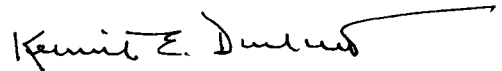


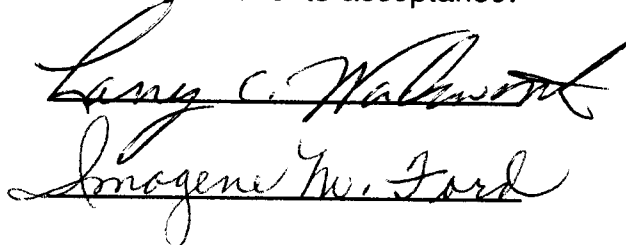
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AN EVALUATION OF FIVE UNDERPADS  
USED FOR INCONTINENCE

A Thesis  
Presented for the  
Master of Science  
Degree  
The University of Tennessee, Knoxville

Anna Rebecca Layman  
August 1989

I wish to dedicate this thesis to my grandparents, Aaron Uel and Dulaney Mae Wattenbarger. If ever asked to define love I would reply, "Granddaddy and Grannie," because they are a true example of every form of love.

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## ABSTRACT

The purpose of this study was to evaluate five underpads used to control incontinence that were commercially available on the Knoxville, Tennessee, market and to quantitatively determine which aspects of composition and/or construction influence the effectiveness of incontinence underpads in keeping the patient dry. The composition of each layer of the underpads was determined. The underpads were subjected to a series of tests that determined weight, thickness, absorbent capacity, retention capacity, wetback, coverstock surface dryness, and wicking performance. In some cases two different methods of testing for the same parameter were used to see if the same results could be obtained. The data obtained were examined using analysis of variance, Duncan's Multiple Range Test, Tukey's Studentized Range (HSD) Test, and the Wilcoxon Matched-Pairs, Signed-Ranks test.

No one underpad performed consistently better than the others in laboratory testing. One underpad, which contained a super-absorbent powder that gelled upon wetting, performed well in most tests but when the results of the test methods were normalized by mass and volume it often was ranked below other products. Underpads which contained thermal calendering performed similarly to products that were not subjected to calendering.

The second of two methods used to test absorbent capacity proved to have fewer uncontrollable variables and was recommended for use in future studies. When the absorbent capacity of the five products was examined it appeared that there was an optimum amount of fluff that can be used for maximum normalized absorbency but determination of this amount was beyond the scope of the present study. One underpad, which was composed of paper tissue bonded to plastic, had a small absorbent capacity, but did retain the liquid that it absorbed. A coverstock should be used on all products to help prevent wetback and leakage of the underpad. A polypropylene coverstock performed better than a rayon coverstock but the performance differences were not significantly different.

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## CHAPTER I

### INTRODUCTION

#### Incontinence

Incontinence, the involuntary voiding of urine or feces, is a unwanted complication in the lives of many Americans. The problem may be the loss of a few drops of urine for one individual while another person may suffer uncontrollable voiding of large amounts of liquid and/or feces. The estimates of how many Americans are incontinent range from 11 million (Jeter, 1988) to 13 to 14 million (Siegwart, 1988) but even these statistics may not account for all incontinence sufferers. Because of the stigma attached to the problem it was, and to a certain extent still is, not discussed in "polite" society. Thus many people suffering incontinence may deny that they have a problem. Incontinence is not an untreatable problem nor does it afflict only the old and feeble. Only about 4% of incontinence victims are in nursing homes (Siegwart, 1988), while many of the rest lead active lifestyles. Incontinence, the loss of bladder and/or bowel control, is a social and hygienic problem (Mandelstam 1986). To quote Dr. Katherine Jeter, (Nonwovens Industry, January 1986) "Incontinence is one of the most embarrassing, debilitating, undignified problems a person can face..."(p. 28). Serious incontinence is especially embarrassing because it signals a severe lack of bodily control. Patients who have been able to cope with other illnesses, handicaps, or growing old may not be able to handle the mental anguish of being incontinent and may feel a sense of hopelessness that can be as tragic as losing their will to live (Palmer 1985). "Urinary incontinence is a symptom rather than a disease" (Jeter, 1988, p. 206). It may be the result of birth defects, pressure exerted on the urethra or bladder, weakening of pelvic muscles, prostate enlargement, urinary tract disorders, a side effect of certain medications, injury, diabetes, stroke, psychological problems and various other health problems. Many victims may become continent again through medical care and bladder retraining. (Jeter, 1988; Incontinence Care, 1986).

While incontinence is a problem for anyone who experiences it, it is especially serious for patients confined to bed. It is this group for which this

study is indirectly concerned. These patients are often confined to bed, and underpads that are laid on the sheets are used to contain the urine. While these are only a very small group of all incontinence sufferers their situation is the most serious. If the person is unable to help himself, he may lay in his urine until someone changes the underpad. Bedridden patients must rely on caregivers to keep them dry and comfortable. Incontinence control may be accomplished through many methods. These vary from catheters to wearable absorbent products to underpads and may be used individually or in conjunction with each other depending on the patient, volume of voids, caregiver, and expense.

The absorbent products may be disposable or reuseable depending upon user's preference. Disposable products tend to be more expensive initially, but the rigorous laundering procedures and sensitivity in handling soiled products may serve to drive up the cost of reuseable products (Wilson & Dallas, January 1986). Environmental issues must also be considered when using disposables, and manufacturers are developing products that are smaller and contain materials which are biodegradable. However, cost and disposability are of secondary importance to many hospitals and nursing homes which use disposables in an effort to protect against the spread of acquired immune deficiency syndrome (AIDS) (Bouda & Bouda, March 1989). Haeker (May 1986) found that the benefits of washable incontinence-care products was greater than those of disposable articles, but the problem of AIDS present today may cancel many of these benefits. For individual patients that do not share laundry facilities with others and who do their own laundry, reuseable items may be the best choice because disposables represent a nonrecoverable cost.

Underpads, 90% of which are used in institutions such as hospitals, nursing homes and long-term care facilities, are a 100 million dollar a year business (Bouda & Bouda, March 1989). These bedpads vary from those containing super-absorbent gel used with heavily incontinent patients to those that are not much more than several layers of tissue paper bound together, and are mainly used to protect bed linens from oozing wounds. The requirements of bedpads used to contain urine vary with patient's needs. A lightly incontinent person may require minimum protection while a heavily

incontinent person will need the most absorbent product available and may use bedpads in conjunction with wearable incontinence aids.

Underpads used with incontinent patients must be absorbent enough to prevent leaks and spills onto the bed linens while keeping the patient dry. Many incontinence sufferers who use underpads are confined to bed and must be kept as dry as possible to prevent the development of skin problems. If the person is unable to help himself, he may lay in his urine until a caregiver changes the underpad. Moisture and warmth, both present in urine, may lead to dermatological problems, especially bedsores and rashes. Lying or sitting in urine is a major factor in the development of bedsores (Bedsores, 1986), so products must not only be absorbent they must keep the moisture away from the patient's skin. If the incontinence aid becomes soaked it should be replaced immediately. Complications from advanced bed sores lead to an estimated 60,000 deaths a year (Brody 1986).

Disposable incontinence products available today range from pads similar to feminine sanitary pads to diapers to underpads. The pads are designed for active people with light to medium incontinence, diapers for people with medium to heavy incontinence, and underpads for bedridden patients. The underpad, which is placed directly on the bed, may be used in conjunction with one of the other two products. Although pads and diapers are very important in today's society, this study will only be concerned with the disposable underpad.

Disposable underpads face a twofold problem of acceptance. Caregivers and patients are not informed on the variety of products available on the market, and the underpads must be inexpensive enough to compete with reusable bed pads. Only in the very recent past has information and advertising about incontinence products become available to the public. Many women with moderate to heavy incontinence use paper towels or sanitary napkins to combat urine loss because they are unaware of the effectiveness of today's products or do not know they exist. While sanitary napkins may be adequate for light incontinence other products are better for heavier losses. Recent advertising by Kimberly-Clark and by Johnson and Johnson has done much to destigmatize incontinence and increase knowledge of products available.

Published research on incontinence aids has mainly taken place in Europe and has dealt principally with wearable products. Cottenden (TAPPI, 1987) found that heavily incontinent people, the group that would use underpads, are poorly provided for in the availability of suitable products. The laboratory portion of Cottenden's work examined the materials and construction of incontinence pads. Tests were used to measure specific volume, absorption capacity and absorption time as well as pad leakage. Mechanical properties of fluff pulps were studied to determine the tendency of the pulp to break up in a pad during use. Coverstock strike-through time was determined using a test developed by the European Disposables and Nonwovens Association (EDANA). The European studies have found that coverstock penetration plays an important role in absorbent efficiency. Cusick and Hopkins, of the Department of Textiles, University of Manchester Institute of Science and Technology, Manchester, England, suggested that incontinence products should have "low wet-back, good fit and provision for ventilation or even self-drying" (Incontinence, Medical Textiles, November 1985, p. 4).

Current standard methods for testing absorbent capacity and wicking in nonwoven materials are not suitable to incontinence aids due to the plastic backing found on most products. Cottenden (TAPPI, 1987) and Shishoo (TAPPI Journal, 1987) have developed test methods for incontinence products. These tests are primarily concerned with wearable disposables but some methods are applicable to underpads.

Penetration was found to be influenced by the fluid used in testing. There is considerable debate on the subject of synthetic urine versus distilled water in testing. Because real urine varies greatly in exact composition and pH from person to person it is difficult to develop an exact model. Shishoo (PIRA 1987) advocated a 0.9% saline solution. Although synthetic urines and distilled water behave differently in absorbency testing there is not enough evidence to mandate one over the other (Cottenden, PIRA 1987, Crews et.al. 1987).

## Purpose of Study

The purpose of this study is to evaluate properties of incontinence underpads that currently are commercially available in the Knoxville, Tennessee market. Specifically, several underpads (5) are to be selected to represent the variety of products available. Compositions of the pads and their physical properties are to be determined. The data obtained to evaluate underpads will then be collectively analyzed to make suggestions on improvements in bed pad construction and composition.

The conclusions drawn by this study should be of value to patients, caregivers, and manufacturers. If dryness can be improved, patients will benefit through increased comfort and improved health. Caregivers will benefit if problems encountered in handling and changing can be reduced. Manufacturers will benefit from an improved underpad that increases customer satisfaction.

These underpads were selected so as to represent a range from the worst to the best products available. Physical and chemical assessments were made and the results used to offer suggestions for improvement while maintaining a commercially acceptable underpad. The five underpads to be studied are: Curity® Disposable Underpads manufactured by Kendall; Durasorb® and PolyGard II®, both manufactured by Professional Medical Products; Johnson's Underpad by Johnson and Johnson; and an Adult Disposable Incontinent Pant manufactured by ConvaTec™ for Squibb™. These are here after referred to as Curity, Durasorb, PolyGard II, Johnson's and Squibb respectively. The Squibb product is a folded diaper that may be pulled apart to be used as an underpad.

## Objectives

The main objective is to quantitatively determine which aspects of composition and/or construction influence the effectiveness of incontinence underpads in keeping the patient dry. An additional objective is to use a survey to assess health caregiver's attitudes in purchasing underpads. The information gained will be incorporated into suggestions for underpad improvement.

### Limitations

1. The small group of five underpads does not represent the entire market.
2. Only underpads will be examined and not other types of incontinence products.
3. Laboratory tests do not simulate the exact conditions of patient use.

## CHAPTER II

### REVIEW OF LITERATURE

This literature review gives an overview of incontinence, incontinence sufferers, the debate of disposable versus reusable incontinence aids, markets information on incontinence products, test liquids, laboratory evaluation procedures, and studies of incontinence products.

#### Incontinence

Incontinence, the "lack of constraint or control over bodily secretions that are normally voluntarily controlled" (Smith and Smith, 1987, p.7), is viewed from many different angles. This definition not only considers urine and feces it also includes tears, sperm, mucus, and milk. Urinary incontinence has been defined by the Standardization Committee of the International Continence Society (ICS) as 'a condition in which involuntary loss of urine is a social or hygiene problem and is objectively demonstrable' (Smith and Smith, 1987, p. 7; Mandelstam, 1986, p. 30). Incontinence is not a disease; it is a symptom. It can result from side effects to drugs, trauma, handicaps, bladder infections, and as a result of surgery to name a few of the many causes.

The ICS has defined stress, urge, reflex, and overflow as the four major types of incontinence. Stress incontinence may be examined as a symptom, a sign, or a condition (Mandelstam, 1986; Palmer, 1985). Urine loss when changing positions, coughing, sneezing, or other physical exertions is the symptom. "The sign denotes demonstrable loss of urine when the intra-abdominal pressure exceeds the urethral pressure" (Palmer, 1985, p. 13) as may be seen by asking the patient to cough or laugh. "The condition of genuine stress incontinence, as defined by the ICS is the involuntary loss of urine that occurs when intravesical pressure exceeds the maximum urethral pressure, in the absence of a detrusor contraction" (Mandelstam, 1986, p. 31). Stress incontinence occurs mainly in women who have given birth although it has been reported in women of all ages with and without children.

Urge incontinence has been defined by ICS as an involuntary loss of urine associated with a strong desire to void. The two types of urge

incontinence are motor urge incontinence, uninhibited detrusor contraction with the awareness to void, and sensory urge incontinence when the bladder is hypersensitive and normal bladder filling is prevented by urethral sensory receptors (Mandelstam, 1986; Palmer, 1985).

According to ICS reflex incontinence is "the involuntary loss of urine caused by abnormal activity in the spinal cord in the absence of sensation usually associated with the desire to micturate" (Palmer, 1985, p. 14). Palmer also notes that the individual with reflex incontinence is unaware of the need to void and urine escapes without conscious knowledge.

Overflow incontinence is defined by the ICS as involuntary loss of urine when the intravesical pressure exceeds the maximum urethral pressure owing to an elevation of intravesical pressure associated with bladder distention but in the absence of detrusor activity. In other words the bladder pressure exceeds the urethra pressure and the detrusor does not contract when the bladder becomes full and there is involuntary loss of urine (Mandelstam, 1986; Palmer, 1985).

### Incontinence Sufferers

Incontinence has been estimated to effect between seven and twelve million people in the U.S., although the actual numbers may be much higher. The elderly and handicapped are not the only people who suffer this affliction. People of all age groups, nationalities, and members of both sexes can suffer incontinence although an estimated 85% of incontinent people are female (Jeter, 1988). Most incontinent people lead normal lives and live at home with incontinence being their major health problem (Norton, 1986). A study completed in Great Britain found that women who have had four or more children are more likely to be incontinent as opposed to women who had never had children. It also found that certain ethnic groups are more likely to experience incontinence. Afro-Caribbean men are more likely to be incontinent while Asian women are less likely to be incontinent (Smith and Smith, 1987). Incontinence can be treated and cured even though it was, until recently, widely viewed as untreatable and caregivers were left by medical personnel to cope with the problem. Norton (1986) estimates that 90% of women with stress incontinence and 80% with urge incontinence can regain

continence if accurately diagnosed before treatment. Exactly how much incontinence can be cured is not known at this time.

The adverse effects of incontinence on patient physical and mental health are often worse than just the loss of urine. Gaining continence is a major step in a child's life and when an older person loses control they may feel that they are returning to being a child. Incontinence not only affects the patient, it affects the caregiver and family. The incontinent individual often feels a sense of hopelessness that results in depression (Mandelstam, 1986). Handicapped persons who are confined to wheelchairs have been found to desire continence over regaining use of their limbs (Smith and Smith, 1987; "Becoming HIP to the Needs of Incontinent People," January 1986). People who are incontinent often want to be left alone and try to hide the evidence from others. They fear discovery and often refuse to engage in their usual social activities (Palmer, 1985; Mandelstam, 1986; Smith and Smith, 1987). Incontinents rank fear of smell, social embarrassment, and sexual restriction as things that affected their lifestyles the most (Smith and Smith, 1987). Those who are under care must also deal with the revulsion, disgust, and anger of their caregivers (Norton, 1986; Palmer, 1985). Family and friends may resent the incontinent for losing control and grieve for the loss of independence that often accompanies the problem. Incontinence can change family dynamics as, if for example, an elderly parent must be cared for in a similar manner to that of a baby (Palmer, 1985). Increased stress, doubts about caregiving, and reports of health deterioration are found in primary caregivers of incontinent patients. The negative feelings on the part of the caregiver may lead to abuse of the incontinent (Ouslander, 1986).

