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Risks and Hazards at Rotary Screen Printing (Part 4/6): Manual Materials-Handling

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Abstract.
This-study aimed at identification of occupational-hazards and risks, associated with *manual* materials- handling (MMH), incorporating manual-lifting, but excluding pushing and pulling. The-study was limited to-printing-section, of a-textile-mill. Questionnaire, observations, and document-analysis, were the-main- research-instruments. Pre-testing, of the-questionnaire, was done, according to the-ISO 20252:2006 (E). Reliability (the-Cronbach's co-efficient) was obtained *via* SPPS-17, version 22, and established high-inter –item-consistency (α >0.87). Descriptive-statistics was employed to-analyze both; qualitative and quantitative-data. The-study established, that some-MMH practices, in the-department, are hazardous and risky, and can-contribute to Musculoskeletal-injuries and/or Musculoskeletal-Disorders. In-particular, absolute-majority of the-respondents, reported, that MMH was their-daily-responsibility; and also-stated, that the-loads, they handle, were, largely, both; heavy (20-50kg), bulky (too-wide (> 50 cm)), and long (> 30cm). Moreover, the-mainstream indicated, that: (1) heavy-loads (rolls of fabric, and containers of dyes/pigments/solvents) were lifted *manually*, in awkward-working-positions, solo (without help), and with *not* knowing of the-weight of the-load, to be-lifted; in-addition, inadequate/ short-handholds made lifting more-precarious, increasing the-risk of injuries, and of dropping the-load; (2) material-handling-equipment was *not* in-good-condition; considerable-force was needed to-push, or pull, equipment, such-as trolleys; (3) repetitive-tasks, and movements, were-routinely carried-out; and (4) the-floor was uneven and sloping, making the-movement of goods, even-more-difficult. Numerous-tailored-recommendations included: preventive technical/engineering-measures (mechanization, and rearrangement of workplace); and organizational/administrative-measures (job-rotation, task-specific training, *proper*-machine and plant maintenance, including Total Productive Maintenance, and good housekeeping), among-others. The-study also-offered a-review of theoretical-background on: Standards for manual-handling; NIOSH-lifting- equation; Preferred-position and zone, for safe-lifting; and Lifting-Principles. The-study is important; foremost, for the-mill-administration, as knowing the-hazards is a-paramount-step on the-road, to their-eradication, or reduction. Furthermore, this-*unfunded*-study also contributed (in its-small-way) to the-body of knowledge, on the-subject-matter.
Keywords: lifting, heavy load, awkward posture, repetitive tasks, MH, MMH.

1. Introduction.

1.1. Materials Handling

Materials-handling (MH) can-be-defined as: 'art and science of conveying, elevating, positioning, transporting, packaging, and storing of materials' (Uttam, 2013). Khanna (2009) defines MH as '*any* transporting, or supporting of a-load, in any-form, by one, or more-workers'. MH involves the-movement of materials, manually, or mechanically, in-batches, or one-item, at a-time, within a-plant. MH involves short-distance-movement, within the-confines of a-building, or between a-building and a-transportation vehicle *(Coyle, 1992).* It utilizes a-wide-range of manual, semi-automated, and automated-equipment, and includes consideration of the-protection, storage, and control of materials, throughout their-manufacturing, warehousing, distribution, consumption, and disposal (Material handling*).* MH can-be-used to-create *time and place utility* through the-handling, storage, and control of material, as distinct from manufacturing, which creates *form-utility* by changing the-shape, form, and makeup of a-material (Apple, 1972).

Manual-tasks used to-be referred-to-as 'manual-handling'. The-term 'manual-task' refers to-physical activity, and is defined in NIOSH Standard for Manual-Tasks (2007) as 'any activity requiring a-person to use any part of their musculoskeletal system in performing their work'. *Manual*-materials handling (MMH) includes: lifting, lowering, pushing, pulling, carrying, holding, moving, dragging, and supporting objects, among-others. The-load can be an-animate (people or animals) or inanimate-objects (boxes, tools, etc.) (Khanna, 2009). The-movement may-be horizontal, vertical, or the-combination of the-two (Uttam, 2013). This-study limited to *manual*-materials-handling, including manual-lifting.

The-main-risk-factors, or conditions, associated with the-development of injuries, in-MMH-tasks, include (WBG, 2007): (1) Awkward-postures (e.g., bending, twisting); (2) Repetitive-motions (e.g., frequent-reaching, lifting, or carrying); (3) Forceful-exertions (e.g., carrying or lifting heavy-loads); (4) Pressure-points (e.g., grasping (or contact from) loads, leaning, against parts or surfaces, that are hard or have sharp-edges); and (5) Static-postures (e.g., maintaining fixed-positions, for a-long-time).

Repeated or continual-exposure, to-one, or more, of these-factors, initially, may-lead-to fatigue and discomfort. Over-time, injury to the-back, shoulders, hands, wrists, or other-parts, of the-body, may-occur. Injuries may include damage to: muscles, tendons, ligaments, nerves, and blood-vessels. Such-injuries are referred-to-as musculoskeletal-disorders (MSDs) and musculoskeletal-injuries (MSIs).

MMH can cause either; cumulative-disorders, from the-gradual-deterioration, of the-musculoskeletal system, such-as lower-back-pain, or acute-trauma, such-as: (1) Strains and sprains, from lifting-loads, improperly, or from carrying-loads, that are either; too-large or too-heavy; (2) Fractures and bruises, caused-by being-struck by materials, or by being-caught in pinch-points; and (3) Cuts and bruises, caused by falling-materials, that have-been improperly stored, or by-incorrectly-cutting-ties, or other-securing devices (Council Directive 90/269/EEC: 1990).

In-addition, poor-environmental-conditions, such-as: extreme-heat, cold, noise, vibration, and poor- lighting, may increase workers' chances of developing MSDs and MSIs. Besides, individual-factors (age, sex, physical-fitness) and organizational-factors (employment-status, payment-methods, working-hours), and work-environment (types of work, equipment, overall-setting) are also important-underlying-factors, for the-progress of work-related MSDs (WRMSDs) (Yitayeh *et al.,* 2015; Deyyas & Tafese, 2014; Lombardo, 2011).

According-to the-Fourth-European Working-Conditions-Survey, carried-out in the-EU-27, in-2005, 35% of *all* workers are exposed to-the-risk of carrying, or moving, heavy-loads, for at-least a-quarter of their-working-time (EU-OSHA, 2007). A-breakdown of rates of exposure to *manual*-handling, by-sector, shows, that workers in agriculture, construction, hotels and restaurants are most-likely to-be-exposed to heavy-loads (68%, 64% and 48% respectively), followed by workers in the-sectors of *manufacturing*, mining, wholesale and retail-trade (close to 42%), and transport and communications, with 35% (Hazardous manual-handling, *nd*).

Besides, according to the-U.S. Bureau of Labor-Statistics, the-rate of non-fatal occupational-injury and illness-cases was 109.4 cases per 10,000 full-time-workers, in 2013, where 45.3% of the-injuries and illnesses were MSDs (USBoL, 2014). It-is-estimated, that globally, the-total-number of WRMSDs-cases (prevalence) in 2014/15 was 553,000, out of a-total of 1,243,000 all-work-related-illnesses. Of which, 66% of the-total, accounts for high-burden, even, in-developing-nations. Moreover, WRMSDs are the-most common work-related health-problem, in-Europe, with almost one-in-four workers reporting backache, and one-in-five, complaining of muscular-pains (HSE, 2015).

Several-scientific-authors published on the-development of occupational-health-issues, relating-to manual-lifting, during-work (see Da Costa, 2010; Van Rijn, 2010; Wai *et al.,* 2010; Jensen, 2008; Cole, 2003; Lotters *et al.,* 2003; Lau, 2000). Manual-lifting and moving-loads is a-major potential-source of back-injuries, among-workers. For-example, Herniated-disks is a-type of exceedingly painful back-injury, found in-workplace-situations. It occurs, when an-injury, to-the-spine, causes the-outer-layer of the-spinal- disk, to-bulge-out, and pressing on the-nerve (Apple, 1972).

On-the-other-hand, overexertion-injuries are the-result of excessive-repetitive-handling, and/or the-use of excessive-force, for a-single-handling. These-injuries involve the nerves, tendons, muscles, and supporting-structures of the-body (Council Directive 90/269/EEC: 1990).

1.2. Local-perspective and the-purpose of this-study

In-the-local-context, several-recent-studies, at the-same-printing-department, have shown, that:

Absolute-majority of the-respondents had at-least-one pain-complain, related to-MSDs. Low-back body-region received the-highest-number of complains, of pain, lasted, for at-least 24hours, for the-last-year (37.5%); last-month (25%); and last-week (12.5%). For the-three-reported-years, overall, MSDs contributed 36% of the-total-number of sick-leave-days, at the-finishing-department, leading to losses of KES 115,950 (USD 1,159.5), excluding direct-costs, and quality of life-costs. The-highest number (60%) of sick-leave-days, attributed-to MSDs, among factory-workers, was due-to hand, wrist, and forearm-pain or injury. For, the-finishing-department, the-same-trend accounted for 55% (Starovoytova, 2017b).

Another-study by Starovoytova (2017c), on two most-dangerous-postures, identified 2nd and 3rd action-level of danger of MSI, necessitating further-investigation, and possible-change/correction. Investigations revealed the-following-risks of MSDs and MSIs, for the-posture #1: (1) awkward-back-posture-- torso bending-forward, at the-waist, with 46 degrees deviation, from neutral- posture; (2) visually-demanding-operation (risk of eye-strain); (3) contact-pressure; (4) stress on lower-extremities; and (5) standing-static-posture. For the-posture #2, the-risks were: (1) awkward-neck and head-posture, with 38 degrees deviation, from neutral-posture; (2) risk of eye-strain; (3) stress on lower-extremities; and (5) standing static-posture.

Moreover, in yet-another-study, at-the-department, the-majority of the-respondents pointed-out on several-psychosocial-hazards, describing their-working-tasks and conditions, as: extensive, heavy, mentally-demanding, with *no* sufficient-time, given, and also as *not* a-secure/stable-job. In-addition, they were *not* able to-influence the-pace of their-work, as it was, largely, dictated by the-machine-speed. Overall, this could manifest in work-related-stress. Secondly, the-respondents were *not* satisfied with the-state Occupational-Health and Safety (OSH), at the-company (manifested in the-lack of: (1) organizational-Health and Safety-Policy; (2) establishmentposition of Safety-Officer, at the-mill; and (3) First-aid-box, in the-department). Mechanical-hazards were-also-reported: some-machines were with unprotected-moving-parts, allowing possible-unprotected or unintentional-start-up (Starovoytova, 2017d).

The-current-study is a-logical-continuation of the-previous-investigations on occupational-risks and hazards, at rotary-screen-printing, with particular-emphasis on *manual*-materials-handling, including manual-lifting. ‘Pushing and pulling’ MMH was excluded, from this-study, as the-issue, is important, and it deserves to-be-given more-detailed-address--in separate-publication (yet to-be-published, under this-series, as number 5/6).

