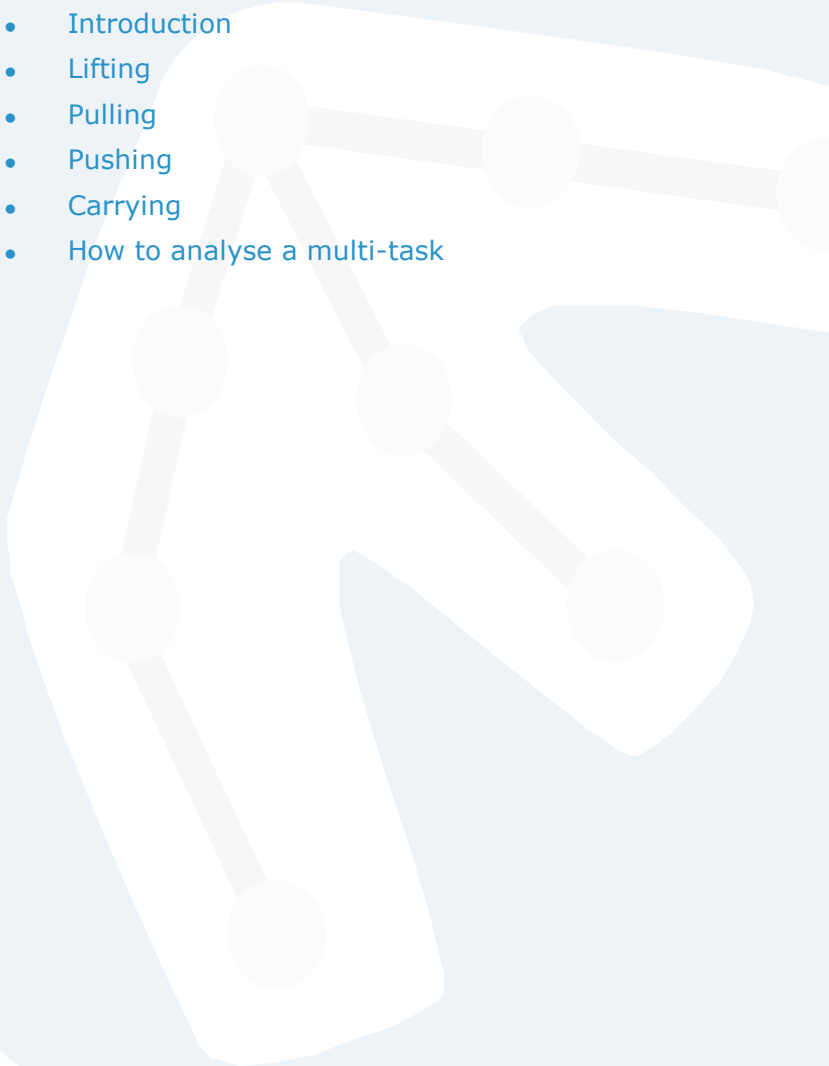


5. MODULES

Single and Multiple Manual Materials Handling

- Introduction
 - Lifting
 - Pulling
 - Pushing
 - Carrying
 - How to analyse a multi-task
- 

INTRODUCTION

Scope of application. The *Manual Materials Handling* module makes it possible to analyse tasks involving lifting, carrying, pushing or pulling loads, as well as combinations of these actions.

When applying this module one has to differentiate between *single tasks* and *multi-tasks*, taking the following into consideration:

- **Single task.** This is so defined when the variables associated with the handling of loads (load mass, load location at origin or at destination, frequency of handling, etc.) do not significantly vary during the task. A *single* task can be:
 - One lifting task.
 - One pushing task.
 - One pulling task.

- **Multi-task.** This is so defined when there are significant differences in the variables associated with the handling of loads, or else when lifting is combined with carrying or pushing is combined with pulling. In these cases the task is considered to be a *multi-task* and is comprised of different *subtasks*, the combinations of which can be as follows:
 - Various lifting subtasks.
 - Various pushing subtasks.
 - Various pulling subtasks.
 - One or various lifting with one or various carrying subtasks.
 - One or various pushing with one or various pulling subtasks.

It is important to clarify that carrying loads cannot be analysed as a *single* task because it is always combined with at least one lifting. Consequently, carrying will always be a *subtask* forming part of a *multi-task*.

For example, if a worker lifts boxes of the same weight, always in the same manner, from and to the same places, this is considered to be a *single* task (one lifting). If, as well as lifting these, the worker carries them to a conveyor belt 5 metres away, this is a *multi-task* (one lifting and one carrying). If there is no carrying but the boxes are deposited at different heights, the task shall also be a *multi-task* (various lifting).

In the case of a worker pulling carts with the same features, this is considered a *single* task (one pulling). If the carts can change weight or size, the task is a *multi-task* (various pulling). If there are carts that are being pushed and pulled, with different shapes and weights, the task shall also be a *multi-task* (various pulling and pushing).

Note: In the case of **lifting multi-tasks**, when the variability is so high (as far as weight and/or handling conditions are concerned) that it involves considering **more than 10 different subtasks**, the risk is analysed with the '*Variable MMH*' module, which is described in the corresponding chapter. If a sequence or **rotation** is performed between two or more different lifting tasks (*single*, *multiple* and/or *variable*) throughout the workday, the risk is analysed with the '*Sequential MMH*', which is also detailed in the corresponding chapter.

Content. The procedure followed for applying this module consists basically of the following:

- Firstly, it is to be specified whether the analysis refers to a single task or to a multi-task.
- Then, the data defining the task (or subtasks) are entered for the corresponding loads handling (lifting, carrying, pushing and/or pulling).
- Using these data, the program calculates a risk level (*index*) for musculoskeletal disorders in the dorsolumbar region of the back.
- Also, if the case so requires, one can perform an [interactive redesign](#) of the task so as to reduce the risk of injury. The software [recommends](#) the changes that should be made to the variables that involve a higher reduction in the risk level.

Source. This module is based on the following procedures for evaluating ergonomic risks in manual materials handling tasks:

- Revised NIOSH lifting equation, from the National Institute of Occupational Safety and Health (NIOSH, 1994).
- ISO 11228-1 (2021). Ergonomics-Manual handling. Part 1: Lifting, lowering and carrying. International Organization for Standardization (ISO).
- Waters, T. R. (2006). Revised NIOSH lifting equation. In W. Marras & W. Karwowski (Eds.), Occupational ergonomics handbook: Second edition, fundamentals and assessment tools for Variable Lifting Index (VLI) 711 occupational ergonomics (pp. 46-1-46-28). Boca Raton, FL: CRC Press
- The INSHT (National Institute for Safety and Hygiene at Work) technical guide on manual material handling (INSHT, 1998).

- EN 1005-2 (2004) standard, relative to manual handling of machinery and its component parts.
- Tables of maximum acceptable weights and forces (Snook and Ciriello, 1991).

LIFTING

This section concentrates on the analysis of a *single* lifting task.

The analysis is started by selecting the *Single MMH* module in the *New task* window (Figure 1).

Next, a *lifting* is selected as the task type to be analysed (Figure 2).

