

Power Wheelchairs *and* User Safety

(also MOTORIZED WHEELCHAIRS)

The National Institute for Rehabilitation Engineering (NIRE) is a non-profit organization which operated clinics to design, dispense and fit customized assistive equipment, with user training, from 1967 through 1996. Working with disabled people and their own doctors and therapists, these NIRE clinics assisted *hundreds* of people having severe and permanent motor impairments. *The N.I.R.E. pioneered the development and use of personalized power wheelchairs (some steered and controlled with inertial guidance systems or with breath controls, by people unable to use hand controls); these included indoor, outdoor, indoor-outdoor models, and some designs capable of climbing curbs or stairs.* During these years, a great deal was learned concerning USER SAFETY and PUBLIC SAFETY. This paper explains many safety questions and issues. The paper is intended to be of assistance to power wheelchair users, new and old. **PERMISSION is herewith granted for the free copying and distribution of this © paper, provided all copies are complete and unaltered and The NIRE is fully credited as the source.**

THIS PAPER is intended for people using, or planning to use, power wheelchairs. It is said that “knowledge is power” and this is especially true for power wheelchair users because of the many safety issues. The power wheelchair user who knows about and understands the various safety issues will enjoy more varied uses of his power wheelchair than the person who must limit his uses out of fear of being injured in situations he may not fully understand. *In this paper, we list, discuss and explain many of the power wheelchair safety issues, including the user’s safe transportation in the power wheelchair, in a wheelchair van – as passenger or driver.*

POWER WHEELCHAIRS – Common Types and Configurations

Folding, Light-Weight power wheelchair models (for indoor use) are often similar in appearance to manual wheelchairs ... except for the presence of two small electric motors and a detachable tray with one or two rechargeable batteries. These wheelchairs are usually compact for indoor use and have small, self-pivoting wheels (casters) in front. Most of these power wheelchair models are controlled by the user’s hand with a small control stick. Quadriplegics unable to use a hand for steering and control may be equipped with a mouth- or breath- control device. These foldable power wheelchair models are usually purchased because they can be folded for storage, for transport in a car or car-trunk, or for transport on a train or airplane. The small-wheels-in-front design enhances maneuverability indoors, in small apartments and tight quarters. **Having casters in front makes these wheelchairs very dangerous to use outdoors** where one or both wheels can suddenly be turned sharply by encountering a crack in the pavement, a rock, a bump, a drop-off, or a sideways incline. *These wheelchair models usually do NOT have electric elevating legrests, backs or headrests which are desired or needed by some wheelchair users.*

Light-Weight “Power-Assisted” wheelchair models are usually similar to folding manual wheelchairs and are manually propelled in similar ways. These wheelchair models do have a battery plus one or two motors for propulsion assistance. Typically, the user is a paraplegic or quadriparetic person who desires to manually propel himself as much as possible for the exercise and resulting health benefits. The power assist feature is enabled and used to climb inclines or for extended distance travel, when the user tires or has insufficient arm strength and so desires to use the power assist feature. These

wheelchair models are often lighter-weight than the folding power wheelchair models discussed above because the intermittent power use allows for smaller battery and motor sizes.

Non-Folding, Stand-Up power wheelchair models (primarily for indoor use) are sometimes used by people, unable to stand unaided, so that they can be stood up by the wheelchair for household chores or to converse face-to-face with non-handicapped people who are also standing. Generally, these models do not rely on swiveling front casters so that they are less maneuverable in small apartments (tight quarters) than conventional folding wheelchairs with casters. When in the elevated position, this type wheelchair has a very high center-of-gravity and can easily topple over. For this reason, the user of a “stand-up” power wheelchair should never put himself in the stand-up position when outdoors or even indoors, on cracked, rough or broken flooring indoors. **Stand-up wheelchairs are safe only on perfectly flat and smooth flooring**, and only if the user is properly strapped to the seat and seat back. *These wheelchair models sometimes have electric elevation of legrests, back or headrest, often helpful for quadriparetics or quadriplegics .*

Combination “Indoor-Outdoor” power wheelchair models are often purchased by people able to have and use only a single power wheelchair. Lack of storage space or limited finances can prevent the safer option: a person’s owning two power wheelchair models – one for optimum indoor use – and another for optimum outdoor use. Typically, the “Combination I/O” power wheelchair compromises both functions and performs poorly at each function due to various unavoidable safety limitations. Outdoor safety requirements usually require that large, powered wheels be in front. These “combo” wheelchairs are probably most useful and safe when used (1) outdoors, on pavements and sidewalks in urban and suburban areas – not on grass or soil in rural areas; and (2) indoors, in nursing homes, assisted living facilities or apartments with wider halls and doorways that facilitate the wheelchair with bigger turning radius and maneuvering space requirements. *These wheelchair models sometimes have electric elevation of legrests, back or headrest, often helpful for quadriparetics or quadriplegics.*

