Physical Work Intensity of In-Plant Milk Run Operator. Part I - Guidelines for Assessment

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Abstract. In European norms and standards, information about maximum weight and maximum force can be found, but there is lack of unified regulations about maximum admissible energy expenditure during work. The paper presents the intensity of physical work, especially physiological guidelines for energy expenditure assessment. Moreover, there are presented polish legal requirements for energy expenditure assessment, which can be treated as general good practices for energy expenditure assessment for blue-collar jobs in logistics sector. The goal of the paper is to present the guidelines for the energy expenditure assessment for in-plant milk run operator.

Keywords: Systems engineering · Logistics 4.0 · Ergonomics
Internal transport system · Manual handling · Energy expenditure

1 Introduction

Global development of logistics determinates increase of demand for logistics workers. Growing significance of that sector is visible in each logistics activities and fields, such as production logistics, which plays an important role in a supply chain. Production logistics realizes several crucial purposes. On the one hand, production logistics should decrease: lead-time of products and loss, costs and inventory in the manufacturing process, on the other hand it should increase: utilization of resources, flexibility of the manufacturing and related logistic process, transparency to support lean philosophy based solutions and quality of products. Moreover, the role of production logistics is to integrate the production logistics into the enterprise resource planning system [1].

The essential in production logistics is to follow the 7R rule which means to provide the right product (e.g. production in progress, components, packaging), to the right internal customer, in the right quantity and quality, from and to the right location, at the right time, for the right costs [2]. An integral part of production logistics, which helps to achieve its goals, is an internal transport, which year by year become more automatized. There are plenty of internal transport jobs, but in the last few years, one of the most popular is in-plant milk run operator. In-plant milk run is the alternative for the most common method of indoor transportation that is forklift [3]. The idea of in-plant milk

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run system [4] is to supply various goods form various locations in one run using train consisting of tugger and several trailers [5]. Usually, milk run is operating according to fixed route and fixed schedule [6] shuttling between workstations in production hall. The main role of operator is to drive train, loading and unloading materials.

In spite of automatization of indoor delivery process, in-plant milk run operator perform many of activities with high physical work intensity. In general, despite the fourth industrial revolution in manufacturing and industry, nowadays in production companies there are still many internal transport operations, which engage physical work of employees. In many cases, the energy expenditure, especially of manual handling operations, is significantly high. That can lead to musculoskeletal disorders and other ergonomics occupational diseases. Biological cost of work is especially high for mature workers and those with limitations. Tasks for each in-plant milk run operator in particular companies are the same no matter how old they are.

Information about maximum weight can be found in European norms and standards, but there are no clear and unified regulations about maximum force and maximum energy expenditure.

2 Intensity of Physical Work – Energy Expenditure

Intensity of physical work is one of the primary characteristics of physical work. The measure of physical work intensity is energy expenditure defined as the amount of energy produced by the body during the performance of work tasks. Physical work intensity depend on factors such as body position, the level of physical exertion required, weight of moved or supported objects, the pace of work task performance, individual characteristics of the worker.

Information about the intensity of physical work is necessary for all jobs not only to enable their comparison with the guidelines concerning maximum permitted values for regular occupational activity but also to facilitate planning and taking preventive actions to limit negative influence of work on health. Physical work intensity should be considered by employers in designing work organization for a job, in calculating the number of workers employed to perform particular jobs, and in planning rest breaks. It is common knowledge that physically strenuous work increases the risk of musculoskeletal disorders and is one of the causes of accelerated degenerative changes (especially in the spine) and related conditions. It is also well known its long-term performance is the cause of accelerated decrease in physical efficiency. Heavy physical work should also be taken into account as a risk factor for cardiovascular diseases such as arterial hypertension or coronary artery disease [7–9].

2.1 Physiological Guidelines for Energy Expenditure Assessment

The intensive of physical work are assessed by comparing measured energy expenditure values for a job with physiology-related regulations specifying the allowed range of physical exertion for daily work. Tables 1 and 2 show a classification of exertion levels used in Poland. The classification does not take account of the age of workers or its influence upon the workers' ability to perform the work. It was developed to protect

people aged 30 to 35 of average fitness against overexertion, based on the principle that a worker performing a job should not use more than 30% of his/her maximal physical capacity [10–12] For people whose physical efficiency (ability to work) is limited (due to age, short height, excess weight,) performing a job involving a specific level of physical exertion will be more demanding, and they will be bearing a greater biological cost [12]. Higher work intensities will expose the older workers to greater relative strain, and therefore increased risk of injury because of overexertion and fatigue [13].

Table 1. Classification of the intensity of physical work on the basis of the effective energy expenditure during per shift [effective kJ] [14].