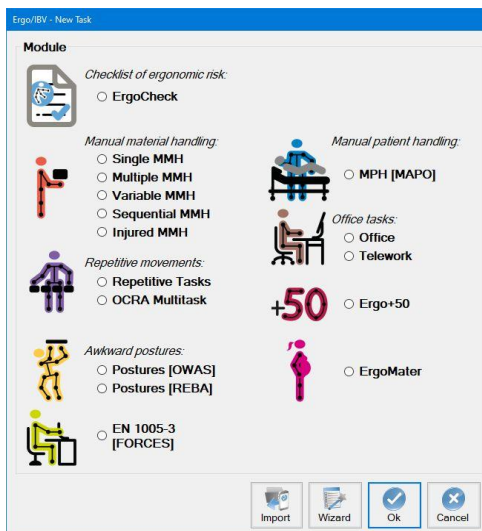


Figure 1: Single MMH module entry



Figure 2: Single MMH - Selection of task type

Identification. This accesses the main window for lifting tasks (Figure 3) in which the following identification data have to be entered:

- **Task.** Assign a name for the task to be analysed.
- **Company.** Enter the name of the company or working center where the task is performed.
- **Date.** Specify the date of the analysis.
- **Observations.** This is for the evaluator to note any relevant explanation about the case (details concerning the task, the department of the company, the recorded video, etc.).
- **Population.** Select the working population considered in the analysis (this affects, together with the age group, the value of the reference weight that will be used in the calculation of risk):
 - *Male*
 - *Female*
- **Age group.** Select the age group of the working population considered in the analysis (this affects, together with the population, the value of the *reference weight* that will be used in the calculation of risk):
 - *20-45 years*
 - *<20 or >45 years*

Ergo/IBV - Manual Materials Handling - Single - Lifting

Task:

Company: Date:

Observations:

Population: Age group:

Variables

Duration: Extended time:

Load mass (kg): Frequency (lifts/min):

	Origin	Destin.
Horizontal location (cm):	<input type="text" value="30,0"/>	<input type="text" value="40,0"/>
Vertical location (cm):	<input type="text" value="65,0"/>	<input type="text" value="100,0"/>
Angle of asymmetry (°):	<input type="text" value="90,0"/>	<input type="text" value="0,0"/>

Coupling:

Control at destination

One handed operation

Two person operation

Three person operation

Additional task

Index: 1,12 1,11

Recommended Mass Limit (kg)

	M ref	HM	VM	DM	AM	FM	CM	OM	PM	AT	EM	RML
Origin	25	0,83	0,97	0,95	0,71	0,52	0,95	1,00	1,00	1,00	1,00	6,70
Destin.	25	0,63	0,93	0,95	1,00	0,52	0,95	1,00	1,00	1,00	1,00	6,73

Figure 3: Single MMH - Lifting – Main window

Variables. Besides the identification data, it is necessary to enter the following variables:

- **Duration.** Select the duration for the task from the pull-down menu, in which there are three categories (short, moderate and long) that depend on the following concepts:
 - *Work-time* period: is defined as a period of uninterrupted work.
 - *Recovery-time* period: is the time elapsing between two work-time periods, in which one is resting or performing light work (such as sitting at a desk or table, monitoring operations, light assembly work, etc.).

Based on the pattern of these periods, the three categories for the task's duration are defined:

- *Short.* This applies when the *work-time* is ≤ 1 hour and is followed by a *recovery-time* of at least equal duration to the *work-time*. For example, an uninterrupted lifting task in 45 minute periods followed by resting (or light task) periods of 45 minutes can be considered to be of *short* duration, as it complies with the two conditions (*work-time* = 45 min,

which is < 1 hour; *recovery-time* = 45 min, which is equal to the *work-time*.

If the *work-time* is ≤ 1 hour but the required *recovery-time* does not comply with the above limit, and a subsequent lifting session is required, then the durations of the consecutive *work-time* periods must be combined to correctly determine the duration category. For example, if the task involves two *work-time* periods of 50 minutes separated by 10-minute rest, the minimum *recovery-time* duration is not met (50 minutes recovery is needed at least). In this case it should be considered a single *work-time* with a total duration of 50+50 minutes, which does not meet the maximum limit for a job of *short* duration and, therefore, must be assigned a *moderate* duration.

- *Moderate*. In this case, the *work-time* must be >1 hour but ≤ 2 hours, and should be followed by a *recovery-time* of at least 0,3 times the *work-time*. For example, in tasks with a *work-time* of 1,5 hours, it is necessary to have a *recovery-time* of at least 27 minutes ($90 \times 0,3 = 27$) for the task to be considered of *moderate* duration.

If the minimum *recovery-time* is not met, then the durations of the consecutive *work-time* periods must be combined in a single period. For example, two 90 minute *work-time* periods separated by 15 minutes of rest are equivalent to a continuous *work-time* of 180 minutes, meaning that it should not be considered as being *moderate* but *long* duration.

- *Long*. These are tasks with *work-time* periods of >2 hours and a maximum of 8 hours.

- **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*

- **Load mass**. Specify, in kilograms, the mass of the object lifted.

- **Frequency**. Indicate the number of lifts performed per minute.
- **Horizontal location** .

Specify, in centimetres, the horizontal distance (dimension H in Figure 4) that exists between the projection on the floor of the mid-point of the hand grasps (point 2 in Figure 4) and the mid-point of the line joining the inner ankle bones (point 1 in Figure 4). The maximum value for this variable is 63,5 cm, since objects at a greater distance cannot be lifted vertically without some loss of balance; if the task requires greater distances, it should be redesigned.

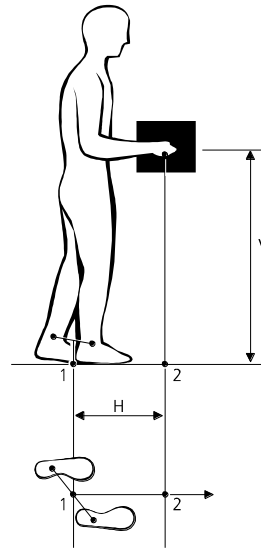


Figure 4: Horizontal location (H) and Vertical location (V) of the load

- **Vertical location**. Specify, in centimetres, the vertical distance from the floor to the mid-point of the hand grasps (dimension V in Figure 4). This variable should be measured at both, the **origin** (when the load is grasped at the origin of the lift) and the **destination** (when leaving the load), to determine the vertical displacement. The vertical location is limited to values from 0 to 178 cm; if this value is exceeded, the task should be redesigned.

- Angle of asymmetry.** Specify, in degrees, the angle of trunk twisting. It can be estimated from the angle formed between the line connecting the heels and the line connecting the shoulders (see some examples in Figure 5). This variable is limited to values between 0 and 135°.

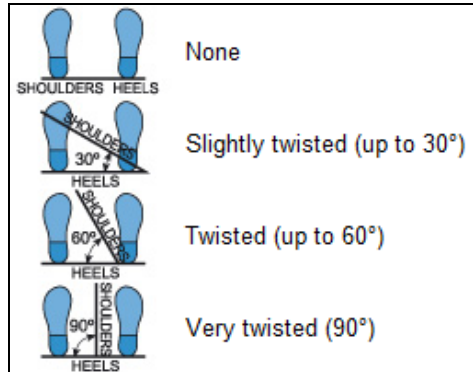


Figure 5. Angle of asymmetry (trunk twisting)

- Coupling.** Specify the nature of the hand-to-load coupling or gripping method, by selecting one of the three categories considering the following:
 - Good** Load length ≤ 40 cm; load height ≤ 30 cm; good handles or hand-hold cut-outs. Easy to handle loose parts and objects with wrap around grasp and without excessive wrist deviation.
 - Fair** Load length ≤ 40 cm; load height ≤ 30 cm; and poor handles or hand-hold cut-outs or 90° finger flexion. Easy to handle loose parts and objects with 90° finger flexion and without excessive wrist deviation.
 - Poor** Load length > 40 cm; or load height > 30 cm; or difficult to handle parts or sagging objects or asymmetric center of mass or unstable contents or hard to grasp object or use of gloves.