Outdoor power wheelchair models were developed many years ago for use by people living in mostly rural countries such as Sweden. Very efficient outdoors, most have large diameter wheels in front to climb with ... and steering may be accomplished, depending on design: (1) by rotating a rear-wheel dolly ...or (2) by powering one of the large front wheels while braking the other. Many such power wheelchair models are able to safely climb grades of as much as 40%; climb curbs and, sometimes, climb outdoor stairs as seen in front of a courthouse or public building. (They do NOT climb stairs indoors due to the smaller steps and steeper grades.) These wheelchairs weigh as much as 400 to 500 pounds, less the user – or up to 650 lbs. or more with the user. If they break down, a tow truck has to be called because of the weight. They sometimes can be used indoors in hotels, hospitals, nursing homes, or public buildings ... which all have wide corridors and strong weight-bearing floors. Generally, these power wheelchairs are not safe or practical for use in an apartment. *These wheelchair models sometimes have electric elevation of*

legrests, back or headrest, often helpful for quadriparetics or quadriplegics. A few have optional elevating seats or stand-up features.

Indoor Stair-Climbing power wheelchair models have been developed and tested over the past thirty years. The developers and manufacturers have generally been unable to obtain product liability insurance coverage and, thus, have not been able to market many of these products. Recently, the U.S. FDA approved yet another stair-climbing power wheelchair which has some very interesting and attractive design features. This stair-climber, as others before it, was designed for use in private homes and apartments as well as in public buildings. The earlier models, by other designers, were primarily for stair-climbing and were rather poor performers for general wheelchair use. The recently approved model appears to perform well in most wheelchair functions, as well as in climbing and descending stairs in private homes, in public buildings, and outdoors. *These wheelchair models may or may not have electric elevation of legrests, back or headrest, often helpful for quadriparetics or quadriplegics.*

A BASIC DANGER OF STAIR-CLIMBING in a wheelchair is the fact that, if an occupied stair-climbing wheelchair falls down a flight of stairs (it could fall from near the top of a 32-step stairway) then serious injury or death to the user is the likely. Others in the area may also be injured or killed.

Each person considering the use of a stair-climbing power wheelchair should think about a lot of different variables, all of which interact with each other. These are just a few of the most significant of these important variables: (1) Does user have firm and immediate manual control of steering, braking and other wheelchair controls? Examples: a paraplegic YES; a quadriplegic NO; users with MS or CP: variable – MAYBE – to what degree? (2) Does user have sharp eyesight for spotting objects or defects on steps? (3) Does user have engineering training or hobby experience in mechanics? If not, can user understand the dynamics of stair-climbing and learn to observe, analyze and think – before climbing stairs? (4) Are the stairs to be climbed in the user’s home? Are they stairs he has climbed and descended in the wheelchair time and time before? Or, is it a new staircase not previously accessed? (5) Has the user visually inspected the stairs before attempting to climb or descend them, for the presence of toys, clothing, and wet or damaged areas? Any of these or other items could cause the wheelchair to fall. (6) Has the wheelchair user had someone else visually inspect the stairs for clutter, wet spots or damage before attempting to climb or descend? (7) Has the wheelchair user been trained to climb and descend a particular flight of stairs by a professional such as the wheelchair engineer, or a therapist or a mobility trainer? (8) Does the wheelchair user regularly climb or descend a new (to him) stairway on his own? Or does he always have another experienced person evaluate the new stairway, first? (9) Who is the first person to try climbing or descending a new stairway, in the power wheelchair? The wheelchair user? Or, his therapist, engineer or other proxy?

Age & Health Factors can be very significant to safety, both in preventing – and in surviving accidents. Examples: (1) Young paraplegic with normal upper body functions and strength. This fast moving person, with good eyesight, may well maneuver fast and vigorously enough to prevent an accident. Even if his wheelchair turns over or falls over

an embankment, the person has the highest chance of surviving with minimal injuries. Or, (2) an elderly paraplegic, or a wheelchair user of any age with upper body weakness and impaired movement abilities, is less likely to prevent an accident or fall at the last moment and is much more likely to suffer serious injuries or death in a fall, collision or accident.