Maintenance of the skin is another problem that incontinents face. The possibility of pressure sores is greatly increased if the patient has uncontrollable incontinence. Complications arising from advanced pressure sores cause an estimated 60,000 deaths a year (Brody, 1986). Both urine and feces provide a warm, moist environment that is conducive to pressure sores. Skin that is in contact with urine or feces must be thoroughly cleansed at least twice a day. Skin irritations may also be due to allergic reactions to materials used in the pad, briefs, etc. or to lotions and creams applied to the skin. Rough surfaces on some incontinence aids may cause friction that will lead to sores. Pressure and friction are more likely to cause skin problems than urine,

and only a small minority of incontinent people develop serious soreness, infections or pressure sores (Norton, 1986). If advanced skin problems are due to incontinence, a catheter might be used to keep the patient dry.

### Incontinence Control

Patient health, mobility, and skin condition must be considered when deciding on the most effective form of incontinence control. This literature review is primarily concerned with fiber containing aids that are used for controlling incontinence. Incontinence aids come in many forms. They can be disposable or reusable, wearable or placed on the bed, for light or heavy incontinence and are available in many different shapes and sizes. These products have three main layers; a facing layer, an absorbent layer and a liquid impervious membrane. They are often composites of nonwoven fabric, tissue paper, wood pulp, textile fibers, super-absorbents, foams, plastic film, etc. (Shishoo, PIRA ,1987). According to Norton (1986) an incontinence aid must:

- (a) be fail-safe, i.e. contain the excreta completely and prevent any leakage through to clothing or the environment at any time and under any circumstances.
- (b) be comfortable to wear and protect vulnerable skin from soreness, chafing or pressure sores.
- (c) be easy for the incontinent person to use and manage for themselves. Where this is not feasible due to physical or mental disability, it should be easy for the carer to use.
- (d) disguise or contain any odour.
- (e) be easily concealed under clothing, neither bulky nor noisy, and so be inconspicuous in use.
- (f) be easy either to dispose of, or wash and clean, as appropriate.
- (g) be reasonable priced and easily available. (pp. 219-220)

The many types of aids available include pads, pad and pant systems, diaper systems, dribble pouches for men, and underpads. When selecting an aid for use the type, amount, pattern, cause, and timing of the incontinence should be considered. Mobility, mental health, availability, manual dexterity,

skin problems, hygiene, facilities for cleaning or disposing of products, personal preference, and price must also be addressed. These products must have adequate instructions for proper usage for maximum effectiveness (Norton, 1986). Often products are ineffective even though they are expensive. They may also be hard to find (Jeter, March 1988). Odor is one problem that manufacturers of incontinent aids must consider. Even if the product is effective and small it is still not acceptable if it does not eliminate odor. Some super-absorbents also help combat the odor problem at the same time they decrease skin irritations through increased dryness (Bouda, March 1981).

Different aids are used with different levels of incontinence and depend on the time of day. Products available for night use are capable of absorbing large amounts of urine (Mandelstam, 1986). Lightly incontinent persons are usually adequately protected with some type of wearable aid. A heavily incontinent person, or an incontinent that is confined to bed, will often use some type of protection that is laid on the bed. These range from plastic mattress covers that are hot and do nothing to protect the patient, to reusable draw-sheets and to disposable underpads. The draw-sheet has a hydrophobic upper layer that allows urine to pass through, a lower hydrophilic layer to absorb urine and it may or may not have a plastic backing (Norton, 1986). Disposable underpads are the original disposable incontinence product ("The Incontinence Care Products Market." March 1988) and are based on the same principle as the reusable draw-sheet. They have a moisture impermeable backing, an absorbent middle layer, and a coverstock top layer. Underpads with nearly every possible combination of backing, absorbent type and amount, finishing treatments, and facing material are produced (George, 1978). The most common underpads are inadequate and consist of five layers of low-quality tissue-paper or wadding with a plastic backing (Norton, 1986). Super-absorbent polymers have been added to underpads to help increase their absorbency and to decrease odor (Palmer, 1985). George (1978) lists three categories of underpads. The low cost pad is an open end, flat plastic backed product with two layers of crepe absorbent and wet strength tissue facing. The second category is the intermediate cost, closed end flat plastic backed pad with three or more layers of crepe absorbent and tissue or nonwoven facing. George's final category is the high

cost, closed and embossed plastic backed pad with fluff absorbent and nonwoven facing. New innovations such as super-absorbents have altered these categories. Technology and designs that become available in the future will continue to redefine what is the best and worst of the products available on the market. Even the most absorbent underpads are not always effective. They do not necessarily protect the patient or the bed as well as other products. If the underpad cannot contain the urine internally the patient ends up lying in a puddle and the bed linens may become wet from spillover. The correct use of these products is important. The underpad should be laid across the bed with the sealed edges at top and bottom. Leakage would be away from the body if the bedpad failed. Caregivers often think that using multiple underpads will help prevent leaks. This is ineffective and leaves the patient lying in a larger wet area (Palmer, 1985; Norton, 1986). Norton also recommends using underpads only for bowel incontinence, slight urine leakage or as a backup to body worn pads. Research is scarce on the effectiveness of underpads but is more widely available on wearable types of incontinence aids.

Wearable aids have become increasingly popular in the last few years but many incontinent people use items readily available in their homes for protection. According to a survey compiled by Dr. Katherine Jeter, (Nonwovens Industry, January 1986, p. 30) "Nearly as many people use paper towels as use sanitary napkins for their incontinence problems, but less than 25% of those that do are satisfied with this solution". For women with light incontinence, sanitary pads may offer the best protection. Sanitary pads are small, convenient, effective, discreet, and lack the stigma often attached to incontinence aids. The disadvantages are cost, and ineffectiveness if the person is heavily incontinent. While they may or may not be the best product available for light incontinence, products designed specifically for use with incontinence are usually more satisfactory for heavier incontinence (Norton, 1986). In fact one researcher emphasized that sanitary pads are not adequate for the management of incontinence ("Textiles in Health Care," November 1985). Incontinent men are reluctant to wear pads designed for incontinence as they feel that they are wearing a feminine sanitary napkin. Many incontinent men will wear jockey shorts or briefs and insert a strategically placed newborn size baby diaper into them to contain lost urine

(Bouda, 1981). Pants, into which an absorbent pad is inserted, are usually well received if they look like normal underwear ("Textiles in Health Care, November 1985). Cottenden, et al. (TAPPI Proceedings, 1987) have made the following recommendations for a perfect pad that would:

- i) Reliably receive urine at the volumes, flow rates, and frequencies leaked by the user;
- ii) Hold that urine without leakage until the pad was changed;
- iii) Have no detrimental effect on the skin;
- iv) Be comfortable both dry and wet;
- v) Have minimal bulk;
- vi) Be easy to dispose of;
- vii) Be easy to put on and take off;
- viii) Be aesthetically acceptable;
- ix) Be cheap. (p. 155)

Pads must be selected with the individual in mind. Size and capacity are two major factors to consider (Mandelstam, 1986). For moderate incontinence a pad, usually oblong in design, that will hold 50-100ml is usually adequate. A large pad is needed to contain leakage amounts greater than 150ml. These pads are often long and bulky with their design varying from oblong, to shaped, to wing-folded. Even larger pads are available for night use (Norton, 1986). Pads may adhere to underwear but many are used with stretch pants. In clinical testing by Cottenden (TAPPI Proceedings, 1987) pads were found to be comfortable when dry but uncomfortable when wet and to have a mildly detrimental effect on skin health.

All in one diaper systems are used with the heavily incontinent, especially if they are elderly. These are often similar to baby diapers. The pant must be available in a variety of sizes. Women may have a very small waist while a man's or an obese person's waist may be much larger. It must also be available to fit all heights of people (Bouda, March 1981). Problems with these products are: they may be bulky and show under clothing, thereby alerting others to the fact that the wearer is incontinent; some of the plastic backings used are noisy; they may be hot and uncomfortable; problems may arise with product disposal; patients that have decreased manual dexterity may have trouble changing the diapers if they do not have a caregiver available; and diapers may make the wearer feel that they are no longer an

adult but have reverted to infancy. The diapers must be referred to as briefs to avoid adverse psychological impact on the patient (Palmer, 1985; Norton, 1986). Mobile patients that are lightly incontinent often prefer to wear a smaller garment and change more frequently rather than wear a noticeable, bulky one ("Textiles in Health Care", November 1985).

The male anatomy allows for more adequate protection from urinary incontinence than is available for females and Norton (1986) gives several examples of aids available for men. Devices such as dribble pouches, penile sheaths, and body-worn appliances into which the penis is inserted are available. Dribble pouches have a plastic backing with a absorbent fluff or a super-absorbent material inside and should only be used for light or dribbling incontinence. The manufacturer must also consider the product's bulkiness to prevent it from being noticeable under pants. Dribble pouches are either worn inside mesh pants or close fitting clothing (Norton, 1986). The penile pouches are usually a latex sheath, applied directly to the penis, that is attached to a collection bag. A major problem with the pouch is holding it in place. Many different methods are used with the best being a double-sided adhesive tape with good memory or medical spray adhesive. There are many variations of body worn appliances, all of which must be fitted by an expert. Most of these consist of straps that hold some type of device, into which the penis or penis and scrotum fit, that is attached to a collection device (Norton, 1986). Absorbent pads must be used for men with fecal incontinence or with a retracted penis. In addition to all the products listed above there are other methods of controlling urine loss (i.e. catheters, occlusive devices, etc.) that must be administered by trained medical personnel.

#### Disposable versus Reusable Incontinence Aids

There is an ongoing discussion over whether disposable or reusable aids are better. Study results have been mixed in regards to the effect on skin condition and the caregiver perceptions of disposable versus reusable products. Haeker (November/December 1985, May 1986) found that disposables increased the number of incidents of skin lesions and often aggravated skin problems that were present. The nursing staff reported that the products were more difficult to use and thus reduced the time they could

spend in other residents' care. Haeker could not accurately determine the economic benefits of either type of product due to a lack of pre-study figures on laundering costs and a 10 percent waste of disposable products that occurred during the study.

Sixty percent of incontinence aids used in nursing homes are disposable (Wilson and Dallas, 1986). But disposability of products is a major ecological concern today and disposable diapers contribute substantially to landfill and water supply contamination. Yet, not only is product disposability an ecological concern, it is a matter of practicality. The incontinent consumer must dispose of the product in a suitable manner. The pads may be burned, but most incontinent people either use a garbage service or are mentally or physically unable to burn the used products. Often bags placed curbside, or placed in a communal garbage bin for pickup, break or are torn open by animals, and this can lead to serious health and social problems with neighbors. Also disposing of pads when the incontinent person is away from home is a problem. If staying with someone it is usually impossible to hide the problem, and the individual's host may not be equipped to eliminate the used pads. Disposal in public restrooms is also a problem. Female restrooms may or may not have bins for disposal of sanitary napkins, but even these may not be adequate for some of the larger pads. Male restrooms often do not have any type of disposal containers, and both sexes may have to wrap their soiled pads and take them home for disposal (Norton, 1986).

Nursing home patients are often aware that disposables are a non-recoverable cost. Patients have been found trying to launder disposable products for reuse (Wilson and Dallas, 1986). When considering that "the average incontinent person uses six briefs or pads a day" (Incontinence Care, September/October 1985, p. 7) incontinence can be very expensive. Disposable products may only be used once and may have to be thrown away unsoiled if the patient is on a toileting program and the product is damaged upon removal and cannot be refastened (Haeker, November/December 1985, May 1986). The Montreal based Med-I-Pant, which manufactures and distributes reuseable briefs and pads, estimates that reuseable briefs have a life expectancy of 80 washings and a pad of 200 washings ("Incontinence Care," September/October 1985). The disposable versus reusable issue has

yet to find an adequate solution and manufacturers must keep it in mind when developing products.

### Markets

The adult incontinence market is difficult to define because items such as sanitary napkins and baby diapers which are not intended for this use are frequently used to control incontinence (Bouda, October 1986). The incontinence product market nevertheless has experienced steady growth in the past. In 1977 factory sales of underpads alone were close to 100 million dollars and were increasing at an annual rate of 3-5% (George, 1978). Predictions in January 1983 were that the sales of adult incontinent pads in the U.S. would reach \$6 billion by the year 2000 (Silk, January 1983). Incontinence pad sales in 1983 were \$200,000,000 with Proctor and Gamble holding 65% of the market. Kimberly-Clark was a distant second with 10%, and all others together had a total of 25% of the market. There were 400,000,000 units produced in 1983, and this number was expected to triple before full market potential is reached (Bouda, Nordgren, and Hessner, October 1984; Bouda, January 1985). The incontinence product market upheld earlier predictions of expansion. Coverstock alone for these products was the fastest growing segment of the disposables market in 1985, increasing at a rate of 18% ("The U.S. Disposable Nonwovens Market," October 1986). Coverstock for sanitary napkins, underpads, and adult diapers was a \$65 million market with 1.2 billion sq. yds, sold in 1984 and 1985 (Jacobsen, August 1986; Starr, December 1984). This was an increase from \$35 million for the same market in 1974. Sales of disposable adult diapers were predicted to increase from \$50 million in 1984 to \$250 million in 1990, but this market was not expected to become profitable without significant investment and five years time (Starr, December 1984). More recent predictions put the potential market at \$2.7 billion by 1990. The adult incontinence pad business had only penetrated 5% of the consumer market as late as January 1987. The growth of both the consumer and medical markets for adult pads was projected to be high as they gain acceptance by moderately to heavily incontinent people, while the underpad market was expected to decline (Starr, January 1987). Starr also predicts that some

disposable adult pad companies may cease production due to excessive competition or when they are no longer committed to their manufacture. Most underpads are used by hospitals for a variety of procedures, while disposable diapers and pads are favored by nursing homes. In 1987 adult diapers were projected to be a \$209.4 million market, followed by pants/pads, \$108.9 million and underpads \$51.5 million ("The Disposable Incontinence Market" January 1987). These predictions were exceeded as the dollar volume of incontinence products reached \$450 million by the end of 1987. Part of the increase was due to higher prices of products as dollar volume increased more than unit volume (Bouda, March 1988). Forecasts for the market in the 1990's is \$2.7 billion, but this figure also includes products used for incontinence control that are not specifically designated as such. As of March 1988 Proctor and Gamble still led the incontinence products market, followed by Kimberly-Clark with 15%. Other national producers are: Baxter Hospital Supply, Dri-Pride, Hosposable Products, Johnson & Johnson, MB Products, Principle Business Enterprise, Professional Medical Products, and Whitestone Products. These companies are now being challenged by private label manufacturers for an ever increasing share of the market ("The Incontinence Care Products Market." March 1988).

Marketing of incontinence aids is hindered by a lack of information available to the public on incontinence and methods of managing it. Both the person with the problem, and the health professionals are uninformed, and they may be confused by the array of products available and when and how to use them (Brown, November 1986). Penetration of the European market is slow because of "better medical training of incontinent people, products are not yet satisfactory, (and) people and/or institutions cannot in many cases afford the prices which we are seeing" (Roussin-Moynier, November 1987, p.8). While as much as \$300 a month may be spent by the incontinent person or a caregiver for incontinence containment in the home, reimbursement for incontinence aids by the Health Care Financing Administration is nonexistent for absorbent products and skin protectives and is limited for such urological devices as indwelling catheters, leg bags, and urethral compression clamps for men (Jeter, March 1988). The stigma attached to incontinence is very apparent when marketing and advertising products. Since incontinence products are not mentioned in polite society, their marketing is similar to the

sanitary napkin market of 25 years ago, unmentionable and incognito. Manufacturers cannot boldly say that they are selling incontinence products but must hide behind pretty words and phrases that are deemed acceptable for the advertising media. As recently as 1986 the American Association of Retired People refused to allow advertising for incontinence products in its magazine *Modern Maturity* because it did not create a positive image. This magazine serves older Americans so it can be said that about 10% of their readership is probably incontinent. Many of these older people refuse to leave their homes because of fear of an accident. Advertisements in this magazine would give them access to information about the range of new products available for incontinence control and would allow them to live a more normal life (Bouda, October 1986). Some manufacturers have begun to advertise and specify products for incontinence. This is helping to bring the problem to the public's attention and will help with product marketing (Jeter, January 1986; Wilson and Dallas, January 1986).

