6. MODULE
Manual Materials Handling - Variable

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INTRODUCTION

Scope of application. The *Variable MMH* module makes it possible to analyze tasks that involve the manual **lifting** of loads with **high variability** in the handling conditions, that is, tasks where the load mass, the height and/or the depth of the handling vary greatly for each lifting. This type of task is performed, for example, in jobs like order picking in a warehouse or baggage handling.

Generally, *Variable MMH* is applicable when the load lifting is so variable that it involves considering the analysis of **more than 10 different subtasks.**

Content. *Variable MMH* maintains the original criteria of the classic NIOSH equation, but it includes a procedure that simplifies the introduction and subsequent analysis of a large amount of data that would not be feasible to analyze with the *Multiple MMH* module.

This procedure requires defining the loads mass lifted by the worker in a work shift, along with their corresponding lifting frequencies. The program groups these loads mass into 5 categories for which the handling conditions (horizontal and vertical location of the load, trunk asymmetry, etc.) must be defined. Then the program simplifies the possible combinations of these variables and generates up to 6 subtasks representative of the demands of the real task. By applying the NIOSH equation for multiple tasks to these subtasks, the *Variable Lifting Index (VLI)* is finally obtained, which represents the risk level of the back dorsolumbar area.

Source. This module is based on:

- The original VLI (*Variable Lifting Index*) procedure, jointly developed by several authors of the NIOSH equation, the EPM research center in Milan and the Polytechnic University of Catalonia [Colombini et al, 2009; Waters et al, 2009].
- In the update carried out in 2016 by the authors and published in HUMAN FACTORS Vol. 58, No. 5, August 2016, pp. 695–711. "*Variable Lifting Index (VLI):" A new method for evaluating Variable Lifting Tasks*".

DATA

Choosing the *Variable MMH* module in the *New Task* window (Figure 1), gives access to the window of such module (Figure 2), where the **identification** data of the case must be entered first: name of the task, company, date of the analysis, observations, population considered (*male or female*) and age group (20-45 years or <20 and >45 years old).

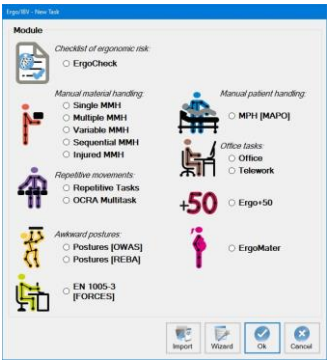


Figure 1. Access to Variable MMH module

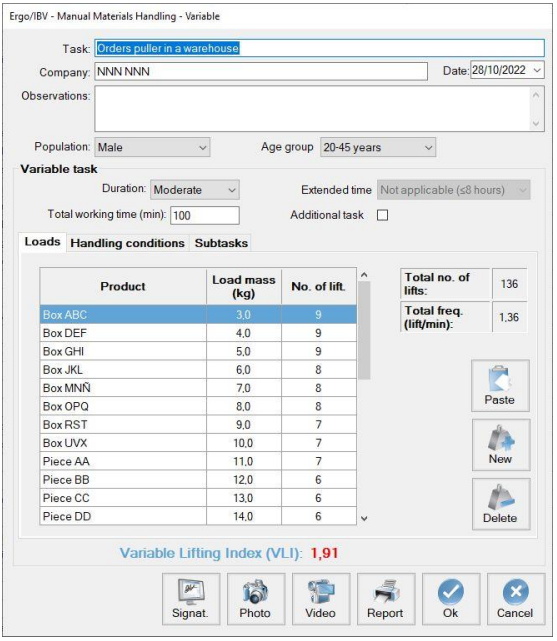


Figure 2. Variable MMH, main window and 'Loads' tab

Then the information that defines variable task is entered:

- **Duration**. Select in the drop-down menu the task duration (*short*, *moderate or long*), with similar criteria to those specified for *Single or Multiple MMH*.
- **Extended time.** Select the corresponding extended work hours value when manual materials handling tasks are performed for more than 8 hours per workday. It should be considered that, for frequencies less than 0.2 lifts/minute, the extended time multiplier will not be applicable, taking the value 1, even if duration values greater than 8 hours are selected.
    - *Not applicable (≤8 hours)*
    - *Between 8-9 hours*
    - *Between 9-10 hours*
    - *Between 10-11 hours*
    - *Between 11-12 hours*
- **Total working time (min)**. Specify, in minutes, the total time spent handling the loads that are later defined (if there are various working periods distributed over the day, add up the accumulated time in all of them).
- **Additional task**. Check the box when the worker performs a task different from the one being analyzed, and which implies a noticeable physical demand.