Work exertion level	Males	Females
Very light	up to 1256	up to 837
Light	1256–3350	837–2930
Moderately heavy	3350–6280	2930–4187
Heavy	6280–8374	4187–5024
Very heavy	>8374	>5204

During the development of the intensity of physical work classification related to energy expenditure per minute, it was assumed that exertion levels corresponding to 25%, 35% and 50% of the VO_2 max would be the boundary values for light, moderately heavy and heavy work respectively [12, 15].

Classification of the intensity of physical work can be used for assessing dynamic work. If intense static exertion is involved, blood flow to the engaged muscles is limited and the ability to exert more effort decreases. Moreover, static exertion causes bodily distress mainly because of increased frequency of heart contractions and blood pressure in relation to the volume of oxygen consumption. Static exertion is to a greater or lesser degree inherent in any physical work. Considering a decreased capacity for further exertion when the work requires intense static exertion, it is recommended that the boundary values of energy expenditure for work exertion levels be lowered by 20% [12].

Job arduousness is a subjectively perceived or objectively measurable reaction of the body to performing a job the intensity of which exceeds the limits of the optimal load or a reaction to performing a job of optimal intensity yet in working conditions that cannot be regarded as optimal. The first group of factors that determine how arduous a job is, which relate to the job itself, comprises the factors that arise from the intensity and type of physical exertion. A job may be described as arduous when it is heavy or very heavy, in the sense of a total energy expenditure, when it involves great static exertion and high degree of repetitive motions. An additional factor that affects whether a job is perceived as arduous is irregular distribution of exertion intensity during a working day and occurrence of what is called peak loads when oxygen consumption is in excess of 50% of VO_2 max. Because individual physical efficiency declines with age, the boundary values of energy expenditure that correspond to peak loads also decrease. Thus, for young women (aged 20–29) the value is 20 kJ/min, whereas for older ones, aged 50 and over, it amounts to – 12.5 kJ/min. For men these values are 33.5 kJ/min and 20.9 kJ/min respectively. Occurrence of peak loads at work

Table 2. Classification of the intensity of physical work on the basis of the effective energy expenditure during per shift per minute [kJ actual/min] [12].

Work exertion level	Males	Females
Very light	up to 5	up 3.5
Light	5–10	3.5–7.5
Moderately heavy	10–20	7.5–12.5
Heavy	20–30	12.5–20
Very heavy	>30	>20

should be considered a cause of work arduousness regardless of whether they are offset with rest breaks to such a degree that the total energy expenditure is modest [16].

Makowiec-Dąbrowska [16] of the Nofer Institute of Occupational Medicine recommends that, depending on the work exertion level, the worker should be provided with extra breaks in addition to the statutory breaks as laid down in the Polish Labor Code [17]. Rest breaks are supposed to prevent the ability to work from declining as fatigue sets in, which is a normal, in fact physiological consequence of any task performance.

According to guidelines, when a job requires heavy work, which means that energy expenditure exceeds 6280 kJ/shift for men and 4187 kJ/shift for women, it is recommended that, apart from what is known as a breakfast break, the second part of the shift be divided with at least one further 10-minute break.

If the energy expenditure exceeds 4606 kcal/shift for women and 6908 kJ/shift for men, it is recommended that additional break time equal to 10% of the total working time be introduced. Individual rest breaks should be set in regular one- or two-hour intervals during the shift.

During very heavy work, when energy expenditure is within the 8374–8792 kJ/shift range for men, it is recommended that the additional break time should amount to 15% of the working time, which means that besides the breakfast break, there should be 7 additional 10-minute rest breaks. If, during very heavy work, energy expenditure stays within the 8792–9210 kJ/shift range for men, it is recommended that additional break time should amount to 20% of the working time, which means that there should be five 15-minute breaks and two 10-minute breaks.

Designers, engineers, OSH and management functions in countries other than Poland where adult populations are similar to that of Poland's may find the guidelines discussed above useful in analyzing physical demands of work.

2.2 Legal Requirements for Energy Expenditure Assessment

In May 2017, important changes were introduced into Polish regulations concerning allowed values of energy expenditure, manual handling load weight, and the required force that a worker needs to exert to initiate object movement. The change was necessitated by amendments to Article 176 of the Labor Code including the new assignment of authority to establish a catalogue of jobs that are arduous, hazardous

and/or harmful to health which only pregnant or breast-feeding women are forbidden to perform.

Presented below are legal requirements for effective energy expenditure only.

Permitted work exertion levels, pursuant to Polish legislation, have been set for men, women, and juveniles.