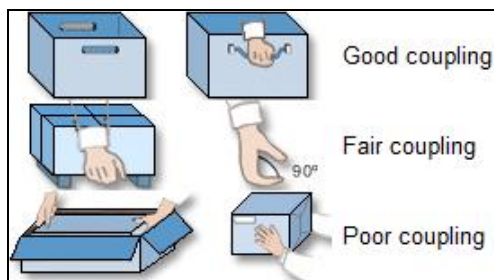


Figure 6. Load grip type

- **Control at destination.** Tick this box only if a significant control is required when leaving the load at the destination. For example, significant control is required when the worker has to position or guide the load with certain precision at the destination, or when the worker has to momentarily hold the object in the air before releasing it, or if it is necessary to relocate the load, once in place, by lifting it once again. By contrast, control is not required in the case of objects that are released or can be dropped, or when it is sufficient at the destination point to guide the object without too much precision and without having to hold it suspended immediately prior to its release.

If control is required, ticking this box will activate 3 variables associated with the final position at destination that have also to be recorded (their definition has already been indicated in the preceding text), and are as follows:

- **Horizontal location**, at **destination**.
 - **Angle of asymmetry**, at **destination**.
 - **Coupling**, at **destination**.
- **One handed operation.** Tick this box when the object is handled with one hand only.
 - **Two person operation.** Tick this box when the object is handled by two persons. Although handling by two persons can reduce the load on one operator, it also creates additional hazards because of difficulties in coordinating the movements and force exertions between the two people performing the lift together.
 - **Three-person operation.** Check the box when the load is handled by three people. Although handling a load between three people reduces the weight supported by each worker, just like with 2 people, this operation poses additional problems due to the difficulty of coordinating the movements and efforts performed by both people during the handling.
 - **Additional task.** Tick this box when the worker performs another task (different to the manual materials handling task that is being analysed) that involves significant physical demands.

Calculations. Once these variables have been entered, clicking the *Index* button in the lifting main window (Figure 3) will make the program calculate and display the following values in this same window:

- Recommended mass limit (RML)**. This corresponds to the load that practically any healthy worker (of the intended population) can lift without the risk of suffering musculoskeletal disorders in the dorsolumbar region of the back.

This value is obtained from the following equation:

$$RML = M_{ref} \cdot HM \cdot VM \cdot DM \cdot AM \cdot FM \cdot CM \cdot OM \cdot PM \cdot AT$$

where

M_{ref} is the *Reference weight* (also called *load constant*), which depends on the *population* considered and the age group. The LC values corresponding to the maximum recommended weight in optimal handling conditions are shown in the table below.

	Male	Female
20-45 years	25 kg	20 kg
<20 or >45 years	20 kg	15 kg

HM is the *horizontal multiplier*, which is obtained from the *horizontal location*.

VM is the *vertical multiplier*, which is obtained from the *vertical location*.

DM is the *distance multiplier*, which is obtained from the *vertical displacement* of the object during lifting; this is computed by subtracting the *vertical location* (V) at the origin of the lift from the corresponding V at the destination of the lift.

AM is the *asymmetry multiplier*, which is obtained from the *asymmetry angle*.

FM is the *frequency multiplier*, which depends on the variables *frequency*, *duration* and *vertical location*.

CM is the *coupling multiplier*, which is obtained from the *coupling* variable.

OM is the *one-handed operation multiplier*, which depends on the variable of the same name.

PM is the *team lifting multiplier*, which depends on the variable of the same name.

AT is the *additional task multiplier*, which depends on the variable of the same name.

EM is the *Extended time multiplier*, which depends on the variable with the same name. The **EM** values are shown in the table below:

Hours of MMH per working day	≤8 hours	8-9 hours	9-10 hours	10-11 hours	11-12 hours
Value of the EM multiplier	1	0.97	0.93	0.89	0.85

Note: This multiplier is only applicable for frequencies greater than 0.2 lifts/min

These *multipliers* can have values between 0 and 1. Value 1 for the *multiplier* corresponds to an optimum value for the associated *variable* (for example, in the case of *horizontal location*, this would correspond to 25 cm or less, which supposes that the object is held next to the body). As the value for the *variable* moves away from the optimum (for example, as the *horizontal location* exceeds 25 cm), the *multiplier's* value is reduced.

Note: The *team lifting multiplier (PM)* has a different interpretation because the value 1 of this multiplier does not correspond to the optimal situation of the associated variable. That is to say, **PM** = 1 when the load is handled by 1 person, but **PM** = 0.66 when the operation is performed between 2 people, and **PM** = 0.50 when the operation is performed between 3 people (lower risk situation, since the weight supported by each worker is reduced). This is due to the value of the *load weight* considered in the estimation of the Risk *Index*, as will be explained below.

If significant control at destination is required the program calculates both, the *RML* at the origin and at the destination; if control is not required, then it just calculates this at the origin.

- **Index.** This is a value representative of the risk level associated with the task. It is obtained from the quotient between the *load mass* (the weight really handled by the worker) and the *RML* (calculated by the program).

Note: When the load is handled by one person the software considers the *load mass* to calculate the *Index*; when the operation is performed by two persons, only half of the *load mass* is used for the calculation; when the operation is performed by three persons, only a third of the *load mass* is used for the calculation.

The risk of injury increases as this *Index* rises, establishing three levels of risk of musculoskeletal disorders in the back's dorsolumbar region depending on its value, whose interpretation is as follows:

- *Acceptable risk* (Index ≤ 1). Most workers should not have difficulty performing this kind of tasks.
- *Moderate risk* ($1 < \text{Index} < 1,6$). This kind of tasks should normally be redesigned in order to reduce risk. Under special circumstances (e.g., when the possible solutions to redesign the task are not sufficiently advanced from a technical point of view), these tasks can be accepted provided that particular emphasis is placed on aspects such as worker education or training (e.g., specialized knowledge about risk identification and prevention), detailed monitoring of the task working conditions, study of the worker physical abilities, and monitoring the worker health through regular medical examinations.
- *Unacceptable risk* (Index $\geq 1,6$). The task must be modified.

If significant control at destination is required, the program calculates both, the *Index* at the origin and at the destination; if control is not required, then it just calculates this at the origin. Should both exist, the program highlights in bold the greatest value and will finally take this value as the risk for the analysed task.

Report

By clicking the *Report* button in the main window for lifting (Figure 3) a *task report* is obtained containing 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.
- **Variables.** This shows all the data that have been entered by the evaluator (Figure 7).
- **Calculations.** This offers the *reference mass* (depending on the population and age group considered), the *RML* (including all the multipliers used for its calculation) and the *Index*, considering the values at origin and at destination if applicable (Figure 7).
- **Risk of the task.** This shows the value obtained for the *Index* and its interpretation, associating colour codes for the different risk levels (Figure 8). As it has been mentioned before, if the index has been calculated at origin and at destination, the greater of these two values is finally considered as the risk of the task.

