2005

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Proceedings of the XIX Annual International
Occupational Ergonomics and Safety Conference
Las Vegas, Nevada, USA
27-29 June 2005

# MATERIALS-HANDLING HAZARD CONTROLS: ASSESSMENT OF HADDON'S INJURY CONTROL STRATEGIES

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**Abstract:** This investigation assessed the applicability of Dr. William Haddon's strategies for controlling hazards involving materials-handling operations in industrial and mining workplaces. Published over 20 years ago, Haddon's strategies purport to include all strategies for preventing and mitigating harm to people, property, and the environment. Students in an undergraduate class were assigned to find tactical examples of each of Haddon's strategies applicable to material handling. Haddon's tenth strategy involving medical care and rehabilitation was not included. Their classifications were analyzed to identify points of confusion as well as points of general agreement. Students found numerous tactics for strategies involving engineering and behavioral strategies. Fewer tactics were identified for strategies involving damage control through effective and timely response.

## 1. INTRODUCTION

In 1980, a widely-recognized pioneer in injury control, Dr. William Haddon, Jr., published an article describing ten strategies for injury control (Haddon, 1980). This generic list was intended to encompass all of the various strategies for preventing injury, mitigating the damage from injurious events, and rehabilitating/restoring the damaged person or thing. The strategies encompass a broad concept of injury, including personal injury caused by traumatic events, damage to health through long-term exposures, and harm to the environment. The strategies have received much recognition in the public and highway safety domains, but practioners in the occupational safety domain have shown limited interest. The reason for writing this paper was to draw attention to the potential value of a universal list of strategies for controlling diverse material-handling hazards and injuries.

The most significant potential value of general strategies is to encourage the safety profession to critically examine the present rule-based approach that evolved through experience, committees, and governmental regulations. The reliance on a rule-based approach makes a negative contribution to the image of occupational safety practioners in the eyes of industrial and governmental managers as well as legislators and judges. The image of being a rule-based field suggests that the educational preparation for practicing occupational safety simply involves memorizing thousands of rules and regulations. How common is it to encounter an industrial manager who believes that all it takes to qualify for the practice of occupational safety is several years of experience in the industry and an 80-hour course on regulations? The continuation of such images will hinder progress in gaining respect and support for occupational safety programs. Greater recognition of Haddon's strategies may help the safety community move beyond the rule-based approach.

A second potential value of having general injury control strategies stems from the segmented evolution of safety. Currently there is very limited communication between safety practioners in the various application domains such as industrial safety, agricultural safety, construction safety, aviation safety, highway safety, maritime safety, railroad safety, public safety, patient safety, consumer product safety, and military safety. Even regulations in the United States reflect the so-called vertical industry approach, with separate standards for general industry, construction industry, maritime industry, and mining. Many practioners in these application domains seem to think their applications are completely different from other application domains. It is very difficult to build a unified safety profession when practioners have this domain-specific perspective. Haddon intended his principles to extend horizontally, throughout all application domains.



ISBN: 0-9652558-2-4

A third potential value of having general injury control strategies relates to the grouping of the safety rules and regulations. Our text books and training courses are structured to discuss in totally separate contexts the safe practices for various technical areas such as electrical safety, machine safeguarding, walking and working surface safety, materials handling, industrial hygiene, environmental protection, fire protection, and hazardous materials. It is as if each topic has nothing to do with other topics. What Haddon did was propose some fundamental hazard control strategies that transcend such traditional technical categories.

A threshold explanation of "strategies" provides a foundation for Haddon's thinking. Figure 1 depicts the relationships among goals, objectives, strategies, and tactics. Goals are broader statements pointing to the general direction an organization wants to go. Goals provide the basis for defining objectives, and each objective should support a goal. An organization may decide on one or more objectives for each goal. Objectives are achieved by choosing strategies. Strategies are implemented by selecting tactics. Each strategy may have one or more tactic; for example, an organization may have a goal of providing an industry-benchmark program in fire safety. There may be objectives for fire prevention, fire suppression, and occupant protection. For each objective, there may be multiple strategies. These strategies might be based on Haddon's ten strategies. For each strategy, there may be multiple tactics.

