14. MODULE EN 1005-3 [FORCES]

INTRODUCTION

Scope of application. Module EN 1005-3 [FORCES] allows you to analyze tasks in which the worker exerts forces associated with the use of controls, pedals or with pushing/pulling objects in a standing posture without the help of wheels, guides, rollers, etc., which may require muscular efforts and therefore cause fatigue, discomfort and even musculoskeletal disorders.

Contents. This module requires selecting those subtasks performed by the worker which involve applying force. The reduced capacity (FBr) must be obtained for each selected subtask by determining the type of activity, the movement speed and the frequency (actions per minute and duration of each action). The risk index (FR) of each subtask analyzed is obtained by comparing the force that is really exerted (F0) – measured with a dynamometer – and the reduced capacity (FBr). The Risk Index (FR) represents the risk of musculoskeletal injury in the subtask analyzed.

Source. The module is based on the EN 1005-3 standard (2009), related to the recommended force limits for machinery operation.

DATA

The analysis is started by selecting the module EN 1005-3 [FORCES] in the *New Task* window (Figure 1).

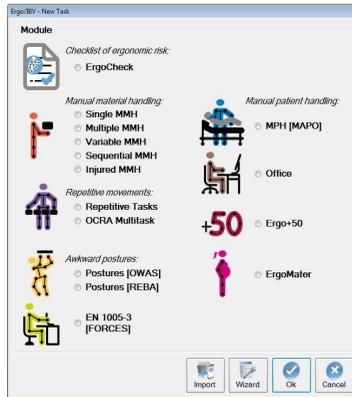This opens the main window of the module (Figure 2), which shows the following:

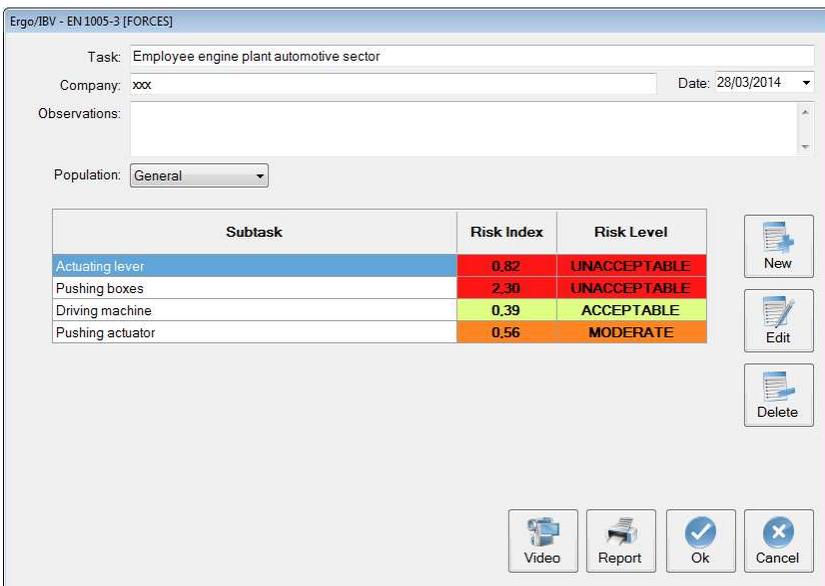Figure 1: Access to the module EN 1005-3 [FORCES]

Figure 2: EN 1005-3 [FORCES] – Main window

- **Identification**. The name of the task and the company, the analysis date and the observations of the evaluator are recorded.

- **Population**: considered:

  o *General*, the values of the maximum isometric force (F_B), have been calculated to ensure the protection of 85% of the population.

  o More protection, the values of the maximum isometric force (F_B), have been calculated to ensure the protection of 95% of the population.

Subtasks. Each subtask to be analyzed is defined. For example, Figure 2 shows the task of an engine plant worker that includes the subtasks of operating a lever, pushing boxes, actuating a machine and pushing an actuator. The name of each subtask is introduced by pressing the *New* button. The *Delete* button allows you to delete the selected subtask from the list (asking for confirmation first). The name of a subtask can be changed by directly writing in the corresponding cell. With the *Edit* button you can access the data screen of each subtask.

How the information associated with each subtask is introduced is described below.

