older people and people with disabilities.

Until recently, designers promoted two different design standards: special accessible products for people with disabilities and general mass-market designs for able-bodied people. When special products are not available, assistive devices bridge the gap to help people get better access to mass market equipment. Current design philosophy, however, has shifted toward inclusive design approaches that will ensure that all products and environments are usable by all people, including those with disabilities. This philosophy has come to be called “universal design”.

This report will examine accessibility to and usability of home appliances. Our intention is to promote innovation in appliance design toward the universal design ideal. We will identify design features that offer universal access to appliances and also provide examples of appliances that incorporate such features. In addition, this report includes an analysis of factors restricting further implementation of universal design. Finally, it concludes with a summary of the state of the art in this area and some recommendations for improving the pace of innovation.

Challenged by Housework

According to the National Institute on Disability and Rehabilitation Research (1989), an estimated 14.1% or 231.5 million non-institutionalized United States residents have an activity limitation (Ficke, 1992). Of these, 8.8 million people are unable to perform a major activity and 13.6 million people are limited in a major activity.

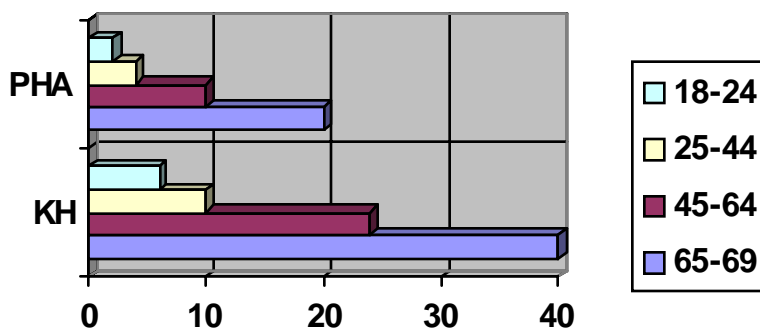
When disability is defined as a limitation in a person's ability to perform selected physical functions, more than 20% or 37.3 million people of all non-institutionalized persons ages 15 and over have difficulty performing a physical function:

Activity	# of people with disability
Walking	19.2 million
Lifting a 10 lb. bag	18.2 million
Going up a flight of stairs	18.1 million
Seeing words and letters in newsprint	12.8 million
Hearing normal conversation	7.7 million
Getting around outside the home	6.0 million
Getting around inside the home	2.5 million

Ficke, 1992.

Limitations in housekeeping are age related. This table (Ficke, 1992) demonstrates this phenomena.

Percent of People Unable to Perform Activity



PHA- Unable to Perform Household Activities

KH- Have Limitations Keeping House

The appliance industry acknowledges that many people with disabilities have difficulty using appliances:

“Using standard kitchen and laundry appliances can be a major challenge for people who work from wheelchairs, who are crippled by arthritis or who are blind. In many instances, a special tool, control or installation may be needed so someone with disability can use an appliance most conveniently. While most of these modifications are made by the user, some manufacturers do offer special aids to help owners adapt their appliances to meet the needs of a specific disability. Such aids include soft adapter knobs for those with arthritic hands and Braille controls and instructions for blind consumers. Some manufacturers and retailers offer these aids at no charge or at a very moderate cost.” (*Whirlpool Corporation, 1986*)

People with disabilities can have great difficulty operating appliances. For example, wheelchair users and people of short stature have difficulty reaching inside refrigerators, washers, dryers and ovens. Many are unable to reach cooktops and rear-mounted controls on ranges, washers and dryers. Those with arthritic hands or hand deformities find it difficult to grasp round knobs and controls; they may be unable to grasp handles on refrigerators, ovens and microwave ovens. Visually impaired people and those with low vision have difficulty reading and understanding written information on control panels. These and other design problems have been identified in a booklet produced by Whirlpool Corporation called *Tools for Independent Living: Suggestions for Installing and Operating Major Home Appliances for Easier Use by Disabled Persons*. The booklet offers many adaptive solutions to combat these difficulties. For example, plexiglas Braille overlays are available to identify controls. Large size type can help read control information by people with low vision. Others may benefit from adjusting the illumination level near the control panel. Task lighting, such as an overhead mounted lamps, can minimize glare and provide better illumination necessary for hard-to-read information. Cooktop surfaces can be made visible to seated people by installing an overhead mirror. Slip-on adapters are available for many round controls; they can be fitted on to provide a soft, enlarged surface for those with limitations of grip. Reachers can be used to

access rear-mounted control panels. Some reachers are designed so they can be operated from a distance. Others can be used to grasp things inside refrigerators, washers and dryers. A strap can be attached to refrigerator door handles to assist those with grasping problems. Another booklet by Whirlpool Corporation, *Design for Independent Living: Kitchen and Laundry Designs for Disabled People* (Whirlpool, 1986) offers further guidance. It includes information on kitchen layouts, accessible appliances and cabinets and guidance on selecting appliances.

Current Regulations

Accessibility in the kitchen is demanded by the Council of American Building Officials/American National Standards Institute (CABO/ANSI), the Americans with Disability Act (ADA) and the Fair Housing Act (FHA). The CABO/ANSI A117.1 Standard is used by government agencies and other organizations to achieve uniformity in technical design criteria. It is also used by non-governmental parties to make facilities accessible by persons with disabilities.

Controlled by the Department of Justice, the Americans with Disabilities Act applies to new construction and alterations in public and commercial facilities. The ADA Accessibility Guidelines (ADAAG) utilize most of the design specifications in CABO/ANSI 117.1. The specifications are designed to ensure that public buildings are readily accessible and usable by people with disabilities.

Appliances in transient places such as hotels, motels, inns, boarding houses, dormitories and resorts are covered by the ADAAG. It requires that kitchens, kitchenettes and wet bars be accessible. CABO/ANSI applies to residential accommodations where state code bureaus have adopted it. Both CABO/ANSI and the ADA Accessibility Guidelines require that at least fifty percent of shelf space in refrigerators/freezers must be within the reach ranges. They specify front and side reach and obstructed and unobstructed reach. For example, unobstructed forward reach to an appliance must range between 15 inches and 48 inches above floor.

