

A ERGONOMICALLY RESEARCH FOR FORKLIFT

Stoyna ELKINA, Nikolay KAZAKOV, George CHERVENDINEV

Technical University of Sofia, Bulgaria

Abstract. This paper provides analytical research and overviews the forklifting in fulfilling loading tasks for different time load during logistics machine maintenance. The point is to show to collect, process and analyze the results of the questionnaire made. Summary information and analyze results will allow to refine the operating conditions of the forklift drivers to provide a basis for new ergonomic requirements and to monitor the working environment again after the introduction of changes.

Keywords: logistics, ergonomic, analyze, questionnaire, loading, forklift, logistics equipment, ergonomic parameters, tiredness

1. Introduction

Material handling equipment depending on the work specifics and its purpose operation is divided to: forklifts and propane forklifts, electro-forklifts, tractors, warehouse equipment, explosion-proof machines and richstakers and equipment auxiliary devices. Each kind has different purpose and technical data. The present paper will explore forklifts and propane forklifts and their influence to the forklift drivers. Each person is unique of his nature and everybody has different needs while performing his duties during forklift driving.

There are different researches made in the forklift area. A questionnaire investigation [1] shows the need of prognosis system of forklifts parameters made in Bulgaria.

2. Basics

The forklift is generally lifting machine driven by an internal combustion engine (ICE). The engines are diesel and propane. In the near past gasoline engines were also used. According to their purpose operating forklifts are towers, high and low forklifts. Rough terrain forklifts are also manufactured. The forklift task is to supply an internal factory transport (IFT), as their main advantage towards other IFT means is easy handling and independence [2]. The diesel forklifts are usually used outdoors, and the propane forklifts are also working indoors – warehouses and halls. Factory trucks usually have a lifting capacity of 1 to 5 tons and lifting height load from 2000 to 6400 mm. Machines for processing containers can reach a capacity of 32 tons and more.

Trucks are a major group of trackless logistics

equipment, which are self-propelled, high universality, relatively low cost and high efficiency. In Bulgaria there are currently 29 companies operating in the field of forklifts [8].

It is known [3] that the forklift drivers' workload during internal factory transport varies depending on the production specifics activity of each plant.

Environment has different impact on forklift drivers. On the other hand the values of ergonomic parameters significantly affect the quality of the logistics system and on the cost of operations [4]. The purpose of this work is to show the research by interviewing and analyzing the forklift drivers when carrying out tasks for different time load operation of logistic machine.

For this purpose, the research was done by arranging meetings and interviews with forklift drivers, meeting the criteria set out in this article, using previously developed questionnaires. Time survey-October-December 2014. The questioned forklift drivers are working in a poultry company and poultry slaughterhouse. The produces farms are situated in Bulgaria – Stara Zagora, Chirpan, Haskovo and Rousse. Each worker has a special driving license for traffic, construction and agricultural machines.

The forklift drivers above production units were completed questionnaires.

3. Questionnaire

The questionnaire was developed following the basic needs and requirements of forklift drivers during the working day and includes several sections of the issues with the main objective body

adaptation and loading and forklift driver's reactions at work in the presence of noise and vibration. The questionnaire includes worker's data - age, sex, length of service of work (months and years) and production base location. The questionnaire is based on the principles [5, 6, 7].

Questionnaire ensures that the forklifts drivers' needs and requirements will be analyzed, as they will directly express their views and participate in

the further improvement of the working environment and operation of forklifts. Completing the questionnaire retain confidentiality of their individual replies. A consumers study (forklift drivers) is an excellent tool to improve the logistics equipment quality and ergonomics.

The questionnaire provided for completion by forklift drivers is as follows.