The-study is, believed to-be-important, as it provided a-reflection of current-practices, at the-station. It also added to-the-body of knowledge, on the-subject-matter. Besides, to-give broader-perspective, the-following-issues were covered, in-subsequent-sections: Standards for manual-handling; NIOSH-lifting equation; Preferred-position and zone, for safe-lifting; and Lifting-Principles.

2. Materials and Methods.

2.1. Description of the-textile-mill, where the-study was conducted.

Recent-study by Starovoytova (2017a) stated, that Rift-Valley-Textiles, Limited (RIVATEX) was incorporated on 19th June, 1975, and was bought, by the-Moi University (MU) in the-year 2007. Before it-went into-receivership, in 1998, and eventually ceasing operations, in the-year 2000, the-mill used-to consume an-average of 2,800 tons of cotton and 550 tons of polyester/viscose, resulting in over 15 million-meters of fabric, per-annum. Before its-collapse it-was the-leading-textile-mill, in East-Africa, with a-reputation of producing the-best-quality-fabrics, with orders of over USD 3,500,000, per-annum. Currently, Rivatex-East-Africa, Limited (REAL) is a-Moi-University-facility, for-research, product development, extension, and production. REAL also has-emerged to-be a-center for training of textile-Engineers and also-offering-opportunity for student-interns, Industrial-attachment, and applied research, to-develop their-careers (Rivatex, EA official-website).

2.2. Main-instruments, used.

Questionnaire, observations, and document-analysis, were the-main-research-instruments.

This-research complied with the-ISO 20252:2006 (E): Market, Opinion and Social-Research Standard; hence, a-preliminary-study was-conducted on one-machine-operator, from a-different-department. Afterwards, the-questionnaire was, adopted, with minor-adjustments.

Besides, verbal-consent was obtained, from-respective-participants, after a-necessary-explanation, about the-purpose, and the-procedure, of the-study. Participation was on-voluntary-basic, and was-done anonymously.

2.3. Structure and design of the-study.

In-order to-conduct a-survey and perform a-document-analysis, the-study was divided-into 3-distinctive parts, which shown in-Figure1.

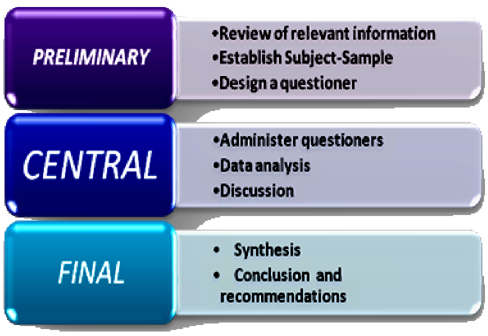


Figure1: Sequential-parts of the-study (Starovoytova & Namango, 2016).

2.4. Sample size and the-rationale for its-selection.

To-evaluate risks and hazards, associated with MMH, among machine-operators, at the-REAL, a-confidential self-report-questioner was designed and used, as the-main-instrument, for this-study, with the-sample-size of 12-subjects (representing the-entire machine-operating-staff, at the-finishing department).

2.5. Data analysis

To-estimate reliability, the-correlation-coefficient was used, according to Kothari (2004). The-Statistical Package for Social-Sciences (SPPS-17, version 22)-computer software-program was applied, to-compute the-

Cronbach's co-efficient. Descriptive-statistics was employed to-analyze both; qualitative and quantitative-data.

2.6. Terminology applied

Definitions and important-differences, between 'hazard' and 'risk' (in the-context of OSH), pointed-out, by Starovoytova (2017b), were applied, in-this-study. Besides, definition of *manual lifting* by the-National Institute for Occupational-Safety and Health (NIOSH) as 'manually grasping an object of definable size and mass with two hands, and vertically moving the object, without mechanical-assistance', was adopted.

3. Results.

3.1. Analysis of validity and reliability of the-questionnaire

Upon-validation, the-general-recommendation made, is that the-instrument was-acceptable, with some- minor-editing. Questionnaire-data was-coded, entered into-SPSS and checked for-errors. Data was analyzed, list-wise, in SPSS, so that the-missing-values were-ignored. Cronbach's - alpha-test of internal-consistency was performed, for perceptions and self-reports, and established high-inter-item-consistency (Cronbach's a > 0.87).

3. 2. Response-rate (RR)

The-questionnaires were administered to 12 machine-operators; 9 *complete*-replies were-received, giving RR of 75%.

3. 3. Demographics of the-participants

Table 1 shows the-demographic-characteristics of the-respondents.

Table1: Demographic-information of the-respondents (analogous to Starovoytova, 2017b).

	Mean	S D	Range
Age (yrs)	25.375	10.23	24 - 43
Duration of Employment (yrs)	2. 75	2.18	1 - 8
Height (cm)	169.07	11.84	146 - 182
Weight (kg)	65.375	9.80	54 - 85

3.4. Responses to the-questionnaire

The-analysis revealed, that:

Absolute-majority of the-respondents, reported, that MH was their-*daily*-responsibility; 100% also-stated, that the-loads, they handle, were, largely, both; heavy (25-50kg), bulky (too-wide (> 50 cm)), and too-long (> 30cm). They also-reported, that handles, or handholds, were *not* provided, on fabric-rolls.

88.9% of the-respondents indicated, that: (1) heavy-objects/loads (for-example: rolls of fabric, or containers with pigments/dyes/solvents) were lifted *manually*. In-addition, they complained, that most of the-times, they have-to-lift heavy-objects *alone*; (2) they were also *not* sure how-heavy, the-loads were, hence, they just approximated; (3) considerable-force was-needed to-push or pull equipment, such-as trolleys; and (4) the-floor was uneven and broken, in several-places.

77.8% reported that trolleys, or other-material-handling-equipment, for moving loads, were *not* kept in good-condition, while 36% disagreed with them.

66.7% indicated, that the-loads were, sometimes, difficult to-grasp, as, after printing, they were still wet.

55.6% reported, that: (1) they have-to-carry-out repetitive-tasks, and could *not* dictate their-pace of work; (2) the-floor was uneven, sloping, likely to-make the-movement of goods more-difficult; (3) they worked in-uncomfortable or awkward-postures and positions.

44.4% of the-workers also-indicated, that:(1) the-loads placed, at the-beginning, or the-end, of lifting, required awkward-postures (bending, twisting, reaching, holding, or even, combination of awkward- postures); for-example, far from the-body, above shoulder-height, or below knee-height; MH also required maneuvering, for-example a-roll-of fabric, have-to-be-placed *accurately*, into position, for printing-process, to-start; and (2) the-workers have-to-make, constantly, repetitive-movements.

33.3% of the-workers agreed, that they, usually, stand or walk, for a-long-periods of time, during their-shifts.

It was also-observed, that; (1) some-storage-racks required the-operators to-repeatedly-obtain rolls of fabric from either; floor-level, or above-shoulder-height.

4. Discussion.

The-respondents, pointed-out, on several-limitations, in MH-practices, at-the-department, which summarized (for-ease of discussion) as-follows: (1) heavy-loads, were lifted *manually*, in awkward working-positions, solo (without help), and with *not* knowing of the-weight of the-load, to be-lifted; (2) material-handling-equipment was *not* in-good-condition; considerable-force was needed to-push, or pull, equipment, such-as trolleys; (3)

repetitive-tasks, and movements, were-routinely carried-out; (4) the-floor was uneven and sloping, making the-movement of goods, more-difficult.

To-propose improvements, on the-current-practices/conditions, the-identified-limitations were discussed, in-the-next-sections (in-the-same-order, as the-above-summary).

4. 1. MMH, including manual-lifting

4.1.1. Manual-handling, at the-department.

Rotary-screen-printing involves the-following main-sequential-steps: (1) Color-Kitchen (printing-paste preparation); (2) Screen-engraving; (3) Printing; (4) Drying; (5) Steaming; (6) Washing; and (7) Drying. The-first-two-steps are considered, as preparatory, which conducted outside the-*actual*-printing-machine.

Rotary-screen-printing is a-so-called 'roll-to-roll' process (R2R), where machine-operators have-to routinely-handle rolls of fabric. Roll-handling, involves the-methods, in-which rolls of fabric are transported, and oriented prior-to, and after fabric-printing. Textile-fabric is manufactured and wound-on a-core, for further-processing, or shipment. Generally, rolls are wound parallel to-the-floor (horizontally); rolls of fabric can-be-stored in both-directions; horizontally or vertically. Roll-handling is required to-transport wound-rolls of grey-fabric, from preparatory-finishing-section to printing-section. In-printing-section the-rolls are transported-to and loaded-in-to the-printing-machines (for fabric-printing), and reloaded, from the-printing-machines, after printing is complete, and then, transported for-storage, or directly, for the-next finishing-process. Roll-handling-methods include: reorienting rolls of fabric, from-horizontal to-vertical, and *vice-versa*, as-well-as: lifting, holding, loading, and lowering the-rolls. In-addition, roll-handling involved lifting, to and from, shelves, racks, and trolleys, and roll-handling in-quality control-areas, e.g. weighing the-roll, among-others.

4.1.2. Analysis of manual-lifting

At the-department, heavy-loads were lifted manually, in awkward-working-positions, alone (without help), the-operators were also *not* sure how-heavy, the-loads were, they just approximated. Due-to common solo-lifting, the-loads were lifted, one-side, at a-time, particularly in the-case of lifting a-roll of fabric (see Figure 2).

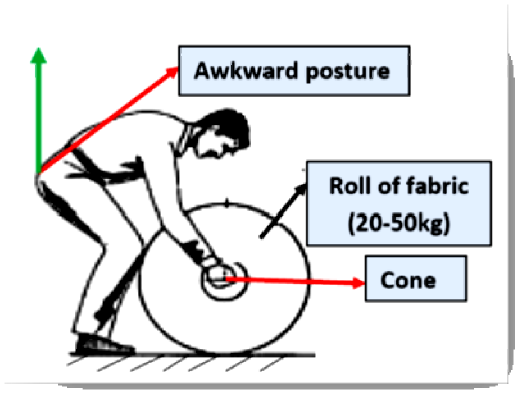


Figure 2: Observed heavy-lifting with awkward-posture.

Depending on the-length, and the-structure, of the-fabric, rolls can be very-heavy. According to Kornit Allegro, the-weight, of a-roll of printed-fabric (with max-roll-outer-diameter of 40 cm; max-roll-width of 180 cm; and max-media-thickness of 15 mm) can reach as-much-as 50kg.

Figure 2 shows a-machine-operator lifting heavy-roll of fabric, from a-ground-level, with bending forward of the-torso (more-than 46 degrees). Besides, there is *no* much-room, for the-legs, to-maneuver; the-legs, actually, are pressing, against the-roll; this is a-hazard of potential-contact-stress. In-addition, this-posture together-with work-arrangement, forced the-operator's-back, to-support *not* only the-lifted weight, but-also the-weight of the-upper-body, which, in-turn, puts excessive-strain, on the-vertebrae. Handling materials, with limited-ability to-maneuver, or stand-up-straight, is increases the-muscular exertion, needed-to-perform this-manual-task.