Reach limits for *forward* reach over an obstruction (e.g. counter, laundry machine).

	in	mm	in	mm
Reach depth	0-20	0-510	20-25	510-635
Reach height	48	1220	44	1120
The clear floor space extending under an obstruction shall be equal to or greater than the reach depth for a maximum of 25 in (635 mm).				

Obstructed *side* reach must be 46 inches maximum, provided the height of the obstruction is no more than 34 inches from the floor and the depth is a maximum of 24 inches. Unobstructed side reach must range between 15 inches above the floor for low side reach and 54 inches for a high side reach.

According to CABO/ANSI A117.1 and the ADAAG, controls and operable mechanisms in appliances such as ranges/cooktops, ovens, refrigerators/freezers, dishwashers and trash compactors must be placed within the reach ranges mentioned earlier, the only exception being electrical and communication receptacles which must be mounted at least 15” above the floor. All controls must be accessible from a clear floor space, 30 inches by 48 inches and they must be operable with one hand. The force required to grasp, pinch and activate the controls must not exceed 5 lb.

Emergency alarm systems are covered in the CABO/ANSI A117.1 and the ADA Accessibility Guidelines. Audible alarms must produce a sound that exceeds the prevailing equivalent sound level in the room by at least 15 dbA or any maximum sound level for the duration of 60 seconds by at least 15 dbA. Visual alarms must observe the following:

1. The lamp must be a xenon strobe type or equivalent.
2. The color must be clear or nominal white.
3. The maximum pulse duration must be two-tenths of one second with a maximum duty cycle of 40 percent.
4. The intensity must be a minimum of 75 candela.
5. The flash rate must be a minimum of 1 Hz and a maximum of 3 Hz.

6. The appliance must be placed 80 inches above the highest floor level or 6 inches below the ceiling whichever is lower.
7. No place in any room must be 50 feet from the signal.

There are many items in the CABO/ANSI A117.1 section on dwelling units that are not included in the ADAAG. Some of these requirements include:

- Clear floor space: appliances, such as ranges/cooktops, ovens, refrigerators/freezers, dishwashers and trash compactors must be accessible from a clear floor space, 30 inches by 48 inches.
- Knee space requirements: The knee space under ranges and cooktops must be insulated and protected from burns, abrasions and electrical shocks. The 30 inches by 48 inches clear floor space can overlap the knee space under ranges and cooktops and the overlap must not exceed 19 inches.
- Control location: The location of controls for ranges and cooktops must not require reaching over burners.
- Oven type and adjacent space: Ovens must be self-cleaning type or be located adjacent to an adjustable height counter with a minimum knee clearance of 30 inches wide. The door latch for side opening ovens must be next to an open counter space. A pull-out shelf is required under an oven with a side opening door which must pull out 10 inches maximum when fully extended. The controls must be located on the front or side panel of the oven.
- Refrigerators: Side-by-side refrigerator/freezers provide the most accessible freezer compartment. Side-by-side refrigerators/freezers must have at least 50 percent of the refrigerator and freezer space located between 9 inches and 54 inches above the floor. Other combination refrigerators/freezers must have 50 percent of freezer space and 100 percent of refrigerator space and controls located between 9 inches and 54 inches. Freezers that do not conform

to the front and side reach specifications mentioned earlier must be self-defrosting.

- Dishwashers: Dishwashers must have rack space accessible from the front of the machine for loading and unloading.

The Architectural Barriers Act (ABA) of 1968 also requires buildings financed with federal funds to be accessible to persons with disabilities.

The 1988 Amendments to the Fair Housing Act established design and construction requirements for new multifamily housing that have five or more units and multifamily dwellings of four or fewer units if the owner does not reside in one of the units. The FHA applies to all multifamily housing, even if built entirely with private support, and, housing built for ownership as well as for lease.

The FHA Accessibility Guidelines include some recommendations about accessibility in kitchens common use and laundries. It requires that the clear floor space in accessible kitchens be at least 30 inches by 48 inches. This allows a parallel approach by a person in a wheelchair at the range and cooktop and either parallel or forward approach to oven, dishwasher, refrigerator/freezer and trash compactor. The Guidelines do not address the placement of controls on ranges or cooktops. It suggests that the controls be placed so that reaching across burners is not necessary.

The Department of Housing and Urban Development has concluded that the requirements of the FHA Accessibility Guidelines (FHAG) do not cover appliance controls and solely requires that kitchens have sufficient space so that an individual in a wheelchair has maneuverability. The Guidelines make minimum mention of environmental controls used on a daily basis such as controls for heating and air conditioning. It simply states that they be placed in “accessible” locations. Electrical outlets for individual appliances sometimes need to be mounted in non-accessible locations but these types of outlets will not be used by people with disabilities on a regular basis. Such

outlets are exempt from the Guidelines. The FHA does not require accessible laundry rooms to install front loading washers. In common use laundry where front loading washers are not provided, owners must provide an assistive device if needed by a resident. Under the Act, a stacked washer and dryer is permissible in a common use laundry. However, an assistive device must be made available to make the units usable by persons with disabilities.

We view the Fair Housing Accessibility Guidelines as the beginning of universal design in housing because they are applicable to all multifamily housing in the U.S.

Universal Design

Universal design is sometimes perceived as a “one-size-fits all” approach. This definition actually contradicts the aspiration of meeting diverse needs. Supporters of universal design argue that the one-size-fits-all approach is exactly the problem with typical mass manufactured items. Due to limited flexibility, these products do not provide choices or allow the adaptations necessary for social inclusion. Universal design, in fact, supports individualization through diversity and flexibility; different designs for different users within the same system or adjustability that can accommodate all. True universal design is often perceived as an unattainable goal. In fact, universal design does not prescribe a final state since nothing is truly universal nor is product development ever finished. Even the advocates of universal design realize that its lofty social goal is almost unattainable, it is nearly impossible to design for all people. The goal, therefore, is to approach these objectives through an ongoing process which might be called “universal designing.”

