
7. MODULE

Manual Materials Handling - Sequential

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INTRODUCTION

Scope of application. The *Sequential MMH* module allows you to analyze various task that involve the manual material **lifting**, either *single*, *multiple* or *variable*, which are performed in a determined **sequence** or **rotation** through the working day. For example, a task is considered to be *Sequential* when, during the same shift, a series of liftings (*single*, *multiple* or *variable*) is performed in a particular job for a certain period of time, and then the worker rotates to (an) other job(s) to perform a different series of liftings (*single*, *multiple* or *variable*) for another determined period of time. Before using the *Sequential MMH* module, the data of each *single*, *multiple* or *variable* **original task** (T_{orig} thereafter, to simplify the explanation) that makes up the rotation should have been previously saved by means of their respective analysis modules (*Single*, *Multiple* or *Variable MMH*).

Content. *Sequential MMH* maintains the basic criteria of the classic NIOSH equation, but it includes a specific procedure for analyzing sequential tasks, which requires the following:

- The evaluator defines how the rotation of the different lifting tasks is organized during the day, specifying the order and time of each event (in one or two 4-hour periods).
- The program subsequently performs a series of calculations and applies an equation to obtain the *Sequential Lifting Index* (SLI), which represents the level of risk for the back dorsolumbar area.

It is assumed that no manual material handling task can last more than 4 continuous hours without a recovery period (such as a lunch or a rest break). Therefore, the rotation is analyzed in a period of 4 hours, or two if necessary. If two hours are analyzed, the program will calculate the SLI of both periods and will take the greater of the two values as the risk of the sequential task.

Source. This module is based on the SLI procedure (*Sequential Lifting Index*), jointly developed by the authors of the NIOSH equation and the EPM research center in Milan [Waters et al, 2007].

DATA

By selecting the *Sequential MMH* module in the *New task* window (Figure 1), the window of this module is accessed (Figure 2), where the **identification** data of the case are entered first: name of the task, company, date of the analysis, observations and **population** considered (*general*, for adult men; *more protection*, for women, young or old workers).

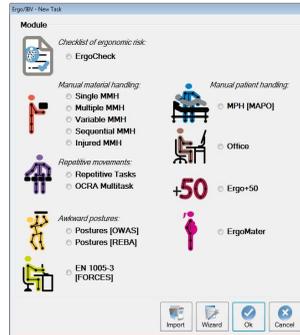


Figure 1. Access to the Sequential MMH module

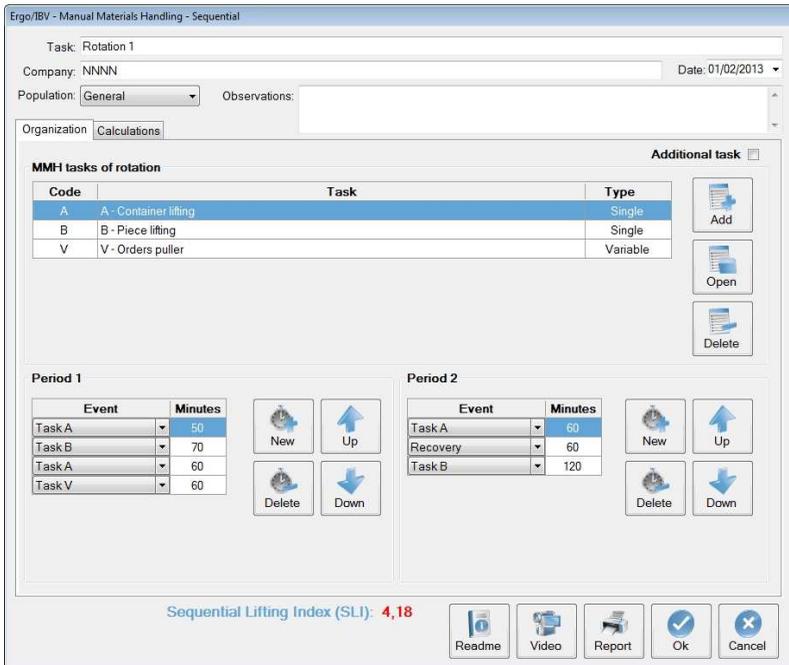


Figure 2. Sequential MMH, 'Organization' tab

Clicking on the *Read Me* button (bottom of the window) summarizes the instructions for use of the *Sequential MMH* module that were previously mentioned.

