

# User Safety Performance Evaluation from Complex Systems Design Phases: Application to Arduous Working Condition

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# About Presenter



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Field of interest:

Evaluation of Solution Concepts in Inventive Design, Industrial Engineering, TRIZ Theory of Inventive Problem Solving

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## Objective

Companies focus to improve the safety performance of their artefacts during designing machines and installing manufacturing systems

Our objective is to propose a method to formulate and evaluate ergonomic information (particularly those related to arduous working conditions) and to use them in design process.

## State of the Art

- Design from a technical point of view [3][4] is no longer sufficient to design an efficient system [5][6].
- In this sense, the concept of integrated prevention has been defined and presented in numerous articles [7]-[13].
- In these works authors proposed framework to consider standard data about user safety and some parameters of hazardous situation , however missing Arduous Working Conditions.

# Labor Code and Components of Arduous Working Conditions

- Since 2016 in France the labor law LA121-3-1, related to Arduous Working Conditions , entered into force with identification of major 10 risk factors .

## Labor Code and Components of Arduous Working Conditions...

- 10 risk factors are provided for by the Labor Code:L4121-3-1

### Marked physical constraints

- Manual handling of loads
- Awkward postures defined as forced positions of the joints
- Mechanical vibrations

### Aggressive physical environment

- Activities carried out in hyperbaric environment (high pressure)
- Hazardous chemical agents, including dust and fumes
- Extreme temperatures
- Noise

### Rhythms of work

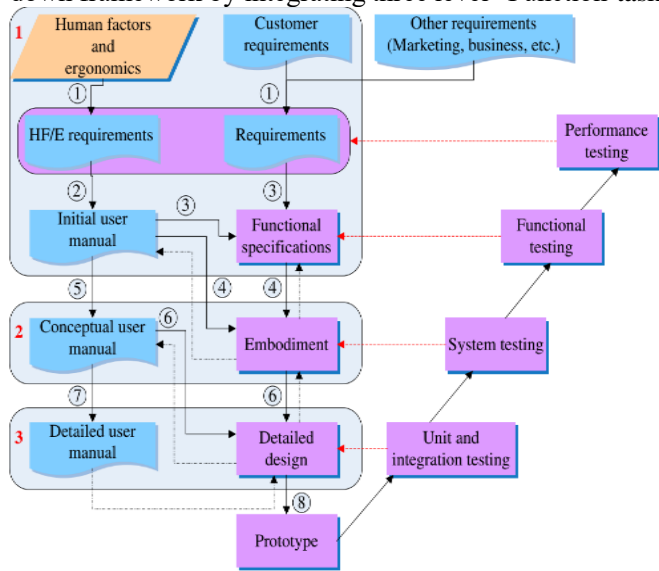
- Night work under certain conditions
- Work in successive alternating teams (shift work in 3 x 8, 2 x 12...)
- Repetitive work

## Methodology Proposed in Literature

- Top-down framework by integrating three level “Function-task-behavior” propose by Sun.
- There is no specific focus on how these requirements could be identified, set out and evaluated to know if they are integrable in design processes.



# The Sun top-down framework by integrating three level “Function-task-behavior”



## Criteria Considered in Our Method

- We considered how to identify, through this field study, the data, parameters, factors, etc. necessary to take into account the arduous working conditions from the design phase.
- Meet the legal obligation, according to the article L4121-3-1 of the French Labor Art (Code).
- Preserving the health and safety of workers.
- Contribute to improve the performance of the system.
- Improve and strengthen social relations.

# Findings from the Company

In comparison with the arduous working condition factors, the following risks are selected. In the partner company only, the following factors were identified. The other factors do not exist in this business. For example, there is only one work shift and no night shift.

	Significant Risks
<b>Raw Material Flow</b>	Thermal environment
	Noise
	Energy
	Fire explosions
	Contact with other users
	Awkward postures
	Driving equipment
	Mechanical Vibration
	Manual handling
<b>Milling Workshop</b>	Noise
	Awkward postures
	Manual handling
	Working Organization
	External intervention
	Mechanical vibrations
	Hazardous chemical material



	Significant Risks
<b>Raw Material Flow</b>	Noise
	Awkward postures
	Mechanical Vibration
	Manual handling
<b>Milling Workshop</b>	Noise
	Awkward postures
	Manual handling
	Mechanical vibrations
	Hazardous chemical Product

# Evaluation of arduous working conditions factor during raw material flow

The following arduous working condition factors are evaluated.

Noise

Awkward postures

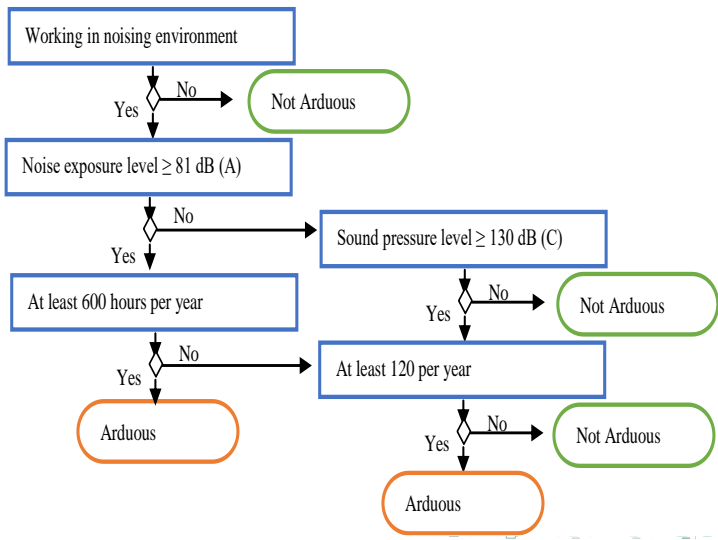
Mechanical Vibration

Manual handling

Hazardous chemical agents

# Noise Evaluation Step

1



# Awkward postures Evaluation



Presence when pushing material onto the conveyor  
We measured the different positions

Bending of Torso		
<p>+1</p>	<p>+2</p>	2
Twist of Torso		
<p>+1</p>	<p>+2</p>	1

# Mechanical vibration Evaluation



The overall duration of use of some machines does not exceed the thresholds per person exposed because several operators use it.

## Manual Handling Evaluation



The operator has to push the long rods of material onto the forklift which is not very suitable because a lot of effort is needed to move the materials.

For pushing the material onto the conveyor, this is very difficult due to the poor condition of the conveyor



## Hazardous chemical agents



The assessment is based on the ND 2233 method and is a common language for doctors, CARSAT, and the labor inspectorate.

## Discussion

- Our industrial partner is a constructor of paper machines.
- We did our analysis for them at a workshop of one of their clients.
- Their objective was to optimize the performance of their artefact in improving not only the user safety by reducing the dangerous conditions and dangerous zones in very short term (operating term) ,but also, by considering the very long-term dangerous factors, like those of arduous working conditions.
- Our work helped them evaluate these factors for the next generation of machines.

# Conclusion

- Finding literature gap regarding method concerning the arduous working conditions .
- We identified and evaluated some arduous working conditions factors in existing systems.
- Then, we proposed to the designer to integrate them in our partner company design process and refine his/her decisions and choices.
- We found that considering the materials used and the organisation of work in the design is possible and makes compliance with standards easier.

## Future Perspective

- In future work, will propose an evaluation of the identified relevant parameters. Also, other areas will be analyzed in other contexts of use to propose a global and more complete approach in order to provide designers with a method considering all field data related to use conditions, but also propose a method to integrate the identified parameters into the design process.

# Thank You

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