WHEELCHAIR Control Methods are also very significant to safety. Most power wheelchairs are controlled solely by the user, without intervention by computers, terrain monitors gyroscopes or autopilots. These power wheelchair models require, for safety, that the user quickly sense, recognize and react to each and every situation, as it arises. The young, healthy paraplegic will usually meet these requirements most rapidly and effectively. The power wheelchair user with weak and/or slow-moving hand responses is more likely to have accidents and may be more severely injured. An **ALTERNATIVE** is available in some more costly power wheelchair models. This is the addition of computer-controlled systems that constantly monitor and correct for: wheelchair position and attitude; forward terrain variations; up and down stairway variations; user commands; and overall wheelchair performance. *In theory*, these power wheelchairs are much safer to operate than those without computer oversight. *In practice*, however, these power wheelchairs are sometimes more dangerous than non-computer wheelchairs. Serious accidents sometimes result from sensing or computer system failures. The failures may be subtle ones not recognized by the wheelchair user. Or, they can be in the form of a sudden, unexpected total failure of the wheelchair computer system, which may result in an accident when occurring at a critical time. Disregarding cost factors and considering safety issues alone, it is difficult to recommend the use of power wheelchairs that have – or that lack- computer monitoring and control capabilities. This type decision is best made with advice, on an individual basis, by each patient’s physician, therapist or mobility trainer. A *“Dead-Man’s” safety control to automatically stop and brake the wheelchair if the user should let go of the wheelchair control stick or slump in his seat, can protect against accidents due to sudden loss of manual control or due to fainting or seizure. This feature is highly recommended and was included in most power wheelchairs dispensed by this Institute.*

USERS of Power Wheelchairs – DISABILITY CATEGORIES & SAFETY RISKS as summarized below, do not include the added hazards of navigating a power wheelchair with poor vision or with susceptibility to fainting or unexpected seizures. It is assumed that all wheelchair users are strapped in for safety. Two straps should be used: one, down, lap to chair – and the other higher up, securing the upper body to the backrest of the wheelchair. *The power wheelchair user must be secured both ways for maximum safety.*

- A) **Paraplegics - Healthy, Fit & Active** are typically the safest users of manual, power-assisted, and fully powered wheelchairs. **LOWEST RISK**
- B) **Amputees – Missing Legs and/or Arms but with active upper bodies** are usually safe users of power wheelchairs, depending on the type of control devices used. If planned and implemented properly, then **LOW RISK**.
- C) **People with Weak or Poorly Controlled Upper Bodies using standard joystick** to reliably control power wheelchairs. This category may include some people

with Cerebral Palsy, some with Multiple Sclerosis, some with Parkinson Disease, and people with many other conditions. Some of these conditions may cause impaired eyesight, slowed reflexes and/or impaired judgment. All should be fully screened for such functional deficits just as for automobile driving safety.

MODERATE RISK.

- D) **People with Little or No Upper Body Movement, using special quad controls** such as mouth joystick, puff & sip breath control, or gyroscopic (inertial) wheelchair controls. HIGH RISK.
- E) **Paralyzed Small People – Children and “very small” Adults ...in special seats** or carriers often need a power wheelchair, most of all when significantly paralyzed. Depending on mechanical implementations, individual conditions, and personalized mobility and safety training, these people are at HIGH RISK.

SAFETY - INFORMATION ... for Users of Power Wheelchairs

- 1) **Mechanical BRAKES** that can be set or released by the wheelchair user are necessary safety items – an absolute “must” for outdoor wheelchair use. Some chairs have mechanical brakes that are hand-operated by a user with normal functioning of both hands - but not by users with impaired hands. Other chairs have no mechanical brakes but use “dynamic braking.” This helps slow the chair to a rapid stop when powered and moving. *It does NOT lock the wheels to prevent rolling down a steep incline. Buyers of power wheelchairs should always insist that the vendor includes mechanical brakes that the user can operate.* They must be operable when moving, to brake, stop and lock the chair. And it must be possible for the wheelchair user to manually lock or to release the mechanical brakes ... when stopped. For quadriplegics unable to move a lever, it is feasible to use standard mechanical brakes that are set, locked and unlocked by small user-controllable electric motors.
- 2) **FRONT-WHEEL Configurations** are very important for user safety. Power wheelchairs for outdoor use should always have powered large wheels in front; never free-swinging casters. Indoor wheelchairs with front casters are safe for outdoor use only on flat, level surfaces. They are at risk on sidewalks because of slab variations and irregularities, and totally unsafe on grass and soil. Wheelchairs with front casters are designed for indoor use because they offer better indoor maneuverability.
- 3) **USER ARM-STABILIZATION** should be considered for the wheelchair user with impaired arm and hand function. An orthotic elbow or forearm support can be installed on the wheelchair to support the hand used to operate the wheelchair’s controls. This support can provide vital stabilization for the hand that steers and controls the power wheelchair.
- 4) **SAFETY SHUT-OFF & BRAKING CONTROLS** should be provided for power wheelchair users who use mouth, breath, or other than hand controls. The user with normal use of one hand can steer the power

wheelchair with the control stick, can operate auxiliary power control switches and can apply or release mechanical brakes. Quadriplegics should have special devices installed immediately to shut the power off and apply the brakes, if special sensors detect the wheelchair moving unsafely or out of control. The seller of the wheelchair and controls should include these safety features, which should be tested with the user and be approved by an occupational therapist..