The demand for universal appliances will increase as society is transformed by demographic change. Advances in medical technology and health care not only enable people who might have died from illness or accidents to survive, they have also lengthened human life spans and improved the quality of life in old age. People are living longer and they are living longer with disabilities. Historically speaking, there are more people now with disabilities than ever before. Moreover, society is finding ways to accommodate and integrate people with disabilities with

the rest of the population. The independent living movement encourages people with disabilities to live an independent life in residential settings. Healthcare reforms have emphasized community integration over institutionalized care. As more people with disabilities have the possibility of living an independent life and the population ages, the demand for accessible homes is increasing. It is important to note that people with disabilities live in households in which not everyone has a disability. Thus, appliances must be usable to all members of a household since everyone uses the same equipment. This includes people of large and small stature, old and young, disabled and not.

Accessible appliances that are designed only to conform to the ABA, ADA or FHA, have limited usability. To insure full usability with such appliances, consumers with disabilities may need to meet their unique functional needs by retrofitting appliances based on recommendations made by manufacturers such as the Whirlpool Corporation or occupational therapists. Since earlier accessibility regulations applied only to a limited number of dwelling units, adaptation to provide greater access made good economic sense. But, now that the FHA requires a much larger number of units to be accessible, there is a real market for appliances with a higher level of accessibility. After all, what good is an appliance you can get to if you can't use it? There will be greater demand for universal design in appliances as enforcement of the Fair Housing Act improves. The Act is enforced by a complaint driven process initiated by the consumers. The CABO/ANSI A117 Committee is currently developing code language for the National Council of State and Building Codes and Standards to reflect the Fair Housing Accessibility Guidelines. This model code will be available to building code agencies who will use them as part of the building code approval process. This will improve enforcement and expand the opportunity for universal design in appliances.

Design Criteria for Universal Design

Although regulations are only a starting point in design for social inclusion, the CABO/ANSI A117.1 requirements and the technical guidelines of the ADAAG and FHAG have important design information. They can be used to provide an initial level of access.

Based on these sources and other research, the following design criteria can be used as a beginning for universal design:

- *Comfortable reach range:* Vertical reach for wheelchair users varies greatly; codes currently require 15"-48" for forward reach and 9"-54" for side reach. These reach ranges assume unobstructed reach, clear floor spaces for parallel approach and knee clearances for front approach.
- *Most comfortable vertical reach:* 24"-48"
- *The horizontal reach:* 24" maximum for a front approach.
- *Clear knee space for wheelchair users:* 30" wide and 27" high
- *Clear knee and toe clearances for wheelchair users:* 30" wide, 9" high and 6" deep.
- *Minimum protrusion:* Objects projecting from walls between the heights 27"-80" should not protrude more than 4" into the passageways.

John Salmen (1995) argues that universal design must go further. It must:

1. Absorb the properties of accessibility.
2. Go beyond the idea that "one size fits all."
3. Acknowledge diversity and suggest a means of social inclusion.
4. Offer choice in the method of use through adjustability and alternative methods of use,
5. Add value to the design.

Besides codes, there are several other sources of design criteria for more usable appliances. Steinfeld and Mullick identified twelve design guidelines for designing objects to be used by hand (Steinfeld and Mullick, 1990).



Figure 1. Finger push(photo by IDEA).



Figure 2. Flat-hand push(photo by IDEA).



Figure 3. Pinch grip (photo by IDEA).

1. Minimize the use of hands, the operation force and the amount of repositioning.
2. Use grip shapes that allow variation in grip type.
3. Size the gripping area and clearances to allow alternatives to the standard grip, including knuckles, the side, back and heels of the hand, and two-handed “pinch” grips - almost anything else will be accommodated if these alternatives are satisfied.
4. For the highest activation force, use bar shapes in a linear motion toward or away from the body, or small plate shapes in an up-down motion. Horizontal bars are better for pushing and vertical bars for pulling.
5. Avoid the use of small plate shapes that have to be pulled toward the body.
6. Avoid a repositioning that requires movement of the wrist. If rotational movement has to be used, use bars as lever handles.
7. Design the device to be used effectively with a hook, finger push or flat hand push grip whenever possible.
8. Adjust the orientation of a device to allow the hand to remain close to the neutral position as possible while an object is being used.
9. Small receptacles, like coin slots, should have openings shaped to guide the secondary objects into the opening.
10. The size limits of cross sections should follow these parameters for applicable grips:

pinch:	.12" (3 mm) - 1.2" (31 mm)
disc:	2" (50 mm) - 2.8" (72 mm)
span :	.5" (12 mm) - 2" (50 mm)
hook :	.5" (12 mm) - 2" (50 mm)
power:	.5" (12 mm) - 1.7" (43 mm)
11. The minimum size of gripping areas should be:

finger push:	.8" (20 mm) dia
flat hand push:	3.5" (88 mm) X 7.6 " (196 mm)
pinch:	1.0" (25 mm)
disc:	.8" (20 mm) deep
span:	.9" (23 mm) deep
hook:	3.5" (88 mm)
power:	5.3 " (135 mm)

12. The maximum operating force should be:

finger push:	3 lbf (1.5 kf)
flat hand push:	8 lbf (3.6 kf)
pinch:	4 lbf (1.8 kf)
disc:	3 lbf (1.5 kf)
span:	3 lbf (1.5 kf)
hook:	11 lbf (5.2 kf)
power:	7 lbf (3.1 kf)

The Trace Center at the University of Wisconsin-Madison has developed consumer product guidelines to avoid problems encountered by people with various disabilities in using standard consumer products (Vanderheiden and Vanderheiden, 1992). The Guidelines can be found on the Trace Center's Web site at <http://www.trace.wisc.edu>.