Other input data and results calculated by the program are included in three tabs, which are accessed by clicking the corresponding tab and whose content is described below.

Loads

The first tab (Figure 2) defines each load handled, together with their lifting frequency, and specifies the following:

- **Product**. Specify the name of the load lifted.
- **Load mass (kg)**. Specify the weight of the load in kilograms.
- **Number of liftings**. Specify how many times the load is lifted.

These loads are shown in a table, whose rows are managed with the buttons on the right. Press the *New* button to create each row of loads, and the *Delete* button to delete the selected load. The *Paste* button allows you to enter in this table data copied from documents created in other formats (Excel, Word, Txt) with the same structure; if there are already data entered

manually, pressing this button will add the data copied at the end of the table.

Note. The 'loads' and the 'total working time' during which these loads are handled determine the **pace** of work. In practice, information on the loads lifted and the corresponding working time can be obtained in different ways. For example:

- If a worker completes 10 order forms during 4 hours of the working day, and the forms contain the products that are picked from the shelves of a warehouse to be placed on pallets, a 'total working time' = 240 minutes is specified and the 'loads' are the products (name, load mass and number of times it is lifted) included in the 10 order forms.

- If 3 workers complete 45 order forms during 5 hours, a *'total working time'* = 900 minutes is specified (5 hours x 60 minutes/hours x 3 workers) and the *'loads'* are the products included in the 45 order forms.

From the previous information, the program automatically calculates and displays the following in the same tab:

- **Total number of liftings**. It is calculated as the addition of all the liftings previously entered.
- **Total frequency (lift/min)**. It is calculated as the ratio between the *total number of liftings* and *the total working time;* it is expressed in liftings per minute.

Handling conditions

The program groups the loads entered into 5 load mass categories that are automatically displayed when moving to the second tab (Figure 3), where the handling conditions of the loads have to be specified. The head of this section shows the following:

- **LOAD MASS categories (kg)**. The program establishes 5 weight intervals on the basis of the minimum and maximum values of the loads entered in the previous tab.
- **Products**. Clicking on the magnifying glass shows the products included in each category (name and associated load mass), to facilitate the work of the evaluator when assigning the handling conditions.

The evaluator must define the handling conditions of the loads, both when picking up the load at the **origin** of the lifting and when leaving it at the **destination**, specifying the following for each load mass category (even

though only one product of the category meets a condition, it must be checked):

- **Horizontal position**. Specify the depth or distance of horizontal reach of the loads by checking one or more of the following options:
  - *Near (<40 cm)*
  - *Medium* (40-50 cm)
  - *Far (>50 cm)*

  If the *'All'* box is checked (which is located on the right), the program will select all the options of the horizontal position for all load mass categories.
- **Vertical position**. Specify the height of the load handling, by checking one or more of the following options:
  - *Ideal* (50-125 cm)
  - *Not ideal* (<50 or >125 cm)

  Again, the *'All'* box allows you to select all the options of the vertical position for all load mass categories.
- **Angle of asymmetry**. Check the box when there are trunk twisting angles greater than 45° in more than 50% of the liftings.
- **One handed operation**. Check the box when there are load liftings performed with one hand.
- **Two-person operation**. Check the box when there are load liftings performed by two people.
- **Three-person operation**. Check the box when there are load liftings performed by three people.