In-addition, inadequate/short-handholds (protruding-cone) made lifting more-precarious, due-to grasping-difficulties, which increase the-risk of MSIs, and of dropping the-load (especially, if it-is-necessary to-change the-grip, during the-lift).

On-the-other-hand, the-muscular-exertion, needed, depends-primarily on the: weight of the-load, and the-distance of the-load's centre of gravity, from the-body. This is referred-to-as the *'bending-moment'*, and is calculated by the-product of the-load's weight (kg) and the-distance (cm). The-moment indicates the-effort, muscles need-to-exert, to-hold the-load. Because the-load, on the-spine, varies-with distance, the-further-away a-load, of a-certain-weight, is from the-body, the-greater-the-effort, needed-to-handle-it; e. g., a-20kg-weight, held-close, to-the-body, will-require the-same effort, as a-5kg, held, at a-distance of 40cm. From the-Figure, it-is apparent, that the-operator can*not*, physically, keep the-load, close to the-his-body, as it-is large and bulky. Overall, the-lifting, shown, can-be-considered as hazardous; according to Tubach *et al.* (2002), there is a 278% increase in-the-forces, on the-spine, in the-bent-position, when compared with the-straight-back (neutral-position). Therefore there is, indeed, a-risk of MSDs or MSIs, for the-operator, performing such-lift.

Lifting heavy-items is one of the-leading-causes of MSIs. In-2001, the-Bureau of Labor-Statistics reported that over 36% of injuries, involving missed-workdays were the-result of shoulder and back-injuries. Overexertion and cumulative-trauma were the-biggest factors in these-injuries.

A-review of biomechanical-factors, involved in work-related low-back-pain reported by Van Dieen & Van der Beek (2009), indicated, that large-proportion, of the-people, with lower-back-pain have a-damaged inter-vertebral-disc. Compression-forces, and twisting and turning, of the-spinal-column, during (heavy) lifting, appear to-play a-role, in this-respect.

Moreover, several-longitudinal-studies examined the-relationship, between lifting and low-back-pain (see Miranda, 2008; Andersen *et al.,* 2007; Van Nieuwenhuyse *et al.,* 2006; Eriksen *et al.,* 2004; Harkness *et al.,* 2003; Tubach *et al.,* 2002; Macfarlane *et al.,*2000). In-most of the-studies, included, the-amount of lifting, and low-back-pain were self-reported, by the-employees. Statistically-significant-associations, between lifting and low-back-pain, were found in the-following-conclusions, that: (1) employees, who lift more-than 10 kg, per-day, are at-higher-risk of more-than 8 sick-days, per-year, due-to low-back-pain (Tubach *et al.,* 2002). (2) lifting 11 kg or more, led to a-significantly-higher-incidence of low-back-pain, in the-past-year, among female-employees (Macfarlane *et al.,* 2000); (3) employees, who lift 25 kg, or more, over 12 times, per-hour, were 3 times, as-likely to-develop low-back-pain, than employees, who do *no* lifting (Van Nieuwenhuyse *et al.,* 2006). Other-studies, however, did *not* find statistically-significant- associations, between lifting and low-back-pain. Based on-statistical-significance, there appears to-be a-threshold, of 10 kg, per 8-hour-working-day.

In-addition, BLS-survey shows, that 80% of occupational-injuries, were to the-lower-back, and that 75%, occurred, while-lifting.

Besides, Jones *et al.* (2007) pointed-out on two-longitudinal-studies examined the-relationship, between lifting and *lower-limb complaints* (including, the-legs from the-hip to the-foot). The-first-study illustrates, that cumulative-lifting of up-to 99 kg, per-hour, resulted in a-significantly-elevated-risk of such-complaints. The-second-study found, that lifting more-than 9kg, with one-hand, and lifting, above-shoulder-height resulted in a-statistically-significantly increased-risk of knee-complaints.

Moreover, three-longitudinal-studies examined the-relationship, between lifting and *upper-limb complaints* (upper-limbs are the-arms, from-shoulder-to-hand). One of the-studies found, that cumulative- lifting of 100 kg, or more, per-hour, resulted in a-significantly-increased-risk of neck and shoulder- complaints. The-other-studies found that neck and shoulder-complaints occur following exposure-to less-than 10 kg of lifting-weight (see Miranda, 2008; Harkness *et al.,* 2003; Feveile, 2002).

If such-complaints persist, for-more than 12 weeks, without interruption, they are considered chronic (HCN, 2012). However, the-longitudinal-studies, into the-effects of lifting, predominantly-focus on pain-complaints (concerning the-lower-back, the-lower and upper-limbs) that persisted, for, at-least, 24 hours, in the-past-year.

The-ICF (International-Classification of Functioning, Disability and Health) model, developed by the-WHO (2001) shows, that disease-related-factors, such-as pain-complaints (in-addition-to-environmental and personal-factors) may affect functional-limitations and participation in-daily-life and work (sick-leave and work-resumption).

The-above-account, demonstrates correlation of work-related-lifting-process and forceful-movements, with symptoms of MSDs, such-as: low-back-pain, upper-limb and lower-limb complaints. Moreover, in the-particular-case, observed during the-study (see Figure 2) lifting was further-complicated by: heavy and bulky-load, awkward-posture, solo-lifting, confined-workspace, and inadequate-length of handholds. On-overall, such-lifting may *not* only lead to MSDs and/or MSIs, but also-limit operator's participation in-daily-work and life.

To-propose control-methods, to-avoid such-consequences, it-is logical, to-review the-theoretical-background, first. This was presented in the-next-sections, including: Standards for manual-handling; NIOSH lifting-equation; Preferred-position and zone, for safe-lifting; and Lifting-Principles.

4.2. Theoretical background/foundation

4.2.1. Standards for manual-handling

According-to Patenaude (2004), standards have-been set, to 'quantify physiological-limits, of an-average worker (e.g., the-maximum-load for *manual*-handling-tasks, performed under optimal-conditions, that can-be-lifted, without injury). The-most-widely-used, by-ergonomists, standards, are: (1) ISO Standard 11228-1; (2) Manual-Material-Handling (MMH); and (3) National-Institute for Occupational-Safety and Health (NIOSH) equation. Table 2 shows the maximum-load-weight, according to-the-indicated-standards.

Table 2: Maximum-load-weight, under-optimal-conditions

Standard	Maximum load weight(kg)	Load can-be-handled by
ISO Standard 11228-1	25	95% of men and 70% of women.
MMH	27	90% of men. Maximum-load for women is 20kg.
NIOSH, 1991	23	90% of the-population (men and women)

Source: Extracted from ISO 11228-1; Mital *et al.* (1997); and Water *et al.* (1993).

The-first-part of the-International-standard: ISO11228 is relevant to-lifting (Ergonomics: Manual handling – Part 1: Lifting and carrying). The-standard applies to-lifting-loads, weighing more-than 3kg. This-standard is also-based on-the-NIOSH-equation (details of which, are provided in-the-next-section), and assumes one-individual, working 8 hours, per-day, while standing, without combining different-tasks. ISO11228-1 provides values, which account for the-intensity, frequency, and duration, of the-task. Holding loads, pushing or pulling, lifting, with one-hand, or while sitting, and lifting, with multiple-people are *not* addressed. The-basic-limit, for lifting, in this-standard is 25 kg, for the-adult working-population, a-weight that is reduced, under sub-optimal-circumstances. The-absolute-limits, defined in ISO11228-1 are: maximum weight of 25 kg; maximum-frequency of 15 times, per-minute; maximum total-weight, carried (cumulative) of 10,000 kg, per-day.

The-standards-value, however, need-to-be-adjusted, according to 5 main-factors, affecting workers' health and safety (Patenaude, 2004), as-follows:

(1) *lifting-duration* (work-time/recovery-time). The-longer this-time is, the-higher the-degree of fatigue (Asfour & Tritar, 1991);

(2) *lifting-frequency* (number of lifts, per-minute): (a) The-combined-effects, of load-weight and lifting-frequency, directly affect worker-fatigue (Stälhammar, 1996; Asfour & Tritar, 1991). In-addition, increases, in-lifting-frequency, diminish the-worker's-capacity to-assess loads (Karkowski *et al.,* 1992); (b) Workers, who are unable to-estimate-loads, correctly, will *not* apply appropriate-muscular-effort and will tire more-easily, than if they had evaluated the-load, correctly (Patenaude *et al.,* 1998);

(3) *properties of load:* (a) the-location of the-load: picking-up loads, from an-elevated-area is more-likely to-cause fatigue (Water *et al.,*1993; Genaidy&Asfour, 1989); (b) the-weight (the-heavier the-load, the-more-risk of MSIs (Hidalgo *et al.,* 1997; Water, *et al.,* 1993); (c) The-grip, on-the-load (is a-function of the-shape, texture (friction-rate), and balance, of the-load); Workers have-to-exert greater-force to-handle-loads with a-poor-grip, in a-safe-way. For-example, handles make boxes much easier, to-handle (Stälhammar *et al.,* 1989).

(4) *working-environment*, including (a) the-layout of work-areas (height of surface, where load is picked-up and deposited); (b) distances, covered with and without load; (c) features of circulation-areas (stairs, graded-surface, elevators, etc.); (d) temperature and humidity-rate. These-variables directly affect the-level of difficulty, associated with manual-handling-tasks (Hidalgo *et al.*, 1997; Water *et al.,* 1993).

(5) *posture of a-worker*: The-physical-strength, required-to-perform the-task, increases-along-with the-distance, between the-center of gravity, of the-load, and that of the-worker. Excessive-distances also cause inter-vertebral-disks, to-compress, increasing the-risk of lower back-injuries (Chaffin & Andersson, 1999).

For-selected-examples, of adjustment-calculations, refer to Patenaude (2004).

Besides, various-other-factors influence the-weight, that can-be-handled-safely. These-include (Council Directive 90/269/EEC: 1990): (1) the-starting-height of the-lift, and the-finishing-height, of the-lift; (2) the-length of time, that lifting takes-place, e.g. 8-hour-shift, 12-hour-shift; (3) the-extent, to-which twisting of the-body, takes-place; (4) whether the-lift is performed, with one-hand, or two-hands; (5) the-distance, that the-object is away, from-the-body; (6) the-size, shape, and texture, of the-object; (7) the-presence of appropriately-placed hand-holds (handles) on the-object; (8) whether or *not* the-lift must-be-performed, in a-space, that restricts, or prevents, worker-movement; (9) the-movement of an-object, with a-changing-centre of gravity e.g., a-fluid, freely-moving, in a-container; and (10) an-object, that is alive, such-as a-person or animal, among-others.

4.2.2. NIOSH lifting-equation

NIOSH defines *lifting* as the-act of *manually* grasping an-object, of definable-size, and mass, with two-hands, and vertically-moving the-object, without mechanical-assistance.

