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-higher-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) establishment-
position 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-insequent-sections: Standards for manual-handling; NIOSH-lifting equation; Preferred-position and zone, for safe-lifting; and Lifting-Principles.


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.

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-

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Figure1: Sequential-parts of the-study (Starovoytova & Namango, 2016).
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 \( \alpha > 0.87 \)).

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.

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>25.375 (10.23)</td>
<td>24 - 43</td>
</tr>
<tr>
<td>Duration of Employment (yrs)</td>
<td>2.75 (2.18)</td>
<td>1 - 8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.07 (11.84)</td>
<td>146 - 182</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>65.375 (9.80)</td>
<td>54 - 85</td>
</tr>
</tbody>
</table>

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 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)
repertoire-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

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 cannot, 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 intervertebral-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.
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 3 kg. 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, standing, without combining different tasks. ISO1128-1 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/recuperation-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 (Stålhammar, 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 (Stålhammar 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, graduated 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 intervertebral 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, 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:

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

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

Table 2: Maximum load weight, under-optimal conditions
\[ \text{RWL (kg)} = 23 \times H_f \times V_f \times D_f \times F_f \times A_f \times C_f \]

The use of the NIOSH-equation is, however, bound by a number of conditions. For example, it cannot 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 cannot 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).

- 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 obscure 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 the 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-reach; (2) a high frequency, or repetition, with insufficient-recovery-periods; (3) a high-rate of work, which cannot 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 preventing 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 known, 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 cannot 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 cannot reduce the-hazard(s), below the-hazard-level, using-the-controls described above, the-employer should-supplement those-controls with interim-measures, that primarily-relay 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 cannot grasp, or lift-it; (2) When they cannot see around/over the-load; (3) When the-load is too-heavy to-handle, for one-person, and (4) When a-worker cannot 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).

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 MHI-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.

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

(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.

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.
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 23 kg) 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 & Hagemmann, employees shall seek additional assistance, when: (1) A load is so bulky they cannot grasp or lift it; (2) When they cannot see around/over the load; (3) When the load is too heavy to handle, for one person, and (4) When a worker cannot 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 a braking system, can be installed (if economically feasible), to allow better access to the rolls.

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 all workers, should-be-provided, when: (1) they are being-inducted into-jobs, which contain risks from manual-tasks; (2) a-new manual-task is-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 of machinery and equipment), among-others.

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 an 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 Aluja & 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; Apel, 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 lateralis (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 Maets 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. Between 2000 and 2006, the Dutch Centre for Occupational Diseases (NvCB, 2012) received reports of 398 cases of occupational carpal tunnel syndrome. 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 RCI's.

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.

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; Sandblasting; 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 cannot 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) cannot 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 identify 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 preventative 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 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 23 kg) 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 all 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 to 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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References.


occupation: a meta-analysis”, *Rheumatology (Oxford)*, 51(2).


HSE – Health and Safety Executive, Handling kerbs; reducing the risk of musculoskeletal disorders (MSDs), HSE information sheet No 57.


loads at high frequency.