One bright note in the marketing of absorbent products is that the manufacturer is making the products more accessible to the public. Aids are becoming available in retail outlets such as grocery stores, and chain drug stores. This is beneficial to the consumer as well as to the manufacturer who experiences increased sales (Brown, Mar 1988). Many of the chain drug stores have their own private label brand of incontinence products and are placing special emphasis on the submarket that targets the moderately to heavily incontinent, because this group uses undergarments which are 44% of total category sales. Customers like private labels because of 25-35% savings and retailers realize about a 15% higher profit margin than on national brands ("Private Label Incontinence: The Latest Success Story." August 1986). Aids are also being made available through mail-order houses who report strong sales in incontinence aids. Direct mail order from the manufacturer has met with mixed success. But specialty mail-order houses which offer many different brands, both disposable and reusable, have gained favor with some pharmacists and other suppliers as well as with individuals. Even with all of the changes taking place in the marketing the products will not sell without education being provided on the types of products available and their correct usage (Brown, March 1988).

## Test Liquids

One important aspect when standardizing the testing of absorbent incontinence products is the test liquid. There is much debate over which liquid is the best model of urine (Cottenden 1987, and November 1987; Crews, et al. 1987; and Shishoo, July 1987, November 1987), because the nature of the liquid influences absorbency. Synthetic urines behave differently from distilled water during absorbency testing, but research is not yet conclusive on which is the best model of urine (Crews, et al. 1987). Urine characteristics such as surface tension, viscosity, pH and density vary with the individual samples. Cottenden, (November 1987) characterized samples of real urine and found this to be true. Also tested were four synthetic test fluids and distilled water. It was found that surface tension and viscosity of distilled water and urine are approximately the same but the viscosity of synthetic test fluids is more temperature sensitive than the viscosity of urine. As the temperature is increased, viscosity decreases. Because of this sensitivity, large temperature differences should be noted when testing absorbent materials.

Real and synthetic urine showed a difference of up to 15% in absorption time with the smallest differences being between water and the real urine. Due to these facts water was chosen to be the best model for urine in testing fluff pulps (Cottenden , November 1987). Cottenden (1987) also found that in testing coverstock strike-through times, synthetic fluids underestimated the time (as compared to real urine) by up to 40%. In these tests, water and saline solutions performed the least satisfactory while two other synthetic fluids were better.

The contents of synthetic urines are varied. Crews, et al. (1987) have developed a synthetic urine that contains: urea, 19.4g; sodium chloride, 8.0g; calcium chloride, 0.6g; magnesium sulfate, 1.0g; and water, 971.0g. Shishoo (July 1987, November 1987) advocates a 0.9% saline solution with pH range of 6.1-6.4. Adjustment of pH is through buffering agents, like  $\text{KH}_2\text{PO}_4$  or  $\text{Na}_2\text{HPO}_4$ . Suggested use conditions are  $20^\circ\text{C} \pm 2^\circ\text{C}$ . Biological stains may be added to aid in visibility and photography. Other synthetic test liquids are available and certain tests specify which liquid to use (Cottenden, 1987).

## Laboratory Evaluation Procedures

Absorbency testing for incontinence is accomplished by many methods. The INDA standard test for absorption, IST 10.0 - 70 (R82) and the very similar ASTM Absorbency Time and Absorptive Capacity tests, D 1117 -80 Section 5, for testing nonwovens are neither suitable for incontinence aids due to the fact that most have a water impermeable plastic backing. Tests have been developed specifically for incontinence aids (Shishoo, July 1987). Cottenden (1987; and November 1987) used tests developed by the Scandinavian Pulp, Paper, and Board Committee (SCAN) and the Norwegian Pulp and Paper Research Institute (PFI). "For SCAN testing a flat cylinder of fluff pulp (3 grams in weight and 50mm in diameter) is prepared in a standard way and placed in a testing apparatus which measures its specific volume, absorption capacity and absorption time. The absorption capacity is defined as the weight of water that one gram of the pulp will hold under a compression of 2.5 kPa and the absorption time is defined as the time taken for water to rise through the full height of the 3 gram pulp specimen" (Cottenden, 1987, pp. 158-159). The PFI test in which a piston is forced through a 1 gram, 50mm diameter disc of the pulp is used to measure the mechanical property of network strength. Network strength is the maximum load required to burst through the pulp sample.

Shishoo (July 1987; and November 1987) has described Swedish Institute for Textile Research (TEFO) tests developed specifically for urinary absorption aids. Shishoo describes these tests in detail in the TAPPI Journal, (July 1987, pp. 94-100):

- Method for determining product's capacity to absorb and retain liquid
  - Method for determining product's retention capacity after spread of liquid in a sample that has been bent to simulate user conditions
  - Method for determining the extent of liquid spread in a sample that has been bent to simulate user conditions
  - Method for determining product's absorption capacity and leakage using a mannequin tester
  - Method for determining product's rate of liquid absorption
  - Method for determining surface dryness on coverstock of wet product.
- (p. 94)

The product's capacity to absorb and retain liquid test utilizes a 100cm<sup>2</sup> circular specimen that is saturated and subjected to weights of 100g at the start of the test, 2.9kg after 10 minutes, and 2kg after an additional 5 minutes. The total pressure after all of the weights have been added is 5kPa. The liquid that is forced out of the specimen is then collected and the volume noted. The amount of liquid left in the specimen, determined by subtracting the amount of liquid forced out of the sample from the original dosage, is the product's capacity to absorb and retain liquid.

Coverstock surface dryness can be tested in a manner similar to the previous test. The sample is saturated and placed under a 100g weight for 2 minutes after which the coverstock is removed and placed on a sheet of nonabsorbent paper. Preweighed filter paper is placed on top and a 20g load is added for 60 seconds. The filter paper is weighed and the amount of moisture gained is noted and used as a measurable parameter for coverstock dryness.

The method of testing retention capacity after liquid absorption in a bent sample consists of placing a sample in a bent frame that simulates the waist and crotch of a human body and saturating it with 300mL of liquid. After 5 minutes the sample is removed and laid flat. A weight is placed in the crotch portion of the sample and after 5 minutes the portion under pressure is cut out and liquid retention is measured at pressures of 3kPa and 5kPa. Retention capacity is the mass of the wet sample minus the mass of the conditioned sample. The results are expressed in grams.

Extent of liquid spread in a bent sample is determined using a bent frame that has uniformly placed liquid sensor pins that penetrate the absorbent material and are attached to a recording unit. Liquid is applied and allowed to spread throughout the specimen for 10 minutes, at which time total liquid spread in the product is noted. Since this device also records the time at which the liquid contacts each of the detectors, a rate of liquid spread can be calculated. Results of this test are expressed either graphically or pictorially, showing the time it takes the liquid front to reach certain distances from the liquid source.

A mannequin tester is used to test absorption capacity and leakage under simulated end-use conditions. This tester developed at TEFO allows for testing of the products in simulated standing and lying on side positions. Rate

of liquid absorption is used to determine the time it takes a given quantity of liquid to penetrate the coverstock and go into the absorbent structure and to be completely absorbed into the structure.

### Studies of Incontinence Products

One hindrance to the disposable absorbent products market is a lack of research on incontinence and incontinence underpads. This is because incontinence itself is not considered to be life threatening (Jeter, March 1988).

Cottenden, et al. (TAPPI, 1987,) have examined both clinical and physical performance of incontinence aids available in U.K. They examined "...the relationships between the clinical performance of the pads, their design features, and the properties of their constituent materials" (p. 155). While this study dealt only with pad and pant systems, most of the information gained can be applied to all incontinence products. The pad and pant systems were selected to be representative of the U.K. market in April 1983. Design features of the pads were noted along with weight and dimensional features. Coverstocks and fluff pulps were extensively examined. Fluff pulps were identified as chemical, mechanical or a mixture of the two and then characterized using techniques developed by the Scandinavian Pulp, Paper and Board Committee (SCAN tests) and by the Norwegian Pulp and Paper Research Institute (PFI test). The SCAN tests were used to measure specific volume, absorption capacity and absorption time as well as pad leakage. Mechanical properties of fluff pulps were studied using the PFI test, which determined the tendency of the pulp to break up in a pad during use. On all tests five repetitions were made and the mean and 95% confidence level calculated for each test parameter. All of the above tests were conducted using water under initial sample conditions of 20°C and 75% relative humidity. A strong ( $r = 0.85$ ) correlation was found between specific volume and absorption capacity and a fair ( $r = 0.56$ ) correlation between specific volume and network strength. Cottenden also found that mechanical pulps increased absorption time as compared to the other pulps tested. Coverstock strike-through time was determined using a test developed by the European Disposables and Nonwovens Association (EDANA). This test was conducted using a 0.9% w/v saline solution under conditions of 23°C and 43% relative

humidity. All pads except one fell within the strike-through time range of 1.00 to 4.18 seconds. Relationships between coverstock materials and strike-through time were not examined due to the variety of unidentified finishing agents assumed to be used in manufacture.

The clinical portion of Cottenden's incontinence pad testing consisted of 137 subjects. "Information was obtained about each subject's medical state, the nature and extent of his or her incontinence problem and his or her general social circumstances" (p, 161). Subjects were also tested for cognitive function. Each subject or caregiver was given three days worth of preweighed pads with instructions to place them in individual bags after use. The used pads were collected and weighed allowing the subjects to be divided into three groups on the basis of the amount and time of day that they lost urine. These three groups were then given the test pads that best fit their type of incontinence according to manufacturers' information. Group I experienced minor daytime urine loss; Group II had heavy daytime urine losses; and Group III suffered both heavy day and night losses. Pads selected for each group were placed in random order and given to the members. Each product in the study was used for seven days. Questionnaires were used to gain assessment of the products' performance and the mean score of each question was determined for correlation with the technical and design data. Cottenden, et al., reported the following results. Group I, having minor urine loss, was relatively well provided for by the market with the choice being a rectangular pad used with marsupial pants. Leakage of incontinence pads was not a serious problem with dry comfort having a positive score and wet comfort receiving a negative rating. Pads were considered to have a slightly adverse effect on the skin, and none of the pads exhibited serious clumping of the pulp fluff. Group II, having heavy day loss of urine, only gave a positive reaction to two of their allotted products, a plastic-backed shaped pad and an all-in-one elastic leg diaper. This group reported problems with leakage but again most pads were given positive dry comfort scores and negative wet comfort scores. It must be considered when examining Group II data that part of the responses were from care providers and not from the actual subject. Clumping and skin health results were very similar to Group I. Group III, having heavy day and night losses of urine, was not adequately provided for and only one pad, a plastic-backed shaped, non-uniform thickness pad, was

given a positive score. Data collected was similar to that of Group II. Correlations between clinical data of Group I for wet comfort and reaction to their pads, had a confidence level of  $p < 0.05$  and was followed by dry comfort and incidence of leakage. These were the three most important considerations of Group I when deciding overall reaction to the pad. It was also found that wet and dry comfort were related with a confidence level  $p < 0.05$ . Leakage and effect on skin had a correlation with a confidence level of  $p < 0.1$  while dry comfort and skin health were weakly related. Groups II and III only exhibited correlation between leakage and overall reaction to pads. In correlations between clinical and design data Group I would prefer a pad approximately 270mm long, 105mm wide, and 11mm thick. Dry comfort for this group was determined by pad width and lateral compressibility with a narrow, compressible pad being the most desirable. Group II desired a pad 530mm long and around 205mm wide but did not specify thickness. Group III desired a 315mm wide pad that was 11mm thick but did not express a clear preference on length. Clinical and technical data correlations were evident for coverstock strike-through time and leakage ( $p < 0.05$ ) for Group I. Group II had no similar correlation and Group III exhibited an unexplained highly significant negative correlation for these two parameters. Pad absorption per unit length and leakage exhibited significant negative correlations in all three groups. Pulp embossing or different configurations of plastic edging showed no evidence of reducing pad leakage. Further research is being conducted by Cottenden and his colleagues to more closely examine certain of the results gained from their study.

### Summary

Incontinence is a serious problem that confronts people of every age, sex, and ethnic group. It is especially formidable to the handicapped, elderly and others who are bedridden or unable to care for themselves as it signals a loss of control over their bodies. The mental disposition, especially of this group, may be as critical as the physical plight as they may consider the loss of continence as a signal of their loss of independence and adulthood. If these patients are left lying in their urine or feces, or if bed linens become soiled due to the use of an inferior product, it compounds their predicament.

Caregivers face the unpleasant task of exchanging the soiled materials with clean and may actually resent the task and the patient's loss of control. Tension between caregiver and the incontinent sufferer, intentional or not, may magnify the accompanying sense of hopelessness. On the physical side of the issue, maintenance of the skin is a critical issue. The warmth and moisture present with incontinence may lead to dermatological problems. Materials used in the underpads may also cause skin irritations and special care must be taken with their selection and in the choice of any possible finishing processes.

The requirements suggested by Norton (1986) and Cottenden (1987) for wearable incontinence aids also apply to underpads as they too must be able to contain the excreta, be leakproof, not cause skin problems, be easy to change and dispose of, and be reasonably priced. Also, type and degree of incontinence must be considered as well as the time of day that the underpad is used. Products used at night should be able to contain large voids of urine and keep it out of contact with the patient at the same time. In some severe cases a wearable absorbent product should also be used in conjunction with the underpad.

Disposable underpads will continue to be used even with the public's concern over the environment and the fact that they cost more than reuseable products. The sensitivity of handling soiled products by caregivers as well as the strenuous laundering procedures required to adequately clean reuseable products influences when purchasing decisions are made. In addition the recent problem of AIDS ensures that disposable articles will continue to be used. Disposable incontinence products are a multimillion dollar business, and manufacturers will continue to improve their products while trying to lower costs to eliminate the advantages of the reuseable items.

Most of the standard testing procedures for absorbent products cannot be used to evaluate incontinence articles. This is because most incontinence aids have a plastic backing and accepted procedures of INDA and ASTM require the specimen to be coiled and placed in a small basket before submerging in water. The plastic backing would prevent penetration and thus skew the data. There are yet no widely accepted testing methods for incontinence aids and most of the published techniques were developed in Europe. Shishoo (July 1987) has developed several procedures for wearable

products that can be adapted for use with underpads. Properties measured in the absorbent should include absorbent capacity, retention under pressure, coverstock dryness, wicking properties, and wetback. Shishoo has developed tests to measure most of these properties plus other procedures to evaluate performance of products that are specific to wearable aids. Additional data not covered by Shishoo can be obtained by simple variations of his tests. For example examining product retention at 80% of absorbent capacity would allow the experimenter to predict possible leakage problems.

The use of test liquids that simulate urine are another concern for the researcher. Several synthetic fluids have been suggested but while some perform better than others, none accurately model urine. This is due to the variation in urine specimens from person to person and the normal deviations in an individual's specimen depending on diet, medication, illness, etc. Because of the lack of an adequate model this research used distilled water which performed well in several tests compared to synthetic fluids (Cottenden, November 1987, Crews, et al. 1987).

Cottenden and his colleagues (1987) have led the way in both clinical and physical testing of incontinence products. They examined the design features, and types and combinations of materials used in pad and pant systems available on the market in England in April 1983. Properties examined were specific volume, absorption capacity, absorption time, pad leakage, coverstock strike-through time, and pulp network strength. They found that individuals suffering heavy day and night time losses of urine were inadequately provided for. Problems that were found with products used by this group included leakage, wet comfort and dry comfort. This is the group that would probably use underpads for at least partial control of incontinence. Most research completed at this time has been mainly concerned with wearable aids. Underpads have been largely ignored. This may be because the wearable articles command a much larger percentage of the market and are in greater demand by the general public. However, many of the findings from these studies help in the understanding of underpad performance even though underpads need to be examined separately from wearable absorbents.