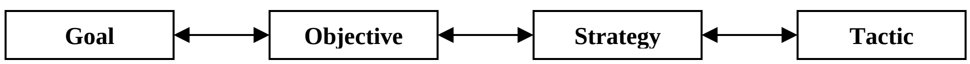


Figure 1: Strategies in relationship to goals, objectives, and tactics

The objective of the paper is to illustrate Haddon's strategies with examples of tactics applicable to materials handling. His first eight strategies apply to for controlling hazards, his ninth to damage control, and his tenth to stabilizing, repairing, and rehabilitating the object of the damage. The tenth strategy was considered beyond the scope of this project. It would apply to medical care, treatment, and rehabilitation of musculoskeletal injuries incurred from material handling tasks; property damage from material handling equipment; and environmental damage from chemical spills and releases. Many of the illustrations came from students taking a safety engineering course at Montana Tech. The course emphasized traumatic injury control, so the examples reflect that. However, several examples apply to control of occupational health hazards, hazards for equipment, and matters of industrial environmental protection.

## 2. METHODS

Students in an undergraduate class were assigned to find tactical examples of each of Haddon's strategies applicable to material handling. Their primary source was the material handling chapter in the course textbook by Ray Asfahl (2003). Their classifications were analyzed to identify points of confusion as well as points of general agreement. Examples of hazard control tactics were selected and tabulated for the first eight strategies, and for damage control for the ninth strategy.

Example tactics are presented in tables. Each table has three columns for: (1) the hazard, (2) that to be protected, and (3) the hazard control or damage control. Various definitions of "hazard" were examined. The definition selected was one from Fred Manuele's book "On the Practice of Safety" (2003): "A hazard is defined as the potential source of harm." Manuele did not list potential sources of harm. For this analysis, our team determined that potential sources of harm consist of active and potential energy, musculoskeletal stress, toxic chemicals, environmentally harmful chemicals, behaviors, conditions, and persons. Where a tactic could arguably fit more than one type of hazard, the team exercised judgment as follows. A protrusion in a walking surface poses a tripping hazard that could be called a condition or a form of gravitational energy that is released when the pedestrian looses balance and falls. We chose the condition category for the state of walking and working surfaces. An area where flammable gases are sometimes present could be considered a toxic chemical or a hazardous condition. The team chose to call this a form of potential energy when considering the flammable nature of the chemical and a toxic chemical when considering the human exposure to the chemical.

## 3. RESULTS

Examples from this exercise are presented in Tables 1 through 9, corresponding to Strategies 1 through 9. Strategy 10 was not included.

Table 1. Strategy 1: To prevent the creation of the hazard in the first place

| Hazard | That to be Protected | Hazard Control |
|---|---|---|
| Momentum energy of a forklift truck not adequately controlled by qualified operator | Pedestrians & property | Issue keys only to persons qualified to operate forklift truck. |
| Fire from ignition of gases released while recharging forklift battery in an uncontrolled location | Person & property | Perform all battery recharging in a designated location where ventilation keeps concentration below flammable range and ignition sources are prohibited. |
| Musculoskeletal stress from manually unloading bags from a truck | Person doing the lifting | Keep bags on a pallet, and use a forklift to load and unload bags from truck. |
| Musculoskeletal stress from manually lifting patient from wheelchair to weight scale | Person doing the lifting | Obtain scale with large platform and ramp to enable weighing patient without removing from their wheelchair. |
| Carbon monoxide emitted from diesel engines of forklift trucks | Personnel | Replace diesel trucks with battery powered trucks. |
| Fall from tripping on corner of floor mat while carrying load | Person | Install mats that are recessed into the floor so there are no protrusions to trip on. |

Table 2. Strategy 2: To reduce the amount of the hazard brought into being

| Hazard | That to be Protected | Hazard Control |
|---|---|---|
| Momentum of fast moving forklift trucks in areas co-occupied with pedestrians | Pedestrians | Limit momentum by limiting speed, either by speed limit rule or a device that limits top speed of trucks. |
| Musculoskeletal stress from lifting load from the floor | Person | Store load on a shelf or platform so it can be lifted using a biomechanically less-stressful posture. |
| Carbon monoxide emitted from diesel engines of forklift trucks left running when not in use | Personnel | Enforce rule that lift truck operators turn engines off when truck is not being used. |
| Carbon monoxide emitted from diesel engines of forklift trucks | Personnel | Keep engines well tuned to reduce CO concentration in emissions. |