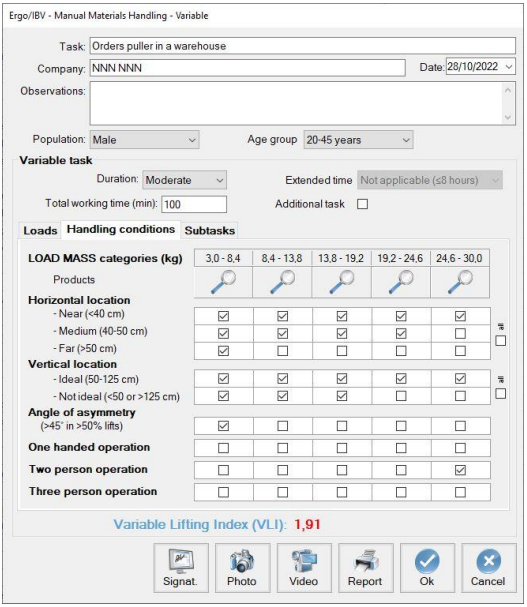
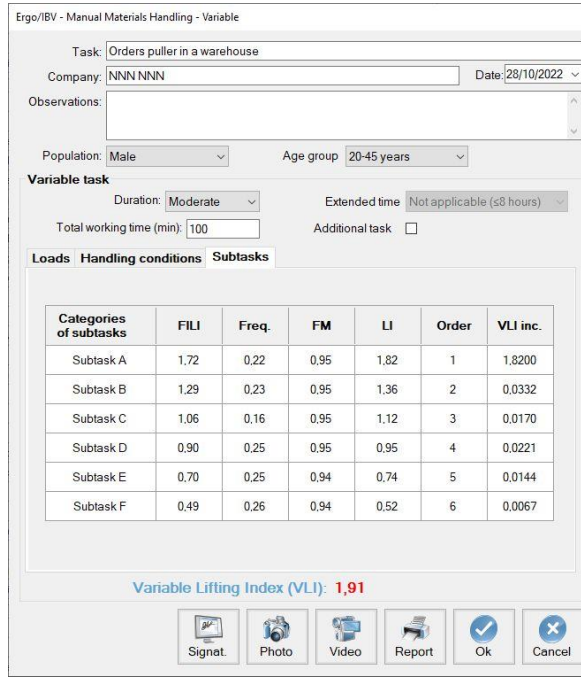


Figure 3. Variable MMH, 'Handling conditions' tab

Subtasks

The combination of the previous data can create a maximum of 30 subtasks (possible combinations of 5 load mass categories x 3 horizontal location x 2 vertical location), which the program later simplifies by generating up to 6 categories of (fictitious) subtasks representative of the demands of the real task. The third tab (Figure 4) shows the following data for each subtask category:



Categories of subtasks	FILI	Freq.	FM	LI	Order	VLI inc.
Subtask A	1,72	0,22	0,95	1,82	1	1,8200
Subtask B	1,29	0,23	0,95	1,36	2	0,0332
Subtask C	1,06	0,16	0,95	1,12	3	0,0170
Subtask D	0,90	0,25	0,95	0,95	4	0,0221
Subtask E	0,70	0,25	0,94	0,74	5	0,0144
Subtask F	0,49	0,26	0,94	0,52	6	0,0067

Figure 4. Variable MMH, 'Subtasks' tab

- **FILI** (*Frequency-Independent Lifting Index*). It is the *lifting Index* of the subtask calculated without considering the *frequency factor* (FM).
- **Frequency**. It is the accumulated frequency liftings of the subtask.
- **FM**. It is the *frequency factor* of the subtask, which depends on the *frequency* of liftings of the subtask and on the *duration* of the task.
- **LI** (*Lifting Index*). It is the risk index of the subtask, when such subtask is considered independently.
- **Order**. The subtasks are shown sorted from highest to lowest risk level, according to their LI.

- **Inc. VLI** (*Increase of the Variable Lifting Index*). It is the contribution of each subtask to the *Variable Lifting Index* (VLI). The addition of all the values in this column provides the VLI.

The data included in this last tab are purely informative and are used by the program to calculate the VLI.

> **Note**: If very few subtask categories are generated, it might be more appropriate and precise to use the *Multiple MMH* module to analyze this task.

Variable Lifting Index (VLI)

By applying the NIOSH equation for multiple tasks to the categories of subtasks generated, the program finally calculates the *Variable Lifting Index* (VLI) and displays it at the bottom of the window. The VLI is a value representing the risk level of musculoskeletal disorder in the dorsolumbar area of the back associated with the variable task. The interpretation of the three risk areas considered is the same as that previously specified for single or multiple tasks:

- *Acceptable risk* (Index ≤1). Most workers should have no problems performing such tasks.
- *Moderate risk* (1< 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* (Index ≥1.6). The task must be modified.