## CHAPTER III

### METHODOLOGY

The objective of this study was to examine underpads and their components to determine what characteristics lead to an underpad with maximum absorbency and minimum wetback and leakage. The following chapter includes the initial market survey, a description of the products used, and the survey. It also contains descriptions of the various test methods used in this research.

#### Hypotheses

The following hypotheses were formulated.

1. Absorbent capacity-method 1 and absorbent capacity-method 2 will be significantly different for the five underpads (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).
2. Wicking capacity and absorbent capacity-method 1 will be significantly different for the five underpads selected (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).
3. Wicking capacity and absorbent capacity-method 2 will be significantly different for the five underpads selected (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).
4. Retention capacity at 3kPa pressure at 80% of absorbent capacity and at 100% of absorbent capacity will be significantly different for the five underpads (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).
5. Retention capacity at 5kPa pressure at 80% of absorbent capacity and at 100% of absorbent capacity will be significantly different for the five underpads (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).

6. Coverstock surface dryness and wetback-method 2 will be significantly different for the five underpads (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).
7. Wetback-method 1 and wetback-method 2 will be significantly different for the five underpads (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).

### Market Survey

An informal market survey was conducted to determine the variety of underpads available to the general public in Knoxville, Tennessee. Druggists listed under the Pharmacy heading in the phone book were contacted and questioned briefly about brands, sizes, and prices of underpads carried. From this information five underpads were selected for evaluation which represented a cross-section of design features available in the local market.

### Materials

The bed pads selected were the Johnson Underpad manufactured by Johnson and Johnson; an Adult Disposable Incontinent Pant manufactured by ConvaTec™ for Squibb™; Curity® Disposable Underpads manufactured by Kendall; and Durasorb® and PolyGard II® manufactured by Professional Medical Products. The Squibb product is a diaper which opens into a underpad. The Johnson's product is comprised of an absorbent tissue paper bonded to plastic backing. Four of the underpads, Curity, Durasorb, PolyGard II and Squibb, are combinations of the following components: a coverstock, underneath which lies a layer of tissue; a layer of absorbent fluff that may or may not have been bonded through thermal calendering; and a plastic backing which helps prevent leaks and spills. The PolyGard II also contains a super-absorbent powder that gels upon wetting.

Fiber composition of the underpads was determined using standard techniques. These included scanning electron microscopy, polarized light microscopy, and thermal analysis. Thermal analysis involved Differential

Scanning Calorimetry (DSC) which determined the polymer's melting temperature. The layers (listed in order) from the top layer that would be in contact with the patient's skin to the bottom layer of plastic backing that is placed against the bed linens. The following compositions appear to include:

I. Curity

|            |                     |
|------------|---------------------|
| coverstock | - rayon             |
| tissue     | - cellulose         |
| fluff      | - cellulose         |
| plastic    | - conventional film |

II. Durasorb

|                |                     |
|----------------|---------------------|
| coverstock     | - rayon             |
| tissue         | - cellulose         |
| fluff (bonded) | - cellulose         |
| plastic        | - conventional film |

III. Johnson and Johnson's

|         |                     |
|---------|---------------------|
| tissue  | - cellulose         |
| tissue  | - cellulose         |
| plastic | - conventional film |

IV. PolyGard II

|                |                                           |
|----------------|-------------------------------------------|
| coverstock     | - polypropylene                           |
| tissue         | - cellulose                               |
| fluff (bonded) | - cellulose with a super-absorbent powder |
| tissue         | - cellulose                               |
| plastic        | - conventional film                       |

V. Squibb

|                |                     |
|----------------|---------------------|
| coverstock     | - rayon             |
| tissue         | - cellulose         |
| fluff (bonded) | - cellulose         |
| tissue         | - cellulose         |
| plastic        | - conventional film |

The conventional film backings showed no regular pattern of micropores, when examined under a polarized optical light microscope. Scattered holes were visible in some samples but these were very scarce and random, so they were assumed to be fabric defects.

### Survey of Health Care Administrators

In order to determine characteristics desired in an underpad by consumers a survey of administrators of longterm healthcare facilities in the East Tennessee area was conducted. The instrument was developed, by considering issues concerning incontinence, its complications, and the problems that had been found to face incontinence underpad users, from information found in the review of literature. The instrument dealt with product purchasing. Factors influencing decision making concerning the underpads that were purchased were examined in detail. The surveys were sent to seventy five Administrators/Directors of Nursing at health care facilities with and cover letter and an enclosed return postage paid envelope. (See Appendix A.)

### Methods

All tests were conducted using samples of the underpads that had been conditioned overnight at 21°C and 65% relative humidity.

### Test Liquids

This research employed distilled water that had been allowed to come to room temperature (21°C) in all test methods requiring liquid. This was due to fact that none of the synthetic fluids that have been previously tested accurately model urine (Crews, 1987) and distilled water was found to behave well when tested against saline solutions.

### Weight

Total weight and the weight of the individual layers of the underpads were determined in accordance with ASTM Test Method D3776-85. Five centimeter square specimens of the underpad were cut randomly from the underpad. A Mettler Balance, a single pan model H72 accurate to 0.0001 gram, was used to obtain a mean weight and its standard deviation for each underpad. The mean weight was used as the representative figure for each type of underpad.

### Thickness

Total thickness and individual layer thickness of the incontinence underpads were determined in accordance with ASTM Test Method D1777-64. Five centimeter square samples were cut from each product. Five determinations on each specimen were made using an Ames Thickness Gauge. Mean and standard deviations were calculated and the mean used to represent each underpad.

### Absorbent Capacity-Method 1

Five 15.24 centimeter (6 inch) square pieces were cut from each underpad. The squares were saturated with distilled water and allowed to drain for three minutes at a 45° angle while held by a metal clipboard. The time was sufficient to allow for complete absorption and to eliminate dripping. The weight of the squares when dry and after draining allowed the absorbent capacity to be calculated by the following: weight of wet sample minus the weight of dry sample equals the weight of water in sample. This value divided by weight of dry sample equals capacity (g/g). The capacity measurement was replicated five times for each underpad.

### Wetback-Method 1

The purpose of the wetback test was to measure the amount of water that the underpad would release through the coverstock after absorption. The entire underpad was conditioned at 21°C and 65% RH overnight. Distilled water was brought to room temperature. Two hundred milliliters of water was delivered to the underpad, from a height of 2.54 centimeters at a rate of 3 milliliters per second. After a time lapse of five minutes two preweighed

squares of blotter paper were placed in the center of the underpad with a glass weight of 152.5 grams on top. Paper and glass weight size were 10.16 centimeters (4 inches) square. After 30 seconds the blotter paper was removed and immediately weighed. The difference in dry and wet weight of the paper was the amount of wetback in grams.

#### Absorbent Capacity-Method 2

This is an adaptation of the procedure developed at the Swedish Institute for Textile Research (TEFO) and reported by Shishoo (TAPPI Journal, July 1987). Figure 1 depicts the testing apparatus which consists of a large funnel with a glass frit and a graduated collection cylinder. A circular specimen with an area of 100 centimeters<sup>2</sup> was conditioned overnight at 21°C and 65% RH. The sample was placed with the plastic backing against the glass frit. One hundred milliliters of liquid delivered at a rate of 7 milliliters per second from a height of 2.54 centimeters was used to saturate the specimen. A 100 centimeter<sup>2</sup> circular weight of 100 grams was promptly placed on the saturated specimen and the assembly allowed to drain for 10 minutes. The amount of liquid collected in the cylinder is determined and used to calculate the absorbent capacity (C) of the product by the following calculation.

$C = a - b$  where  $a$  = total liquid dosage (100 milliliters)

and  $b$  = liquid unabsorbed (milliliters) under 100Pa pressure

Seven replications were completed for each underpad examined and the results are reported to the nearest milliliter.

#### Retention Capacity

This is a continuation of Absorbent Capacity-Method 2. After determining the amount of unabsorbed liquid at the end of 10 minutes in the preceding test, 2.9 kilograms of weight was loaded on top of the sample for a total pressure of 3kPa (100Pa were already on the specimen from the previous test) and the assembly allowed to drain for five minutes. The amount of liquid in the cylinder at the end of this elapsed time is noted and an additional 2 kilograms of weight were added for a final total of 5kPa. The wetted sample was allowed to stand for five more minutes and the amount of liquid collected in the cylinder was then determined. The amount of liquid

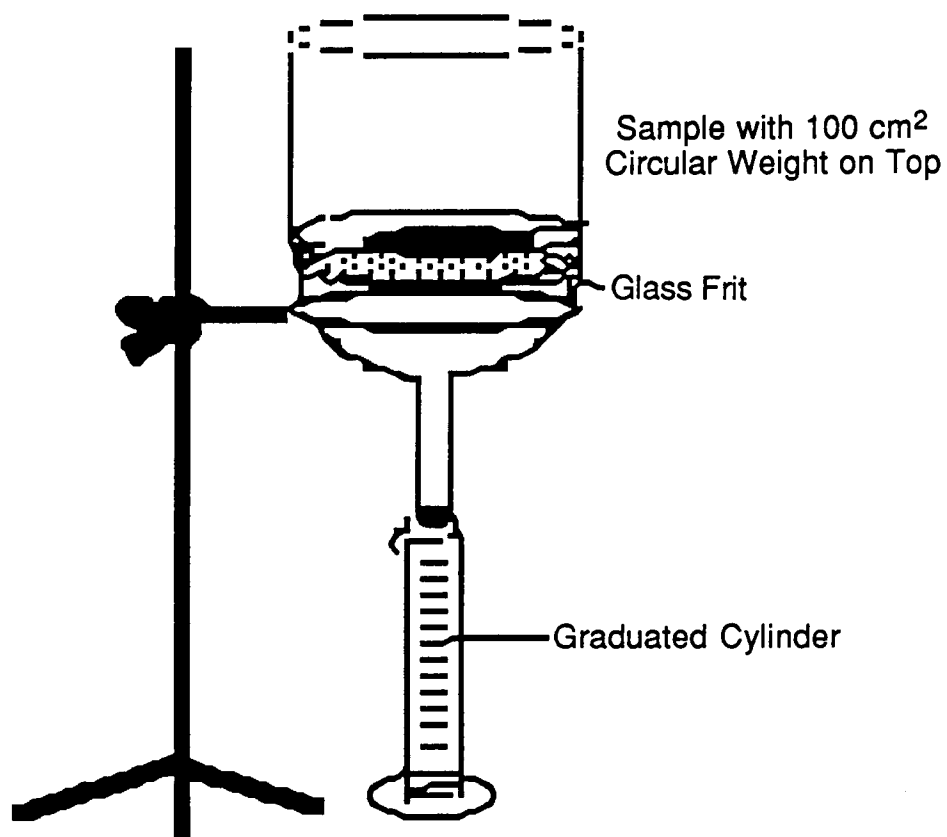


Figure 1. Equipment Setup for Absorbent Capacity-Method 2

( $C_{rm}$  and  $C'_{rm}$ ) retained in the bedpad under the two different pressures was determined by;

$$C_{rm} = C - c \quad \text{where } C = \text{absorption capacity}$$

$c$  = liquid unabsorbed under 3kPa pressure

and

$$C'_{rm} = C - c' \quad \text{where } C = \text{absorption capacity}$$

$c'$  = liquid unabsorbed under 5kPa pressure

Seven replications of this tests were completed for each underpad and the results expressed to the nearest milliliter.

#### Retention Capacity at 80% of Absorbent Capacity

After determining each product's absorbent capacity by method 2, the mean was determined for each underpad. The procedure for absorbent capacity-method 2 and retention capacity were then followed using enough liquid for each bedpad to comprise 80% of its original absorbent capacity. The only data recorded were the two retention capacity measurements. Data were recorded to the nearest milliliter and seven replications were completed for each product.

#### Coverstock Surface Dryness

The equipment in the Absorbent Capacity-Method 2 was used to test coverstock surface dryness as set forth in procedures developed by TEFO and reported by Shishoo (TAPPI Journal July 1987). A 100cm<sup>2</sup> circular sample was used. The specimen was placed with the plastic backing on the glass frit of the funnel. The test liquid dosage is determined by multiplying the sample's areal mass (g/m<sup>2</sup>) by 8% to give the liquid amount in milliliters which is delivered at a rate of 7 ml per second from a height of 2.54 cm. Following this, a pressure of 100Pa added. After 2 minutes the coverstock is removed and placed on a nonabsorbent surface. Prewedged blotter paper is positioned on it along with a 20 gram weight. This condition is allowed to remain for 60 seconds, after which the blotter paper is removed and weighed. The difference between dry and wet paper weight is then determined to the nearest 0.0001 gram. This difference, a measure of surface wetness, was replicated seven times.

### Wetback-Method 2

A 100cm<sup>2</sup> circular and pre-conditioned specimen was placed on the glass frit of a funnel coverstock side up. Blotter paper of the same dimensions was preweighed. One hundred milliliters of distilled water was placed on the sample in the funnel at a flow rate of 7 ml per second from a height of 2.54 cm. A circular plate weighing 100 grams with an area of 100cm<sup>2</sup> was promptly placed on the wet product and the specimen allowed to drain for ten minutes. At the end of this time the 100 gram plate was removed and replaced by the blotter paper and a 20 gram circular plate with an area 100cm<sup>2</sup>. This was allowed to stand for sixty seconds after which it was removed and the moistened blotter paper weighed. The difference in dry and moist weight of the paper, a measure of surface wetness, was determined to the nearest 0.0001 gram. The test was replicated seven times.

### Wicking Test

This test is an adaptation of Harnett and Mehta's (July 1984) Transverse Wicking "Plate" test and the equipment utilized is schematically shown in Figure 2. The water container on the balance is raised with the laboratory jack until the surface of the glass frit is moist but water is not standing on it. A stopwatch started with the placement of an 100cm<sup>2</sup> circular specimen coverstock side down on the glass frit. The weight loss of the water on the balance is noted every ten seconds for three minutes. This is enough time for the product to absorb as much distilled water as it can and for the readings to stabilize. This test is replicated seven times for each product and the weight loss, representing wicking capacity is reported to the nearest 0.1 gram.