There are two-versions of the-NIOSH-equation: (1) for single-task lifting-jobs; and (2) for multi-task lifting-jobs. The NIOSH single-task-equation is the-most well-known and is most-frequently applied, as manually-lifting, a-specific-load, can-be-considered a-single-task lifting-job. This NIOSH-equation allows the-difficulty, of a-lifting-task, to-be-calculated, based on six-components (NIOSH, 1994; Water *et al.,* 1993): (1) *H*, the-horizontal-distance, from the-object to the-ankles (cm); (2) *V*, the-vertical-distance, from the-object to the-ankles (cm); (3) *D*, the-displacement of the-object or vertical-travel-distance (cm); (4) *F*, the-frequency and duration of the-lift (number, per-minute, and number of hours); (5) *A*, the-rotation of the-body or trunk-angulations (degrees); and (6) *C*, contact with the-object.

Depending on the-contribution of each-component, to the-difficulty of the-lifting-job, it-is expressed as a-factor between 1 (favorable and optimal-situation) and 0 (unfavorable-situation). The-recommended weight-limit (RWL) is calculated by multiplying the-load constant (LC) of 23 kg, by these-six-factors:

$$RWL\ (kg) = 23 \times Hf \times Vf \times Df \times Ff \times Af \times Cf$$

The-use of the-NIOSH-equation is, however, bound by a-number of conditions. For-example, it can*not* be applied to: (1) one-handed-lifting; (2) repeated-lifting, during a-working-day, longer-than 8 hours; (3) lifting, while kneeling or sitting; (4) lifting, with limited-room, for maneuvering; (5) for unstable-loads; (6) lifting with-aids; and (7) lifting, that involves high-acceleration.

The-equation also can*not* be used, if the-distances, or angulations, become too-great (>135°). The-assumption is also-made, that the-employee's contact with the-floor is solid (*no* unstable-contact or slippery-floor), and that climatological-conditions remain, within certain-margins, i.e. the-temperature does *not* drop below 19 °C or rise above 26 °C.

In-addition, the-NIOSH-equation is based on the-assumption, that activities, other-than-lifting, such-as pushing, pulling, carrying, walking, or climbing, make a-negligible-contribution (of less-than 10%) to the employee's overall-activity.

Due-to the-multiple-components and conditions, the-application of the-NIOSH-equation, is time-consuming and complex, particularly, where multi-task (and varied) lifting-jobs are performed, by a-large-population of employees (ILO, 2014).

4.2.3. Preferred-position and zone, for safe-lifting.

According to ErgonomicsPlus, load should-be-lifted, as-close to-the-body, as-possible (preferably in-the-green-zone, shown in Figure 3). The-green-zone is considered, there, as '*excellent*' combination of the-load-weight and distance, from the-body, to-lift the-load, safely. As the-distances (horizontal, vertical, or both), and the-weight of the-object, increase, the-lifting becomes '*safe'* (moving from the-green to the-yellow-zone), and then '*dangerous'* (moving to the-red/danger zone).

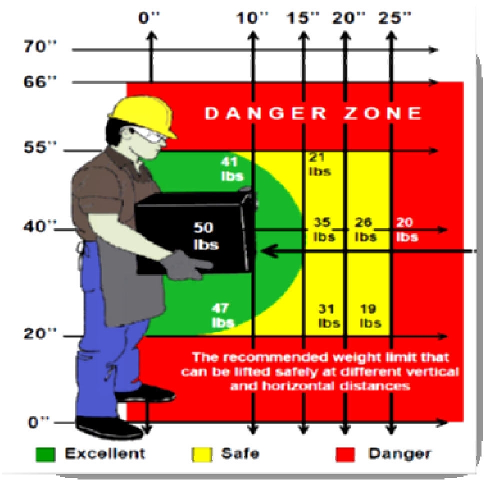


Figure 3: Weights and safety-zones, for lifting objects (Adopted from ErgonomicsPlus).

Moreover, several-risk-factor may increase, the-occurrence of injury, particularly, back-injury, from manual-lifting. These-factors are related to the-different-characteristics of the: (1) load; (2) task; (3) organization of the-work; (4) work-environment; and (5) the-worker (Griffith *et al.,* 2012). In-particular, *manual*-lifting, at-work can-become-hazardous, if:

The-*load* is: (1) too-heavy; There is *no* exact-weight-limit, which is absolutely-safe. A-weight of 25 kg is heavy to-lift, for most-people, especially if the-load is handled several-times, in an-hour; (2) too-large; if the-load is large, it is *not* possible to-follow the-basic-rules, for lifting and carrying (e.g. to-keep the-load as-close to-the-body as-possible); thus, the-muscles will-get-tired more-rapidly; moreover, the-shape or size, may-obscures the-worker's- view, thus increasing the-risk of slipping, tripping, or falling; (3) unbalanced or unstable-objects, or if the-contents can-move, make it difficult, to-hold the-center of gravity of the-load, close to-the-middle of body; this leads to uneven-loading of muscles and fatigue; moreover, liquid causes uneven-loading, of the-muscles, and sudden movements of the-load can make the-worker lose-their-balance, and fall; (4) difficult to-grasp; this can result in the-object, slipping and causing an-accident; loads with sharp edges, or with-dangerous-materials, can injure workers. Gloves usually make the-grasping, more-difficult, than with bare-hands. Providing the-objects with handles, or using aids, for gripping, reduces the-load on the-worker.

The-task and organization of the-work, if it requires: (1) awkward-postures or movements, e.g. a-bent and/or twisted-trunk, raised-arms, bent-wrists, over-reaching; (2) a-high frequency, or repetition, with insufficient-recovery-periods; (3) a-high-rate of work, which can*not* be influenced by the-worker; and (4) unstable-loads, or loads handled with the-body in an-unstable-posture.

The-work-environment, if it has: (1) insufficient-room, in-particular, vertically, to-carry-out the-activity; this may lead to-awkward-postures; (2) uneven-floors, thus presenting tripping-hazards, is unstable, or is slippery, in relation to-the-worker's footwear; (3) bad-position of the-load, or work-place-design, causing reaching with the-arms, bending, or twisting the-trunk, and elevated-arms, yield high-muscular-force; (4) variations in floor-levels or in working-surface, requiring the-load to-be-manipulated on different-levels; (5) unsuitable-temperature, humidity, or ventilation, making workers feel tired; sweat makes it hard to-hold-tools, meaning, that more-force must-be-used; cold can-make hands numb, making it hard to-grip; and (6) insufficient-lighting, increasing the-risk of accidents, or force-workers into-awkward-positions, to-see, clearly, what they are doing.

Individual-characteristics, such-as: (1) lack of experience, training, and familiarity with the-job; (2) age: the-risk of low-back-disorders increases with age, and with the-number of years, at-work; (3) physical dimensions, and capacity, such-as: height, weight, and strength; (4) prior-history of MSDs, in-particular, back-disorders; (5) Personal-lifestyle (smoking may, for-example, increase the-risk of low-back-disorders); and (6) Willingness to-use personal-protective-equipment (for-example, clothing and footwear).

Moreover, MH of heavy-loads can cause injuries, if the-load suddenly-hits the-worker, or causes slipping, or falling. Handling of smaller-loads, for a-long-time, without rest, can also-result in fatigue. For a-tired-person loads can-become too-heavy, after hours of handling, resulting in faulty-movements, and the-risk, of MSIs and MSDs, will increase.

4.2.4. Lifting-Principles

Lifting-process can-be-broken-down into following-consecutive-stages (ILO, 2014): (1) Preparation; (2) Lifting; (3) Carrying; and (4) Setting-Down.

Preparation, before lifting, or carrying, includes planning of the-lift. The-following-questions could-be helpful, in this-process: (1) How heavy/awkward is the-load? Should mechanical-means/aids (e.g. a-hand-truck) be-used, or another-person should-be-approached, for help? Is it possible to-break the-load, into smaller-parts? (2) What is the-final destination? Is the-path clear of obstructions, slippery-areas, overhangs, stairs, and other-uneven-surfaces? Are there closed-doors, that need to-be-opened? (3) Are there adequate-handholds on the-load? Is there a-need for gloves, or other-personal-protective-equipment? Can the-load be-placed, in a-container, with better-handholds?

For-proper-*Lifting,* a-person should: (1) Get as-close to-the-load, as-possible; (2) Try to-keep elbows and arms, close to the-body; (3) Keep back straight, during the-lift, by tightening the-stomach-muscles, bending, at the-knees, keeping the-load centered in front, and looking up and ahead; (4) Get a-good-handhold and do *not* twist, while lifting. Do *not* jerk; use a-smooth-motion, while lifting.

When *Carrying* is needed, the-following-guidance should-be followed, where (1) a-person should *not* twist, or turn, the-body; instead, feet should-be moved, to-turn. (2) Hips, shoulders, toes, and knees, should-stay facing the-same-direction; (3) the-load should-be kept, as-close to-the-body, as-possible, with elbows close to the-sides. (4) In-case of fatigue, the-load should-be put-down, and the-person should-rest, for a-few-minutes.

Setting-Down of the-load, should-be performed in reverse-order of picking it up: (1) The-worker should-bend, at the-knees, *not* the-hips; (2) The-head should-be kept-up, stomach-muscles tight, with *no* twisting of the-body; (3) Again, the-load should-be kept, as-close, to the-body, as-possible; and finally (4) The-lifter should-wait, until the-load is secure, to-release the-handhold(s).

Moreover, to-minimize the-likelihood of a-back-injury, when lifting, the-following-steps should-be taken a-lifter should (UTA, 2007): (1) *plan ahead, before lifting* (e.g. the-load, to-be-lifted and the-final-destination should-be know, to-help prevent from making awkward-movements, or turning-awkwardly, while-holding heavy-object. The-path should-be clear of any-obstacles; also if lifting-something with another-person, both, should agree on the-plan; (2) *Stand close, to the-load* (with feet spread-apart, about shoulder-width; one-foot should-be-put slightly in-front of the-other, for balance); (3) *Bend, at the-knees* (Squat-down, bending at the-knees (*not* waist), keeping back, as-vertical-as- possible); (4) *Control the-load* (by getting a-firm-grasp of the-object, before beginning the-lift); (5) *Lift with legs* (beginning slowly-lifting with legs, by straightening them; the-body should *not* be twisted, during this-step); and (6) *Keep load close to-the-body* (Once the-lift is complete, the-object as close to the body as possible. As the load's center of gravity moves-away, from the-body, there is a-dramatic-increase in-stress, to the-lumbar-region, of the-back.

From the-author's perspective, lifting-principles are, largely, common-sense, nevertheless, many- people failed to-apply-them, timely, consistently, correctly, and entirely (with *no* fragmentation).

4.3. Controls of the-hazards, associated with manual-handling

This-section covers universal/general recommendations, as-well-as ergonomic-tailored-suggestions.