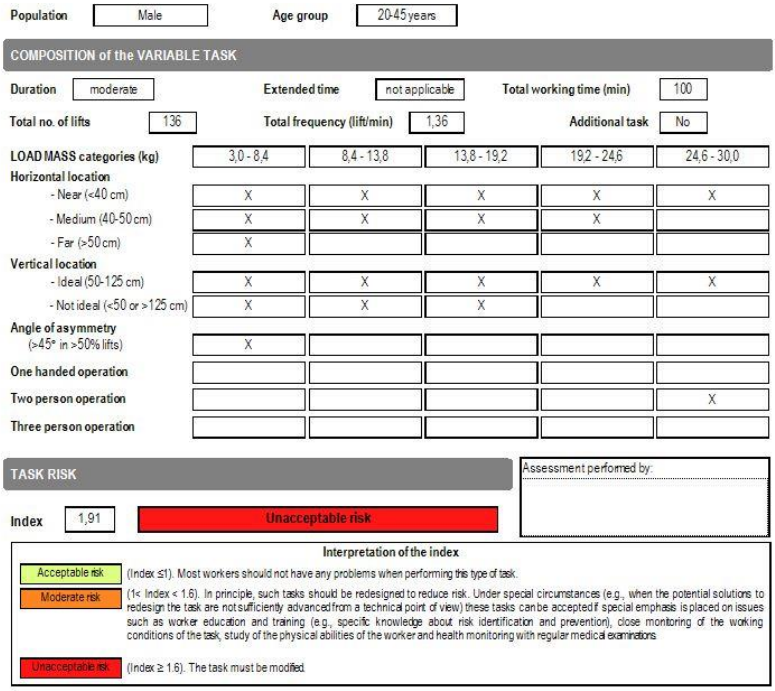
REPORT

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

- **Identification**. It includes date, name of the task and the company, evaluator's observations, population, and age group considered in

the case. If a photograph was added to the task, it will also appear in this section.

- **Components of the variable task** (Figure 5). It shows the data entered and the values calculated that define the variable task.
- **Risk of the variable task** (Figure 5). It includes the *VLI* value and its interpretation, and associates color codes with the different risk levels.



Population	Male	Age group	20-45 years		
COMPOSITION of the VARIABLE TASK					
Duration	moderate	Extended time	not applicable	Total working time (min)	100
Total no. of lifts	136	Total frequency (lift/min)	1,36	Additional task	No

LOAD MASS categories (kg)	3,0 - 8,4	8,4 - 13,8	13,8 - 19,2	19,2 - 24,6	24,6 - 30,0
Horizontal location					
- Near (<40 cm)	X	X	X	X	X
- Medium (40-50 cm)	X	X	X	X	
- Far (>50 cm)	X				
Vertical location					
- Ideal (50-125 cm)	X	X	X	X	X
- Not ideal (<50 or >125 cm)	X	X	X		
Angle of asymmetry (>45° in >50% lifts)	X				
One handed operation					
Two person operation					X
Three person operation					

TASK RISK		Assessment performed by:
Index	1,91	Unacceptable risk

Interpretation of the index	
Acceptable risk	(Index ≤1). Most workers should not have any problems when performing this type of task.
Moderate risk	(1< Index < 1.6). In principle, such tasks should be redesigned to reduce risk. Under special circumstances (e.g., when the potential solutions to redesign the task are not sufficiently advanced from a technical point of view) these tasks can be accepted if special emphasis is placed on issues such as worker education and training (e.g., specific knowledge about risk identification and prevention), close monitoring of the working conditions of the task, study of the physical abilities of the worker and health monitoring with regular medical examinations.
Unacceptable risk	(Index ≥ 1.6). The task must be modified.

Figure 5. Variable MMH. Report (components, risk of the variable task)

- **Categories of subtasks** (Figure 6). It provides the data associated with the subtasks (fictitious) generated by the program.
- **Loads (detail)** (Figure 6). Finally, all the data entered for each load (product, load mass, and number of liftings) are grouped in the appropriate load mass category.

CATEGORIES of SUBTASKS

Categories	FILI	Freq.	FM	LI	Order	VLI inc.
Subtask A	1,72	0,22	0,95	1,82	1	1,8200
Subtask B	1,29	0,23	0,95	1,36	2	0,0332
Subtask C	1,06	0,16	0,95	1,12	3	0,0170
Subtask D	0,90	0,25	0,95	0,95	4	0,0221
Subtask E	0,70	0,25	0,94	0,74	5	0,0144
Subtask F	0,49	0,26	0,94	0,52	6	0,0067

LOADS (detail)

	Product	Load mass (kg)	No. of lifts
LOAD MASS category (kg): 3,0 - 8,4			
	Box ABC	3,0	9
	Box DEF	4,0	9
	Box GHI	5,0	9
	Box JKL	6,0	8
	Box MNÑ	7,0	8
	Box OPQ	8,0	8
LOAD MASS category (kg): 8,4 - 13,8			
	Box RST	9,0	7
	Box UVX	10,0	7
	Piece AA	11,0	7
	Piece BB	12,0	6
	Piece CC	13,0	6

Figure 6. Variable MMH. Report (categories of subtasks, detail of the loads)