A team of experts in universal design has developed some guiding principles (Story, 1997). The Principles of Universal Design provide a useful general summary of all the issues involved. They are:

1. Equitable Use
2. Flexibility in Use
3. Simple and intuitive Use
4. Perceptible Information
5. Tolerance for Error
6. Low Physical Effort
7. Size and Space for Approach and Use

Please note that it is not our position that accessibility codes be abolished to achieve universal design. We believe that while accessibility codes are necessary to ensure minimum access, universal design should provide minimum access and more. Simply put, universal design is good design that has high social value. It has a democratic emphasis and bridges the gap be-



Figure 4. Span grip (photo by IDEA).



Figure 5. Disk grip (photo by IDEA).



Figure 6. Hook grip (photo by IDEA).



Figure 7. Power grip (photo by IDEA).

tween many functional, cultural, production, aesthetic and economic issues through an intelligent and responsive solution.

Universal Appliances

The home appliance industry is continually developing new features in response to consumer demand and to obtain a competitive edge. Thus, several manufacturers are already producing appliances that have universal design features. These manufacturers have focused on the development of a line of appliances that offer a high degree of usability for everyone. It is important to note that the companies mentioned here are not the only manufacturers of appliances that have universal design features; there are others producing similar appliances. The examples are being used as illustrations of strategies for achieving universal access.

Refrigerators

Most refrigerators project out and encroach into the kitchen floor space beyond the base cabinets (Fig. 8). Unless they are located in low traffic areas, protruding refrigerators reduce clear passage areas. Refrigerators that are nearly flush with the base cabinets providing a wider and more accessible clear floor area (Fig. 9). These refrigerators are designed with mechanical equipment at the top rather than at the rear.

The primary purpose of the refrigerator is to store food items for future retrieval, but many designs do not allow easy storage or retrieval. Fortunately, there are designs that offer excellent storage ability. Some models have a folding shelving system. This allows rapid adjustment of the space inside to accommodate storage containers of various sizes. Frigidaire models incorporate the “Gallon Door Bin”, which is designed to keep food items in place (Fig. 10). This system prevents tall bottles from toppling when the door is in use. A “Refreshment Center”, as in the GE Profile Series, provides easy access to frequently used items and also reduces door openings, thus saving energy (Fig. 11).

Continuous door handles on refrigerator doors provide infinite grasping positions. Being equally convenient for all users, they



Figure 8. Typical protruding refrigerator (photo by GE)



Figure 9. GE Profile "Built -In" refrigerator (photo by GE)



Figure 10. Frigidaire's "Gallon Door Bin" (photo by Frigidaire).



Figure 11. Frigidaire's "Refreshment Center" (photo by Frigidaire).

are a good example of universal design. However, most handles, due to their shallow grasp area, are difficult for people with hand problems or those who have larger hands. Tubular handles offer better grasping possibilities but not the infinite range of positions.

Many refrigerators provide good visibility to stored items. This reduces the need to pull out drawers to find contents. Water dispensers are one of the most frequently used convenience features in refrigerators. Some also offer illuminated water dispensers (Fig. 12). They improve visibility for those with low vision or in low lighting conditions. A front mounted control system offers easy access; it is conveniently located, very visible and easy to operate. For health conscious consumers, built-in water filtering systems save loading bottled water.

Many people have difficulty accessing vertically stacked refrigerators. Certain models have bottom mounted freezers that pull out for easy access. Most refrigerators retain spilled food and facilitate cleaning.

There are many other design strategies that could significantly improve the usability of refrigerators. For example, the current trend in refrigerator design is to provide a great deal of door-mounted storage (Fig. 13). This can make the door heavy and difficult to operate. Some commercial refrigerators are equipped with foot pedals that facilitate door opening. Such a device, if incorporated in residential models, if still usable for hand use, could facilitate door opening for everyone: frail people, those with weak arm strength or those who may have their hands occupied from carrying food items. Electrically operated door openers that work with the press of a switch, would be even better. Most storage requires adjusting shelves manually to accommodate different container sizes. This deters people from adjusting shelves on a daily basis. An electronically operated system that will adjust shelves at the touch of a button greatly facilitates storage and retrieval.

Few refrigerators on the market have large clear toe spaces. As a result, people need to stand back from the storage area, over-extending themselves when reaching into the refrigerator and lifting heavy items. Toe clearance can reduce the chance of back pain or injury.



Figure 12. Illuminated water dispenser (photo by Sub Zero).



Figure 13. Expressions Side-by-Side Refrigerator (photo by Expressions).



Figure 14. Side mounted control panel cooktop (photo by Jenn-Air).



Figure 15. GE Profile CleanDesign Cooktop (photo by GE).



Figure 16. Frigidaire's smooth top surface cooktop (photo by Frigidaire).

Cooktop

Cooktop safety is linked to the visibility of the heat source; most people with low vision have difficulty seeing gas flames. Many people, especially those with cognitive problems, have difficulty knowing which burner is on when using electric ranges. The most visible heat is radiant heat, followed by halogen heat and, lastly, heat from electric elements. Front or side mounted control panels are safer than rear mounted panels (Fig. 14). They eliminate the need to reach over a flame. Jenn-Air's Designer Line is equipped with lighted controls that glow if a burner is on. Safety can be further enhanced if there is feedback on which burners are hot to touch even after they have been turned off. This can be accomplished by controls illuminated with two different colors of light. One color indicates when burners are on and another indicates when they are still unsafe to touch. Some cooktops come with a time-controlled or pressure switch safety device that will shut the appliance off after a certain period of time if there is no pot on the burner. Accidents can result when people turn on a wrong burner. Spatial "mapping" of controls to burner location lowers the chance of this mistake (Fig. 15). This means that the layout of the controls corresponds to the layout of the burners, e.g. the left rear control turns on the left rear burner. Many people have difficulty reading control panel graphics. Back lighted control panels are more legible.

While cooking, food items collect under grills and burners, making it extremely difficult to clean and maintain the cooktop area. Glass cooktops (Fig. 16) are the easiest to clean followed by cooktops that have solid elements.