Under the Regulation of the Minister of Labor and Social Policy of March 14, 2000 on occupational safety and health of manual handling and other physically demanding work tasks (Journal of Law No. 26, Item 313 as amended; No. 82, Item 930; No. 56, Item 462; No. 0 Item 854), the effective energy expenditure [18]:

- for men for physical work involving lifting and carrying objects throughout the shift must not exceed 8400 kJ, and for irregular work (performed no more than 4 times per hour, if the total time of the work performance does not exceed 4 h per 24 h) - 30 kJ/min.
- for women for work involving physical effort including lifting and carrying objects throughout the shift must not exceed 5000 kJ, and for irregular work (performed no more than 4 times per hour, if the total time of the work performance does not exceed 4 h per 24 h) - 20 kJ/min.

For pregnant and breastfeeding women the boundary values for energy expenditure are specified in the Regulation of the Council of Ministers of April 3, 2017 on the catalogue of jobs that are arduous, hazardous and/or harmful to the health of pregnant and breastfeeding women (Journal of Laws of 2017, Item 796) [19]. The catalogue of jobs hazardous or harmful to the health of pregnant and breastfeeding women includes:

- as regards pregnant women, all jobs for which the maximum permitted values of physical exercise in terms of effective energy expenditure for the job exceed 2900 kJ per shift, and for irregular work (performed no more than 4 times per hour, if the total time of the job performance does not exceed 4 h per 24 h) - 7.5 kJ/min;
- as regards breastfeeding women, all jobs for which the maximum permitted values of physical exertion in terms of effective energy expenditure for the job exceed 4200 kJ/shift, and for irregular work (performed no more than 4 times per hour, if the total time of the job performance does not exceed 4 h per 24 h) - 12.5 kJ/min.

The regulations referred to above do not specify precise limits on energy expenditure by age and physical condition of the worker. According to the 'Practical guidelines on periodic medical evaluation of workers' included in the Regulation of the Minister of Health and Social Welfare of May 30, 1996 on periodic medical evaluation of workers, the scope of worker medical prevention and medical opinions issued for purposes specified in the labor code (Journal of Laws of 1996, No. 69, Item. 332 as amended) [20], it is the responsibility of the occupational medicine practitioner to take account of age-related physiological differences and changes during the initial and periodic medical evaluation of the worker. For physical work requiring energy expenditure of over 1500 kcal/8 h (6280 kJ/8 h) or 3 kcal/min (12.5 kJ/min) for men, and over 1000 kcal/8 h (4187 kJ/8 h) or over 2 kcal/min (8.3 kJ/min) for women, periodic medical evaluation should be performed every 5 years; whereas for workers over 45 years of age - every 3 years. Workers must not perform manual handling work unless they have been issued a medical clearance to perform such work tasks.

Physically demanding jobs entail additional rights for the workers and obligations for the employer. Under the Regulation of the Council of Ministers of May 28, 1996 on prophylactic meals and beverages (Journal of Laws of 1996, No. 60, Item 279) [21], the employer is required to provide workers in particularly difficult working conditions with free meals and drinks.

The employer provides meals when, among others:

- work related energy expenditure per one shift is greater than 2000 kcal (8374 kJ) for men, and greater than 1100 kcal (4605 kJ) for women;
- energy expenditure related to work performed in enclosed spaces where due to technical requirements the temperature is below 10 °C or where the wet bulb globe temperature index (WBGT) exceeds 25 °C is at least 1500 kcal (6280 kJ) for men, and at least 1000 kcal (4187 kJ) for women;
- energy expenditure related to work performed in open spaces in the winter period (November 1 ÷ March 31) is at least 1500 kcal (6280 kJ) for men, and at least 1000 kcal (4187 kJ) for women;

Furthemore, the employer provides beverages for workers performing physically demanding jobs that require actual energy expenditure per shift in excess of 1500 kcal (6280 kJ) for men, and 1000 kcal (4187 kJ) for women.

The employer provides beverages in quantities that satisfy the needs of the workers, cold or hot depending on the working conditions.

3 Energy Expenditure Assessment in Relation to Milk Run Concepts

To know physical demands of work is crucial for work process managing. One of the needed element for the assessment is the work process description that is why in-plant milk run operator work was described.

An In-Plant Milk Run, in logistics, is a delivery method for mixed loads. The operator is both: distributing and collecting goods during a round trip from several internal suppliers to several internal clients [22].

There are different concepts of milk run that is why it can be classified according to various criteria. If the general condition would be taken under consideration can be identified criteria such as [6]:

- material source,
- handling unit,
- replenishment principle.