Section 1 – Body adaptation

No.	Description	Parameter	2h	4h	6h	8h	12h
1	Organism adaptation	Memory					
		Ability to think					
		Reflexes					
		Work for contingencies					
		Tiredness of eyes in natural light					
		Tiredness of eyes in artificial light					

Section 2 – Organism stress

2	Organism stress	Posture					
		Monotony					
		Stress intention					
		Body exercise (hands, legs, body)					
		Mental stress (nervous system)					

Section 3 - Forklift driver's reactions under noise and vibration

3	Forklift driver's reactions under noise and vibration	Conversation					
		Whisper					
		Hubbub					
		Silence					
		Road noise					
		Pinger					
		Motor vibration					
		Cabin vibration					

Section 4 – Basic data worker position “forklift driver”

Age

Gender

Work experience in the workplace (months and years):

Section 5 – Assessment Guidance about forklift driver's stress

Rating	Level rating	Assessment Guidance forklift about forklift driver's stress
0	Neutral	Lack of adequate monitoring and indicator experience does not give you the opportunity to make an objective assessment
2	Low	Low stress. Not obvious effects or predictable results. Minimal risk of accidents
3	Medium (normal)	Body response. Early stress stage, delayed reactions and body tiredness. Medium risk
4	High	High stress. High risk tending to more high risk. Premises availability of accidents. Required regulated break
5	Very high	Visible tiredness of the worker tending to the utmost abilities. Created dangerous situation at the workplace. Very high risk. Several prolonged breaks

4. Research results

Research results are summarized at the table, as

follow.

QUESTION	FREQUENCY				
	2h	4h	6h	8h	12h
Section 1 – Body adaptation					
Memory	2.00	2.04	3.07	3.80	3.60
Ability to think	2.00	2.33	2.80	3.27	3.33
Reflexes	2.00	2.60	3.20	3.87	4.07
Work for contingencies	2.20	2.60	3.13	3.73	4.20
Tiredness of eyes in natural light	2.00	2.47	2.67	3.40	3.87
Tiredness of eyes in artificial light	2.00	2.80	3.20	3.73	3.67
Section 2 – Organism stress					
Posture	1.87	2.47	2.87	3.60	3.20
Monotony	2.20	2.80	3.00	3.60	4.00
Stress intention	2.00	2.47	2.87	3.47	3.53
Body exercise (hands, legs, body)	1.87	2.47	3.13	3.80	3.47
Mental stress (nervous system)	2.00	2.60	3.20	3.64	3.60
Section 3 – Forklift driver’s reactions under noise and vibration					
Conversation	1.87	2.33	2.53	2.93	2.53
Whisper	1.87	2.33	2.87	3.20	3.07
Hubbub	2.20	2.67	2.93	3.60	3.87
Silence	2.00	2.47	2.73	3.00	3.20
Road noise	2.00	2.73	3.27	3.73	3.87
Pinger	2.00	2.60	3.13	3.67	4.00
Motor vibration	2.07	2.67	3.26	4.00	3.73
Cabin vibration	2.07	2.67	3.13	4.00	3.80

The alternation dynamics, defined by the relative parameter “growth rate” is also of interest (table 2).

QUESTION	GROWTH RATE $\delta_{i,i+1} = \frac{q_{i+1}}{q_i} \cdot 100\%$				
	2h	4h	6h	8h	12h
Section 1 – Body adaptation					
Memory		102	150	123	95
Ability to think		117	120	117	101
Reflexes		130	123	121	105
Work for contingencies		118	260	119	112
Tiredness of eyes in natural light		124	108	127	114
Tiredness of eyes in artificial light		140	114	117	98
Section 2 – Organism stress					
Posture		132	116	125	89
Monotony		127	107	120	111
Stress intention		116	2,87	121	101
Body exercise (hands, legs, body)		132	127	121	91
Mental stress (nervous system)		130	123	114	99
Section 3 – Forklift driver’s reactions under noise and vibration					
\		125	109	116	86
Whisper		125	123	115	96
Hubbub		121	110	123	108
Silence		124	111	110	107
Road noise		137	120	114	104
Pinger		130	120	117	110
Motor vibration		129	122	123	93
Cabin vibration		129	117	128	95