Using controls can be difficult for people with limitations of grip. Round controls are the most difficult to operate. Everyone has difficulty using round shapes, particularly when their hands are greasy. Controls shaped to facilitate gripping can improve access and convenient use.

Conventional Ovens

Bending over to lift heavy items is the hardest part of using an oven. Often people can over-extend themselves and sustain serious back injury. For those who already have back injuries,

lifting items in and out can be extremely painful. Wall mounted ovens are located at convenient height; they are safe and easy to use for standing users because they require no bending (Fig. 17).

While wall mounted ovens are easy to use, their control panels are usually difficult to reach since they are located at the top of the oven; this is especially true in double ovens. Side mounted control panels or a control panel between two stacked ovens improves convenience and use.

Most ovens on the market offer sophisticated programming possibilities. The method of operation, however, can be incomprehensible. As a result, these features may not be used. Simplified programming improves usability of automated controls greatly. As with cooktops, back lighted control panels increase readability and comprehension.

It is difficult for many people to slide out oven shelves that are loaded with heavy items. Roll-out shelves or electrically operated shelves would facilitate sliding.

The fold-down door offers an intermediate resting surface for hot and heavy items. The fold-down door, however, limits front access. Such ovens need to be approached at the side by people whose reach is limited. Side mounted doors, as found on microwave ovens, could facilitate oven use by seated users but none are currently produced.

Microwave Ovens

Microwaves can be located over a range, in the wall, on a shelf or on a counter. The counter location is usable for the broadest population. If they have counter space adjoining them, this location also facilitates transfer of hot items. Most microwave ovens are equipped with side opening doors (Fig. 18). Fold down doors, as in conventional ovens, could provide a work surface useful for transferring hot items. Unlike conventional oven doors, the smaller size would not present an obstruction. The majority of microwave ovens available in the market offer sophisticated programming possibilities. This can intimidate many people. Simplified programming greatly improves op-



Figure 17. Wall mounted oven(photo by GE).



Figure 18. Jenn-Air Microwave oven (photo by Jenn-Air).

eration. Back-lighted control panels and symbols also increase comprehension of information.

Dishwasher

A large portion of households in the United States are made up of single people or small families. They do not need the standard size dishwasher. Richlund Sales markets a compact dishwasher for smaller households (Fig. 19). This portable model can be installed in many different locations making it highly accessible and usable.



Figure 19. Compact dishwasher (photo by Richlund Sales).

Older dishwasher models have many cycle options. Newer models have sophisticated controls to reduce decision making. For example, GE makes a dishwasher that can sense the degree of soiling on dishes and automatically adjust the cycle to accommodate it. Back lighted control panels and iconic signs increase comprehension.

Most dishwashers require bending for loading and unloading. A higher mounting location (Fig. 23 and 24) can prevent over-extension and reduce pain for those with back problems. Some kitchen designers have begun mounting the unit off the floor. However, a standard mount is not yet provided by the manufacturers. Illumination in the interior can help the user ascertain the condition of dishes and also help those who have low vision. Loading detergent often requires operating small containers at low positions; this can be difficult for many people to do. An easy-to-load system would greatly increase convenience and facilitate use.

Washers/Dryers

Rear mounted control panels combined with lack of toe clearance can lead to over-extension of back, arm and leg muscles when using laundry appliances. Higher bases can raise the vent height and minimize the need for stooping down.

Front loading washers and dryers can be used from a seated position. While the majority of dryers are front loading, there are not many front loading washers. Moreover, most dryers have their controls at the rear. Frigidaire has a front loading washer and dryer in the Gallery Collection. They can be installed side-by-side or up and down based on user preference and avail-



Figure 20. GE Spacemaker dryer (photo by GE).

able space. Side-by-side installation greatly facilitates transferring laundry. Both appliances are equipped with control panels in the front (Fig. 20). These panels are easy to understand and operate. The washer is efficient and has a built-in detergent dispenser in the control panel. This makes it easy and economical to use. Richlund Sales markets a combination washer/dryer (Fig. 21). This appliance both washes and dries, without the need to transfer wet laundry.



Figure 21. Combination washer/dryer (photo by Richlund Sales).

Achieving Universal Design

Several corporations are developing universal design strategies for appliances. They view these strategies as a means to improve competitiveness by both, making a better product and also enhancing marketability of existing features. Some new appliances are even being developed in response to the universal design philosophy.

General Electric

General Electric takes a “systems approach” to design. They focus their marketing on the kitchen as an environment made up of appliances, cabinets, counters and fixtures. They emphasize both meeting user needs and compatibility between all the elements. GE demonstrated its approach through a concept called “Real Life Design”(Fig.22).



Figure 22. GE "Real Life Design" (photo by GE).

“Some people call it Universal design. Others call it Lifespan design. We think, a better, more accurate description is simply good design. It can be appreciated by everybody because it makes so much sense in everybody’s life. It takes into account that most people don’t fit the stereotypical norm. Baby boomers in huge numbers are finding out that they aren’t as spry or sure sighted as they used to be. Along with the usual problems faced by an aging population, Real Life Design also acknowledges a wide range of physical and mental abilities and impairments. It even acknowledges that a great many of our most worthy citizens are children!”

GE demonstrated its Real Life Design approach through a demonstration kitchen designed by Mary Jo Peterson. The experi-



Figure 23. GE "Real Life" kitchen (photo by GE).



Figure 24. GE dishwasher in the "Real Life Design" kitchen (photo by GE).

ence of designing this kitchen taught GE and Mary Jo Peterson several important lessons.