4.3.1. Universal-recommendations

The-following-measures can-be-considered, to-reduce the-occupational-risks, while undertaking MMH:

(1) *Prevention-measures* (The-negative-health-effects of manual-handling can-be-prevented by trying to-eliminate or, at-least, reduce the-risk-factors, involved). The-following-hierarchy of prevention-measures should-be used: (a) *Elimination* (First, can the-work be designed and organized in such-a-way, that manual-handling can-be-avoided, completely, or, at-least, restricted (*via* Design-controls, including job design/redesign (altering the-way a-job is done or making changes to the-work-area, tools or equipment, e.g. using powered or mechanical-handling-equipment, such-as: conveyor-belts, lift-trucks, electric-hoists, or gravity-inclined roller-tracks); and (b) *Technical-measures* (If manual handling can*not* be avoided, automation, mechanization, and the-use of lifting and transport-equipment, should-be considered (e.g. conveyors, hoists, cranes, vacuum-lifting-devices, lift-tables, pallet-trucks, lift-trucks, barrows, trolleys) (EU-OSHA, 2007; Apple, 1972);

(2) *Organizational/administrative-measures* focus on reducing the-amount of time, workers are exposed-to a-risk-factor. They should *only* be considered, if elimination of manual-handling is *not* possible, and if technical-measures are *not* effective, in reducing the-risks, involved in MMH. These-measures include: (a) work-organization (rotating workers, avoiding peaks, in workflow, etc.); (b) task-specific training (ensuring that workers are trained in their-specific-work, including the-use of tools, or mechanical-aids); (c) maintenance-programs (servicing and maintaining, tools and lifting-equipment, on a-regular-basis); and (d) personal-protective-equipment (PPE) – providing PPE such-as: knee or shoulder-pads, or gloves, where needed. For-example, heavy or frequent-manual-handling-tasks should-be carried-out by several-people or, if possible, the-amount, that is handled, should-be-reduced, or the-load split, into smaller-ones. Besides, the-rate of manual-handling should *not* be set, by a-machine, supervisor, or colleagues. The-time, taken to-carry-out manual-handling-tasks should-be extended, by taking-breaks, or by alternating-them, with other-tasks, so that the-muscles have-time-to-recover (EU-OSHA, 2007; Apple, 1972).

Moreover, if an-employer can*not* reduce the-hazard(s), below the-hazard-level, using the-controls described above, the-employer should-supplement those-controls with interim-measures, that primarily-rely on-individual work-practices, and/or PPE (e.g. team-lifting and training, on-work-techniques). Since these-are temporary-measures, the-employer should-continue to-look for alternative-measures, that will-address the-hazard, on a-permanent-basis (Department of Labor and Industries, 2000).

Materials, that have-to-be manually-lifted, should-be placed at 'power-zone' height, about mid-thigh to mid-chest (see Figure 2). Workers should-maintain neutral and straight-spine-alignment, whenever possible. Besides, when manually-moving-materials, employees shall follow *proper*-lifting-techniques. According to Bolz & Hagemann, employees shall seek additional-assistance, when: (1) A-load is so-bulky they can*not* grasp, or lift-it; (2) When they can*not* see around/over the-load; (3) When the-load is too-heavy to-handle, for one-person, and (4) When a-worker can*not* safely handle the-load, manually.

On-the-other-hand, *team-lifting*, could-create its-own-hazards, and, according to-author's opinion, it can bring more-problems, than it can solve, as the-likelihood of injury, due-to: slipping, tripping, falling, and dropping the-load, is *greatly*-increased. In-particular, Griffith *et al.*(2012) and EU-OSHA (2007), pointed-out on the-limitations of team-MH, as-follows: (1) inexperience in one, or some of the-helpers/ lifters, may-mean the-load is *not* shared as-well-as it could-be; (2) workers may *not* exert-force, simultaneously; (3) coordination-loss, by-individual-workers, due to foot/hand adjustments, they-make, to-fit-in with other-team-members, will-reduce the-force each-can-exert: (4) if operating on-steps or a-slope, most of the-weight will-be-borne by-handlers at the-lower-end; and (5) unexpected-increased loading and/or change in-balance, because one-team-member loses his/her grip.

In-this-regard, team-handling, and particularly, team-lifting, should-be used *only* with proper co-ordination and careful-planning, of the-lift. As-such, the-participants, should-carefully-discuss the-plan for the-lift, including any-verbal-instructions/commands, that will-be-used, to-initiate-actions and to-warn of hazards.

4.3.2. Ergonomic-recommendations

Several-approaches were developed, to-control and to-reduce the-hazards, associated with *manual*-handling. They can-be-grouped, according to Cal/OSHA (2007), as: (1) *Engineering-improvements* (reconfiguring the-task, by re-arranging; modifying; re-designing; and providing, or replacing of: tools, equipment (e.g., using positioning-equipment, such-as lift/tilt/turn tables, hoists, balancers, and manipulators), workstations, packaging, parts, processes, products, or materials); and (2) *Administrative-improvements* (job-rotation (by-limiting the-amount of time, workers spend on 'hazardous-job'); specific-task-training; proper maintenance; and PPE).

4.3.2.1. Engineering-improvements.

Improper MMH can-lead to-injuries and MSDs, mostly, in the: back, abdomen, neck, upper-and lower-limbs, and joints. Careful-job-design, or re-design, can-avoid problems, better protect workers, and increase productivity.

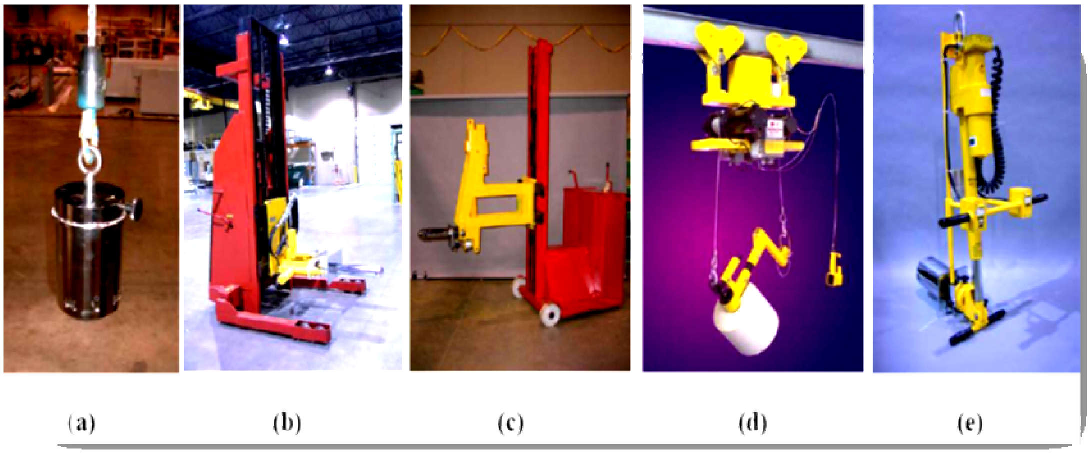
(a) Proposals of mechanization of heavy-lifting, at the-department.

Manual-handling-tasks are defined as any-activity, where workers grasp, manipulate, carry, move (lift, lower, push, or pull), hold, or restrain a-load. MH-tasks may-be-redesigned, to-minimize the-weight, range of motion, and frequency of the-activity. Alternatively, mechanical-assistance may-be employed.

Proper roll-handling-methods are required, to-ensure plant-personnel safety, and to-minimize losses, associated with roll-damage (in-case of its-fall). If technically and economically-feasible, equipment can-be-used, to-reduce and, sometimes, even, replace the-need to-manually-handle materials. Most-existing MH-equipment is only *semi-automated,* because a-human-machine-operator is still-needed, for tasks such-as: loading/unloading, that are difficult and/or too-costly to-*fully* automate. Nevertheless, ongoing-advances, in-sensing, machine-intelligence, and robotics, have made it-possible, to-fully-automate an-increasing number of manual-handling-tasks.

Roll-handling-equipment is available, to-move rolls, without-reorienting-them. This-equipment operates with hoists, mounted, overhead, and by using core-probes (which inserted inside-a-core, of a-fabric-roll), with mechanically-actuated-teeth, to-grip-rolls, that are perpendicular, to the-floor. Horizontal-roll-movers, however, in-addition to-probes, need load-leveling-capability, so the-unit does *not* tip.

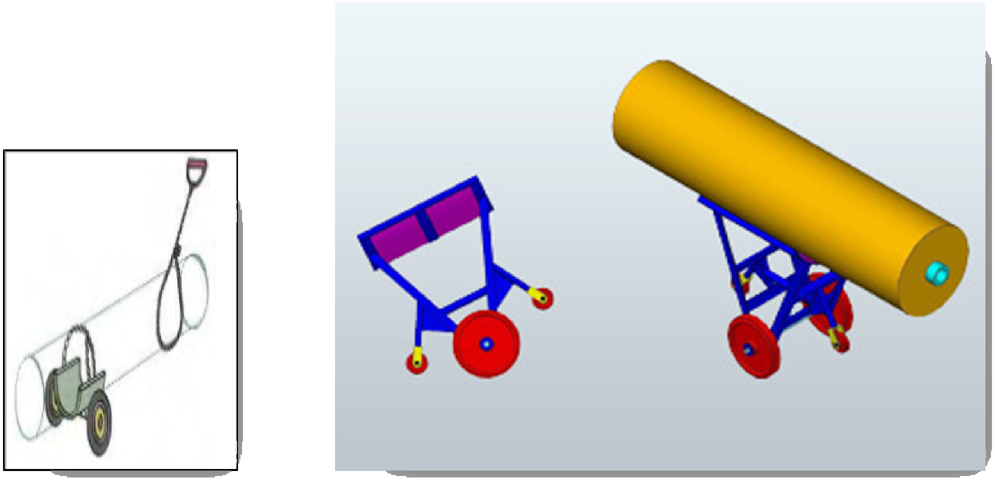
Fork-truck / core-probe-devices are used in lighter-roll-applications, where damage to-the-outside, of the-roll, is a-concern. These-devices can-be designed to-mount to-any-standard fork-truck. The-core-probe pivots, to-orient the-rolls, from horizontal to-perpendicular, and *vice versa*. There are two-types of lift-truck /core-probe-devices: (1) a-rigidly-mounted-probe; and (2) a-flexible-mounted-unit. For more-details, including advantages and disadvantages, of each-type, refer to manuscript, by Damour, on Roll-Handling. Selected-examples of roll-handling-equipment are shown in Figure 4.



Keys:
(a) Truck for lifting and moving perpendicular-rolls;
(b) Lift-truck with rigidly-mounted-probe;
(c) Lift-truck (flexible-mounted-unit);
(d) Overhead roll-handling-system, for use with two-hoists;
(e) Overhead roll-handling system, for use with single-hoist.

Figure 4: Selected-examples of roll-handling-equipment (Photos courtesy of Tilt-Lock Inc).

On-the-other-side, cost of industrialized-mechanization, of roll-handling, can-be high, particularly for a-developing-country, like Kenya. In-this-regard, smaller and more-affordable-devices can-be-considered, by the-mill's management, such-as, for-example: a-Roll-Handling-Gadget and a-Roll-Handling-Trolley (by Paras Engineers), shown in-Figure 5(a) and (b), respectively. These simple and inexpensive-devices, reduce the-application of force, in an-awkward-posture, and enable the-task, to-be-performed, *safely*, by one-employee.