Table 3. Strategy 3: To prevent release of the hazard that already exists

| Hazard | That to be Protected | Hazard Control |
|---|---|---|
| Ignition of flammable atmosphere in the forklift-battery charging area | Person & property | Avoid ignition sources in battery charging area by rules, including no smoking. |
| Ignition of flammable atmosphere in the forklift-battery charging area | Person & property | Keep concentration of flammable gas below the flammable range by ventilation. |
| Gravitational energy of forklift truck forks while elevated for truck maintenance | Person | Block forks to assure they cannot fall while mechanic is working below. |
| Musculoskeletal stress when placing a heavy load at destination of a lift | Person | Drop load rather than placing it. May require a fixture on destination surface to force load into desired position. |
| Fall of forklift truck and operator off loading dock when truck trailer rolls away unexpectedly | Person & property | Set truck brake and chock wheels before loading or unloading trailer. |

Table 4. Strategy 4: To modify the rate or spatial distribution of release of the hazard from its source

| Hazard | That to be Protected | Hazard Control |
|---|---|---|
| Gravitational energy of an elevator | Person & property | Effective brakes and counterweights |
| Momentum energy of a haul truck descending a hill | Person & property | Effective brakes and competent driver |
| Burning coal on a conveyor | Property | Automatic sprinkler system above conveyor to limit spatial distribution of fire |
| Gravitational energy of old roofing material being thrown from roof to truck bed below | Personnel & property | Provide a chute with large opening at top to channel materials into smaller opening at truck bed. |
| Musculoskeletal stresses from shoveling spilled materials from under a conveyor | Person | Reduce spillage with better conveyor design. At spillage point, install spillage alarm to stop belt when spillage is occurring. |

Table 5. Strategy 5: To separate, in time or in space, the hazard and that which is to be protected

| Hazard | That to be Protected | Hazard Control |
|---|---|---|
| Gravitational energy of load supported by a crane | Personnel | Designate area underneath load movement as “No Personnel Permitted” area. |
| Gravitational energy of load supported by a crane | Personnel | Procedure for crane operator to watch for people and avoid moving load over area occupied by people. |
| Controlled explosion in a mining operation to break up rock | Personnel | Procedures to clear personnel from area and detonate only after confirming no personnel in area. |
| Moving conveyor located where workers are tempted to cross by jumping | Personnel | Build a bridge over the conveyor. |
| Diesel exhaust gases in underground mines | Personnel | Ventilate gases away from personnel |
| Handling containers of chemicals that emit hazardous gases during mixing | Personnel | Procedure to perform chemical handling in a proper fume hood. |
| Equipment operator who shows up for work high on some drug | Persons & equipment | Supervisors trained to notice signs of drug usage, and a program for keeping the operator off the job until clear of drugs. |

Table 6. Strategy 6: To separate the hazard and that which is to be protected by interposition of a material “barrier”

| Hazard | That to be Protected | Hazard Control |
|---|---|---|
| Gravitational energy of packaged materials on high shelves in a warehouse where forklifts operate | Forklift operator | Provide a Falling Object Protective Structure on each forklift. |
| Contact of coal miner with electrical energy in the heavy electrical cable used to power a continuous miner | Personnel | Provide multiple layers of electrical insulation to assure an adequate insulative barrier between conductive wire and miners who manually move the cable. |
| Gravitational energy of heavy metal parts being manually handled | Person | Wear steel-toed footwear. |
| Momentum energy of small objects falling from overhead | Personnel | Hardhats worn by personnel. |
| Toxic chemicals that might be released from storage containers while being handled at disposal site | Personnel | Workers wear respirators for protection from the specific toxic chemical. |

Table 7. Strategy 7: To modify relevant basic qualities of the hazard

| Hazard | That to be Protected | Hazard Control |
|---|---|---|
| Force required to handle a tool are concentrated on a small skin surface area | Person | Provide a tool with more rounded edges that will distribute the force over a larger skin-surface area. |
| Musculoskeletal stress from manually handling a moderately-heavy object with poor hand coupling | Personnel | Redesign the object to provide suitable handholds and/or reduce the object's weight. |
| Carrying heavy suitcase during business trips causes fatigue of shoulder muscles | Person | Start using a suitcase with wheels. |
| Slippery spots on a concrete walking surface due to a spilled liquid; a hazard for worker carrying a load | Personnel | Etching the surface to increase roughness will improve friction even when wet. |