- 5) **Traversing INCLINES** – Always steer UP or DOWN an incline. *NEVER travel across an incline* ... because the wheelchair is likely to fall over, sideways, if you do. For wheelchairs with casters in front, *avoid areas in the pavement or path that tilt to one side* to avoid having the wheelchair roll off the path and over an embankment.
- 6) **Avoiding GROUND OBSTACLES to Wheels ...** such as stones, cracks, curbs, etc. which must be seen and avoided by the wheelchair user to prevent sudden deflection of the wheelchair to one side, off the path.
- 7) **BATTERIES should be Fully Charged** before leaving home. It is dangerous to be stranded outdoors in a power wheelchair with dead batteries. Periodically, the batteries should be checked by a technician for proper fluid levels and for remaining charge capacities.
- 8) **Always have a CELL PHONE ...** for safety. People with impaired hand dexterity, unable to operate a standard cell phone, can have a cell phone attached to the wheelchair that is modified for use by even a quadriplegic. If you cannot afford monthly cell phone fees, then get a “911-only” cell phone for which there are no monthly charges. Cell phones should be wired to work from both internal battery and wheelchair battery. Electrical noise filters may be needed to suppress motor noise.
- 9) **Powered VENTILATOR Users** should have a separate rechargeable battery on the wheelchair, for the ventilator. This assures that the ventilator will not fail even if the power wheelchair battery is exhausted. There should be an audible alarm device and the wheelchair should have a cell phone or a 911 phone.
- 10) **Avoid RAIN and SNOW** which are especially hazardous to power wheelchair users, and to their expensive equipment. Try to stay out of falling rain or snow; try to stay off wet, slippery surfaces coated with rain or snow. If you have to travel in rain or snow, use a wheelchair van, door to door.
- 11) **When being TRANSPORTED in a Wheelchair Van** always make certain that: (a) the wheels of the wheelchair are locked to the floor of the van; (b) that the wheelchair undercarriage or seat is tightly strapped down to the floor. (c) that the wheelchair user is strapped DOWN to the seat – and BACK , from the chest to the seat’s back structure. Countless wheelchair users have been thrown forward, out of their chairs, into the

windshield and to their deaths because they did not follow these precautions. These must apply whether the van is privately owned, rented or a public for-hire service vehicle.

- 12) **Outdoor STAIR-CLIMBING Wheelchairs.** Outdoor steps are usually wider, deeper and shallower than inside steps, and often of shorter height. **Some outdoor power wheelchairs** with large, powered wheels in front, are designed to safely carry the user up or down flights of outdoor steps, as found in front of courthouses or public buildings. ***These chairs cannot safely carry a person up or down the types of stairs found indoors, in homes, offices and public buildings.*** Never try on indoor stairways!
- 13) **Indoor STAIR-CLIMBING Wheelchairs** *are the most dangerous to use* because indoor steps are steep, narrow, high and have short depths as compared with outdoor steps. Most indoor stairways are not designed to support heavy weight in one area and can crack or break without warning. Also, indoor steps often have poor visibility so that unseen clutter, wet spots and damaged areas can cause the heavy power wheelchair to slip, slide, lose its grip on the stairs, and crash to the bottom injuring or killing the user. CAUTION: Always have an able-bodied wheelchair technician or mobility trainer who is familiar with the stair-climber, test climb and descend a particular flight of indoor stairs before the wheelchair user tries it. Even then, the wheelchair user should climb and then descend the same stairway two or three times in the presence of the technician or trainer. **CAUTION: Stair-climbing wheelchairs may be unsafe in a private home** because they are heavy. With batteries, such a wheelchair may weigh about 400 lbs. Add 200 lbs. for the user and the total weight can equal 600 lbs. This is enough weight to crack, break or dislodge one or more steps, causing the wheelchair and user to fall down the entire flight of stairs.
- 14) **Periodic Preventive MAINTENANCE** is absolutely necessary to maintain the safety of any power wheelchair, stair-climbing or not. We recommend daily minor, and weekly major inspections by the user. We also recommend a professional inspection at least once every 3 months for most users, and as often as once a month for very active and/or severely disabled users. If tires are air-inflated, air pressure should be checked before each day's use. Solid tires should be visually inspected for breaks. ***For SAFETY, legal and financial reasons, it is recommended that all power wheelchair service be provided by the seller, by the manufacturer or by a local mechanic who is designated as a "manufacturer's representative".***

For additional information or free technical support, please email: nire@warwick.net
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