Subtask data

The *Subtask data* window, which is accessed with the *Edit* button, is automatically headed by the name of the subtask. In addition, you can record observations about the subtask in the header of this window, where the clarifications on the subtask that are considered to be important can be specified (Figure 3):
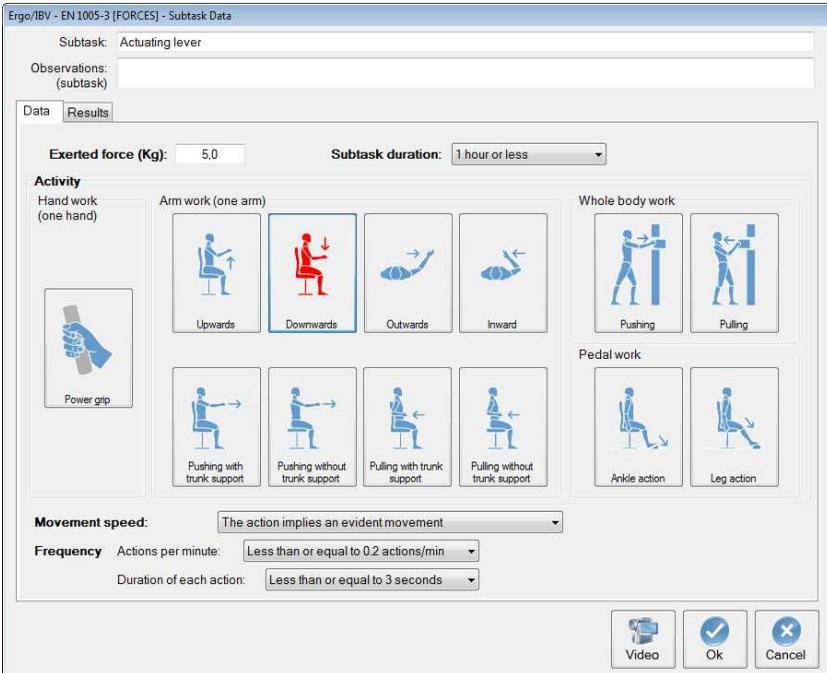
Figure 3: EN 1005-3 [FORCES] – Subtask data

The necessary data for the analysis of the subtask are collected in this *Data* window, as indicated below.

Data (Figure 3).

- **Exerted force (Kg)**: specify the force (measured with a dynamometer) that the worker is really applying.
- **Subtask duration**: select the relevant option from the drop-down menu.

    - o 1 hour or less
    - o Between 1-2 hours
    - o Between 2 and 8 hours

- **Activity**: Select one of the buttons to specify the type of activity involved in the subtask under analysis:

    - o Working with the hand

- - Grabbing with the whole hand
  - o Working with the arm
    - - Upwards
    - - Downwards
    - - Outwards
    - - Inwards
    - - Pushing with supported trunk
    - - Pushing with unsupported trunk
    - - Pulling with supported trunk
    - - Pulling with unsupported trunk
  - o Working with the whole body
    - - Pushing
    - - Pulling
  - o Working with the foot
    - - Action of the ankle
    - - Action of the leg

- **Movement speed**. Select the relevant option from the drop-down menu:
  - o The action involves immobility or very slow movement
  - o The action involves noticeable movement

- **Frequency**. Select the relevant options:
  - o Actions per minute
    - - Less than or equal to 0.2 actions/min
    - - Between 0.2-2 actions/min
    - - Between 2-20 actions/min
    - - More than 20 actions/min
  - o Duration of each action
    - - Less than or equal to 3 seconds
    - - More than 3 seconds

Results (Figure 4). Once all the data have been entered in the previous screen, the assessment results are shown in the *Results* tab. This screen shows the calculations for the codings specified in the data screen. To do this, the program assigns the corresponding score according to the tables included in the UNE-EN standard 1005-3, and obtains the risk index (FR) and the risk level of each subtask analyzed by comparing the reduced capacity (FBr) with the force actually exerted by the worker (F0).