Table 8. Strategy 8: To make that to be protected more resistant to damage from the hazard

| Hazard | That to be Protected | Hazard Control |
|---|---|---|
| Musculoskeletal forces from handling heavy loads can strain a muscle | Person | Strength training increases muscular strength capability, so the load handled becomes a lower percentage of the person's strength capability, and this reduces risk of muscle injury. |
| Musculoskeletal forces from handling heavy loads can harm joint surfaces and sprain ligaments | Personnel | Strength training increases muscular strength, which helps stabilize joins involved in load handling. Stable joints are less likely to be injured than unstable joints. |
| Lack of continuous tension on the wire rope of a crane leads to gradual loss of strength | Property (rope) | Keep a "headache" ball on the end of the rope to maintain tension. |
| For the wire rope of a crane, repetition of high-low tension cycle leads to fatigued strands that eventually break, resulting in less rope strength | Property (rope) | Regular oiling and other maintenance reduces damage to strands and helps extend life of rope. |

Table 9. Strategy 9: To begin to counter damage already done by the environmental hazard

| Hazard | That to be Protected | Damage Control |
|---|---|---|
| Heat stress from manual materials handling in a hot environment | Person | Treat heat stroke immediately by immersion in cold water. Treat heat exhaustion by rest and cooling skin. |
| Hazardous gases from a hospital fire threaten patients and care providers moving to an exit | Personnel | Provide and maintain emergency egress system so people can get out before inhaling too much harmful smoke. |
| Miners trapped underground after a mine explosion | Personnel | Rapid, coordinated response by well-trained mine rescue teams. |
| Hazardous materials spilling into soil after transport truck overturned | Environment | Rapid response by well-trained HAZMAT team. Emergency communication system in place. |
| Uneven walking surface | Person | Treat sprained ankle using ice pack to minimize swelling. |

## 4. DISCUSSION

The types of hazards for each strategy are listed below, in order of hazard category (active and potential energy, musculoskeletal stress, toxic chemicals, environmentally harmful chemicals, behaviors, conditions, and persons).

- Strategy 1: two of energy, two musculoskeletal stresses, one condition, and one toxic chemical.
- Strategy 2: one of energy, one musculoskeletal stress, one hazardous behavior, and one toxic chemical exposure.
- Strategy 3: three of energy, one musculoskeletal stress, and one condition (unexpected gap between loading dock and trailer). The loading dock example could have just as easily been called a potential gravitational energy hazard.
- Strategy 4: four forms of energy and one of musculoskeletal stress.
- Strategy 5: four forms of energy, two toxic chemicals, and one hazardous person.
- Strategy 6: four forms of hazardous energy and one toxic chemical.
- Strategy 7: one form of energy, two musculoskeletal stress, and one hazardous condition.
- Strategy 8: two musculoskeletal stress, and two hazardous equipment conditions.
- Strategy 9: one form of energy, one toxic gas, one hazardous atmospheric condition, one environmentally harmful chemical spill, and one hazardous condition.

Students found numerous tactics for strategies involving engineering and behavioral strategies. It was quite challenging to find material handling tactics for the ninth strategy involving damage control through effective and timely response and escape from hazardous conditions.

Most tactics were classified without difficulty, but some presented controversy. One controversy involved numerous applications of noncompliance with a safety rule or standard operating procedure. For example, if steel toed boots are required due to handling heavy metal parts, and someone does not wear them, is the noncompliant behavior a new hazard or a failure to implement a hazard control tactic? It may be quite reasonable to refer to safety rule violations as hazardous behaviors; however, it appears the more technically correct concept is to refer to such behavior is a failure of a hazard control tactic. It does not create a new hazard. Haddon’s article appears to embrace this concept. However, it leaves us with an untidy issue – should there be a specific strategy to recognize human behavior complying with a safety rule, or more generally with a behavioral hazard control tactic? Haddon’s strategies recognize the use of such controls, but not the employee’s behavior of following, or not following the practice.

In order to attain agreement on the classification of tactics into strategy categories, it is essential to clearly specify both the hazard and “that to be protected”. Vagueness on these points accounted for much of the disagreement in classification and generated discussion of the definition of a hazard. Additionally, there is no clear place for hazard control tactics involving personnel complying with safety rules. The results also suggest that to attain broader acceptance of Haddon’s strategies among occupational safety practitioners, some degree of translation from Haddon’s original papers is required. It is concluded that Haddon’s first nine strategies, with a bit of clarification, could provide a set of overarching principles for preventing and mitigating harm associated with materials handling.

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## 6. ACKNOWLEDGMENTS

Some authors of this article were partially supported by Grant No. T03/CCT81449 and/or Grant R25 OH 008319 from the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health. The contents are solely the responsibility of the authors and do not necessarily represent the official views of the National Institute for Occupational Safety and Health.