(a) **(b)**

Figure 5: Simple and cost-effective roll-handling-devices (by Paras Engineers).

(b) Rearrangement of work-place

It was-observed, that high-level storage-racks required the-operator to-climb, or to-descend, a-ladder, while holding-onto a-fabric-roll. This involves hazardous-manual-handling and, even, potential-fall-hazards.

As-mentioned-earlier, rolls can-be of different-weight and size, depending on the-specific-order. The-study proposed, that during-storage, rolls should-be-organized, according to-weight, so that heavier-rolls are stored, at a-convenient-height, for safe-handling. According to-EU-OSHA (2007), the-best-level of muscular-effort can-be exerted, at-about knuckle-height (70-80 cm). Where possible, loads should-be-stored, at this-level; storage, above-shoulder-level, or close-to the-floor, except for-light or infrequently-used-items, should-be-avoided; an-intermediate-surface, so the-worker can-rest the-load, for a-moment, before shifting-grip, if the-object, must-be-lifted, from a-low to a-high-position, should-be-provided.

Besides, the-workers should-receive adequate-information on at-least, the-*approximate*-weight of the-load, they are to-handle. Heavier-rolls (above 23kg) should-be handled by mechanical-aids, while lighter rolls be-handled-manually. When manually-moving-materials, employees shall follow *proper* lifting-techniques. According to Bolz & Hagemann, employees shall seek additional-assistance, when: (1) A-load is so-bulky they can*not* grasp or lift-it; (2) When they can*not* see around/over the-load; (3) When the-load is too-heavy to-handle, for one-person, and (4) When a-worker can*not* safely handle the-load, manually. Team-lifting, however, should-be used as a-last-resort, due-to its-own-hazards.

Secondly, it-was-proposed to-store rolls, inside larger-tubes (see Figure 6); the-forces, required to-retrieve the-rolls, is reduced, as they are *not* stored directly, on-top of each-other. This is also an-affordable-solution. Besides, a-fixed-height moveable-platform, with braking-system, can-be installed (if economically-feasible), to-allow better-access, to-the-rolls.

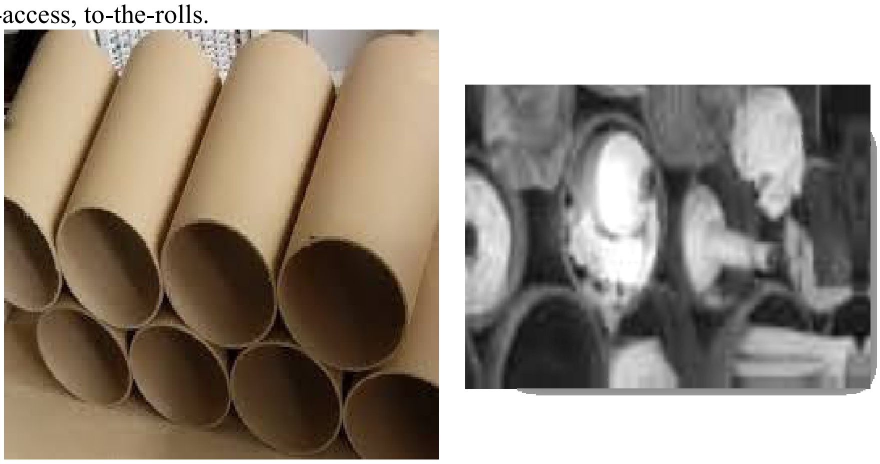


Figure 6: Storing rolls inside larger-tubes.

Moreover, it was observed, that operators also-handle heavy-containers of dyes/inks/pigments/solvents, during paste-preparation (in-color-kitchen), which necessitated application of significant-force. To-avoid MSIs and/or MSDs, most-frequently-used-containers should-be stored (as-much-as-possible and practicable), between shoulder and waist-height, to-minimize bending and reaching, during in-process-handling. Pigments and dyes should-be ordered, from the-supplies, in smaller-volumes (if available), to-reduce heavy-manual-lifting.

4.3.3. Administrative-improvements

The-next-means of control, to-consider, is administrative-controls, such-as: worker-training, equipment-maintenance, and job-rotation. Personal-protective-equipment (PPE) is to-be-considered, as a-last-line of defense. CSA Standard Z462 provides detailed-selection-criteria for PPE, including: body, hand, head, face, eye, and hearing-protection. PPE *must* be approved, or certified, by agencies, as required by the-OSH Code.

Job-Rotation is a-process of periodically-moving employees, between different-jobs, or tasks, to-minimize monotonous-activities, and overexertion, of particular-muscles, or tendons. The-jobs, within the-rotation, should use differing muscle-tendon-groups, allowing for rest and recuperation. Tasks should-be-categorized, based-on parameters, such-as: (1) repetition; (2) force-exertion; (3) maintaining awkward-postures, for prolonged-periods; and (4) the-areas of the-body, affected.

According to a-publication by Hazardous Manual-Handling, relevant-*training*, for a*ll* workers, should-be-provided, when: (1) they are being-inducted into-jobs, which contain risks from manual-tasks; (2) a-new manual-task is introduced, or a-task has-been-redesigned; and (3) new-equipment (mechanical-aids), tools, or furniture (adjustable-items) are introduced. In-addition, refresher-training should-also be-provided, to-make-sure safe-work-practices are maintained. Practical, on-site-demonstrations, using tasks-workers, has the-added-advantage of reminding workers and supervisors, of correct-procedures. Training e.g., on lifting-techniques, should *not* be used, as a-substitute for the-redesign of a-task and/or use of mechanical- aids. Relying on ‘safe’ worker-behavior is the-least-effective-method of controlling the-risk of injury, as many can-fail to-remember the-training, received, particularly during stressful-situations.

4. 4. Maintenance

It was reported, that some material-handling-equipment was *not* in good-condition; considerable-force was, claimed, needed, to-push, or pull MH-equipment, such-as trolleys.

High-force, or sustained-forces can-be-required to-move-trolleys, especially, if regular-maintenance of wheels, castors, and bearings, is *not* undertaken. Moreover, accidents and injuries, may-happen, because lifting-equipment is *not* inspected and maintained, regularly (E-Facts, #14).

Maintenance may-be-defined as the-chronological-activities, or as the-process of systematic-activities, done for keeping the-machines, or equipments, well, so that they will *not* fail, during-operation (WorkSafe, 2002). Functions of maintenance include: (1) To-maintain machinery and equipment, at optimum-operation speed, and production-efficiency; (2) To-ensure best-possible-level of quality of product (the continuous-operation of the-machinery reduces stoppages-time, resulting in better-quality and less-wastage); (3) To-minimize the-idle-time, resulting from the-machinery break-down; and (4) To-reduce the-production cost (by increasing the-life-time-cycle of machinery and equipment), among-others.

Basically, there are 2-principally-different systems of maintenance; Break-down (emergency), and Planned-maintenance. Regardless of the-system, maintenance involves the-following-operations: (1) *Setting/Adjustment* (e.g., the-activities to-set, or install, the-machine-parts, or required-ancillaries); (2) *Checking* (e.g., examination of machine-condition, to identify/detect faults); (3) *Repairing* of identified faults; and (4) *Overhauling.* The-main-elements of maintenance include (McKone *et al.,* 2001): (1) *Inspection / check up* (External – sound, noise, vibration; and Internal – spare-parts, shafts, motors, and other-mechanical and electrical-installation); (2) *Lubrication* (is the-application of lubricant, in the-machinery, during operation / break-down); (*3) Planning and scheduling* (a-routine/ scheduling is made for maintenance, to-be-followed strictly); (4) *Training* – proper-training is essential, for both; beginners and experienced-workers; and (5) *Recording and analysis* –Keeping records is paramount; it provides data for analysis, and its-outcome, such-as maintenance-schedule-guideline and trouble-shooting.

At the-mill, trolleys were used extensively, and they play a-major-role in reducing manual-handling - however: poorly-maintained-wheels can-become clogged-with waste-material, or stick, due-to-wear, increasing the-force, which must be exerted, to-move-them. Systematic-cleaning and maintenance of wheels, is, therefore, needed, to-ensure that risks of injury are minimized. The-study also-recommends, that maintenance-department and its-personnel, should-ensure trolleys have suitable-wheels, for the-terrain, and that; they are regularly-cleaned and maintained. Large-wheels, or castors, with low-friction-bearings, should-be-preferably-used, to-reduce force. The-configuration of the-wheels and the-placement of fixed *vs.* swivel-wheels, on the-trolley, can-also-help, to-reduce force. It should also be-ensured, that trolleys are equipped with suitable-hand-brakes, where ramps are used. Moreover, *all*-equipment should-be thoroughly examined, prior its-use, and after any-major-alteration, done, which could-affect its-operation. Examination should-be done, at-intervals, recommended by the-manufacturer, of a-particular MH equipment.

Furthermore, Jerry Matos (2014) proposed the-following five-ways, to-help MH-equipment, last longer:

(1) *Employees training*: When employees do *not* know how-to-properly-operate a-particular-piece of equipment, they can-put-themselves, and others, at risk of occupational-injury. Besides, they may subject the-equipment to-applications, for which it was *not* designed. This-equipment is more-likely to-wear-out, rapidly, requiring premature-overhauling. Training is especially-important, for preparing employees, to-work-with new-technology, with which they have *not* previously had experience. It-is recommended, that protocols are established, for assessing each employee's mastery of the-equipment, before certifying/allowing them, to-use the-equipment, on their-own. Refresher-training, especially when a-piece of equipment is upgraded, should-be also provided.

(2) *Observation and Communication:* Supervisors should-talk, daily, with equipment-operators, on any-changes, they might note, in the-way equipment is operating. This-way, the-issues, noticed, in material handling-equipment, can-be, quickly and proactively, addressed. Employee-training should also-stress the-importance of reporting of such-equipment-problems. In-addition, any-damage to-equipment, should-be reported, immediately, to-limit the-severity of damage, such-as extensive and costly-repairs.

(3) *Following Original-Equipment-Manufacturer (OEM) Instructions*: Maintenance-requirements may-vary, from one brand/model of equipment, to the-next; 'one size' of maintenance-protocols does *not* necessarily fit all-pieces of equipment, therefore, it-is recommended to-strictly-follow the-Original Equipment-Manufacturer (OEM) Instructions.

(4) *Preventive-Maintenance:* A-comprehensive-preventive maintenance-program can helps in many-ways, such-as: (a) to-avoid unscheduled-downtime, due-to equipment-breakdowns; (b) to-schedule downtime; (c) to-service equipment, and replace wearing-parts, before they fail; and (d) to-avoid the-high-cost of emergency-repairs; (e) to-enable to-keep equipment, operating at optimal-efficiency; and (f) extend serviceable-life from the-equipment.

(5) *Predictive-Maintenance:* This-is considered as a-good-complement to a-preventive-maintenance program. By monitoring use of the-equipment (the-hours, and types of use, it undergoes) better keeping a-track, of when service should-be-performed, and when parts are nearing the-end, of their-expected lifetime, ultimately needing to-be-replaced. Monitoring can-be done either; manually, or by means of automated-systems (with real-time-updates, regarding the-condition of the-equipment).