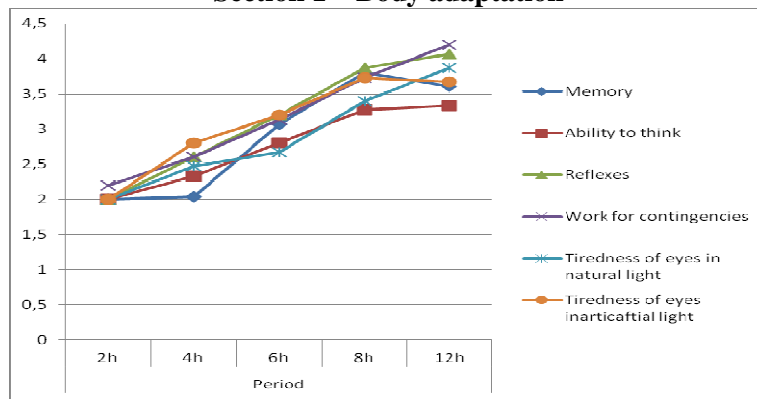
Section 4 – Basic data worker position “forklift driver”

Average of the inquired participants: 43 years and 3 months

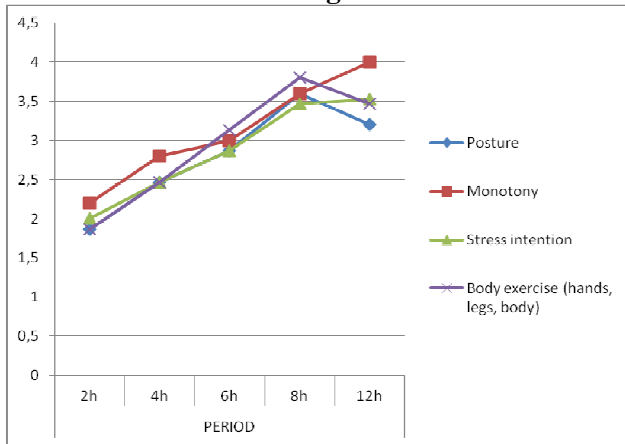
Sex: male

Work experience in the workplace (Average of the inquired participants; months and years): 11 years and 6 months