### Statistical Analysis

Data was analyzed using analysis of variance (ANOVA) to make comparisons between tests (where applicable) and across products. Duncan's Multiple Range Test and Tukey's Studentized Range (HSD) Test were also employed to examine product performance. The Duncan's test is preferred here because it is a more liberal procedure which will detect a finer discrimination between two means. A Wilcoxon Matched-Pairs Signed-Ranks

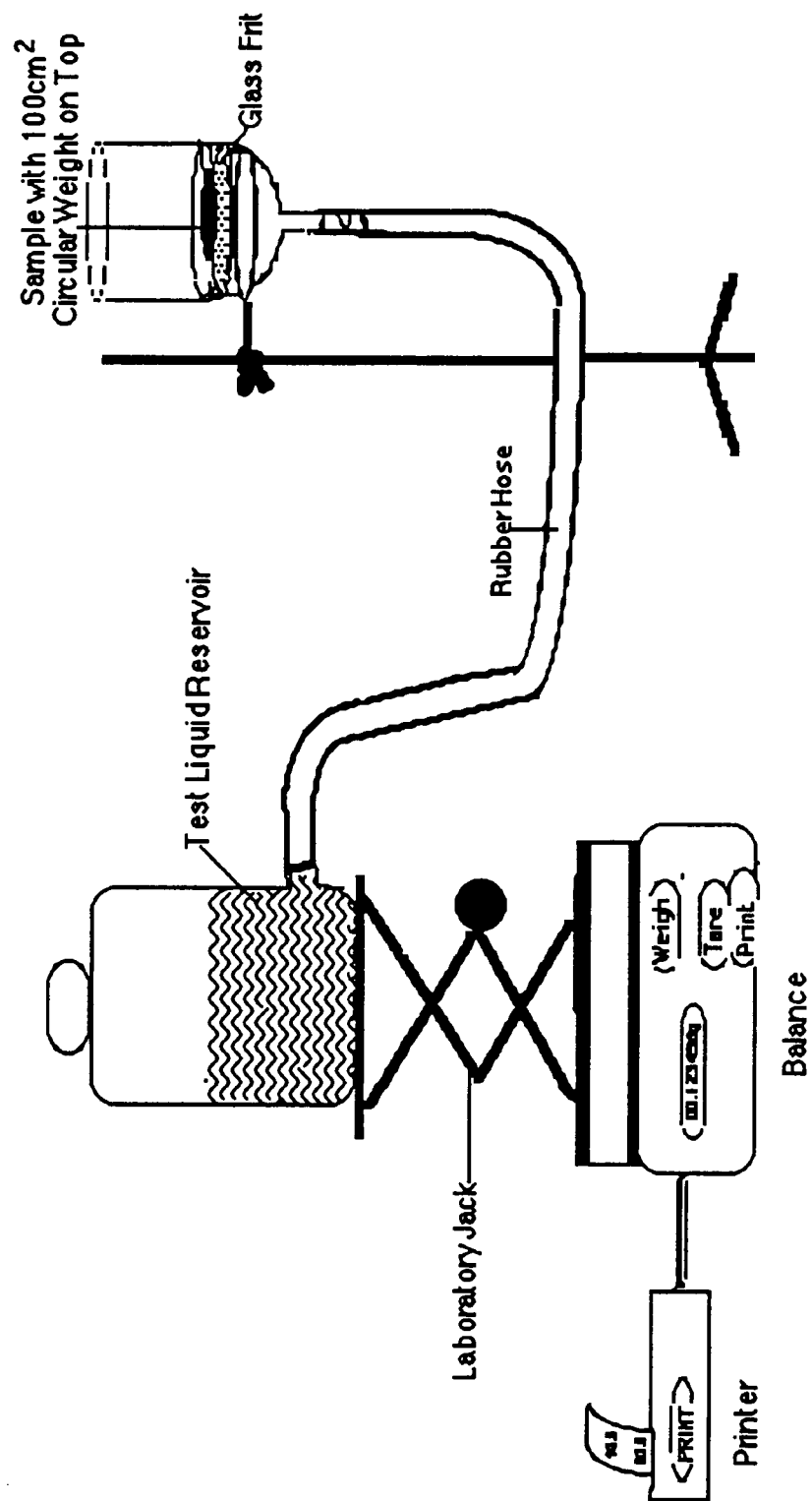


Figure 2. Equipment Setup for Wicking Test

test was utilized to examine performance of the underpads in the Retention Capacity test.

## CHAPTER IV

### PRESENTATION AND INTERPRETATION OF RESULTS

The purpose of this study was to evaluate commercially available underpads and to determine which properties contribute positively to the product's performance. Due to a lack of appropriate standard tests, new methods of appraising absorbent underpads' performance had to be devised. This required that products' performance and test methods both be evaluated. The Duncan's Multiple Range Test was used to compare the underpads' performance on all evaluations. Across product and between methods comparisons using analysis of variance were made where applicable. In all studies the underpads were conditioned at 21°C and 65% RH overnight before conducting the tests. Distilled water that had been allowed to come to room temperature at the same conditions as the underpads was utilized in all procedures. When analyzing the data, differences in specimen size were removed by normalizing results.

### Results

#### Hypothesis One

*Absorbent capacity-method 1 and absorbent capacity-method 2 will be significantly different for the five underpads selected to be evaluated (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).*

In examining this hypothesis, analysis of variance shows that a level of significance of  $p=.0001$  was found to exist for comparison of method 1 and 2 ( $F=137.91$ ), products ( $F=19.98$ ), and for method x product ( $F=12.82$ ) comparison. These results, as summarized in Table 1, were used to accept *hypothesis one*. When a Duncan's Multiple Range Test was used to examine the absorbent capacity, as determined by method 1, of the five underpads it was found that the PolyGard II and Durasorb underpads had means that were significantly different from each other and from the other three underpads. These results are shown in Table 2. The means for method one when normalized for mass and volume showed that the PolyGard II underpad absorbed the most liquid, followed by the Durasorb underpad, and these

Table 1. Analysis of Variance for Differences Between  
Absorbent Capacity-Method 1 and Absorbent  
Capacity-Method 2 and for Differences  
Between Products.

| Source           | df | SS     | MS    | F      | p>.05 |
|------------------|----|--------|-------|--------|-------|
| Method           | 1  | 73.75  | 73.75 | 137.91 | .00** |
| Product*         | 4  | 42.74  | 10.69 | 19.98  | .00** |
| Method x Product | 4  | 27.43  | 6.86  | 12.82  | .00** |
| Total            | 9  | 147.92 |       |        |       |

\*Products have been normalized by mass and volume.

\*\* .0001

Table 2. Duncan's Multiple Range Test for Differences on Absorbent Capacity-Method 1 by Product with Means Normalized for Mass and Volume

| Duncan Grouping* | Product     | Mean** | N=replications |
|------------------|-------------|--------|----------------|
| A                | PolyGard II | 6.48   | 5              |
| B                | Durasorb    | 4.79   | 5              |
| C                | Curity      | 3.75   | 5              |
| C                | Johnson's   | 3.38   | 5              |
| C                | Squibb      | 3.03   | 5              |

\*Means with the same letter are not significantly different.

\*\* ml/g-cc

were followed by Curity, Johnson's, and Squibb in that order. Absorbent capacity-method 2 results, when normalized by mass and volume, exhibited a different ranking of means when analyzed by the Duncan's Multiple Range test than was found with absorbent capacity-method 1. Curity was found to have the largest absorbent capacity by method 2. The Durasorb, Johnson's, and PolyGard II underpads had means which did not exhibit significant differences. The Squibb product absorbed the least. These results can be found in Table 3.

### Hypothesis Two

*Wicking capacity and absorbent capacity-method 1 will be significantly different for the five underpads selected to be evaluated (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).*

Analysis of Variance for this hypothesis, as shown in Table 4, exhibits a level of significance of  $p=.0001$  across methods ( $F=318.32$ ), product ( $F=49.19$ ), and method x product ( $F=26.16$ ). On the basis of this, *hypothesis two* will be accepted. When product ranking was examined using Duncan's Multiple Range Test, it was found that the Curity and Durasorb underpads did not exhibit significantly different means. The other three underpads exhibited means that were significantly different from each other and from the Curity and Durasorb means. PolyGard II absorbed the most water and was followed by Squibb, then the Curity and Durasorb underpads, and the final category held the Johnson's underpad. These results are found in Table 5.

### Hypothesis Three

*Wicking capacity and absorbent capacity-method 2 will be significantly different for the five underpads selected to be evaluated (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).*

Exploration of *hypothesis three* using analysis of variance shows that significant differences ( $p=.0001$ ) exist for methods ( $F=326.52$ ), products ( $F=41.29$ ), and for methods x product ( $F=47.07$ ). On the basis of the results summarized in Table 6 this hypothesis was accepted. Duncan's Multiple Range Test (Table 7) for wicking capacity and absorbent capacity-method 2 shows that only the Curity and Durasorb underpads have means that are not significantly different.

Table 3. Duncan's Multiple Range Test for Differences in Absorbent Capacity-Method 2 by Product with Means Normalized by Mass and Volume

| Duncan Grouping* | Product     | Mean** | N=replications |
|------------------|-------------|--------|----------------|
| A                | Curity      | 7.85   | 7              |
| B                | Durasorb    | 6.91   | 7              |
| B                | Johnson's   | 6.50   | 7              |
| B                | PolyGard II | 6.48   | 7              |
| C                | Squibb      | 4.92   | 7              |

\*Means with the same letter are not significantly different.

\*\* ml/g-cc

Table 4. Analysis of Variance for Differences Between Wicking Capacity and Absorbent Capacity-Method 1 and for Differences Between Products.

| Source           | df | SS      | MS      | F      | p>.05 |
|------------------|----|---------|---------|--------|-------|
| Method           | 1  | 3402.88 | 3402.88 | 318.32 | .00** |
| Product*         | 4  | 2103.28 | 525.82  | 49.19  | .00** |
| Method x Product | 4  | 1118.64 | 279.66  | 26.16  | .00** |
| Total            | 9  | 6624.80 |         |        |       |

\* Results have been normalized by mass and volume.

\*\* .0001

Table 5. Duncan's Multiple Range Test for Differences Between Wicking Capacity and Absorbent Capacity-Method 1

| Duncan's Grouping* | Product     | Means (ml) | N=replications |
|--------------------|-------------|------------|----------------|
| A                  | PolyGard II | 23.40      | 12             |
| B                  | Squibb      | 15.39      | 12             |
| C                  | Curity      | 10.65      | 12             |
| C                  | Durasorb    | 10.64      | 12             |
| D                  | Johnson's   | 5.89       | 12             |

\*Means with the same letter are not significantly different.

Table 6. Analysis of Variance for Differences Between Wicking Capacity and Absorbent Capacity-Method 2 and for Differences Between Products.

| Source           | df | SS      | MS      | F      | p>.05 |
|------------------|----|---------|---------|--------|-------|
| Method           | 1  | 2969.66 | 2969.66 | 326.52 | .00** |
| Product*         | 4  | 1502.08 | 375.52  | 41.29  | .00** |
| Method x Product | 4  | 1712.52 | 428.13  | 47.07  | .00** |
| Total            | 9  | 6184.26 |         |        |       |

\* Means have been normalized by mass and volume.

\*\* .0001

Table 7. Duncan's Multiple Range Test for Differences Between Wicking Capacity and Absorbent Capacity-Method 2

| Duncan's Grouping* | Product     | Means (ml) | N=replications |
|--------------------|-------------|------------|----------------|
| A                  | PolyGard II | 20.98      | 14             |
| B                  | Squibb      | 14.57      | 14             |
| C                  | Curity      | 11.72      | 14             |
| C                  | Durasorb    | 10.86      | 14             |
| D                  | Johnson's   | 7.09       | 14             |

\*Means with the same letter are not significantly different.

#### Hypothesis Four

*Retention capacity at 3kPa pressure at 80% of absorbent capacity and retention capacity at 3kPa at 100% of absorbent capacity will be significantly different for the five underpads to be evaluated (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).*

In examining this hypothesis, a significant difference was found in retention capacity at 3kPa pressure at 80% of absorbent capacity and retention capacity at 100% of absorbent capacity ( $F=1595.85$ ). Table 8 summarizes the statistical results. On the basis of these findings *hypothesis four* was accepted. When the findings for *hypothesis four* were ranked using a Duncan's Multiple Range Test each underpad was found to exhibit means which were significantly different but the more conservative Tukey's (HSD) test showed the Durasorb and Curity underpads as having means for which differences could not be inferred. These results are shown in Tables 9 and 10.

#### Hypothesis Five

*Retention capacity at 5kPa pressure at 80% of absorbent capacity and at 100% of absorbent capacity will not be significantly different for the five underpads to be evaluated (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).*

The ANOVA results for this hypothesis is shown in Table 11. A significant difference ( $p=.0$ ) was found across the two methods. On the basis of these results *hypothesis five* was accepted. A Duncan's Multiple Range test, shown in Table 12, was used to rank the performance of the underpads and all of the means were significantly different. But the Curity and Durasorb underpads did not exhibit significantly different means when examined with the Tukey's (HSD) test as can be seen in Table 13.

Since the retention capacity at 3kPa and retention capacity at 5kPa were taken on the same specimen a Wilcoxon Matched-Pairs Signed-Ranks test was performed to compare each product's performance across the retention tests. While it was not significant at  $p=0.05$  the Johnson's underpad exhibited behavior ( $p=.04$ ,  $N=7$ ) that was different from the performance of the other four products ( $p=.02$ ,  $N=7$  for Curity, Durasorb, PolyGard II, and Johnson's).

Table 8. Analysis of Variance for Differences at 3kPa Between Retention Capacity-Method 1 and Retention Capacity at 80% of Absorbent Capacity by Product.

| Source           | df | SS   | MS   | F       | p>.05 |
|------------------|----|------|------|---------|-------|
| Method           | 1  | 0.27 | 0.27 | 1595.85 | .0    |
| Product*         | 4  | 0.20 | 0.05 | 294.23  | .00** |
| Method x Product | 4  | 0.17 | 0.04 | 249.43  | .00** |
| Total            | 9  | 0.64 |      |         |       |

\*Products have been normalized by mass and volume.

\*\* .0001

Table 9. Duncan's Multiple Range Test for Differences Between Retention Capacity, at 3kPa Pressure, and Retention Capacity at 80% of Absorbent Capacity, at 3kPa Pressure, by Product

| Duncan Grouping* | Product     | Mean (ml) | N= replications |
|------------------|-------------|-----------|-----------------|
| A                | Johnson's   | 0.20      | 14              |
| B                | Durasorb    | 0.10      | 14              |
| C                | Curity      | 0.09      | 14              |
| D                | PolyGard II | 0.07      | 14              |
| E                | Squibb      | 0.05      | 14              |

\*Means with the same letter are not significantly different.

Table 10. Tukey's Studentized Range (HSD) Test for Differences Between Retention Capacity at 3kPa Pressure and Retention Capacity at 80% of Absorbent Capacity at 3kPa Pressure by Product

| Tukey Grouping* | Product     | Mean (ml) | N=replications |
|-----------------|-------------|-----------|----------------|
| A               | Johnson's   | 0.20      | 14             |
| B               | Durasorb    | 0.10      | 14             |
| B               | Curity      | 0.09      | 14             |
| C               | PolyGard II | 0.07      | 14             |
| D               | Squibb      | 0.05      | 14             |

\*Means with the same letter are not significantly different.

Table 11. Analysis of Variance for Differences at 5kPa Between Retention Capacity-Method 1 and Retention Capacity at 80% of Absorbent Capacity by Product.

| Source           | df | SS   | MS   | F       | p>.05 |
|------------------|----|------|------|---------|-------|
| Method           | 1  | 0.23 | 0.23 | 1216.07 | .0    |
| Product*         | 4  | 0.18 | 0.05 | 239.29  | .00** |
| Method x Product | 4  | 0.15 | 0.04 | 200.08  | .00** |
| Total            | 9  | 0.58 |      |         |       |

\*Products have been normalized by mass and volume.

\*\* .0001

Table 12      Duncan's Multiple Range Test for Differences Between Retention Capacity at 5kPa Pressure and Retention Capacity at 80% of Absorbent Capacity at 5kPa Pressure by Product

| Duncan Grouping* | Product     | Mean (ml) | N=replications |
|------------------|-------------|-----------|----------------|
| A                | Johnson's   | 0.19      | 14             |
| B                | Durasorb    | 0.09      | 14             |
| C                | Curity      | 0.08      | 14             |
| D                | PolyGard II | 0.06      | 14             |
| E                | Squibb      | 0.04      | 14             |

\*Means with the same letter are not significantly different.

Table 13. Tukey's Studentized Range (HSD) Test for Differences Between Retention Capacity at 5kPa Pressure and Retention Capacity at 80% of Absorbent Capacity at 5kPa Pressure by Product

| Tukey Grouping* | Product     | Mean (ml) | N=replications |
|-----------------|-------------|-----------|----------------|
| A               | Johnson's   | 0.19      | 14             |
| B               | Durasorb    | 0.09      | 14             |
| B               | Curity      | 0.08      | 14             |
| C               | PolyGard II | 0.06      | 14             |
| C               | Squibb      | 0.04      | 14             |

\*Means with the same letter are not significantly different.

### Hypothesis Six

*Coverstock surface dryness and wetback-method 2 will be significantly different for the five underpads to be evaluated (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).*

At a level of significance  $p > 0.05$  analysis of variance ( $F = 835.67$ ) revealed that this hypothesis could not be rejected. When examined across products, however, a significant difference ( $p = .06$ ) was found. No significant difference ( $p = .60$ ) was found when method x products was examined together. These results are summarized in Table 14. Duncan's Multiple Range Test (Table 15) for differences between coverstock surface dryness and wetback-method 2 show that the Johnson's underpad exhibited a mean that was significantly different from the other four underpads. This was due to an absence of coverstock on the Johnson's underpad.