In-addition, the-author would-like-to-propose, to the-mill's administration, to-consider a-relatively noble-approach, of Total-Productive-Maintenance (TPM), which was proven, to-be rather-successful. TPM is a-innovative-Japanese-concept of team-based preventive and productive-maintenance, which can-be defined-as: 'a-program for *fundamental*-improvement of the-maintenance-functions in an-organization, which involves its-entire-human-resources' (Katkamwar *et al.,* 2013), from top-executive to the-floor operator. According to TPM-principles, the-responsibility, for optimizing-equipment, lies *not* just with the-maintenance-department, but with all-plant-personnel. The-concept of 'I (machine-operators) operate, You (maintenance-department) fix' is *not* followed. The-major-difference, between TPM and other-maintenance-concepts, is that the-operators are also-made to-involve in the-maintenance-process, of the-equipment, they operate. TPM is a-*complete*-system for maintenance, which aims at achieving optimal-production-environment free of defects, downtime, stoppages, and accidents. In-particular, the-emphasis is put on the-six-big-losses of manufacturing: (1) machine-breakdowns; (2) setup-loss and minor-adjustments; (3) minor-stoppages; (4) slow-running; (5) start-up-errors; and (6) product-defects (Gitachu, 2017). TPM has-been-proven to-be-successful, in-helping to-dramatically-increase the-productivity and overall-equipment-effectiveness (see Ahuja & Khamba, 2007; Chan *et al.,* 2005; Eti *et al.,* 2004; McKone *et al.,* 2001).

4.5. Repetitive-tasks and movements

It was reported, that repetitive-tasks, and movements, were-constantly carried-out, at the-department.

Many-machines are designed to-achieve industrial-efficiency, by breaking-down manufacturing processes into-simple-steps, that machines can-carry-out. While some-steps can-be fully-automated, the-requirement for human-machine-interaction usually remains for key-operating-steps, like loading of fabric-rolls, quality-inspection, and final-removal of the-rolls, after printing. These-steps require repetitive-movement, by the-machine-operator. The-sectors, in which repetitive-movements are most common, include the-meat processing-industry, the-machining and manufacturing-industry, retail, and construction. In these-sectors, almost half of *all*-employees indicate they regularly-need to-perform repetitive-movements (TNO, 2012; Arbobalans, 2011; Voskamp *et al.,* 2008; Peereboom *et al.,* 2008).

Repetition, on-the-other-hand, is a-major-contributor of most-MSDs (Apple, 1972), as the-same-muscles are being-used, continuously. Work is considered repetitive, when: (1) the-duration of a-work-cycle is less-than 30 seconds; or (2) a-fundamental activity, in the-work-cycle is repeated, for more than 50% of the-work-cycle-time; (3) Work must-be-performed, continuously, for a-minimum of 60 minutes (Griffith *et al.,* 2012).

Besides, according to HCN (2013), a-movement is repetitive if the-upper-limbs (joints of the-shoulders, elbow, wrists, and hand) perform repeated (short, cyclical) motions. Movements, that also-involve lifting, or carrying a-burden, are *only* called repetitive, if this-burden weights less-than three-kilograms. If the-burden, however, weighs three-kilograms, or more, the-movement is considered as lifting or carrying (Voskamp *et al.,* 2008; Peereboom *et al.,* 2008).

Repetitive-movement can result in an-increase in 'wear and tear' of body-tissues, because of the limited-opportunity for them, to-recover, during repetitive-work; a greater-potential for muscle-fatigue, which may be-followed-by an-inflammatory-response and tissue-damage. Repetition, itself, is hazardous, but is even-more-so, when combined-with awkward-postures, forceful-exertions, and fast-movements. Repetitive-movements may-become harmful to-workers' health, leading to chronic-MSDs, as the-same joints and muscle-groups, perform the-same-action often, quickly, and vigorously, over an-extended-period, without giving the-body sufficient-time, to-rest, to-remove the-waste-products, and to-recover.

The-author came-across a-number of scientific-publications, on the-development of health related-problems, due to-repetitive-movements (see Barcenilla *et al.,* 2012; Mayer *et al.,* 2012; Rijn *et al.,* 2009a, b; Palmer, 2007; Aptel, 2002; Van der Windt, 2000).

In-particular, according to HCN (2013); Garg *et al.* (2012); Harris *et al.* (2011); Fung (2007); Nathan (2005); Haahr & Andersen (2003); Nathan *et al.* (2002); and Leclerc (2001), repetitive movements may-be-associated with an-increased-risk of specific-upper-limb-disorders, including *subacromial impingement syndrome* (a-condition of soft-tissues in the-shoulder-joint); *medial epicondylitis* (inflammation or irritation of the-attachment-point of ligaments, on the-inside of the-elbow-joint); *epicondylitis laterals* (inflammation or irritation of the-attachment-point of ligaments, to the-outside of the-elbow); *wrist tendinosis* (degeneration of the-tendon in the-wrist); and *carpal tunnel syndrome* (narrowing around the-middle-nerve, in the-wrist). In-addition, repeated-movements are associated with an-increased-risk of hip, knee, and foot, and general-pain. The-repetitive-movements may-be also associated-with an-increased-risk of non-specific upper-limb-complaints (McBeth, 2003).

Besides, HCN (2013) cited Maetis Arbo, who found, that the-diagnosis of carpal-tunnel-syndrome resulted in 0.2% of absentee-days (in a-six-month-period) among all-registered-employers (CBO, 2005). Between 2000 and 2006, the Dutch-Centre for Occupational-Diseases (NCvB, 2012) received reports of 398 cases of occupational-carpal-tunnel-syndrome (50 to 80 occupational-disease-reports, per-year). In 2000, carpal-tunnel-syndrome was responsible for 0.8% of reported occupational-diseases, for 1.2% in-2001, and 1.3% in 2003. In 1999, 260 people were declared work-disabled, based on the-diagnosis carpal-tunnel-syndrome (0.28%), and 366 people in 2002 (0.4%). *Lateral-epicondylitis* is the-second most-commonly-reported shoulder, arm, or hand-complaint, responsible for about 270 reports, per-year. Each-year there are about twenty-reported-cases of work-related medial-epicondylitis.

Moreover, Repetitive-strain-injury (RSI), is the-term, commonly-used, to-describe a-set of musculoskeletal-symptoms, affecting workers, who perform repetitive-tasks, over a-prolonged-period, most commonly in the-hands, wrists, and arms, although, other-areas may-be-affected, depending on-the-type of work, performed. In-the-year 2000, the-Health-Council published an-advisory-report on RSI, where it was defined as a-syndrome of complaints to: neck, upper-back, shoulder, upper-arm, or forearm, elbow, wrist, hand, or combinations thereof, resulting in disability, or participation-problems. The-syndrome is characterized by a-disruption of the-balance, between burden and capacity, with a-variety of potential causes. In-addition to-limited recovery-time, psychological-burdens, and limited-social-support, repetitive-movements are mentioned, as a-possible-cause of RSIs (Gezondheidsraad, 2000). RSI causes considerable-pain and discomfort, in the-affected areas, e.g., loss of grip-strength, in the-hand. Over-time, disability can-become so-severe, that temporary, or permanent-cessation of employment results.

Andersen *et al.* (2007) found, that employees, who performed repeated-movements, for between 45 and 60 minutes, per-hour, were almost-twice, as-likely to-have elbow/forearm/hand-complaints, as employees, who spend less-than 9 minutes, per-hour, performing repetitive-movements. Another-study by Andersen *et al.* (2003) found, that employees, performing between 16 and 40 repeated-shoulder-movements, per-minute, were one and a-half-times more-likely to-develop neck/shoulder-complaints, than employees, who did *not* perform any-repeated-shoulder-movements. A-study by Nahit (2003) established, that employees, who spend two-hours or more, of their-workday, performing repeated-arm or hand-movements, are almost three-times as-likely to-develop forearm-complaints, as employees, who spend less-than two hours of their-workday, performing repeated-arm or hand-movements. Macfarlane *et al.* (2000) also identified, that employees, who spend half of their-workday or more, performing repeated-arm or hand-movements, are about three-times, as-likely to-have forearm-complaints, as employees, who do *not* perform any-repeated hand-movements. These-examples show, that frequency, or intensity, of repetitions is an-important-predictor of potential-RCIs.

The NEN-ISO 11228-3:2007 'Ergonomics – Manual handling – Part 3: Handling of low loads at high frequency' standard provides ergonomic-recommendations, for repetitive-movements, including high frequency, manual-displacement of loads, lighter than 3 kg. The-standard lists methods for risk management, with a-preference for the Occupational Repetitive Action (OCRA) method (for estimating the-risk of overburdening the-upper-limbs, due to repetitive-handling of light-burdens).

At-the-department, repetitive-motions, as reported, were performed, constantly; examples include: workers, preparing printing-paste, in the-color-kitchen; and monitoring of actual-printing-process, on rotary-screen-printing-machine. The-study recommended to-automate repetitive-tasks, wherever possible; Plan work-schedules, so that workers can take regular-breaks (breaks can-be short, but regular); Practice job-rotation (e.g., rotating workers, through different-work-activities, during their-shifts, to-reduce the-extent and duration, required for the-repetitive-movement. To-facilitate rotation, efforts should-be-made to-cross-train employees, in-several-operations, such-as: paste-preparation, roller-engraving, and paste reclaiming, among-others.

4.6. Conditions of the-floor.

The-majority of the-respondents, claimed that, the-floor, at the-printing-department, was uneven, sloping, and was likely-to-make, the-movement of goods, more-difficult. In-addition, it-was-observed, that the-floor-surface, in some-areas, was damaged (e.g., uneven and broken-concrete; and worn-down anti-slip-paint), particularly, in the-areas of the-entry, to the-department, probably, due-to high-traffic, among other-reasons. Moreover, contamination of the-floor was also-noticed. *Contamination* can-be defined, here, as-anything that ends-up on a-floor; for-example: oil, grease, cardboard, product-wrapping, broken-yarn, small-pieces of fabric, dust, etc. It can-be a-by-product of a-work-process, or be due to-adverse weather-conditions, such-as rainwater. The-above-conditions, individually, or cumulatively, can lead to-injuries (due-to high-risk of slips, trips, and falls). Besides, they could-interfere with smooth materials-handling, as more-force is required to-push, or pull the-transported-loads.

According-to the-U.S. Department of Labour, every-year, over a-third, of all-major-injuries, reported, is the-result of slips and trips. In-both; manufacturing and the-services-industry, injuries from slips and trips, are the-most-common-cause of non-fatal major-injury. Slips, trips, and falls make-up the-majority, of general-industry-accidents, which account for: (1) 15 % of all-accidental-deaths, per-year; (2) About 25% of all-reported-injury-claims, per-fiscal-year; and (3) More-than 95 million lost-work-days, per-year (about 65% of all-work-days, lost).