VARIABLES							
Duration	<input type="text" value="long"/>	Horizontal location (cm)	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="30,0"/></td><td><input type="text" value="40,0"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="30,0"/>	<input type="text" value="40,0"/>
Origin	Destin.						
<input type="text" value="30,0"/>	<input type="text" value="40,0"/>						
Extended time	<input type="text" value="not applicable"/>	Vertical location (cm)	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="65,0"/></td><td><input type="text" value="100,0"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="65,0"/>	<input type="text" value="100,0"/>
Origin	Destin.						
<input type="text" value="65,0"/>	<input type="text" value="100,0"/>						
Load mass (kg)	<input type="text" value="7,5"/>	Angle of asymmetry (°)	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="90,0"/></td><td><input type="text" value="0,0"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="90,0"/>	<input type="text" value="0,0"/>
Origin	Destin.						
<input type="text" value="90,0"/>	<input type="text" value="0,0"/>						
Frequency (lifts/min)	<input type="text" value="3,333"/>	Coupling	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="far"/></td><td><input type="text" value="far"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="far"/>	<input type="text" value="far"/>
Origin	Destin.						
<input type="text" value="far"/>	<input type="text" value="far"/>						
		One handed operation	<input type="text" value="No"/>				
		Two person operation	<input type="text" value="No"/>				
		Three person operation	<input type="text" value="No"/>				
		Additional task	<input type="text" value="No"/>				

CALCULATIONS					
M ref - Reference mass (kg) for the intended population	<input type="text" value="25"/>				
HM - Horizontal multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="0,83"/></td><td><input type="text" value="0,63"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="0,83"/>	<input type="text" value="0,63"/>
Origin	Destin.				
<input type="text" value="0,83"/>	<input type="text" value="0,63"/>				
VM - Vertical multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="0,97"/></td><td><input type="text" value="0,93"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="0,97"/>	<input type="text" value="0,93"/>
Origin	Destin.				
<input type="text" value="0,97"/>	<input type="text" value="0,93"/>				
DM - Distance multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="0,95"/></td><td><input type="text" value="0,95"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="0,95"/>	<input type="text" value="0,95"/>
Origin	Destin.				
<input type="text" value="0,95"/>	<input type="text" value="0,95"/>				
AM - Asymmetry multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="0,71"/></td><td><input type="text" value="1,00"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="0,71"/>	<input type="text" value="1,00"/>
Origin	Destin.				
<input type="text" value="0,71"/>	<input type="text" value="1,00"/>				
FM - Frequency multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="0,52"/></td><td><input type="text" value="0,52"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="0,52"/>	<input type="text" value="0,52"/>
Origin	Destin.				
<input type="text" value="0,52"/>	<input type="text" value="0,52"/>				
CM - Coupling multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="0,95"/></td><td><input type="text" value="0,95"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="0,95"/>	<input type="text" value="0,95"/>
Origin	Destin.				
<input type="text" value="0,95"/>	<input type="text" value="0,95"/>				
OM - One handed operation multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="1,00"/></td><td><input type="text" value="1,00"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="1,00"/>	<input type="text" value="1,00"/>
Origin	Destin.				
<input type="text" value="1,00"/>	<input type="text" value="1,00"/>				
PM - Team lifting multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="1,00"/></td><td><input type="text" value="1,00"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="1,00"/>	<input type="text" value="1,00"/>
Origin	Destin.				
<input type="text" value="1,00"/>	<input type="text" value="1,00"/>				
EM - Extended time multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="1,00"/></td><td><input type="text" value="1,00"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="1,00"/>	<input type="text" value="1,00"/>
Origin	Destin.				
<input type="text" value="1,00"/>	<input type="text" value="1,00"/>				
AT - Additional task multiplier	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="1,00"/></td><td><input type="text" value="1,00"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="1,00"/>	<input type="text" value="1,00"/>
Origin	Destin.				
<input type="text" value="1,00"/>	<input type="text" value="1,00"/>				
RML - Recommended mass limit (kg) <small>RML = Mref x HM x VM x DM x AM x FM x CM x OM x PM x EM x AT</small>	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="6,70"/></td><td><input type="text" value="6,73"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="6,70"/>	<input type="text" value="6,73"/>
Origin	Destin.				
<input type="text" value="6,70"/>	<input type="text" value="6,73"/>				
Index (Load mass / RML)	<table border="1"><thead><tr><th>Origin</th><th>Destin.</th></tr></thead><tbody><tr><td><input type="text" value="1,12"/></td><td><input type="text" value="1,11"/></td></tr></tbody></table>	Origin	Destin.	<input type="text" value="1,12"/>	<input type="text" value="1,11"/>
Origin	Destin.				
<input type="text" value="1,12"/>	<input type="text" value="1,11"/>				

Figure 7: Single MMH - Lifting - Report (variables and calculations)

TASK RISK		Evaluator (name and signature)
Index	1,12	Moderate 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 8: Single MMH - Lifting – Report (risk of the task)

Redesign

Clicking the *Redesign* button in the main window for lifting (Figure 3) accesses a window allowing one to redesign the task being analysed (Figure 9). Redesign is performed by modifying the lifting variables so as to obtain a lower *Index*, thereby reducing the worker’s risk of injury. This is a process guided by the software by means of a series of recommendations.

Redesign is **interactive**, meaning that the evaluator can modify the variables and the new risk *Index* is automatically calculated. Changing the variables can be done by entering the new value directly in the corresponding box or by using the button located on the right of each variable so as to increase or reduce its value (in the categorical variables *one handed operation*, *two-person operation*, *three-person operation* and *additional task*, the change is accomplished by marking or unmarking the box located to the right of each variable).

Ergo/IBV - Manual Materials Handling - Single - Lifting - Redesign

Task: Packaging of products

Company: NNN NNN Date: 28/10/2022

Observations:

Population: Male Age group: 20-45 years

Variables

Duration: Long Extended time: Not applicable (≤8 hours)

Load mass (kg): 7,5 Frequency (lifts/min): 3,333

	Origin	Destin.
Horizontal location (cm):	<input checked="" type="checkbox"/> 30,0	<input checked="" type="checkbox"/> 40,0
Vertical location (cm):	<input checked="" type="checkbox"/> 65,0	<input checked="" type="checkbox"/> 100,0
Angle of asymmetry (°):	<input checked="" type="checkbox"/> 90,0	<input type="checkbox"/> 0,0
Coupling:	<input checked="" type="checkbox"/> Fair	<input checked="" type="checkbox"/> Fair

One handed operation
 Two person operation
 Three person operation
 Additional task

Index: 1,12 1,11

Recommended Mass Limit (kg)

	M ref	HM	VM	DM	AM	FM	CM	OM	PM	AT	EM	RML
Origin	25	0,83	0,97	0,95	0,71	0,52	0,95	1,00	1,00	1,00	1,00	6,70
Destin.	25	0,63	0,93	0,95	1,00	0,52	0,95	1,00	1,00	1,00	1,00	6,73

Ok Cancel

Figure 9: Single MMH -Lifting – Interactive redesign

Recommendations. As it has been indicated before, the software offers recommendations to conduct the redesign. A reduction in the *load mass* is always recommended at first and a modification to the most critical variable (that is, the one that associates the lower *multiplier*) afterward. A red arrow on a button placed beside the variable indicates that it is a recommendation; the arrow will point upwards if the variable needs to be increased and downwards if it has to be reduced (except for the categorical variables *one handed operation*, *two-person operation*, *three-person operation* and *additional task*, where the arrow points horizontally).

As changes are made to the variables, the values of the risk *Index* and, obviously, the *RML* are automatically updated. Besides, highlighted in red is the multiplier associated with the recommended modification at every moment.

Disqualifying variables. On occasions, certain lifting variables may be conditioned by actual limitations in the task meaning that they cannot be modified. Should there exist such restrictions, one can disqualify the appropriate variables so that these are not taken into account by the program when it comes to recommending a modification in the redesign. To this end, the 'X' mark on the button beside the variable (which shows the recommendations) should be removed by pressing it. When a variable is disabled, its value cannot be modified, which can be enabled again at any time to include it in the redesign (by pressing again the button in order to show the 'X' mark). It is important to mention that, initially, the only variables qualified by the program are those that can reduce the *Index*.