- Kitchen as a system of interchangeable elements: All elements must be compatible. Compatibility between appliances, cabinets, counters and fixtures is essential to good kitchen design. This requires designing elements to be interchangeable in order to meet specific needs. Manufacturers of appliances, cabinets and fixtures, therefore, must collaborate with each other to design workable connections that ensure a better fit between them.
- Appliances as a system of components: Appliance placement is a key to making an efficient kitchen. Appliances need to be adaptable for many placement possibilities. Universal design will often require making alterations to the appliances such as changing a door swing or relocating a control panel. Minor modifications must be carried out easily to achieve a good fit and attractive appearance.
- Appliance/user relationship: Kitchens are designed for use by several people in a household or different people over time. This requires that a range of working conditions be provided (Fig. 23). Appliances must be designed to accommodate the constantly changing conditions in the kitchen. For example, it should be possible to install appliances at various mounting heights, e.g. raised dishwashers and lowered cooktops. The design of each work center should also take all components into consideration at once. For example, the dishwasher height should facilitate loading and unloading of dishes from the sink and cabinets (Fig. 24).

Sub Zero

Unlike most refrigerators available in the market, Sub-Zero's 700 Series is not a single refrigerator unit, but rather it is a set of several smaller components. These components are available in the form of cabinets or drawers and are interchangeable. The 700 series is a major breakthrough in appliance design; it allows a refrigerator/freezer to be decentralized. For example, a drawer unit for vegetables can be located near the

sink; eggs can be in another drawer near the cooktop; milk, juice and leftovers in the cabinet by the table; the frozen food in the cabinet by the microwave. There are many advantages to decentralizing a refrigerator/freezer. Components can be located based on needs of a task, like type of cooking or individual user requirements like low drawer height for children and high cabinet height for adults. The location can be based on the overall design of the home, for example two units in the kitchen, one in the basement and one in the bedroom. Flexible design also allows incremental change; refrigerator unit heights can be altered as children grow and their location changed as the family composition changes. Flexible design is, of course, a primary characteristic of universal design.

AD/AS

AD/AS manufactures a device to power adjustable counters (Fig. 25). The device is a relatively inexpensive lifting system that can be added to many cabinet components. They collaborate with other companies, primarily cabinet manufacturers, to produce adjustable cabinets. Collaboration can add value to the appliance not attainable by a single manufacturer. The result is a transformation of the traditional cabinet into a hi-tech appliance. Dissemination of this innovation clearly has significant implications for fixture and cabinet design.

Garment Care

Garment Care, a dry cleaning company is in the process of filling a niche market by providing a unique delivery service. They are marketing a new appliance for safe and convenient home delivery of clothes and groceries. Called Smart Box, this appliance will be climatically controlled and electronically networked. It will overcome the “nobody-home/lack-of-security” problem in today’s neighborhoods. It could foster a shift in shopping behavior from “shopping-in-the-store” to “direct-to-home.” The major consumers of the Smart Box service are expected to be busy people who have no time to shop, home bound individuals, people who have no access to transportation and those disinterested in shopping.



Figure 25. AD/AS Adjustable countertop device (photo courtesy of GE).

Barriers to Innovation

Over the last century and a half, many social, technological and marketing forces have played an important role spurring development and innovation in appliance design. In the mid 1800's, the need to improve the working conditions of women originated the concept of home appliances through the concept of mechanized domestic work. During the early 1900's, mass production technology made the cost of this technology affordable for the average US household. But, appliance design conformed to the technological constraints of volume production at low cost - uniformity for the lowest common denominator. During the mid 1900's, competition to increase market share brought the advent of styling to attract the most buyers. The faster pace of life also was addressed by more and more convenience features and an emphasis on efficiency.

As we come close to the new millennium, there is a change in social trends. There seems to be a shift towards more pluralistic values and more of a concern for actual performance rather than just superficial styling and "featurism". While it is difficult to accurately identify the forces behind these shifts, they could be attributable to: 1) the demographic change which is creating a more diverse population, and 2) the aging of the baby boomers and their parents which is making all of us aware that the young today are the aged of tomorrow, 3) long experience with products that are difficult to use and even understand. Social and economic studies have shown that tomorrow's elderly will be different from today's elderly. They will need and demand products and services that are not currently available in the market. They are unlikely to accept assistive products as a solution to their needs and they will have the purchasing power to move product design in a new direction.

Universal design is the new approach to innovation. It is socially focused and supports the need to serve all members of the community equitably. It is technologically directed, using production technology to support individualized goals. It is market oriented, focused on making products and services economically accessible to all people. Yet, there are many barriers restricting innovation in universal appliance design. These barriers are grounded primarily in perceptions and attitudes to-

wards universal design. The removal of these misconceptions is essential for more rapid innovation.

Universal design is for the “handicapped.”

Many consumers and producers believe that universal design is for people with disabilities. It is often confused with assistive design which is more focused towards serving the unique needs of individuals. The concept of universal design, or “design for all” has been supported primarily by the disability community. Designers of universal products and environments have paid special attention to their needs. Designers recognize that these needs are not contradictory to the needs and preference of the other people. However, accommodating people with disabilities is only a the base line for universal design. Broadening the focus can avoid stigmatizing the universal design concept. Universal design should also be sensitive to issues of age, culture, race, gender and social condition. Universal designs should work for a diverse population, without demonstrating bias for one particular user group.

There is no need for universal design.

The misconception that universal design is for “the handicapped” has lead to the feeling that no one else needs it or wants it. However, the concept of universal design is grounded in the notion of usability. It demands that all things have to be usable by all people, not just by people with disabilities. Universal design is about usefulness in general. This idea works well for manufacturers, designers and consumers. They are all keen on seeing more usable products in the market. The history of mass production demonstrates the desirability of constant improvements in safety, convenience and usability. There is great support for design, development and production of products that a large group of people can use. For example, the early models of fax machines were developed for reporters to wire news and photographs. They became popular when people realized how useful these machines are for conducting business. Adjustable seats were designed for the safety of those operating war machines, for example aircraft pilots and tank operators. They became popular when the general public began to demand safer and more comfortable automobiles. The telephone was designed for people with hearing impairments. Where would we be without it today? Cell phones were developed for military communications. The desirability of portable communications has made these phones popular among the general public.