In-general, slips, and trips occur, due-to a-loss of footing, between the-shoe and the-walking-surface, or an inadvertent-contact, with a-fixed or moveable-object, which may-lead-to a-fall. There is a-variety of situations, that may-cause slips, trips, and falls, such-as: Polished, or freshly-waxed floors; Transition, from one-floor-type to another; Sloped-walking-surfaces; Shoes with wet, muddy, greasy or oily-soles; and Clutter, among-other-reasons (McBeth *et al.,* 2003).

Slips, in-particular, happen, where there is too-little-friction, or traction, between the-footwear and the-walking-surface. Common-causes of slips are: wet or oily-surfaces; occasional-spills, and splashes of liquids; weather-hazards (change from a-wet to a-dry-surface); dusty-floors; sloping-surfaces; loose, unanchored-rugs or mats; and flooring, or other-walking-surfaces that do *not* have same-degree of traction, in all-areas, among-others. On-the-other-hand, *trips* happen, when worker's-foot collides (strikes, hits) an-object, causing them, to-lose-balance, and eventually, fall. Most-trip-injuries are caused by obstructions, on-the-floor, and by uneven-walking-surfaces. The-former is particularly hazardous, as employees, moving about, may *not* always be-able to-see, where, exactly, they are putting their-feet, especially if they are carrying-load. Common-causes of trips are: obstructed-view; clutter, on the-way; wrinkled-carpeting; uncovered-cables; holes, or cracks; and uneven (steps, thresholds) walking-surfaces, among-others. In-addition, according to McBeth *et al.*(2003): (1) trips can-occur, when there is 1cm or less, change in the-height, of the-flooring; (2) a-floor, that is slip-resistant, when dry, may *not* be slip-resistant, when wet; and (3) floor-roughness is more-effective, than slip-resistant-footwear, in reducing slips.

Common-injuries that occur, with such-conditions, are: Cuts and grazes; Bruises; Sprains and strains; Fractures; and Loss of consciousness, among-others. Increased-risk, of injury, may-arise-from other-factors, such-as: poorly-organized walk-ways; inadequate/unsuitable-lighting; incorrect cleaning-procedures; rushing around, fatigue, while handling a-load, among-others.

To-prevent, or control, such-hazards, the-following-approaches can-be-applied: (1) continuing-floor maintenance; (2) testing for slip-resistance, and improving it; (3) checking and applying the-cleaning requirements, of the-flooring; (4) choosing appropriate-shoes; and (5) Good-housekeeping.

In-particular, division 2.3 (Buildings and their-Precincts) of The-Occupational-Health and Safety-Regulations (1995) state, that: 'floors *must* have an-even, unbroken and slip-resistant-surface, that as-far-as-reasonable, is free, of indentations, or other-obstructions, that could-cause a-person to-trip, or stumble'. In-this-regard, ongoing-maintenance, of the-floors, is important, and this may-include: repairing, or replacing its-surface.

Floor-maintenance is considered under the-umbrella of plant-maintenance, and *not* under machinery maintenance (presented, in one of the-previous-sections). Nevertheless, the-fundamental activities/ principles, for both, are the-same: to monitor, identify, repair, record, and analyze any-detected-abnormality, in industrial-operations.

For the-finishing-department, the-following specific-recommendations, were-tailored: (1) any-changes in-heights, of the-floor, should-be fixed; and (2) the-broken-concrete should-be repaired, to-ensure floor heights and surfaces are consistent; (3) slip-resistance should-be-improved with surface-treatments (if required). For-example *via*: Adhesive-strips; Coatings; Grinding; and Proprietary-treatments, such-as: a-mild-etch; Sand-blasting; and Strong-acid-etches. For-more-details (e.g., on typical-application for use) for any of the-listed-treatments, refer to HB 197:1999; (4) the-improved slip-resistance should-be maintained with the-appropriate (for the-surface) cleaning-method; (5) where floor/surface can*not* be fixed-immediately, any-height or surface-changes, should-be highlighted, with contrast colors, or strips (e.g. yellow/reflective paint, or tape). In-addition, ramps, raised-platforms, and other-changes of level, should-be avoided; if, however, it-is *not* possible, they must be-highlighted, with signs, or bright-paint.

On-the-other-hand, contamination, at the-departmental-floor, should-be-controlled by: drip-trays, for leaks; lids on cups and containers; good-sized durable and moisture-absorbent-mats, placed at-building/ department entrance, to-wipe and dry shoes. If, however, contamination, (say from bad-weather) can*not* be-stopped, from getting onto a-floor, it must-be-ensured, that it-is cleaned, quickly and effectively.

Floors should-also-have sufficient-roughness, to-avoid slips, tips, and falls. There-are a-number of certified-methods, to-assess-surfaces, for slip-resistance, as-outlined in-relevant Australian-Standards, as-well-as other-testing-methods, e.g.: roughness-testers, or sled-tests. These-tests indicate the-relative slipperiness of surfaces, under different-conditions, with some-results reported in 'coefficient of friction'. For-example: (1) a-coarse bitumen-surface will-have a-high-coefficient of friction, and will *not* be-slippery, and is likely to-be-safe, for rapid-walking; and (2) an-icy-surface will-have a-very-low coefficient of friction, and will-be extremely-slippery, requiring great-caution.

It-is-important to-note, however, that there is *no* one 'correct' or 'safe' level of slip-resistance, as it depends on the-interaction of many-factors, including: the-type of floor-surface; contaminants; work-tasks; cleaning-method; workers-footwear; their-activity; and environmental-conditions (OSHA, 2002).

Moreover, incorrect-cleaning can-make floors more-slippery. In-addition, the-process of cleaning, itself, can-create slip and trip-hazards, especially for those, entering the-cleaning-area. People, often, slip, on-floors, which have-been left wet, after cleaning. Pedestrian-access, to-smooth, slippery, wet-floors should-be stopped *via* the-use of signs, barriers, locking-doors, or cleaning in-sections.

More to the-point, it-is a-common-practice, at most-industries, to-purchase one-type of cleaning product, for the-entire organization, including: production, maintenance, storage and dispatch-departments, eateries, and administration-offices, among-others. Cleaning-requirements, however, are very-different, and directly-depend on the-activities, the-type of contaminants, and the-floor-type, to be-cleaned. The-study recommended, that these-requirements should be-checked and applied, as-strictly-as-possible.

In-addition, an-effective cleaning-regime requires a-good-management-system, to-help identifying problem-areas, with the-floor, at the-department. The-following-points, should-also be-noted: (1) The-right amount of the-right-cleaning-product, should-be used; (2) Detergent needs time, to-work on-greasy-floors; (3) Cleaning-equipment will *only* be-effective, if properly maintained; (4) A dry-mop, or squeegee, will-reduce floor-drying-time; and (5) At, times, spot-cleaning is sufficient, instead of cleaning of the-entire area.

Besides, according to WorkSafe (2002), footwear, the-right-shoe-sole, in-particular, can-be important, in-preventing slips-injuries, in the-workplace. Different-types of footwear can perform-differently, in different-situations. For-example, urethane and rubber-soles are considered as the-least slippery-types, on-wet-floors. Also, sole-patterns should *not* become-clogged, with any-waste or debris, on the-floor; they should-be checked, by a-worker, daily, for any-signs of wear and clogging.

Furthermore, 50% of all-trip-accidents are caused by bad-housekeeping (OSHA, 2002). Good-housekeeping is the-first and the-most-important-level of preventing falls, due to-slips and trips. It includes: cleaning all-spills, immediately; marking spills and wet-areas; mopping or sweeping debris, from floors; removing, from walkways and always keeping-them free of clutter; securing (tacking, taping, etc.) mats, rugs and carpets that *do* not lay flat; keeping working-areas and walkways, well-lit; and replacing used-light-bulbs and faulty switches, among-others.

Good-housekeeping, on-the-other-hand, does *not* cost much-money (if-at-all); it just takes a-personal understanding, on what constitutes good-housekeeping, and determined-effort, at-both-levels; personal and organizational, in its-implementation. Without good-housekeeping-practices, any other-preventive measures, such-as: installation of superior-flooring, specialty-footwear, or training, will *not* be completely-helpful.

5. Conclusion and Recommendations.

MMH is an-unavoidable-activity, in any-manufacturing-industry, including textiles. The-study established, that several-MMH-practices, and some-aspects of the-environment, in which they are conducted, in the-department, are hazardous and risky, which can contribute to MSIs and/or to MSDs.

To-improve the-current-practices, numerous-recommendations, both; general and tailored, were made. The-following-account is a-summary of *major*-recommendations:

Regarding MMH:

1) The-workers should-receive adequate-information on at-least, the-*approximate*-weight of the-load, they are to-handle;
2) Heavier-rolls (above 23kg) should-be-handled, by-mechanical-aids, while lighter-rolls be-handled-manually;
3) When manually-moving-materials, employees shall follow *proper*-lifting-techniques;
4) Team-MH, and particularly team-*lifting*, should-be used as a-last-resort;
5) Relevant-training, for a*ll* workers, should-be-provided;
6) *Mechanization* of the-MMH-operations, *via* smaller and affordable-devices, such-as, for-example: a-Roll-Handling-Gadget and a-Roll-Handling-Trolley, should-be considered, by the-management;
7) During-storage, rolls should-be organized, according their-weight, so that heavier-rolls are stored, at a-convenient-height, for safe-handling;
8) To-store rolls, inside larger-tubes;
9) Most-frequently-used-containers should-be stored (as-much-as-possible and practicable), between shoulder and waist-height, to-minimize bending and reaching; and
10) Pigments/dyes/solvents should-be ordered, from the-supplies, in smaller-volumes (if available), to-reduce heavy-manual-lifting.

Regarding machine-maintenance

1) *All*-equipment should-be thoroughly-examined, prior its-use, and after any-major-alteration, done, which could-affect its-operation. Examination should-be done, at-intervals, recommended by the-manufacturer, of a-particular MH-equipment; and
2) Total-Productive-Maintenance (TPM) approach should-be considered for implementation, at the-mill.

Regarding repetitive-tasks:

1) To-automate repetitive-tasks, wherever possible;
2) Plan work-schedules, so that workers can take regular-breaks (breaks can-be short, but regular);
3) Practice job-rotation (e.g., rotating workers, through different-work-activities, during their-shifts, to-reduce the-extent and duration, required for the-repetitive-movement); and
4) To-facilitate rotation, efforts should-be-made to cross-train employees, in-several-operations, such-as: paste-preparation, roller-engraving, and paste-reclaiming, among-others.

Regarding the-floor condition:

1) *Continuing*-floor-maintenance is recommended; In-particular: (a) any-changes in-heights, of the-floor, should-be fixed; and (b) the-broken concrete should-be repaired, to-ensure floor-heights and surfaces are consistent; (c) slip-resistance should-be-improved with surface-treatments;
2) Testing for slip-resistance, and improving it;
3) Checking and applying the-cleaning-requirements, of the-flooring;
4) Choosing appropriate-shoes; and
5) Good-housekeeping.

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