Example of redesign. In Figure 9, the *Index* value is 1,12 (*redesign is necessary*) and the software recommends to reduce the *load mass*. Supposing that the *load mass* cannot be modified in this case, one should proceed to disqualify this variable; then the software recommends to modify the duration of the task (Figure 10). When changing from *long* to *moderate* duration, the *Index* value becomes 0,75, which means a *tolerable risk* (Figure 11).

Saving the redesigned task. Finally, it may be of interest to save the complete task as redesigned. To do this, click the *OK* button in the redesign window (Figure 11) and specify the new name to be assigned to the redesigned task. In this way the data for the original task are not lost.

Ergo/IBV - Manual Materials Handling - Single - Lifting - Redesign

Task: Packaging of products
 Company: NNN NNN Date: 28/10/2022

Observations:

Population: Male Age group: 20-45 years

Variables

Duration: Long Extended time: Not applicable (≤3 hours)

Load mass (kg): 7.5 Frequency (lifts/min): 3.333

	Origin	Destin.
Horizontal location (cm):	30.0	40.0
Vertical location (cm):	65.0	100.0
Angle of asymmetry (°):	90.0	0.0
Coupling:	Fair	Fair

One handed operation
 Two person operation
 Three person operation
 Additional task

Index: 1,12 1,11

Recommended Mass Limit (kg)

	M ref	HM	VM	DM	AM	FM	CM	OM	PM	AT	EM	RML
Origin	25	0.83	0.97	0.95	0.71	0.52	0.95	1.00	1.00	1.00	1.00	6.70
Destin.	25	0.63	0.93	0.95	1.00	0.52	0.95	1.00	1.00	1.00	1.00	6.73

Ok Cancel

Figure 10

Ergo/IBV - Manual Materials Handling - Single - Lifting - Redesign

Task: Packaging of products
 Company: NNN NNN Date: 28/10/2022

Observations:

Population: Male Age group: 20-45 years

Variables

Duration: Moderate Extended time: Not applicable (≤3 hours)

Load mass (kg): 7.5 Frequency (lifts/min): 3.333

	Origin	Destin.
Horizontal location (cm):	30.0	40.0
Vertical location (cm):	65.0	100.0
Angle of asymmetry (°):	90.0	0.0
Coupling:	Fair	Fair

One handed operation
 Two person operation
 Three person operation
 Additional task

Index: 0,75 0,75

Recommended Mass Limit (kg)

	M ref	HM	VM	DM	AM	FM	CM	OM	PM	AT	EM	RML
Origin	25	0.83	0.97	0.95	0.71	0.77	0.95	1.00	1.00	1.00	1.00	9.94
Destin.	25	0.63	0.93	0.95	1.00	0.77	0.95	1.00	1.00	1.00	1.00	9.99

Ok Cancel

Figure 11

PULLING

This section shows how to analyse a load pulling *single* task. The analysis is started by selecting *Single MMH* in the *New task* window (Figure 1), and then choosing *Pulling* as the type of task to be analysed (Figure 2).

This accesses the main window for pulling tasks (Figure 12) in which, as well as the **identification** data for the case (task name, company, date, observations and intended population), the following **variables** have to be entered:

Ergo/IBV - Manual Materials Handling - Single - Pulling

Task: Pulling a cart

Company: NNN NNN Date: 11/01/2005

Observations:

Population: Male

Variables

Initial force (kg): 25,0 Distance (m): 20,0

Sustained force (kg): 15,0 Frequency (pulls/min): 0,500

Grip height (cm): 95,0

Calculations

Recommended initial force limit (kg): 20,06

Recommended sustained force limit (kg): 11,37 Index: 1,32

Signat Photo Video Report Redesign Ok Cancel

Add signature

Figure 12: Single MMH - Pulling – Main window

- **Initial force.** Specify, in kilograms, the force needed to put the load into movement.
- **Sustained force.** Specify, in kilograms, the force needed to maintain the load in movement along the route.
- **Distance.** Indicate, in metres, the distance the load has to travel.
- **Frequency.** Specify the number of pulls performed per minute.

- **Grip height.** Specify, in centimetres, the height of the coupling of the load.

Once these variables have been entered, clicking the *Index* button will make the software **calculate** and display in this same window the following values:

- **Recommended initial force limit.** This is the *initial force* (in kg) that is recommended not to be exceeded for the intended population. It depends on the variables mentioned before, and is obtained from table values.
- **Recommended sustained force limit.** This is the *sustained force* (in kg) that is recommended not to be exceeded for the intended population. It depends on the variables mentioned before, and is obtained from table values.
- **Index.** This represents the risk level associated with the pulling task. This *Index* is the maximum of the two following values:

(a) the quotient between the *initial force* (that really exerted by the worker) and the *recommended initial force limit* (calculated by the software)

(b) the quotient between the *sustained force* (that actually exerted by the worker) and the *recommended sustained force limit* (that calculated by the software).

To advise the evaluator as to whether it is the *initial force* or the *sustained force* that is critical when calculating the task's *Index*, the software highlights the value of the corresponding *limit* in black (Figure 12).

Using this *Index* there are three risk levels to be considered, with the same interpretation as indicated for lifting tasks:

- *Acceptable risk* ($\text{Index} \leq 1$).
- *Moderate risk* ($1 < \text{Index} < 1,6$).
- *Unacceptable risk* ($\text{Index} \geq 1,6$).

Report

By clicking the *Report* button, in the main window for pulling, one can obtain a *task report* containing the identification data, the variables entered by the evaluator, the calculations made by the software and, finally, the risk of the task together with its interpretation.

Redesign

Clicking the *Redesign* button, in the main window for pulling, one accesses a window for redesigning the task being analysed (Figure 13) by modifying the variables so as to obtain a lower risk *Index*.

The features of this window and its functioning are similar to what is indicated above for the interactive redesign of lifting tasks.

Ergo/IBV - Manual Materials Handling - Single - Pulling - Redesign

Task: Pulling a cart

Company: NNN NNN Date: 11/01/2005

Observations:

Population: Male

Variables

Initial force (kg): 25.0 Distance (m): 20.0

Sustained force (kg): 15.0 Frequency (pulls/min): 0.500

Grip height (cm): 95.0

Calculations

Recommended initial force limit (kg): 20.06

Recommended sustained force limit (kg): 11.37

Index: 1,32

Ok Cancel

Figure 13: Single MMH - Pulling – Interactive redesign

PUSHING

To analyse a *single* pushing task one proceeds in an identical manner to that explained for the previous section on pulling tasks, as they start with similar data. Only shown here is the main window for pushing tasks (Figure 14), in which the **variables** necessary for the analysis are to be entered: *Initial force, Sustained force, Distance, Frequency* of the pushes and *Grip height*.

The screenshot shows the main window of the Ergo/IBV software for a single manual materials handling (MMH) pushing task. The window is titled "Ergo/IBV - Manual Materials Handling - Single - Pushing". It features several input fields and sections:

- Task:** A text input field.
- Company:** A text input field.
- Date:** A dropdown menu showing "24/03/2017".
- Observations:** A large text area for notes.
- Population:** A dropdown menu.
- Variables:** A section containing five input fields:
 - Initial force (kg):
 - Sustained force (kg):
 - Distance (m):
 - Frequency (pushes/min):
 - Grip height (cm):
- Calculations:** A section showing two calculated values:
 - Recommended initial force limit (kg):
 - Recommended sustained force limit (kg):
 A blue "Index:" label is positioned to the right of these values.
- Buttons:** At the bottom, there are five buttons: "Video" (with a video camera icon), "Report" (with a printer icon), "Redesign" (with a notepad icon), "Ok" (with a checkmark icon), and "Cancel" (with an 'X' icon).