Organization

The organization of the sequential task is defined in the first tab of the window (Figure 2) by recording the data listed below.

MMH tasks of rotation. First, each lifting task that makes up the rotation is identified and, as already mentioned, they should have been previously created in the usual way by using the appropriate module (*Single, Multiple or Variable*). Each T_{orig} is incorporated to the *task list of the rotation*, which is managed by means of these buttons:

- *Add.* It shows a window where the evaluator assigns a short **code** (3 characters maximum) to identify the task, and then another window appears (Figure 3) in which the T_{orig} task that will be added to the task list of the rotation must be selected. This selection task only shows those T_{orig} that are in the current work folder (that is, where the sequential task was created).
- *Open.* It displays the selected task in the task list of the rotation and only allows the data to be viewed. The T_{orig} can only be edited by opening it from the work folder.
- *Delete.* It deletes the selected task in the task list of the rotation, and all its associated *events* (those that were defined below), after asking for confirmation. This function does not remove the T_{orig} from the work folder.

The task list of the rotation shows the following data for each row:

- **Code** assigned by the evaluator to identify the task.
- **Task**, which is the name of the T_{orig} (created from the appropriate module).
- **Type**, which specifies whether the T_{orig} is single, multiple or variable.

TASK	COMPANY	DATE	MODULE
V - Orders puller	NNNN	19/01/2013	Variable MMH
Packaging of products	xxxx	10/01/2005	Single MMH Lifting
B - Piece lifting	NNNN	17/01/2013	Single MMH Lifting
Orders puller in a warehouse	xx.xx	03/12/2010	Variable MMH
A - Container lifting	NNNN	16/01/2013	Single MMH Lifting
Shelving boxes	xx.xx	16/09/2005	Multiple MMH

Figure 3. Sequential MMH, window to select the rotation task

Periods. Two periods, of 4 hours each, are shown, which makes it possible to specify how the rotation occurs during the working day using the tasks defined in the previous section. A single period can be defined, or both if necessary. To do this, the exact sequence of each **event** is entered (and its duration in **minutes**), and the following options are selected from the drop-down menu:

- **Task 'n'**. An option appears for each T_{orig} defined in the task list of the rotation (identified by the code).
- **Additional task.** It refers to a task different from those being analyzed and which implies a noticeable physical demand.
- **Recovery.** It includes the time during which the worker rests or performs light tasks (desktop work, visual control of operations, light assembly tasks, etc.).

Press the *New* button to create each row of events, and the *Delete* button to delete the selected event. The *Up/Down* buttons allow you to change the order of the selected row of events.

Additional task. Check the appropriate box (top right of the 'Organization' tab) if there is any **additional task** that involves a noticeable physical demand at any time during the working day. For example, when this type of event has been entered in any of the periods analyzed, or when there is any **additional task** in the second period, although such period has not been analyzed (because it does not include lifting tasks).

With regard to how the program **works**, it is important to point out some concepts:

- Each T_{orig} used in the rotation exists independently from the sequential task. It is created in advance and when it is added to the sequential, the latter saves only a reference to the T_{orig} (no copy is saved).
- If a T_{orig} that is already used in a sequential task disappears (or its name changes), such sequential task will be invalidated. This entails that the SLI cannot be calculated as long as the T_{orig} is not recovered or deleted from the task list of the rotation.
- If the data of a T_{orig} that is already used in sequential task are modified, the result of the sequential will be also modified.
- A T_{orig} can be used in more than one sequential task. In that case, modifying the T_{orig} will also modify all the sequential tasks in which it was used.
- If the events specified in a period do not total 240 minutes, then the program will internally add a 'Recovery' time at the end of the last event to complete 4 hours, in order to perform the relevant calculations.