### Hypothesis Seven

*Wetback-method 1 and wetback-method 2 will be significantly different for the five underpads to be evaluated (Curity®, Durasorb®, Johnson's, PolyGard II®, and Squibb™).*

Examination of *hypothesis seven* by analysis of variance shows that it can only be partially rejected. The level of significance for across method ( $p = .0001$ ,  $F = 113.75$ ) and for method x product ( $p = .0001$ ,  $F = 12.02$ ) show that this part of the hypothesis cannot be rejected. The analysis of variance ( $F = 3.51$ ) across products at a level of significance of  $p = .01$  does allow for rejection. These results are summarized in Table 16. When a Duncan's Multiple Range Test was used to examine products for differences between wetback-method 1 and wetback-method 2, three levels were found as shown in Table 17. In testing wetback the smaller the mean the better the performance of the product. The PolyGard II underpad exhibited the least amount of wetback, but its mean was not significantly different from those of the Johnson's and Curity underpads.

### Survey of Health Care Administrators

Because only nine usable responses were received from seventy-five surveys mailed out, specific conclusions may not be drawn from the survey.

Table 14. Analysis of Variance for Differences Between  
Coverstock Surface Dryness and  
Wetback-Method 2.

| Source           | df | SS      | MS      | F      | p>.05 |
|------------------|----|---------|---------|--------|-------|
| Method           | 1  | 3088.92 | 3088.92 | 835.67 | .00** |
| Product*         | 4  | 35.16   | 8.79    | 2.38   | .06   |
| Method x Product | 3  | 7.03    | 2.34    | 0.63   | .60   |
| Total            | 8  | 3131.11 |         |        |       |

\*Products have been normalized by mass and volume

\*\* .0001

Table 15. Duncan's Multiple Range Test for Differences Between Coverstock Surface Dryness and Wetback-Method 2

| Duncan's Grouping* | Product     | Means (g) | N=replications |
|--------------------|-------------|-----------|----------------|
| A                  | Johnson's   | 0.87      | 7**            |
| B                  | Curity      | 0.71      | 14             |
| B                  | Squibb      | 0.70      | 14             |
| B                  | Durasorb    | 0.69      | 14             |
| B                  | PolyGard II | 0.67      | 14             |

\*Means with the same letter are not significantly different.

\*\*Johnson's underpad did not contain a coverstock layer.

Table 16. Analysis of Variance for Differences Between  
Wetback-Method 1 and Wetback-Method 2  
and for Differences Between Products.

| Source           | df | SS    | MS   | F      | p > .05 |
|------------------|----|-------|------|--------|---------|
| Method           | 1  | 7.17  | 7.17 | 113.75 | .00*    |
| Product          | 4  | 0.88  | 0.22 | 3.51   | .01     |
| Method x Product | 4  | 3.03  | 0.76 | 12.02  | .00*    |
| Total            | 9  | 11.08 |      |        |         |

\*.0001

Table 17. Duncan's Multiple Range Test for Differences Between Wetback-Method 1 and Wetback-Method 2

| Duncan's Grouping* | Product     | Means** | N=replications |
|--------------------|-------------|---------|----------------|
| A                  | Squibb      | 2.64    | 11             |
| A B                | Durasorb    | 2.60    | 11             |
| A B C              | Curity      | 2.52    | 11             |
| B C                | Johnson's   | 2.39    | 11             |
| C                  | PolyGard II | 2.31    | 11             |

\*Means with the same letter are not significantly different.

\*\*In these tests the smaller the mean the better the product performed. Therefore, the PolyGard II underpad allowed the least wetback. Means are in grams.

Nonetheless, respondents ranked control of leaks and spills as having the most influence on decision making in reference to the underpad that they used. Brand name had the least influence on choice of product. The following results on influence in decision making in reference to the underpad used are in order of decreasing importance: control of leaks and spills; absorbent capacity of underpad; control of odor; size of underpad; ease of replacement; price; compact storage; and brand name.

### Discussion

Absorbent capacity-methods 1 and 2 were compared since they supposedly evaluated the same property. Different size specimens were used in the two methods so data was normalized to mass and volume before comparisons were made. When assessed across all products by the Duncan Multiple Range Test as shown in Tables 2 (p. 40) and 3 (p. 42), and Tukey's Studentized Range (HSD) test, both methods exhibited significantly different means with Method 2 displaying the larger mean of 6.53ml to Method 1's mean of 4.28ml. The discrepancies in these methods lay in the procedures. Method 1 consisted of pouring liquid on a specimen held on a clipboard which resided at a 45° angle until it was saturated and then allowing it to drain until dripping was diminished. Problems arose with this technique in that no matter how gently the water was applied it washed out particles of fluff from some products. This was especially apparent in the PolyGard II underpad which contained a super-absorbent that was lost from the cut edges of the specimen as it absorbed water and the fluff structure was unable to retain it. Another problem was the fact that the specimen was held in place by a clip. Liquid that might have possibly drained off could have been held behind the clip. Although extreme care was taken when removing the wet sample from its draining position and transferring the sample to the balance some water may have been lost during handling.

The results of the Duncan's Multiple Range test and the Tukey Studentized Range (HSD) test for absorbent capacity by method 1 that have been standardized for weight and volume are shown in Table 2 (p. 40). When testing for absorbent capacity the higher the mean the more liquid the product will hold. The PolyGard II product, which contains a super-absorbent powder,

exhibited the highest capacity and was significantly different from the other products. The second category contained only the Durasorb product in the Duncan's test but the Tukey's method contained the Curity product within this group, as well as in the third category. As far as this study was able to determine the largest macrostructure difference that was evident between the Durasorb and Curity bedpads was that the Durasorb underpad had been subjected to a thermal calendering process. The Squibb product, which had the largest mass of the five underpads, performed the least satisfactory by this method.

Absorbent capacity-method 2, which involved delivering water to the specimen from a height of 2.54cm, was followed by placing a 100 gram circular weight on it. After allowing it to drain for 10 minutes the difference in amount of water placed on the underpad and the amount that drained off was noted. This method was inconsistent with Shishoo's (July 1987) proposed test in that the 100 gram circular weight used in this study did not have a built-in tube for liquid delivery to specimen at the center. In the present study, the weight was placed on the product after the water had been applied. The procedure was consistent with Shishoo's technique in all other steps. The water was from a separatory funnel that had been set to deliver 7 milliliters of liquid per second. Drawbacks to this procedure were also present. It was possible, but not probable, that the underpad specimens were not completely saturated because a set amount of liquid was applied to all products. The placement of the weight after wetting the underpad might have forced liquid out of the specimen but care was taken to avoid this problem by placing the weight gently, but quickly, on the product. The most serious complication experienced with this procedure was that when testing the PolyGard II underpad the glass frit became clogged with super-absorbent. To prevent this the funnel was flushed between each replication to remove any residual super-absorbent.

Absorbent capacity as determined by method 2 gave different results from method 1 when both procedures were standardized for weight and volume. All products performed much better in this method except the PolyGard II underpad which remained the same (PolyGard II means: method 1=6.47ml; method 2=6.47ml). Consequently this may be the result of the fact that the liquid was poured onto the product and allowed to run off in method 1

while the excess water drained off more slowly in method 2. The latter is comparable to actual use conditions where the liquid would remain on the underpad until absorbed unless the patient moved and the excess liquid ran off onto the bed linens. The results of method 2 are shown in Table 3 (p. 42). Again the Squibb (means: method 1=3.03ml; method 2= 4.92ml) underpad performed poorly and its mean was significantly different from the other products nor was it considered similar to any of the other bedpads.

The wicking test, which measures water loss from a reservoir as it wicks into an absorbent material, was compared to absorbent capacity-methods 1 and 2. Only the final measurement taken in the wicking test was used based on the premise that by the end of three minutes the rate of liquid absorbed in to the underpads had stabilized and it was thus assumed to be completely saturated. Again using the Duncan's test the means between the wicking test and method 1, found in Table 5 (p. 44), were significantly different as was the comparison of wicking behavior with method 2, found in Table 7 (p. 46). This disproved the premise that the wicking test at 100% was comparable to the capacity of the product. The difference is that the absorbent capacity tests saturate the specimen with more water than it would hold while the wicking test does not allow for excess water to be absorbed.

The Retention Capacity procedure was tested using a Wilcoxon Matched-Pairs Signed-Ranks test to compare the measurements taken at 3kPa pressure with the ones taken at 5kPa. "The Wilcoxon test takes into account the magnitude as well as the direction of the difference for each pair" (Huck, 1974, p. 205). It was found, when the retention capacity of all the products was normalized by mass and volume, that there was no significant difference in the ranking of the data taken at the two pressures. This means that across the two pressures the underpads performed in the same order when the data was ranked. The amount that leaked out of the underpads at 3kPa was ranked and the leakage at 5kPa fell into the same ranks. This was expected.

When the retention capacity at 3kPa and 5kPa was compared by products with a Wilcoxon matched-pairs signed-ranks test, all products performed in the same order. However, the Johnson and Johnson underpad was very close to the critical value while the other products had the same value of 0.0180 for the 2-tailed P value. The discrepancy in the Johnson and

Johnson product was attributed to the paper structure of its absorbent material, which was basically two layers of highly absorbent tissue bonded together. This type of structure would show most of its liquid loss under the first pressure and might not lose additional water under the higher pressure. This was proven by the data obtained. The fluff structures that comprised the absorbent component of the other underpads would release more under the additional pressure and allow liquid to be squeezed from the specimen.

When retention at full capacity was compared with retention at 80% of absorbent capacity, as determined by method 2, the results were as expected. The product does not exhibit as much leakage when it is not completely saturated and there is simply redistribution of the liquid within the pad as pressure is applied. When examining the retention capacity data obtained, by the same procedure using 80% of the product's capacity, all of the products exhibited means that were significantly different by the Duncan's test at both pressures (Tables 9 (p. 49) and 12 (p. 52)). The more conservative Tukey's test, for retention at 3kPa pressure, gave four groupings with the Durasorb and Curity underpads displaying means that were not significantly different, as shown in Table 10 (p. 50). Retention measure at 5kPa pressure showed three groups of means by Tukey's test, as shown in Table 13 (p. 53). The Johnson and Johnson product performed the best when comparing the retention at the two capacities. This again follows from its absorbent paper structure. The products that performed well in this test, namely the Johnson and Johnson, Durasorb, and Curity underpads, should not exhibit excessive leaking when in use. The low retention capacity of the PolyGard II and Squibb underpads when data was normalized by mass and volume, shows that the amount of fluff contributes to retention capacity because these two underpads contained the most fluff. In test data that has not been normalized by mass and volume these two products exhibited a higher percentage of water retained than did the Durasorb and Curity products.

Coverstock surface dryness and wetback-method 2 were compared to see if a relationship existed between them. Analysis of variance showed that there was no relationship ( $F=835.67$ ) between the two methods. When these methods were examined across products by the Duncan's test, found in Table 15 (p. 56), it was found that the presence of coverstock on a product reduced the wetback of underpad. The Johnson and Johnson underpad did not have

a coverstock and very likely is responsible for allowing more wetback than the other products which contained a coverstock layer.

Except for the Johnson and Johnson product which did not have a coverstock layer all of the products in the study performed similarly when coverstock dryness was compared to wetback method 2 by the Duncan's test. This means that the polypropylene coverstock found on the PolyGard II underpad did not perform significantly different from the rayon webs contained by the other products. However, the PolyGard II's mean, for wetback, in this comparison was the smallest of all the products and the smaller the mean the more desirable the product. Manufacturers will have to decide for themselves what type of coverstock they desire for their product. A slight edge in performance by the hydrophobic polypropylene web may not be incentive enough to justify a higher material cost to the overall product if polypropylene costs more than a hydrophilic rayon coverstock. Coverstocks can be made more repellent by the addition of hydrophobic finishes. Determining whether these finishes were used on any of the products evaluated was beyond the scope of this study.

The results of the wicking test across products are depicted graphically in Figures 3 and 4. Figure 3 depicts the temporal performance of the underpads. The PolyGard II underpads exhibit a superior wicking capacity due to the presence of a super-absorbent powder present in its structure. The Squibb product also performs quite well, but this is because it has the most fluff to absorb the moisture. The Curity and Durasorb underpads perform almost identically. This is not surprising because the only apparent difference between the two is the presence of thermal bonding in the Durasorb underpad. The Johnson and Johnson product does not have the capacity of the other products but it does show an initial wicking rate similar to the Squibb underpad.

When the results of the wicking test are normalized to amount absorbed by mass and volume, the results of this method take on a different appearance. Figure 4 represents the wicking test data normalized in terms of product mass and volume which, for comparative purposes, reflects the performance of the underpads in terms of their material rather than mass alone. As can be seen in this figure the initial wicking rates of the Curity, Durasorb, and Johnson's underpads are over twice that of the PolyGard II and

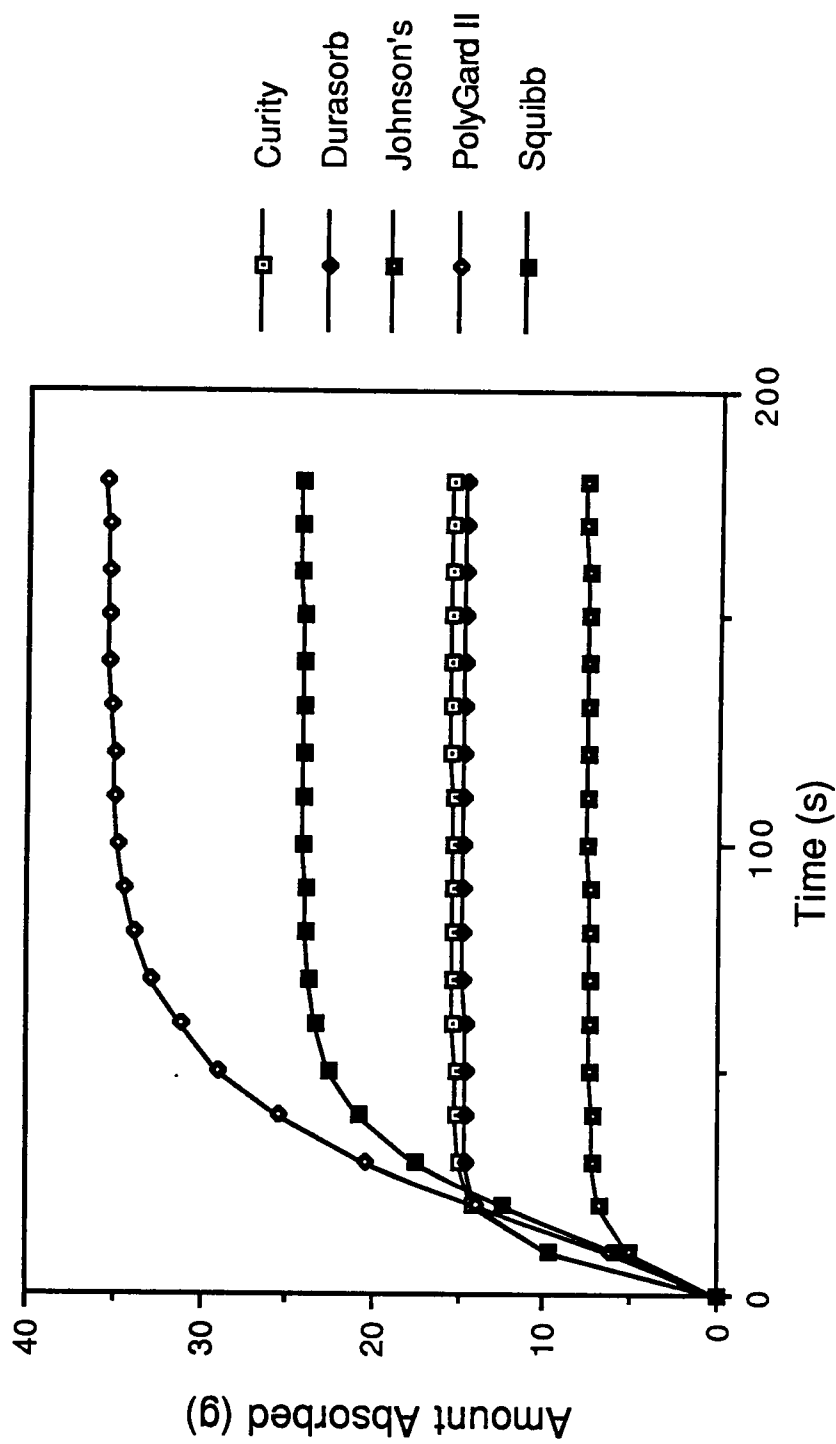


Figure 3. Wicking Response Curve (Average Curve for Each Product)