Changing demographics have created a new momentum in product design. The baby-boomers are already learning from watching their parents about the desirability of useful accessible products and how important they are for maintaining independence in old age. Everyone who has a family member with a disability is learning about the importance of accessibility in the community. The general public is learning about accessibility, as people with disabilities lead more socially integrated lives. The enforcement of mandates to end discrimination based on disability is the most powerful means of education. As a result, people are more aware of the value and the need for universal design features in products and environments. Universal design is user-responsive design. It advocates listening to consumers, translating their needs into usable designs, and marketing them as affordable products. Those who practice it will undoubtedly flourish in the years ahead.

People are not willing to pay for universal features.

There is a misconception that universal features have to be expensive and that people are not willing to pay for them. There is very little basis to this belief since design features that provide universal access are useful to a large body of users. There is no such thing as a “universal feature for people with disabilities,” or “universal features for the elderly,” or “universal features for able-bodied people.” A feature that appeals only to a specific user-group, is not universal. Universal features are usable by a variety of people. They must have mass appeal. For example, water dispensers in refrigerators are a universal design feature. They are useful for children, older people, those with disabilities and able-bodied adults. Initially developed as a convenience feature for those too lazy to open the door, the water dispenser was a novelty item. As a result, it used to be expensive. As other people began to learn about its value, water dispensers were incorporated in more models of refrigerators. From a special purpose item, they are becoming a universal feature. Greater demand for water dispensers lowered their price; they are now more affordable.

It is essential to overcome the misconception that universal appliances are only beneficial for people with disabilities. This idea persists because universal design is often confused with assistive, adaptive, accessible and transgenerational/life-span designs. Unlike universal design, all these concepts are directed

to serve the needs of people with disabilities or the aged. While universal design is none of these, it is all of them and more. Universal design is all encompassing. It is not just for people with disabilities. It is not code responsive, but code inclusive. It is not only social, technological or market oriented, it is all three.

The Future

The current approach to appliance development has focused on designing “one appliance at a time.” This approach has produced a diverse set of products that do not work well with each other, except in appearance. Unlike the machines for contemporary industrial production and office work that are designed for better interface and work flow, home appliances are independent pieces of equipment. As a result, the work flow in the home is intermittent and needs constant monitoring. This may be fine for most people, but it can be very demanding for others. Most importantly, however, better integration could produce significant benefits for everyone. A combination washer-dryer, for example, eliminates the need to transfer clothes and can eliminate human intervention during the process. They would benefit not only people with disabilities but many other groups such as pregnant woman, people with arm and back problems, those who hate housework and the time-impaired. Everybody would benefit from such appliances because they minimize human attention and facilitate work flow.

Digital technology, enables machine-to-machine communication such as the interaction of television and video-tape-recorder. They recognize each other’s presence, automatically connect when programmed to do so and record programs. Digital synchronization eliminates human presence and offers power and convenience to do complicated tasks easily. Nicholas Negroponte, Director of MIT’s Media lab, suggests that linking appliances to better serve people will be a major emphasis of the digital revolution (Negroponte, 1995). He calls this unification or inter-communication. Linking coffee makers with grinders, already brews freshly ground coffee. If an alarm clock is added, the three can inter-communicate and brew freshly ground coffee without human interaction to anticipate the user’s needs. Negroponte suggests developing a network of information between appliances and other components of the house-

hold such as between refrigerators and cabinets. Refrigerators and cabinets can automatically maintain an inventory and inform the user about what and when to replenish. Better yet, the two can be linked with a car. The car can remind the user to pick up food items on the way home, or, even as the user passes the supermarket, if a global positioning system is included.

Today's homes have more than one hundred microprocessors. But they are not yet communicating. As a result, they require a great deal of human attention. They cannot talk with each other about what food is available and when and how to prepare it. Inter-communication could revolutionize appliance design. Just like the coffee grinder/maker, the freezer could transfer food in the microwave oven, set cooking conditions, prepare the food and deliver it when desired, all without human intervention. Digital technology will reduce the need for users to communicate with machines. This will assist all of us in performing tasks involved in everyday living.

A short time ago, General Electric Plastics launched a prototype house project called Living Environments. It demonstrated many applications of future technology. The project conceived of the building as an enormous electromechanical device, made up of many integrated systems - functional, structural, electronic - all controlled by a central home computer. Among its many interesting features were:

- There were two areas for food preparation. The center island had adjustable height work/seating surfaces. The main cooking facility had hot and cold areas to prepare foods and keep them at proper serving temperatures.
- A separate functional area was provided for preparing convenience meals. This included a mini-fridge, with a countertop vegetable crisper and a cooking tower with a microwave oven.
- The main cooking surface also had portable units. Food could be prepared at other kitchen workstations or in the dining room.
- There was a bottle and package recycling center with a bar code reader to segregate engineering plastics from commodity plastics.

This “kitchen of tomorrow” demonstrated how far digital technology could take our traditional kitchen.

Students in the Art Center College of Design worked on a kitchen of the future project for Whirlpool Corporation, called Kitchen 2000. They were asked to be architecturally innovative and consider non-traditional kitchen layout and conceive how the kitchen of the future might look and work. Students were required to produce appliances designs that were real “machinery,” and search for and apply future technology that might make life a little easier and more fun in the kitchen. The students visualized the future kitchen as a domestic workstation and like a contemporary work station for information processing. They saw the kitchen as a place for processing food and an environment that supports interaction between people and appliances. Instead of a room with built-in cabinets, plumbing and appliances, the students created free-standing pieces that could be arranged in a numerous ways for maximum mobility and to reflect the preferences of an individual user. Here a few examples of their ideas:

“Cool Column” (Refrigerator) by Darrek Rosen

This is a doorless refrigerator that opens on two sides (Fig. 26). A cool air tornado swirls around the circumference of the interior keeping the inside cool, while a vertical curtain of air moves down over each large opening through jets in the top and bottom of the frame, keeping warm air out. The upper portion has chilled, rotating clear shelves for conductive cooling and visual access to food and drink. The freezer compartment is located on the bottom, which retracts on drawer slides. Above it are two side-by-side crisper drawers. A modular heat exchanger is located on top for energy efficiency and would be completely removed and replaced to service. The cool column can be easily moved around in the kitchen. It can also serve as room divider which happens to hold food. People from the adjoining room can reach inside for ingredients to make a sandwich or get a drink.