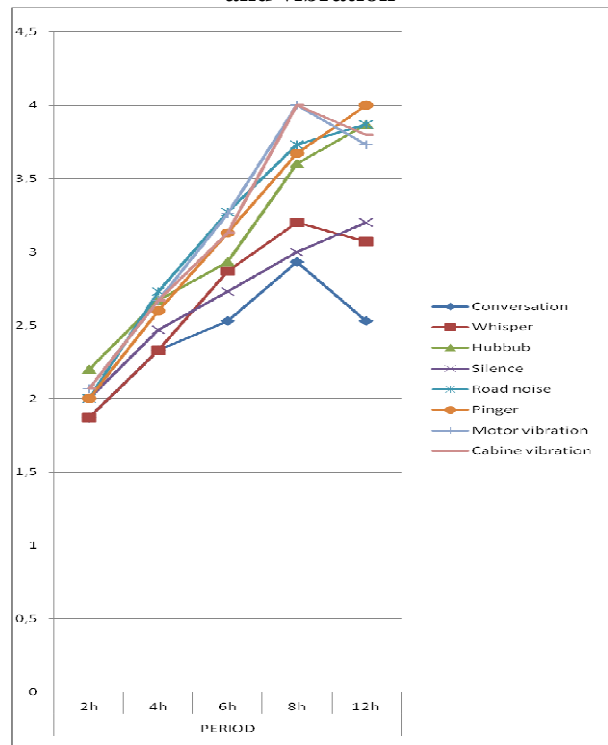
Section 1 – Body adaptation



Section 2 – Organism stress

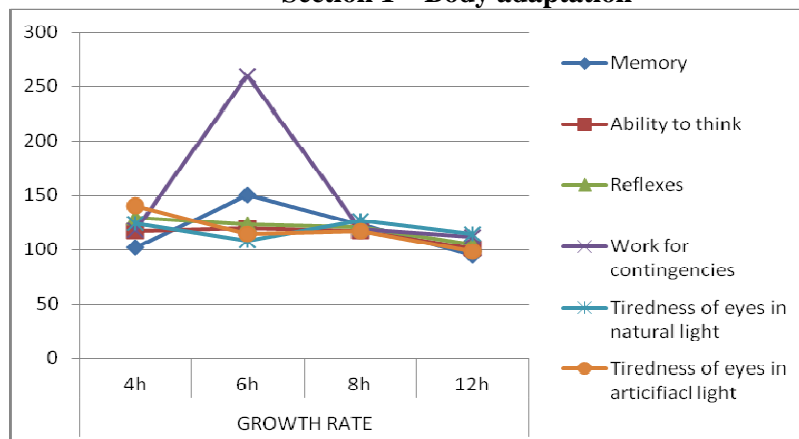


Section 3 – Forklift driver’s reactions under noise and vibration

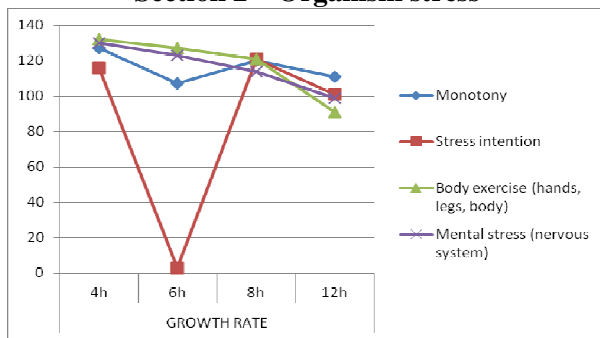


Parameter growth rate (Table 2)

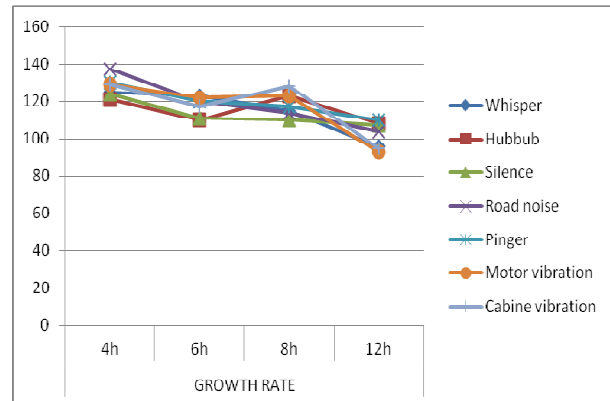
Section 1 – Body adaptation



Section 2 – Organism stress



Section 3 – Forklift driver’s reactions under noise and vibration



5. Analysis of the results

By summarizing the results can be made the following conclusions. Some of them are completely statistical and other really interesting. The age range of interviewee forklift drivers is from 29 years to 60 years including. The questionnaire is filled in only by men. There are no women and people entitled to work after retirement.

It should be noticed that the forklift drivers have different workplaces - production buildings and working conditions. Some of them are working in a warehouse - the entrance area is open and there are only sheds (forklifts). Other forklift drivers are working at the output area - in a completely closed environment without access to external weather conditions and high level of cleanliness and sterility (electro-forklift drivers). Other forklift drivers are working in production halls, some in halls "without walls" directly exposed to weather conditions. The calculations and analysis are used rounded to two decimal places and in a period. Allowed 1% operator error in data entry and processing.

The answers are in ascending order of loading; viz. longer duration of work load is higher.

5.1. Section 1 - Body adaptation

- Data analysis is based on pre-set parameters - memory, ability to think, reflexes, work for contingencies, tiredness of eyes in natural and artificial light.
- The age and working experience affect to the forklift driver's physical condition.
- In the first hours (2h) from the start of the work shift all forklift drivers regardless of workplace and the nature of work are less exhausted. The explored parameters were normal.
- Specifically is the workers’ ratio working for contingencies. Experienced staff and experts reported body response and average tiredness.