The reduced capacity (FBr) is obtained by the following equation:

$F_{Br}= F_B$ x mv x mf x md

where:

- **F_{Br}**: it is the reduced capacity, which shows the maximum effort limit to be applied.
- **F_B**: it is the maximum isometric force, obtained according to the type of activity and the reference population.
- **mv**: it is the velocity multiplier, which is associated with the speed at which the subtask being analyzed is performed. Rapid contraction movements reduce the ability to generate force.
- **mf**: it is the frequency multiplier, associated with the duration and frequency of the actions. The actions which are frequently repeated cause fatigue and thus reduce the ability to generate force.
- **md**: it is the duration multiplier; it is associated with the cumulative duration of similar actions.

Figure 4: EN 1005-3 [FORCES] – Results

The risk index (FR) is obtained from the ratio between the force exerted (F0) and the reduced capacity (F$_{Br}$).

Depending on the **risk index (FR)** obtained, three potential **risk levels** are considered which, in turn, entail a determined **interpretation or assessment** that indicates the urgency of the ergonomic intervention (need to carry out actions in order to reduce the risk), as shown in the table below.

Risk Index	Risk Level	Interpretation
index≤ 0.5	Acceptable	Negligible risk of disorder or injury. No need for intervention.
0.5<index≤0.7	Moderate	Risk that cannot be ignored. It must be analyzed more rigorously by considering additional risk factors[1]
Index >0.7	Unacceptable	Obvious risk of disorder or injury. Measures must be taken to reduce it.

Both the risk index and the risk level have associated color codes in order to make it easier to interpret them. Once calculated, these results are also shown in the main window of the module next to the name of the subtask (Figure 2).

[1] Additional risk factors

Working posture	While using the machine, the user should be able to change posture easily and frequently. The joints should not adopt extreme positions.
Movement precision and acceleration	The actions that require high accelerations involve great efforts and therefore the risk of injury increases.

Movements requiring precision must be performed slowly. |
Vibration	The machine should not transmit any vibration to the worker.
Man-machine interaction	The worker should have full control over the pace of work, and be able to activate/deactivate the machine at any time.
PPEs	Work clothes and/or the use of PPEs may restrict the movements of the worker. This factor should be considered in the design of the machine (sufficient space and decreased strength must be taken into account).
Work environment	Predictable environmental conditions (extreme temperatures, high humidity, etc.) as well as lighting conditions during machine operation.

REPORT

By pressing the *Report* button at the bottom of the main window, you can access the requested report, which includes the following:

- **Identification**. It includes general information about both the case (location where it is saved, date of analysis, name of the task, company and observations of the evaluator) and the population on which the assessment has been carried out (general or more protection). You can also include an image of the task if you have configured a video source.

Figure 5: EN 1005-3 [FORCES] – Report-Identification

- **Risk of the subtasks** (Figure 6). This section summarizes the results obtained for all the subtasks analyzed. The name and the results obtained for both the risk assessment and the risk level – with their color codes – are displayed for each subtask analyzed. At the end of this section, the interpretation table for the risk assessment is included (with three potential levels of risk and the corresponding interpretation).

SUBTASK RISK

Subtask	Risk Index	Risk Level
Actuating lever	0,82	UNACCEPTABLE
Pushing boxes	2,30	UNACCEPTABLE
Driving machine	0,39	ACCEPTABLE
Pushing actuator	0,56	MODERATE

Interpretation of the index

Acceptable risk	(Index < = 0.5). Negligible disorder or injury risk. No need to take action.
Moderate risk	(0.5 < Index ≤ 0.7). The risk cannot be ignored. A more rigorous analysis which considers additional risk factors is necessary.
Unacceptable risk	(Index > 0.7). Obvious disorder or injury risk. Action must be taken to reduce it.

Evaluator (name and signature)

Figure 6: EN 1005-3 [FORCES] – Report – Risk of the subtasks

- **Detail of the subtask** (Figure 7). Each subtask is headed by its name and observations. A section with the data used to perform the task analysis (force, duration, activity, velocity and frequency) is displayed below. The results of the assessment are shown at the bottom, which include all the calculations of the items recorded in the coding of the subtask as well as both the risk index and the risk level of that subtask.

Figure 7: EN 1005-3 [FORCES] – Report-Detail of the subtask