Figure 26. "Cool Column" (photo by Steven A. Heller).



Figure 27. "Malibue" (photo by Steven A. Heller).



Figure 28. "Jet Stream" (photo by Steven A. Heller).



Figure 29. "Food Closet" (photo by Steven A. Heller).

“Malibue” (countertop and sink) by Rob Bruce and John Wee

This design is an integrated sink, cooktop and work surface (Fig. 27). Cooking heat is provided by surface “hot spots”, and a recessed crock pot. An adjunct countertop floats above the work surface, providing a small serving area.

"Jet Stream" (free-standing burner) by Ed Hawkins

This burner has many high octane heat sources called candles (Fig. 28). The burner rests on a free-standing portable base that makes it possible to cart around; it can stay in a kitchen or be rolled outdoors for barbecues. The cooking pan handle can be captured by non-slip-coated “fingers” of various lengths, allowing custom pan design. Special fittings can be added to adapt the burner’s holding capability for many types of cooking vessels such as a wok or other odd shaped pans.

“Food Closet” (computerized pantry) by Marde Burke

This free standing smart unit stores and dispenses dry goods that are stored in climate controlled rotating cylinders (Fig. 29). Double doors can be opened to take goods out directly from the shelves, or, the desired product can be automatically dispensed when it is called up on a removable interactive screen. To replace goods, an inventory microprocessor uploads to the supermarket’s computer, indicates the necessary items for purchase. The storage unit can be placed against the exterior wall of the house adjacent to the garage so goods can be loaded as they are brought from the supermarket. Using the bar codes on canned or dry goods, the unit reads where food should go, keeps track of the inventory, and maximizes shelf life by maintaining optimum temperature and humidity. It also comes with a menu planner that presents menu based on what items are stored in the unit.

“Microwave Dome” by Takanori Kawai

This is a portable, rechargeable warming device that uses microwave technology to warm food right on the plate just before eating (Fig. 30). It offers two important benefits; first, being portable, it can be easily transported outdoors for a backyard picnic or a lunch in the countryside. Second, on-plate warming eliminates the need to transfer food between containers for eating and warming thereby reducing dishware and cleaning.



Figure 30. "Microwave Dome" (photo by Steven A. Heller).

“Dish Cylinder” (dishwasher) by David Zimmeroff

This dishwasher features over-under independent compartments with on-board water heater, gray water reclamation and a foot pedal to operate the door when arms are full (Fig. 31). The washing compartment has a two-tiered carousel that works like a lazy-susan; it eliminates the difficulties associated with reaching inside a dishwasher to load and unload dishes. A separate open tub on the top of the main washing cylinder cleans small items ultrasonically when they are loaded on a submersible rack. This method assures hygienic cleaning of utensils which can often trap particles of food that escape ordinary washing.



Figure 31. "Dish Cylinder" (photo by Steven A. Heller).

“Palm Power” by Simon Huang

This is a hand-held device with three functions in one. The first, is a versatile power mixer and food processor with a variety of interchangeable blades and attachments. In this mode, it is a powerful hand tool for many food preparation tasks. Then, it converts into a dishwashing mode and it works like a hand-held cleaning utensil. Finally, it transforms into a wet/dry countertop vacuum cleaner for fast efficient clean-up of the entire counter and preparation area. The unit connects to a vacuum line nearby; it can squirt water and detergent and collects debris in a disposable filter cartridge.



Figure 32. "Palm Power" (photo by Steven A. Heller).

Conclusion

The germ of universal design in home appliances has been around for a long time. It dates back to the beginning of the Material Feminist movement that identified the need to improve

working conditions for women in the home. Universal design is really user-oriented design that places great importance on satisfying user needs and preferences. For over 100 years appliances simplified work, reduced effort and reduced the need for human attention. But up until recently, they failed to take into account needs and requirements of people with disabilities, the elderly and those with different physical characteristics.

Demographic changes are expanding the populations not accommodated by the design of most appliances. Safety, usability and convenience in home design will increase in importance as more and more older people and people with disabilities live independently. Moreover, the demand for universal appliance design will increase as people become more aware of its benefits. Legislation, like the ADA and the Fair Housing Act, are contributing to attitude change and helping to develop a market. This market will grow more as the marketplace adapts to population diversity. There are already many good examples of universal features in appliances, particularly those that offer tangible and understandable benefits to all.

Universal design can serve as a marketing theme. Producers can use it as an opportunity to increase demand. To be effective, designs should have a broad appeal. The focus should not be on accessibility for people with disabilities alone. As in many examples above, design should focus on its use by a diverse population. They should emphasize the universal value of increased safety, convenience and usability.

Although there are many barriers to implementation of universal design in appliances, the major barrier is attitude change but value is a concern as well. These appliances must be cost competitive because they have to compete with generally available products. Increased costs must be accompanied by clear benefits to usefulness. Modular design can bring costs down and within the reach of users who may find certain appliance unaffordable. Modularity also reduces the need to abandon an old appliance when expanding capacity or adding features. Add-on features could be purchased as people can afford them and need them.

Universal appliances must also have a universal aesthetic appeal. That is, their appearance should not favor a certain group

of users. Designs that allow people to customize the product's appearance appeal to all users.

Companies interested in marketing universal appliances can begin by introducing "usable features" for a variety of user preferences. It is also essential to inform the users of these features by making them visible. This can be accomplished in one or all of the following ways: self advertise features by making them visible on the appliances; design them to attract visual attention; publicize them so people become aware of them. As more people learn about their presence, they will recognize their value. Of course, appliance manufacturers must do careful research and development to address the many factors contributing to the acceptance of these products by users, new builders and remodelers.

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