Risk assessment is medium.

- First body stress signs appear at 4h of work shift. +50% of forklift drivers did not register a change in state at the explored parameters, but others have a sense of reactions of the organism tiredness.
- The tiredness data after 6h are heterogeneous. The range is from low to high tiredness. The ability to think and the memory overlap as reactions from vehicle drivers. Higher percent tiredness is registered with reflexes and work for contingencies. Forklift drivers’ tiredness grew sequentially in ascending order.
- Special attention is given to the easy reactions once at work in daylight and once at work in artificial light. The light has a huge impact on workers nevertheless the nature of their work and position. In dark days, the brightness in the room is not enough and it is required additional lighting from an artificial source. Harmful to the eyes would be efforts to perform visual work in low light.
- For the daily work of a person in a closed room even during the day is often necessary to add a local lighting. Light sources in the workplace should be suitably located, so not to cause glare. This effect is undesirable because it reduces the quality of the perceived image and may cause headache, fatigue, and overexertion. The eyes tiredness at artificial light is higher than the eyes tiredness in natural light. As an exception it is shown, that the experienced forklift drivers working continuously at artificial light, does not affect their ability to work and the tiredness is low.
- Working more than 8 hours with regulated breaks is not recommended. In practice, however, there are registered cases in which is applied unauthorized work shift and workers tiredness up

to 12 hour shifts.

- Workers with big work experience, don't allow 12 hour work shift and not considered employable in working conditions.
- The younger and less experienced forklift drivers get tired less in comparison with the more experienced and older colleagues.
- Forklift drivers responses in the questionnaire for parameter "memory tiredness" at 8h and 12h variety from high to very high. As an exception to the general mass, some respondents indicated low body tiredness for parameters memory and ability to think. And one of them even considered unfit in 12h. Body reflexes and work for contingencies are assessed as very demanding. The majority of the forklift drivers believe, that they should have several regulated breaks and have visible fatigue tiredness. As an exception is indicated, disability to work in 12h work shift. There are no prerequisites for accidents. It is required mandatory regulated break.

5.2. Section 2 – Organism stress

- Data analysis is based on pre-set parameters – posture, monotony, stress intention, body exercise (hands, legs, body) and mental stress (nervous system).
 - The age and work experience affect to the forklift driver's physical condition.
 - In the first hours (2h) from the start of the work shift all forklift drivers regardless of workplace and the nature of work are less exhausted. The explored parameters were normal.
- An exception for parameter "posture" is a forklift driver that assessed the behavior of the body as neutral in posture and body exercise (hands, legs and body). He doesn't have enough surveillance and experience for that indicator. His assessment at parameter "monotony" is in the other exorbitance – very high tiredness regardless of the work shift length. Visible tiredness of the worker tending to the utmost abilities. Created dangerous situation at the workplace. (1).
- First signs of body stress appears at 4h work shift. Workers estimated organism stress at 4h as low and normal. First signs of delayed effects and risk assessment are medium. The case described in (1) isn't included at 4h work shift.
 - The tiredness data at 6h work shift are heterogeneous. The range is from low to high tiredness. The posture and stress intention overlap as reactions from vehicle drivers. Higher percent tiredness is registered with parameter "mental stress" of forklift drivers (nervous system).

Forklift drivers' tiredness grew sequentially in ascending order. The case described in (1) isn't included at 6h work shift.

- Working more than 8 hours with regulated breaks is not recommended. In practice, however, there are registered cases in which is applied unauthorized work shift and workers tiredness up to 12 hour shifts.
- Workers with big work experience, don't allow 12 hour work shift and not considered employable in working conditions. In section 2, it was noted that more forklift drivers agreed that 12h work shift is inadmissible. Most of forklift drivers are of the opinion that the monotony does not affect their work ability with different duration of the work shift. The case described in (1) isn't included at 8h and 12h work shifts.