Figure 14: Single MMH - Pushing – Main window

In this case, the software **calculates** the *Recommended initial and sustained force limits* and the risk *Index*. Once these values are obtained, the **report** and interactive **redesign** possibilities for the task are also the same as those mentioned above for pulling tasks.

CARRYING

As indicated in the introduction to this module, carrying loads cannot be a *single task* because it is always accompanied by, at least, one lifting task. Accordingly, it will always be a *subtask* that forms part of a *multi-task*, which can comprise one or various lifting and one or various carrying subtasks.

The following section details *how to analyse a multi-task* (including its different *subtasks*). Only shown here is how to enter the **variables** in the main window for carrying (Figure 15):

The screenshot shows a software window titled "Ergo/BV - Manual Materials Handling - Multiple - Carrying". It contains the following elements:

- Subtask:** A text input field containing "From conveyor belt to shelves".
- Company:** A text input field containing "NNN NNN".
- Date:** A dropdown menu showing "28/10/2022".
- Observations:** An empty text area with a vertical scrollbar.
- Population:** A dropdown menu showing "Male".
- Variables:** A section containing four input fields:
 - Load mass (kg):** 12.0
 - Frequency (carries/min):** 3,000
 - Distance (m):** 2.2
 - Grip height:** A dropdown menu showing "Hips".
- Calculations:** A section showing "Recommended mass limit (kg): 17.83" and "Index: 0,67".
- Buttons:** "Ok" and "Cancel" buttons at the bottom right.

Figure 15: Multiple MMH - Carrying – Main window

- **Load mass.** Specify, in kilograms, the mass of the load carried.
- **Distance.** Specify, in metres, the distance over which the worker is carrying the load.
- **Frequency** Specify the number of carries performed per minute. It is important to clarify that this frequency refers to the carrying *subtask*, and should be calculated with regard to the total duration of the *multi-task's* cycle (which covers all of the subtasks it comprises). This aspect will be commented on in more detail in the following section (*how to analyse a multi-task*).

- **Grip height.** Specify the coupling height to which the load is to be carried, by selecting one of the two options from the pull-down menu (Figure 16): hip height or elbow height.

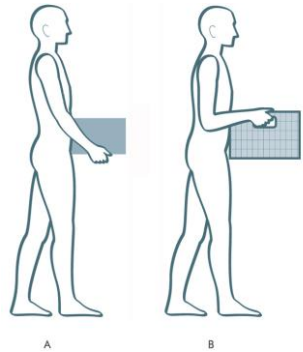


Figure 16: Carrying – Grip height:
A) hips, B) elbows

Once these variables have been entered, clicking the *Index* button will make the program **calculate** and display in this same window the following values:

- **Recommended mass limit.** This is the mass (in kg) that is recommended not to be exceeded for the intended population. It depends on the variables mentioned before, and is obtained from table values.
- **Index.** This represents the risk level associated with the carrying of the load and is obtained from the quotient between the *Load mass* (that actually handled by the worker) and the *Recommended mass limit* (that calculated by the software).

Report and Redesign

As one can see in Figure 15, the main window for carrying does not have *Report* and *Redesign* buttons. This is because carrying is always a *subtask* in a *multi-task* and, accordingly, both functions are accomplished from the *multi-task* main window, as indicated in the following section.

HOW TO ANALYSE A MULTI-TASK

By selecting the *Multiple MMH* module in the *New task* window (Figure 1), and specifying afterwards that this is a *multi-task*, one accesses the main window that allows this type of analysis to be performed (Figure 17).

Ergo/IBV - Manual Materials Handling - Multiple

Task: Shelving boxes

Company: NNN NNN Date: 28/10/2022

Observations:

Population: Male Age group: 20-45 years

Multi-task

Duration: Long Extended time: Not applicable (≤8 hours) Additional task:

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	1.06	2	0.290
Upper shelf	Lifting	1.11	1	1.110
From conveyor belt to shelves	Carrying	0.67	3	0.088

Composite Index (CI): 1.49

Buttons: New, Copy, Open, Import, Delete, Export

Bottom bar: Signat., Photo, Video, Report, Redesign, Ok, Cancel

Figure 17: Multiple MMH – Main window

In this window, as well as entering the case's **identification** data (name of the task, company, date of the analysis, observations, population, and age group considered), one has to enter the following information defining a *multi-task*:

- **Duration.** Select the task duration from the pull-down menu, with three options being available (*short*, *moderate* and *long*). The definition of this variable is similar to what was explained for lifting tasks, but one has to bear in mind that it refers here to the duration of the overall *multi-task* (that is, including all of its subtasks).

- **Additional task.** Tick this box when the worker performs another task (different to the manual materials handling *multi-task* that is being analysed) that involves significant physical demands.
- **Subtasks.** Specify, in the *multi-task* composition table, the different *subtasks* it contains. As indicated in the introduction section for this module, one can compose multi-tasks with subtasks of the same type (various lifting, various pushing tasks or various pulling subtasks) or of different type (in this case one can only combine lifting with carrying subtasks, or else pulling with pushing subtasks). For example, in Figure 17 one can see the case of a worker who is taking boxes from a conveyor belt and bringing them onto a shelf that has two levels. This task is broken down into three *subtasks*: two lifting (corresponding to the upper and lower shelves) and one carrying subtask (bringing the box from the belt to either of the shelves).

Managing the data of the subtasks table is performed using the buttons on its right, the functions of which are as follows:

- *New.* This allows the subtasks making up the *multi-task* to be entered one by one. This button leads to a window in which the type of subtask is to be selected (Figure 18). Clicking here on any of these options provides access to the main window for the subtask in question and in which the variables commented on in the preceding sections are to be entered (*lifting, carrying, pushing or pulling*).
- *Edit.* This allows the data for the subtask selected in the table to be modified.
- *Delete.* This allows the subtask selected and all the associated data to be deleted.
- *Copy.* This allows the subtask selected and all the associated data to be copied. By clicking this button the copied subtask is added at the end of the table, having the same name as the original one as default (it is identified that this is a copy); afterwards, the evaluator should select this copy, edit the appropriate modifications (including the new name for the subtask) and save them by clicking the *OK* button. The possibility of copying subtasks can be very useful when entering very similar subtasks that are differentiated in a few data.
- *Import.* This button allows a new subtask from an existing single task to be included in the work folder. The new subtask will be a copy of the single task, except the *Population, Age Group, Duration and Additional task* data, for which the *multi-task* data will be kept.

- *Export.* This command allows the selected subtask to be saved as a single task.



Figure 18: Multiple MMH – Selection of subtask type

Frequency of subtasks. It is important to highlight the way in which the *Frequency* variable is to be considered when entering this in the window corresponding to each subtask. The number of load handling per minute of each *subtask* is calculated by reference to the total time occupied by the *multi-task* cycle, which covers all of its subtasks. For example, in the aforementioned case the cycle is to consist of the following: the worker starts by taking a box from the belt, carries it to the shelf unit and leaves it on the lower shelf, he or she returns to take another box from the belt, carries it to the shelf unit and leaves it on the upper shelf, returning to the conveyor belt to take another box; the duration of this cycle is 40 seconds. As, during this time the worker performs a lifting subtask of each type and 2 carrying actions, the following frequencies are obtained: 1,5 lifts per minute (one for each of the lifting subtasks) and 3 carries per minute.