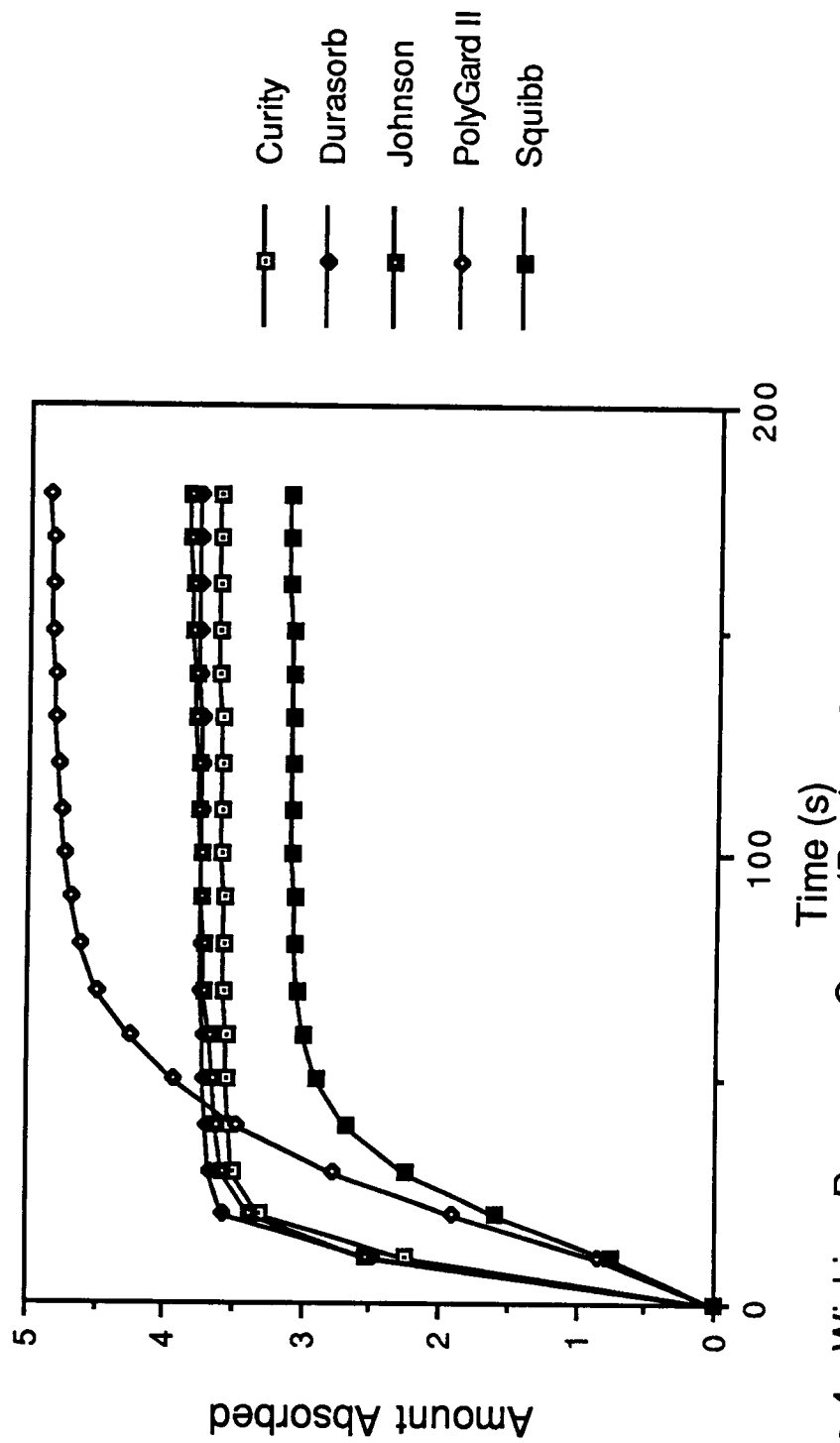


Figure 4. Wicking Response Curve (Product Curves Normalized by Mass and Volume)

Squibb bedpads. The normalized results show the the PolyGard II product again displays the highest capacity. The main differences between Figure 3 and Figure 4 are in the results of the Johnson's and Squibb underpads. The Squibb product wicks the least amount of water by weight and volume. This was consistent with the finding of absorbent capacity-method 2 as was shown in Table 3 (p. 42). The Johnson's product performed similarly to the Curity and Durasorb underpads when the results were normalized. Results of the wicking data show that the super-absorbent allows for a slower initial rate of wicking but permits a greater wicking capacity.

Comparison of wetback-method 1 and wetback-method 2 suggested that the test methods were significantly different. Wetback-method 1 consisted of placing distilled water onto the center of the entire underpad and allowing it to soak in for five minutes. Preweighed blotter paper was then placed in the center of the underpad with a 152.5g weight on top and allowed to remain for 30 seconds before removing and weighing the moistened blotter paper. Wetback-method 2 only used a small sample of the underpad and 100ml of water was used. It was allowed to drain for 10 minutes, and then preweighed blotter paper was placed on the sample for 60 seconds under a 20g weight. Method 2 allowed for more consistency across products as the effective size of the sample remained the same for all underpads. Dimensions of underpads vary greatly, and the liquid was allowed to migrate outward over a larger area in some products when using method 1. Table 17 (p. 58) shows the Duncan's Multiple Range Test for differences between wetback-methods 1 and 2. The PolyGard II, Johnson's, and Curity products performed the best and did not exhibit means that were significantly different from each other. The Curity and Johnson's mean were also not significantly different from the Durasorb underpad. While the Squibb underpad allowed for the most wetback, its mean was not significantly different from the Durasorb and Curity underpads.

When Health Administrators were asked to rank the relative importance of factors in the decision making process with reference to the underpad used, the survey found the following associated with decreasing requirement: 1. control of leaks and spills; 2. absorbent capacity of underpad; 3. control of odor; 4. size of underpad; 5. ease of replacement; 6. price; 7. compact storage; and 8. brand name. These results indicate, that for the respondents,

patient comfort and well being are more important than administrative problems such as price and storage. Brand name had little or no influence on choosing an underpad. Comments on price indicated that while it was important it was more important to have a underpad that was effective and did not harm the patient. Only one respondent cited price as the most important factor influencing decision making. One respondent was under contract and another ordered supplies from a parent hospital's storehouse, both of which limit their choice of products. Overall it appeared that the administrators wanted the best product at the least price.

## CHAPTER V

### SUMMARY AND CONCLUSIONS

#### Summary

Incontinence is a serious problem that affects many Americans each year. It is especially detrimental to persons who are confined to a bed or a wheelchair. This group of non-mobile people often use underpads as a means of containing urine that has been lost involuntarily. The purpose of this study was to evaluate properties of incontinence underpads that were commercially available in the Knoxville, Tennessee market. Specifically, five underpads were selected to represent the variety of products available. Laboratory tests were collectively analyzed and used to evaluate the five underpads so suggestions could be made on improvements in underpad construction and composition.

Current research available on incontinence aids has mainly been conducted in Europe by Cottenden and his associates (1987). Furthermore, the test methods for characterizing the relevant properties have been developed mainly in Europe, again by Cottenden and coworkers, as well as by Shishoo (July 1987). "In the absorbent, measurable properties include wicking rate, absorption rate, absorption capacity, wetting time and retention under pressure" (Medical Textiles, November, 1985, p. 4).

This study has examined absorption capacity, retention under pressure, wicking rate and variations of these as well as investigated wetback and coverstock surface dryness. The five underpads were selected for evaluation after conducting a survey of the Knoxville, Tennessee market. The pads were: Curity® Disposable Underpads manufactured by Kendall; Durasorb® and PolyGard II®, both manufactured by Professional Medical Products; Johnson's Underpad by Johnson and Johnson; and an Adult Disposable Incontinent Pant manufactured by ConvaTec™ for Squibb™. The Squibb product was a folded diaper that could be unfolded for use as an underpad. The Johnson's product was comprised of an absorbent tissue paper bonded to plastic backing. Four of the underpads, Curity, Durasorb, PolyGard II and Squibb, were combinations of the following components: a coverstock, underneath

which was a layer of tissue; a layer of absorbent fluff that was bonded through thermal calendering (except in the Curity underpad which had no bonding); and a plastic backing which helped prevent leaks and spills. The PolyGard II also contained a super-absorbent powder that gelled upon wetting. In addition to the laboratory experiments a survey of Health Care Administrators in East Tennessee was conducted. Response to the survey was poor and general conclusions could not be drawn from it.

No one underpad performed consistently better than the others in all laboratory tests. The PolyGard II underpad which contained a super-absorbent powder performed well in most tests but when the results of the test methods were normalized by mass and volume it often was ranked below other products in the component measured. The Curity and Durasorb underpads, which differ mainly in that the Curity product has not been thermally bonded, performed similarly across most tests. Even when their means were significantly different according to Duncan's or Tukey's grouping they were ranked next to each other. Performance of the Squibb and Johnson's underpads varied across test methods. The Johnson's underpad performed well in retention under pressure, but it absorbed the least amount of test liquid of all the underpads tested.

### Conclusions

When comparing test methods for determining absorbent capacity, the test recommended by Shishoo (July 1987) exhibited fewer possibilities for error and led to more uniform testing. Although it might have been possible that the samples were not completely saturated in absorbent capacity-method 2, the amount of test liquid used appears sufficient for most products and, because some fluid was not held, saturation is assumed essentially complete. Absorbent capacity as determined by method 2 should be used in future research instead of absorbent capacity-method 1.

Absorbent Capacity-method 1 was developed because it used equipment similar to existing test methods (INDA Standard Test 80.0-70 [R82]). If it had proved equivalent to method 2, absorbent capacity-method 1 would have very useful for the consumer since it required no set volume of liquid, no special rate of liquid delivery, and did not require the liquid to be

applied from a given height, method 1 could have been used by untrained personnel under non-standard laboratory conditions. This would have allowed the consumer to estimate absorbent capacity of underpads and to rapidly determine which to use to control light, medium, and/or heavy incontinence.

Testing of wetback by two methods found that wetback-method 2 had fewer uncontrolled variables. Of major importance was the fact that wetback-method 2 used a sample of specific size for all products while the sample size varied in method 1. Also the sample was completely saturated by wetback-method 2, but may not of been completely wet in method 1 depending on the underpads' absorbent capacity and wicking capability in pulling moisture away from the penetration site. How these test methods for determining wetback compare to wetback under real conditions is not known. Therefore, a single procedure will not be recommended over another, although method 2 is more uniform across all products. Also, although it has been shown that distilled water works well, better predictions will be obtained if the absorbent product that contains a super-absorbent be tested using a saline solution that models urine.

Due to the performance of the Curity and Durasorb underpads during the laboratory tests, it was concluded that thermal calendering, while it may serve to strengthen the fluff network of the absorbent product, did not greatly enhance performance. The PolyGard II underpad, which contained super-absorbent, appeared to perform well in the laboratory tests, but when the data was normalized by mass and volume, it was found to absorb less test liquid than some of the other underpads. The Squibb product was the thickest of the five underpads examined and had the greatest mass. But it often did not perform much better than the Durasorb and Curity underpads in tests. When data was normalized by mass and volume, the Squibb product often performed the poorest of all the products. It appears that there is a optimum amount of fluff that can be used for maximum absorbency by mass and volume. The determination of the optimum amount of fluff to use was beyond the scope of this study. Because the Curity and Durasorb underpads performed well by most methods in terms of weight and volume, it would be worth investigating how super-absorbent added to a product with an amount

of fluff similar to these two products would perform against the PolyGard II underpad which had a greater mass and was thicker.

The Johnson's underpad varied from the other underpads in this study in that it was composed of paper tissue bonded to plastic and did not contain any fluff or have a coverstock. Under actual use conditions it would not absorb a great amount of liquid but what it does absorb it will retain, even under substantial compression. This underpad performed well in terms of its mass and volume. Due to these findings it is suggested that the Johnson's underpad not be used with patients that suffer from moderate to heavy urinary incontinence. However, it would provide excellent protection for patients who perhaps have a minor wound that is draining after surgery as it would keep the patient dry and also protect the bed linens.

A coverstock should be used on underpads. The hydrophobic polypropylene web found on the PolyGard II underpad performed very well in the coverstock surface dryness test, but when this test was compared with wetback it did not perform significantly different from the more hydrophilic rayon coverstocks used on the Curity, Squibb, and Durasorb underpads. This difference in performance was due to the materials found underneath the coverstock. A coverstock should allow liquid to penetrate but prevent it from re-emerging and coming into contact with the patient. The comparison of the coverstock surface dryness and wetback tests show that, while the polypropylene web does show some advantage, its selection over the rayon webs might as well be left to the manufacturers. Coverstocks will probably be selected generally on price.

### Implications

This study suggests that there is an optimum weight and volume of fluff that could be used for optimizing a normalized absorbency. The addition of super-absorbent powder to this fluff would yield increased absorbency while serving to minimize wetback. Thermal calendering of fluff used in underpads does not yield an apparent advantage in performance over uncalendered fluff other than perhaps limiting the shift in absorbent materials. A coverstock should be used on absorbent products. The polypropylene coverstock used on one product performed slightly better than the rayon coverstocks used on

other underpads, but one cannot be recommended strongly over the other from the data examined. These factors should be taken into consideration by manufacturers when producing an underpad that will be effective, yet economically desirable.

### Recommendations

Findings in this study indicate areas where further research is needed.

- Studies should be undertaken to determine optimum weight and volume of fluff needed for anticipated performance of an absorbent underpad.
- A test to determine clumping of moistened underpads should be developed. This test should use a warmed test liquid to determine how the adhesives used in the products will hold under conditions similar to actual use.
- Future studies should include a broader selection of underpads and more replications should possibly be made on each of the samples and their tests.
- If the absorbent underpad contains a super-absorbent the test methods should be completed using a synthetic urine.
- This study should be updated when an accurate model for urine is found.
- Only method 2 for determining absorbent capacity should be used to study absorbent products.
- The wicking test should be redone using a computer for data acquisition, thus allowing the dynamic wicking curve to be precisely determined.
- Another survey of health care administrators should be conducted with a larger sample and across a broader geographic area.
- Another survey instrument should also be developed.

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## APPENDIXES

## APPENDIX A

### COVER LETTER AND SURVEY FORM

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THE UNIVERSITY OF TENNESSEE  
KNOXVILLE

April 7, 1989



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College of  
Human Ecology

---

Textiles,  
Merchandising  
and Design

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Dear

The University of Tennessee recently began an interdisciplinary research program to investigate adult incontinence products. The goal of this research, funded by the UTK Center for Materials Processing is to analyze the structure and properties of current incontinence products, generate recommendations for product improvements and disseminate our findings in industrial and academic publications and presentations.

Anna Rebecca Layman is evaluating incontinence underpads as a partial requirement for the completion of the Master's of Science degree in Textiles and Apparel. Her research focuses on a laboratory evaluation of underpads and a survey of the use of these pads in health care facilities.

You are part of a carefully selected list of health care providers. This research can only be completed if you can and do answer the enclosed questionnaire. It will take approximately 15 minutes of your time. Please return the completed questionnaire in the stamped envelope by April 21, 1989.