5.3. Section 3 – Forklift driver's reactions under noise and vibration

- Data analysis is based on pre-set parameters – conversation, whisper, hubbub, silence, road noise, pinger, motor vibration and cabin vibration.
- The age and work experience affect to the forklift driver's physical condition.
- In the first hours (2h) from the start of the work shift all forklift drivers regardless of workplace and the nature of work are less exhausted. The explored parameters were normal.
- As an exception of questionnaire parameters is a forklift driver, who in conversation and whisper indicates a neutral attitude due to insufficient observations. Very high body stress and disability to work is registered to parameter "hubbub". Forklift drivers' reactions for parameters silence, road noise and pinger are the same for different periods of tiredness. They are assessed as normal and medium risk. There is no difference for parameters "motor and cabin vibration" (2).
- First signs of body stress appears at 4h work shift. Workers estimated organism stress at 4h from low to high. First signs of delayed effects and risk assessment are medium. The case described in (1) isn't included at 4h work shift. The research shows, that the forklift drivers reactions for parameters "conversation, whisper, and hubbub" are identical in different time periods. Homogeneous is the opinion for parameters "silence, road noise and pinger. The workers must be enough sufficiently concentrated and adequate in emergency and disaster situations. There is no difference in forklift drivers reactions for parameters "motor and cabin vibration". The case described in (1) isn't included at 4h work shift.

- The tiredness data at 6h work shift are heterogeneous. The range is from low to high tiredness. The conversation, whisper and hubbub overlap as reactions from vehicle drivers. Higher percent tiredness is registered with parameter "road noise". Forklift drivers' tiredness grew sequentially in ascending order. The workers must be enough sufficiently concentrated and adequate in emergency and disaster situations. Their answers are well thought out and risk is measured. There is no difference in forklift drivers reactions for parameters "motor and cabin vibration". The case described in (2) isn't included at 6 h work shift.
- Working more than 8 hours with regulated breaks is not recommended. In practice, however, there are registered cases in which is applied unauthorized work shift and workers tiredness up to 12 hour shifts.
- Workers with big work experience, don't allow 12 hour work shift and not considered employable in working conditions. In section 2, it was noted that more forklift drivers agreed that 12 h work shift is inadmissible. Forklift drivers' answers for memory tiredness at 8h and 12h work shifts is mostly very high (80%), 15% of them believe the organism stress is high and 5% are the exceptions, which won't work at 12h work shift or don't have enough work experience and practice in such working conditions. The case described in (2) isn't included at 8h and 12h work shifts.
- There is no difference in forklift drivers' reactions for parameters "motor and cabin vibration".
- A constant behaviour of the forklift driver is regardless of time duration.

5.4. Other findings

- Forklift driver answers are identical and for parameter "workplace".
- There are exceptions. They form a small percentage of the overall statistics, which show – or sparingly answers or misunderstanding due to not enough work experience (0 – neutral evaluation). Available is also the other extreme – do not use "0". For example, a worker with a work experience of one month thought that he has all necessary knowledge.
- Analysing the results, it could be seen identical forklift drivers' answers working together. A similar phenomenon was observed in the overall scale to whole sections of the questionnaire.
- 2/3 of the participants are professional workers in their position. The remaining 1/3 are workers with professional experience of at least five years.

- More experienced forklift drivers were answering more adequately. Less experienced forklift drivers were answering mechanically even in the absence of work experience (one participant in the questionnaire has only for one month work experience to the date of the questionnaires).
- As a disadvantage should be noted forklift drivers reactions at 12h work shifts. Only 5% of them are disabled to work at such tiredness.
- The analysis shows that the younger and less work experience forklift drivers are resistant to stress and strain. Older and more experienced workers get tired more easily and the tiredness has a greater impact on their ability to work.
- The questionnaire is filled in experimentally by people, failure to occupy position "forklift driver", but working in identical environment and working conditions. Their opinion overlaps in some parameters with the forklift drivers.

Gratitude

The researches, the results of which are presented in this publication are funded by internal competition of Technical University of Sofia, Bulgaria 2012, for which the authors express their gratitude.

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Received in April 2015