Once the data for all of the subtasks making up the *multi-task* have been entered, the following information is displayed on its main screen (Figure 17):

- **Composite Index (CI).** This is the risk Index for the *multi-task*, the value for which appears just below the subtasks table. The interpretation for the three risk zones considered according to their value is the same interpretation as that indicated for single tasks:
 - *Acceptable risk* (Index ≤ 1). Most workers should not have difficulty performing this type of tasks.
 - *Moderate risk* ($1 < \text{Index} < 1,6$). This kind of tasks should normally be redesigned in order to reduce risk. Under special circumstances (e.g., when the possible solutions to redesign the task are not sufficiently advanced from a technical point of view), these tasks can be accepted provided that particular emphasis is placed on aspects such as worker education or training (e.g., specialized knowledge about risk identification and prevention), detailed monitoring of the task working conditions, study of the worker physical abilities, and monitoring the worker health through regular medical examinations.
 - *Unacceptable risk* (Index $\geq 1,6$). The task must be modified.
- **Subtasks table.** For each of the entered subtask the software displays the following data:
 - Type.** This indicates whether it is a lifting, carrying, pushing or pulling subtask.
 - SI** (Single Index). This is the risk index for the subtask, this being considered independently.
 - Order.** The subtasks are ordered from higher to lower risk, according to their SI. Also, the whole file for the subtask with the highest risk is highlighted in red.
 - CI inc.** (Composite Index increment). This is the contribution made by each subtask to the *Composite Index* (CI). The sum of all the values for this column produces the CI.

Report

By clicking the *Report* button in the main window (Figure 17) a report on the *multi-task* is obtained containing various sections:

- **Identification.** It includes date, name of the task and 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.
- **Multi-task composition.** This shows the *duration* and *additional task* variables, together with the subtask table comprising the multi-task and its associated data (Figure 19).
- **Risk of the multi-task.** This includes the value of the Composite Index (CI) and its interpretation, associating colour codes for the different risk levels (Figure 19)
- **Subtasks detail.** Finally, a sheet with the variables, calculations and associated risk is included for each subtask.

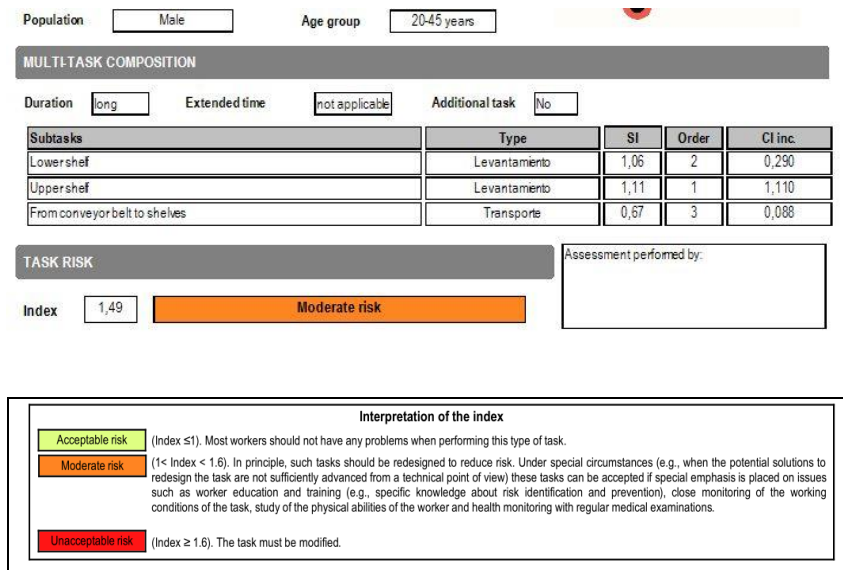


Figure 19: Multiple MMH – Report (composition and risk of the multi-task)

Redesign

Clicking the *Redesign* button in the main window for the multi-task (Figure 17) provides access to a window allowing interactive redesign (Figure 20) by modifying its variables so as to obtain a *Composite Index* (CI) with a lower risk.

Ergo/IBV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes

Company: NNN NNN Date: 28/10/2022

Population: Male Age group: 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	1,06	2	0,290
Upper shelf	Lifting	1,11	1	1,110
From conveyor belt to shelves	Carrying	0,67	3	0,088

Composite Index (CI): 1,49

Lifting

Duration: Long Extended time Not applicable (≤8 hours)

Load mass (kg): 12,0 Frequency (lifts/min): 1,500

	Origin	Destin.
Horizontal location (cm):	<input checked="" type="checkbox"/> 28,0	<input checked="" type="checkbox"/> 28,0
Vertical location (cm):	<input checked="" type="checkbox"/> 90,0	<input checked="" type="checkbox"/> 20,0
Angle of asymmetry (°):	<input checked="" type="checkbox"/> 45,0	<input type="checkbox"/> 0,0
Coupling:	<input type="checkbox"/> Good	<input type="checkbox"/> Good

One handed operation
 Two person operation
 Three person operation
 Additional task

Single Index (SI): 1,06 1,04

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

Figure 20: Multiple MMH – Interactive redesign

The upper part of this window displays the *subtasks* table that make up the multi-task, where the subtask to be redesigned is to be selected. The lower part of the window offers the variables of the subtask selected above. The logical approach is to start the redesign in the subtask with the highest SI (the table file is highlighted in red).

Relationships. As this is a multi-task, the variables for the different subtasks can be related between each other. For example, the load mass is the same in the lifting as it is for the carrying in this multi-task. For this

reason, the program displays a warning in the redesign window indicating that changing one variable in a subtask can require an appropriate change in another subtask or subtasks.

Procedure. From here on the functioning of the redesign is similar to that for single tasks:

- There are buttons for modifying the variables' values.
- The software makes *recommendations*, by showing an arrow in the variable that it is most important to modify in each moment.
- There are boxes for *disqualifying variables* (depending on the restrictions that exist in the actual task), so that these are not taken into account by the software when it comes to suggesting changes.
- As the variables are modified, all of the information on the screen is updated: the Composite Index (CI) and the values corresponding to the subtasks (SI, Order and IC inc.).
- The redesigned task is *saved* by clicking the *OK* button and assigning it a new name (so as not to lose the data for the original task).

Note: Occasionally, during the redesign process there can arise light increments of the Composite Index (CI) after a subtask is improved. This is due to the procedure used for calculating the CI. In any case, the strategy will be to continue improving the subtasks so as to improve the CI.

Example of redesign of a multi-task. Detailed step by step below is a possible redesign for the example commented on above, whose CI is 1.23 (Figure 20):

- One starts by disqualifying the boxes for the variables that cannot be modified. Assuming that in our example this corresponds to the *load mass* and the *frequency* of handling, these variables are to be disqualified by clicking the corresponding boxes, in the two lifting and in the carrying subtasks (Figure 21).
- As the subtask with the highest Single Index (SI) is that for the upper shelf (highlighted in red in Figure 20), redesign is started by selecting this subtask in the table. The recommendation that appears in this is to reduce the *duration* (Figure 21); this measure can be applied, for example, by rotating the workers.
- When a *duration* changes from long to moderate, the CI is reduced from 1.49 to 1.06 and a new recommendation is shown: reduce the *vertical position at destination* (Figure 22).

- If this variable is reduced from 150 to 140 cm, the CI is reduced down to 1.02 and the subtask of the lower shelf—highlighted in red—becomes the subtask with the highest SI (Figure 23).
- Selecting this subtask shows the recommendation to reduce the *angle of asymmetry at the origin* (Figure 24).
- When this variable is reduced from 45 to 35° in both liftings (assuming that in this example it is a related variable), the CI is reduced down to 1.01 and the software recommends that the *vertical position at destination* should be increased (Figure 25).
- When this variable is increased from 20 to 25 cm, the CI is still 1.01 and the subtask of the upper shelf—highlighted in red— is again worse (Figure 26).
- Selecting this subtask shows the recommendation to reduce the *vertical position at destination* (Figure 27).
- Finally, reducing this variable down to 135 cm reduces the CI down to 0.99, which means an acceptable risk (Figure 28).