We greatly appreciate your cooperation. If you would like an abstract of the thesis please indicate on your questionnaire.

Very Truly Yours,

*Anna Rebecca Layman*

Anna Rebecca Layman  
Graduate Student

*Kermit Duckett*

Kermit Duckett, Ph.D.  
Professor

Enclosure

Apparel/Interior Design/Merchandising/Textile Science  
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## ADMINISTRATOR'S

| 1. Name of underpad | Manufacturer | Price | How long used? |
|---------------------|--------------|-------|----------------|
| _____               | _____        | _____ | _____          |
| _____               | _____        | _____ | _____          |
| _____               | _____        | _____ | _____          |
| _____               | _____        | _____ | _____          |
| _____               | _____        | _____ | _____          |

2. How many different brands/products do you consider? \_\_\_\_\_
3. How many underpads are used in a month? \_\_\_\_\_
4. How many underpads do you stock at any given time period? \_\_\_\_\_
5. Do you stock underpads specifically for night/heavy, day/light? \_\_\_\_\_
6. How many sales representatives call on you with incontinence products? \_\_\_\_\_
7. In general, how often do they visit you, every \_\_\_\_ week, every \_\_\_\_ month?
8. Comment on price as an important factor in decision making \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

9. Rate the relative importance of the following in your decision making?

(VI = very important, MI = moderately important, LI = of little importance)

- |                                   |                         |
|-----------------------------------|-------------------------|
| a. control of leaks or spills     | VI ____ MI ____ LI ____ |
| b. ease of replacement            | VI ____ MI ____ LI ____ |
| c. control of odor                | VI ____ MI ____ LI ____ |
| d. size of underpad               | VI ____ MI ____ LI ____ |
| e. compact storage                | VI ____ MI ____ LI ____ |
| f. absorbent capacity of underpad | VI ____ MI ____ LI ____ |
| g. price                          | VI ____ MI ____ LI ____ |
| h. brand name                     | VI ____ MI ____ LI ____ |
| i. other _____                    | VI ____ MI ____ LI ____ |

10. Rank the relative importance of the following items in your decision making with reference to the underpad/pad you use? (1 = most important, 7 = least important).

- \_\_\_\_ a. control of leaks and spills
- \_\_\_\_ b. ease of replacement
- \_\_\_\_ c. control of odor
- \_\_\_\_ d. size of underpad
- \_\_\_\_ e. compact storage
- \_\_\_\_ f. absorbant capacity of underpad
- \_\_\_\_ g. price
- \_\_\_\_ h. brand name
- \_\_\_\_ i. other \_\_\_\_\_

11. Which of these factors is most important in providing satisfaction for wearable incontinence pads? \_\_\_\_\_  
 \_\_\_\_\_

## APPENDIX B

### SUPPLEMENTAL TABLES

Table B.1. Analysis of Variance for Differences On Absorbent  
Capacity-Method 1 by Products.

| Source   | df | SS    | MS   | F     | p>.05 |
|----------|----|-------|------|-------|-------|
| Product* | 4  | 38.74 | 9.69 | 24.90 | .00** |
| Total    | 4  | 38.74 |      |       |       |

\*Products have been normalized by mass and volume.

\*\* .0001

Table B.2. Tukey's Studentized Range (HSD) Test for Differences on  
Absorbent Capacity-Method 1 by Product with Means  
Normalized for Mass per Volume

| Tukey's Grouping* | Product     | Mean** | N=replications |
|-------------------|-------------|--------|----------------|
| A                 | PolyGard II | 6.48   | 5              |
| B                 | Durasorb    | 4.79   | 5              |
| B C               | Curity      | 3.75   | 5              |
| C                 | Johnson's   | 3.38   | 5              |
| C                 | Squibb      | 3.03   | 5              |

\*Means with the same letter are not significantly different.

\*\* ml/g-cc

Table B.3. Analysis of Variance for Differences On Absorbent  
Capacity-Method 2 by Products

| Source   | df | SS    | MS   | F     | p>.05 |
|----------|----|-------|------|-------|-------|
| Product* | 4  | 31.42 | 7.86 | 12.43 | .00** |
| Total    | 4  | 31.42 |      |       |       |

\*Products have been normalized by mass and volume.

\*\* .0001

Table B.4. Tukey's Studentized Range (HSD) Test for Absorbent Capacity-Method 2 with Means Normalized by Mass and Volume

| Tukey Grouping* | Product     | Mean** | N=replications |
|-----------------|-------------|--------|----------------|
| A               | Curity      | 7.85   | 7              |
| A B             | Durasorb    | 6.91   | 7              |
| B               | Johnson's   | 6.50   | 7              |
| B               | PolyGard II | 6.48   | 7              |
| C               | Squibb      | 4.92   | 7              |

\*Means with the same letter are not significantly different.

\*\*ml/g-cc

Table B.5. Tukey's Studentized Range (HSD) Test for Differences Between Wicking Capacity and Absorbent Capacity-Method 1

| Tukey Grouping* | Product     | Means (ml) | N=replications |
|-----------------|-------------|------------|----------------|
| A               | PolyGard II | 23.40      | 12             |
| B               | Squibb      | 15.39      | 12             |
| C               | Curity      | 10.65      | 12             |
| C               | Durasorb    | 10.64      | 12             |
| D               | Johnson's   | 5.89       | 12             |

\*Means with the same letter are not significantly different.

Table B.6. Tukey's Studentized Range (HSD) Test for Differences Between Wicking Capacity and Absorbent Capacity-Method 2

| Tukey Grouping* | Product     | Means (ml) | N=replications |
|-----------------|-------------|------------|----------------|
| A               | PolyGard II | 20.98      | 14             |
| B               | Squibb      | 14.57      | 14             |
| B C             | Curity      | 11.72      | 14             |
| C               | Durasorb    | 10.86      | 14             |
| D               | Johnson's   | 7.09       | 14             |

\*Means with the same letter are not significantly different.

Table B.7. Tukey's Studentized Range (HSD) Test for Differences Between  
Coverstock Surface Dryness and Wetback-Method 2

| Tukey Grouping* | Product     | Means (g) | N=replications |
|-----------------|-------------|-----------|----------------|
| A               | Johnson's   | 0.87      | 7**            |
| A               | Curity      | 0.71      | 14             |
| A               | Squibb      | 0.70      | 14             |
| A               | Durasorb    | 0.69      | 14             |
| A               | PolyGard II | 0.67      | 14             |

\*Means with the same letter are not significantly different.

\*\*Johnson's underpad did not contain a coverstock layer.

Table B.8. Tukey's Studentized Range (HSD) Test for Differences  
Between Wetback-Method 1 and Wetback-Method 2

| Tukey Grouping* | Product     | Means | N=replications |
|-----------------|-------------|-------|----------------|
| A               | Squibb      | 2.64  | 11             |
| A B             | Durasorb    | 2.60  | 11             |
| A B             | Curity      | 2.52  | 11             |
| A B             | Johnson's   | 2.39  | 11             |
| B               | PolyGard II | 2.31  | 11             |

\*Means with the same letter are not significantly different.

APPENDIX C

TEST PROCEDURES

### Absorbent Capacity-Method 1

Equipment: A smooth surface with attached clip (a stainless steel clipboard) that can be tilted at a 45° angle.

Specimen: Six inch by six inch samples were cut in a random order from the conditioned underpad. Five samples were cut from each underpad to be tested.

Procedure: Place preweighed specimen on the clipboard, just barely catching the edge under the clip. Tilt at a 45° angle and carefully pour test liquid on sample until completely saturated. Allow sample to drain for 3 minutes and then weigh the moistened sample. The absorbent capacity is determined by taking the difference in the dry and wet weight of the sample and then dividing this difference by the weight of the dry sample to give capacity in g/g.

### Wet Back-Method 1

Equipment: A separatory funnel that has been set to deliver 200ml of water over a period of  $60 \pm 1$  seconds. This funnel should be placed in a ring stand so that it will be 2.54cm (1in) above the surface to be wetted. A 4inx4in square glass weight and preweighed blotter paper of the same dimensions are also needed.

Specimen: The entire underpad was used after conditioning overnight at 20°C and 65% relative humidity. Four replications of this test were made for each product evaluated.

Procedure: The underpad was placed on a flat surface. Test liquid (200ml) was delivered to the center of the underpad from a height of 2.54cm. The liquid was allowed to soak into the underpad for 5 minutes and then preweighed blotter paper with the glass weight on top was placed in the center of the underpad. The paper and weight were allowed to remain for 30 seconds. The blotter paper was then removed and weighed. The difference in dry and wet weight was then determined to give the product's wetback in grams.

### Absorbent Capacity-Method 2

- Equipment:** A funnel large enough to hold the samples, that has a coarse (40-60 microns) glass frit. A separatory funnel that has been set to deliver test liquid at a rate of 7ml/s and a circular 100g weight that has a bottom surface area of 100cm<sup>2</sup>. A graduated cylinder is needed to collect the liquid that drains off the sample.
- Specimen:** One hundred centimeter<sup>2</sup> circular sample is cut at a random position from a underpad that has been conditioned at 20°C and 65% relative humidity overnight. Seven samples are cut from each underpad to be tested.
- Procedure:** Place the sample in the funnel with the plastic backing against the glass frit. Deliver 100ml of test liquid at a rate of 7ml/s from a height of 2.54cm. Immediately place the 100g weight on top of the moistened sample and allow product to drain for 10 minutes. Absorbent capacity is determined by subtracting the amount of liquid that has drained into the graduated cylinder at the end of 10 minutes from the original (100ml) dosage. Seven replications of absorbent capacity-method 2 are made for each product tested. Units are milliliters.

### Retention Capacity

**NOTE:** This is a continuation of absorption capacity-method 2 and specimen is the same as used in the previous test.

- Equipment:** The same equipment as used in absorption capacity-method 2 is used. A 2.9kg weight or weights that collectively weigh 2.9 kg are needed to generate a pressure of 3kPa. To determine retention capacity at 5kPa an additional 2kg weight is needed to bring the total weight (including the 100cm<sup>2</sup> circular weight) to 5kg.
- Procedure:** For retention capacity at 3kPa immediately after determining absorbent capacity, place 2.9kgs of weight on top of the sample and 100g circular weight. If using more than one weight to make up this amount always place in the same order and with the weight as nearly in the center of the 100g circular weight as

possible. Allow sample to drain for 5 minutes and then determine the amount of test liquid in the cylinder. Retention capacity at 3kPa is determined by subtracting the amount of liquid unabsorbed at 3kPa pressure from the absorption capacity. Seven replications are made for each product tested. To determine retention capacity at 5kPa an additional 2kg of weight is placed on the sample immediately after determining retention at 3kPa. Again the sample is allowed to drain for 5 minutes and the amount of liquid that leaks into the cylinder is determined. Retention capacity (ml) at 5kPa is determined by subtracting the amount of liquid unabsorbed at 5kPa pressure from the absorbent capacity. Seven replications are made for each product tested.

#### Retention Capacity at 80% of Absorbent Capacity

Note: The same equipment and the same size specimen as used in the absorbent capacity-method 2 and retention capacity tests were used in this procedure.

Procedure: For each underpad to be tested 80% of the mean absorbent capacity is determined from absorbent capacity-method 2. This amount was placed on the sample at a rate of 7ml/s. A 100g circular weight was placed on top and the specimen allowed to drain for 10 minutes. Retention capacity at 80% of absorbent capacity was then determined using the procedure described to determine retention capacity.

#### Coverstock Surface Dryness

Equipment: A funnel large enough to place the samples on a coarse (40-60 microns) glass frit, a separatory funnel that has been set to deliver test liquid at a rate of 7ml/s, and a circular 100g weight that has an area of 100cm<sup>2</sup>. A container is needed to collect any test liquid that might drain off even though this liquid will not be measured. A 20g circular weight with an area of 100cm<sup>2</sup> and

blotter paper cut into 100cm<sup>2</sup> circular pieces that have been preweighed are also needed.

**Specimen:** One hundred centimeter<sup>2</sup> circular samples are cut at random from a underpad that has been conditioned at 20°C and 65% relative humidity overnight. Seven test samples are cut from each underpad to be tested.

**Procedure:** The test liquid dosage (8%) is determined by multiplying the sample's areal mass (g/m<sup>2</sup>). The sample is placed with the plastic backing on the glass frit and the liquid dosage applied at a rate of 7ml/s. The 100g weight is placed on top and allowed to remain for 2 minutes so the liquid can soak into the absorbent core. The coverstock layer is then removed and placed on a nonabsorbent surface (coated weighing paper was used in this study) with the preweighed blotter paper and the 20g weight on top. This was allow to stand for 60 seconds. The moist blotter paper was then removed and weighed. Difference in dry and wet weight, representing the water content of the coverstock, was determined and reported to the nearest 0.0001grams. Seven replications of coverstock surface dryness were made for each underpad evaluated.

### Wetback-Method 2

**Equipment:** A funnel large enough to hold the samples, that has a coarse (40-60 microns) glass frit. A separatory funnel that has been set to deliver test liquid at a rate of 7ml/s and a circular 100g weight that has an area of 100cm<sup>2</sup>. A container is need to collect any test liquid that might drain off but the amount of liquid will not be measured. A 20g circular weight with an area of 100cm<sup>2</sup> and blotter paper cut into 100cm<sup>2</sup> circular pieces that have been preweighed are also needed.

**Specimen:** One hundred centimeter<sup>2</sup> circular samples are cut randomly from a underpad that has been conditioned at 20°C and 65% relative humidity overnight. Seven samples are cut from each underpad to be tested.

Procedure: Place sample with plastic backing against the glass frit. Deliver 100ml of test liquid to sample at a rate of 7ml/s. Place circular plate (area: 100cm<sup>2</sup>; mass: 100g) on specimen and allow to drain for 10 minutes. Remove 100g plate and place preweighed blotter paper and a 20g circular plate (area: 100cm<sup>2</sup>) on top of sample and allow to stand for 60 seconds. Blotter paper is then immediately weighed and the difference in dry and wet weight determined to the nearest 0.0001g. This value, in ml, is the amount of wetback. Seven replications are made for each underpad to be evaluated.

### Wicking Test

Equipment: The equipment setup for this test was shown in Figure 2 (p. 37). Equipment needed is: a toploading balance (this one held up to 12kg) with attached printer; laboratory jack; container to hold test liquid; funnel with coarse (40-60 micron) glass frit; rubber tubing to connect funnel to water reservoir; 100g circular weight (area, 100 cm<sup>2</sup>); and a stopwatch.

Specimen: One hundred centimeter<sup>2</sup> circular samples are cut randomly from a underpad that has been conditioned at 20°C and 65% relative humidity overnight. Seven samples are cut from each underpad to be tested.

Procedure: The test liquid reservoir is raised until the surface of the glass frit is moist (but water is not standing on it). The specimen is placed coverstock side down on the frit with the 100g circular weight on top. A stopwatch is started with the placement of the weight and a reading of the weight of test liquid lost from the reservoir to the sample is taken every 10 seconds over an interval of 3 minutes. This is sufficient time to allow the amount of liquid wicked into the sample to stabilize. The result can be plotted on a time versus amount curve. This procedure was replicated seven times for each underpad evaluated.

## VITA

Anna Rebecca Layman was born in Athens, Tennessee on September 12, 1965. She attended Ten Mile Elementary School in Ten Mile, Tennessee and later graduated from Meigs Consolidated High School located in Decatur, Tennessee, in May 1983. After receiving her Associates in Arts degree in 1985 from Hiwassee College in Madisonville, Tennessee, she completed her undergraduate work at the University of Tennessee, Knoxville. There she received her Bachelor of Science degree in Textile Science spring quarter 1987.

She entered the Graduate program at the University of Tennessee, Knoxville during the Summer of 1987 and accepted a position as a graduate research assistant on an EPA sponsored project on pesticides. She remained on this project until it ended in January 1989 and then accepted a position as a graduate teaching assistant with the Department of Textiles, Merchandising, and Design. During this time she was also completing research for her thesis. She received her Master of Science degree from the College of Human Ecology in the Summer of 1989. Her major was Textiles and Apparel.