Calculations

Once the organization of the rotation is entered, the program automatically performs a series of calculations that are shown in the second tab of the window (Figure 4). In every period analyzed, a row for each lifting task included in that period shows the following data:

- **Task**. Identification code of the task for which the calculations were performed.
- **Type** of lifting task (single, multiple or variable).
- **M ref** Reference mass (*load constant*) that is applied in the calculations, according to the **population** considered in the analysis of the sequential task: *general* (M ref=25) or *greater protection* (M ref=15). The calculation will consider this data and will ignore that of the T_{orig} .
- **AT**. Factor that is applied in the calculations in another **additional task** is performed (AT=0,8) or does not exist (AT=1) during the working day. The calculation will consider this data and will ignore that of the T_{orig} .

- **Total frequency.** Number of handlings per minute that are performed in the task (if it is a multiple task, it is obtained by adding the frequency of each subtask that makes it up).
- **Real duration.** It is the duration of the task considered separately, that is, ignoring the rest of the lifting tasks in that period. It is automatically calculated from the data of the organization by using an algorithm that takes into account the classic criteria of the three duration categories (*short, moderate or long*), according to both the continuous or non-stop '*period of work*' and the '*recovery period*' between two working periods.
- **LI.** It is the *Risk Index* that the lifting task (LI, CI or VLI, if the task is *single, multiple or variable* respectively) would have considering the *frequency factor* (FM) associated with the **real duration** previously calculated (and ignoring the duration defined in the T_{orig}).
- **Total duration.** It is the duration of all the lifting tasks in that period, considered together. It is calculated by using the algorithm above mentioned.
- **LI max.** It is the *Risk Index* that the lifting task (LI_{max}, CI_{max} o VLI_{max}, if the task is *sim*) would have considering the *frequency factor* (FM) associated with the **total duration** previously calculated (and ignoring the duration defined in the T_{orig}).
- **FT.** It is the fraction of time of the task with respect to the 4-hour period considered (obtained by dividing the duration of the task, in minutes, by 240 minutes).
- **Sort by LI_{max}.** The tasks are sorted from highest to lowest risk according to the value of their LI_{max} (o CI_{max} o VLI_{max}).

NOTE: These calculations explain why the Risk Index shown when a T_{orig} is opened from the task list of the rotation is different from that later shown in the calculation tables of the SLI. Specifically, for each T_{orig} , the data (and associated factors) related to the **population** (M ref), the **additional task** (AT) and the **duration** (FM) used to calculate the Indices in the Sequential may be different from that shown in such T_{orig} .