Ergo/BV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes

Company: NNN NNN Date: 28/10/2022

Population: Male Age group 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	1,06	2	0,290
Upper shelf	Lifting	1,11	1	1,110
From conveyor belt to shelves	Carrying	0,67	3	0,088

Composite Index (CI): 1,49

Lifting

Duration: Long Extended time: Not applicable (≤8 hours)

Load mass (kg): 12.0 Frequency (lifts/min): 1.500

	Origin	Destin.
Horizontal location (cm):	28.0	28.0
Vertical location (cm):	90.0	150.0
Angle of asymmetry (°):	45.0	0.0

Coupling: Good Good

One handed operation

Two person operation

Three person operation

Additional task

Single Index (SI): 1,05 1,11

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

Ok Cancel

Figure 21

Ergo/BV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes

Company: NNN NNN Date: 28/10/2022

Population: Male Age group 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	0,86	2	0,077
Upper shelf	Lifting	0,90	1	0,900
From conveyor belt to shelves	Carrying	0,67	3	0,088

Composite Index (CI): 1,06

Lifting

Duration: Moderate Extended time: Not applicable (≤8 hours)

Load mass (kg): 12.0 Frequency (lifts/min): 1.500

	Origin	Destin.
Horizontal location (cm):	28.0	28.0
Vertical location (cm):	90.0	150.0
Angle of asymmetry (°):	45.0	0.0

Coupling: Good Good

One handed operation

Two person operation

Three person operation

Additional task

Single Index (SI): 0,85 0,90

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

Ok Cancel

Figure 22

Ergo/IBV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes

Company: NNN NNN Date: 28/10/2022

Population: Male Age group: 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	0,86	1	0,860
Upper shelf	Lifting	0,85	2	0,076
From conveyor belt to shelves	Carrying	0,67	3	0,088

Composite Index (CI): 1,02

Lifting

Duration: Moderate Extended time: Not applicable (≤8 hours)

Load mass (kg): Frequency (lifts/min): 1,500

	Origin	Destin.
Horizontal location (cm):	<input checked="" type="checkbox"/> 28,0	<input checked="" type="checkbox"/> 28,0
Vertical location (cm):	<input checked="" type="checkbox"/> 90,0	<input checked="" type="checkbox"/> 140,0
Angle of asymmetry (°):	<input checked="" type="checkbox"/> 45,0	<input type="checkbox"/> 0,0

Coupling: Good Good

One handed operation
Two person operation
Three person operation
Additional task

Single Index (SI): 0,84 0,85

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

OK Cancel

Figure 23

Ergo/IBV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes

Company: NNN NNN Date: 28/10/2022

Population: Male Age group: 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	0,86	1	0,860
Upper shelf	Lifting	0,85	2	0,076
From conveyor belt to shelves	Carrying	0,67	3	0,088

Composite Index (CI): 1,02

Lifting

Duration: Moderate Extended time: Not applicable (≤8 hours)

Load mass (kg): Frequency (lifts/min): 1,500

	Origin	Destin.
Horizontal location (cm):	<input checked="" type="checkbox"/> 28,0	<input checked="" type="checkbox"/> 28,0
Vertical location (cm):	<input checked="" type="checkbox"/> 90,0	<input checked="" type="checkbox"/> 20,0
Angle of asymmetry (°):	<input checked="" type="checkbox"/> 45,0	<input type="checkbox"/> 0,0

Coupling: Good Good

One handed operation
Two person operation
Three person operation
Additional task

Single Index (SI): 0,86 0,85

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

OK Cancel

Figure 24

Ergo/BV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes

Company: NNN NNN Date: 28/10/2022

Population: Male Age group: 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	0.85	1	0.850
Upper shelf	Lifting	0.85	2	0.076
From conveyor belt to shelves	Carrying	0.67	3	0.088

Composite Index (CI): 1,01

Lifting

Duration: Moderate Extended time: Not applicable (≤8 hours)

Load mass (kg): 12,0 Frequency (lifts/min): 1,500

	Origin	Destin.
Horizontal location (cm):	28,0	28,0
Vertical location (cm):	90,0	20,0
Angle of asymmetry (°):	35,0	0,0
Coupling:	Good	Good

One handed operation

Two person operation

Three person operation

Additional task

Single Index (SI): 0,83 0,85

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

Ok Cancel

Figure 25

Ergo/BV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes

Company: NNN NNN Date: 28/10/2022

Population: Male Age group: 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	0.83	2	0.073
Upper shelf	Lifting	0.85	1	0.850
From conveyor belt to shelves	Carrying	0.67	3	0.088

Composite Index (CI): 1,01

Lifting

Duration: Moderate Extended time: Not applicable (≤8 hours)

Load mass (kg): 12,0 Frequency (lifts/min): 1,500

	Origin	Destin.
Horizontal location (cm):	28,0	28,0
Vertical location (cm):	90,0	25,0
Angle of asymmetry (°):	35,0	0,0
Coupling:	Good	Good

One handed operation

Two person operation

Three person operation

Additional task

Single Index (SI): 0,83 0,83

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

Ok Cancel

Figure 26

Ergo/IBV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes
 Company: NNN NNN
 Date: 28/10/2022
 Population: Male Age group: 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	0.83	1	0.830
Upper shelf	Lifting	0.83	2	0.074
From conveyor belt to shelves	Carrying	0.67	3	0.088

Composite Index (CI): 0,99

Lifting

Duration: Moderate Extended time: Not applicable (≤8 hours)
 Load mass (kg): 12.0 Frequency (lifts/min): 1.500

Origin		Destin.	
Horizontal location (cm):	<input checked="" type="checkbox"/> 28.0	<input checked="" type="checkbox"/> 28.0	<input type="checkbox"/>
Vertical location (cm):	<input checked="" type="checkbox"/> 90.0	<input checked="" type="checkbox"/> 135.0	<input type="checkbox"/>
Angle of asymmetry (°):	<input checked="" type="checkbox"/> 45.0	<input type="checkbox"/> 0.0	<input type="checkbox"/>

Coupling: Good Good

Single Index (SI): 0,83 0,83

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

Ok Cancel

Figure 27

Ergo/IBV - Manual Materials Handling - Multiple - Redesign

Task: Shelving boxes
 Company: NNN NNN
 Date: 28/10/2022
 Population: Male Age group: 20-45 years

Multi-task

Subtasks	Type	SI	Order	CI
Lower shelf	Lifting	0.83	1	0.830
Upper shelf	Lifting	0.83	2	0.073
From conveyor belt to shelves	Carrying	0.67	3	0.088

Composite Index (CI): 0,99

Lifting

Duration: Moderate Extended time: Not applicable (≤8 hours)
 Load mass (kg): 12.0 Frequency (lifts/min): 1.500

Origin		Destin.	
Horizontal location (cm):	<input checked="" type="checkbox"/> 28.0	<input checked="" type="checkbox"/> 28.0	<input type="checkbox"/>
Vertical location (cm):	<input checked="" type="checkbox"/> 90.0	<input checked="" type="checkbox"/> 135.0	<input type="checkbox"/>
Angle of asymmetry (°):	<input checked="" type="checkbox"/> 55.0	<input type="checkbox"/> 0.0	<input type="checkbox"/>

Coupling: Good Good

Single Index (SI): 0,80 0,83

WARNING: One variable can be related to some other variable/s from other subtask/s; if you modify it, you also have to make the suitable changes in other subtask/s.

Ok Cancel

Figure 28