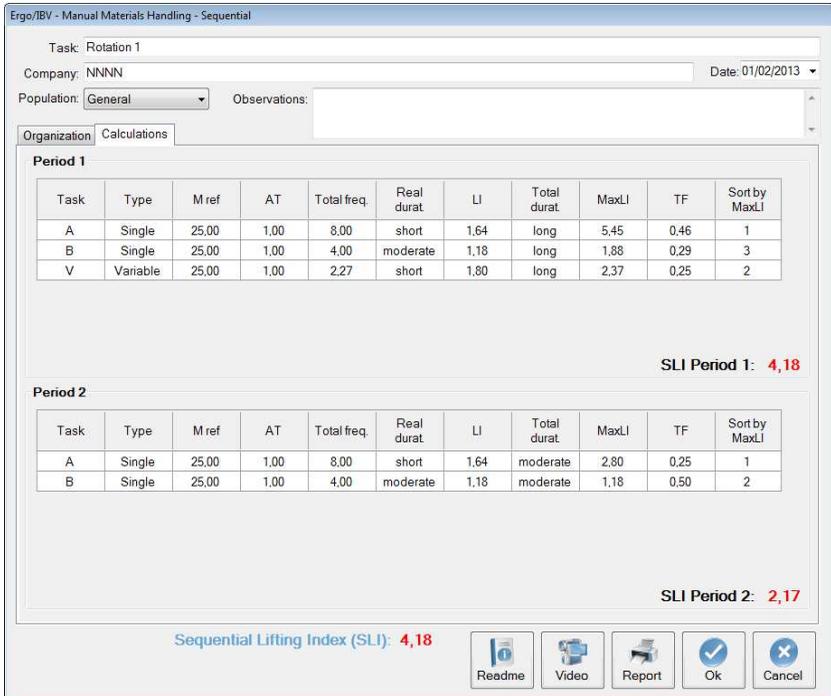


Figure 4. Sequential MMH, 'Calculation' task

Sequential Lifting Index (SLI)

Finally, from these calculations and applying a specific equation to analyze sequential tasks, the program obtains the *Sequential Lifting Index* (SLI). If the two periods were analyzed, the SLI of both is calculated and the greater of the two values is taken as the risk of the sequential task, being shown as such at the bottom of the window.

The SLI is a representative value of the risk level of musculoskeletal disorder in the back dorsolumbar area that is associated to the sequential task. The interpretation of the three risk areas considered is the same as that for single, multiple or variable tasks:

- *Acceptable risk* (Index ≤ 1). Most workers should not have any problems when performing this type of task.

- *Moderate risk* ($1 < \text{Index} < 1.6$). Normally, this type of tasks should be redesigned to reduce risk. Under special circumstances (for example, when the possible solutions of task redesigning are not advanced enough from the technical point of view), these tasks can be accepted provided that special emphasis is placed on aspects such as the training of the worker (for example, specialized knowledge in risk identification and prevention), detailed monitoring of the working conditions of the task, study of the physical capacities of the worker, and monitoring of the worker's health through periodic medical examinations.
- *Unacceptable risk* ($\text{Index} \geq 1.6$). The task must be modified.

NOTE: When tasks are sorted by their L_{max} , the greater L_{max} is established as L_{max_1} (and its corresponding LI as LI_1), the second one as L_{max_2} (and its corresponding LI as LI_2) and so on. The SLI is finally calculated using the following equation:

$$SLI = LI_1 + (L_{\text{max}_1} - LI_1) \times K$$

where

$$K = \left(\sum L_{\text{max}_i} \times TF_i \right) / L_{\text{max}_1}$$

REPORT

Pressing the *Report* button in the window of the *Sequential MMH* module generates a document that contains the following sections:

- **Identification.** It includes the location (work folder where the task was saved), date, name of the task and company, observations of the evaluator, population considered, and an image of the task (if a video source was configured).
- **Components of the sequential task** (Figure 5). It shows the list of the lifting tasks that make up the rotation and specifies whether there is or not an additional task at any point during the working day.
- **Risk of the sequential task** (Figure 5). It includes the *SLI* value and its interpretation, and associates color codes with the different risk levels.
- **Organization** (Figure 6). It shows how the events of the sequential tasks are distributed over one or two periods, if applicable.

ORGANIZATION										
Period 1					Period 2					
Event	Minutes									
Task A	50									
Task B	70									
Task A	60									
Task V	60									
Event	Minutes									
Task A	60									
Recovery	60									
Task B	120									
CALCULATIONS										
Period 1										SLI = 4,18
Task	Type	M ref	AT	Total freq.	Real durat.	LI	Total durat.	MaxLI	TF	Sort by MaxLI
A	Single	25,00	1,00	8,00	short	1,64	long	5,45	0,46	1
B	Single	25,00	1,00	4,00	moderate	1,18	long	1,88	0,29	3
V	Variable	25,00	1,00	2,27	short	1,80	long	2,37	0,25	2
Period 2										SLI = 2,17
Task	Type	M ref	AT	Total freq.	Real durat.	LI	Total durat.	MaxLI	TF	Sort by MaxLI
A	Single	25,00	1,00	8,00	short	1,64	moderate	2,80	0,25	1
B	Single	25,00	1,00	4,00	moderate	1,18	moderate	1,18	0,50	2

Figure 6. Sequential MMH. Report (organization and calculations)