According to material source criterion in milk run there can be automated storage system, manual storage system, production supermarket and buffer area. For each of that material source system there are different physical demand of work. In manual storage system the energy expenditure is expected to be the highest. If the matter of handling unit is being consider, also it can be noticed that the energy expenditure differs. Operator can carry small load carriers (SLC), such as bins, boxes, large load carriers (LLC), like pallets, special carriers (e.g. for sequenced provision) or mixed

carriers (big bags, roll containers). During manual handling not only the weight of load is important but also size and handles of units. Also the fact if loading and unloading are possible on both sides of the platform is important for the results of energy expenditure assessment. Also replenishment principle such as Kanban, reorder level, sequenced orders or demand-oriented can influence the physical work intensity, as they are connected with different pace of work and number of steps.

If the organizational structure is being considered, there can be identified criteria like [6]:

- route,
- assignment of vehicle to route,
- milk-run control principle,
- integration of loading process,
- integration of empty bins process.

Milk run train can have fixed route, dynamically planned route or flexible route. If the route is fixed, which means the operator is repeating tasks, assessing energy expenditure is much easier than in other cases, moreover, results of the investigation conducted in different days, will not differ so much. The same situation occurs when the vehicle is fixed assign to route – it is much easier to prepare timing and receive similar results in different measurements. If the assignment of vehicle to route is flexible comparability of results from research carried out at different times can be difficult.

Also milk-run control principles such as tact (fixed schedule), workload-oriented control, permanent control, on demand control can influence both: energy expenditure and the measurement, as according to it employees can change the way they are performing they work. Loading process can be a part of tour or there can be separate loading and buffering of loaded trailers. The level of integration of that process also has impact on the intensity of physical work. Another criterion that can influence energy expenditure level is process of empty bins integrating. Operator can exchange bin one-by-one, pick-up them on demand or do not integrate them.

Another criterion of milk run classification can be the level of automatization of train. Trains can be manual, semiautomatic or fully automatic. In semiautomatic trains, driver is manually operating the vehicle, but the train positions itself at the stopping point. Fully automatic trains are operating without any operator, that means that loading and unloading of pallets or other containers is automatic. Therefor the more automatized train the lower energy expenditure should be.

Based on classification criteria six milk run concepts can be identified [6]:

- supermarket, self-loading,
- supermarket with pre-picking and buffer,
- whole pallets milk run, single small bin supply,
- automated storage system with buffering and manual loading,
- automated storage system with half-automated loading and buffering,
- automated storage system, drive-thru loading.

In the first concept “supermarket, self-loading” a milk run operator, according to the orders, loads bins prepared in logistics supermarket onto milk run train, and after

that using fixed route, he drives to the production workstations. Loading and order picking in the supermarket last quite long, approximately 80% of work shift. While stopping at the stations operator unloads the bins and collect empty bins. He is operating according to the schedule and orders are mainly generated using Kanban. Driving time is only small percentage of work shift. In this concept, there is supremacy of manual handling that increases the energy expenditure. Researches of the authors of the paper reveled that in most of the cases the energy expenditure exceed polish maximum permitted value, what is presented in the second part of the article (Physical Work Intensity of In-Plant Milk Run Operator. Part II – Case study).

Second concept "supermarket with pre-picking and buffer" assumes supermarket with pre-picking and buffer. The difference between the firs concept is the fact that an additional supermarket worker loads the milk run train. The milk run operator picks up prepared train. There has to be fixed schedule and the milk run operator is responsible for delivering goods only. Milk run operator is a driver and he unload goods. In this concept, manual handling during loading in the supermarket consumes less energy but if the logistics planner increase the number of cycles energy expenditure for unloading on the shop floor will be higher.

Third concept "whole pallets milk run, single small bin supply" is connected with caring whole pallets with small bins or elements, but the issue is that there is only one material per pallet. There is a forklift loading in the warehouse done usually by logistics workers. Authors of the article concluded from their research that in many cases milk run operator has to load the read made pallets on the train. Milk run system operates in a fixed tact with a schedule and materials are fixed to the train. When the train reaches the workstation, the milk run operator separates the cart with pallet from the train. There is lack of automatization of unloading process. In this concept, there are high temporary task forces for pulling the loaded cart with the pallet, which can result with high pick energy expenditure.

In the concepts: "automated storage system with buffering and manual loading" and "automated storage system with half-automated loading and buffering" milk run operator delivers the bins to workstation, unload them and collect empty bins. The last concept assumes automated storage system with drive-thru loading. Small load carrier are operated in a flow rack. Bins roll onto the train simultaneously. This concept also disclaims manual handling in order to loading stuff from supermarket, so the energy expenditure for milk run operator during loading process is expected to be lower. It is important to highlight that all those solutions can increase the energy expenditure for other tasks if the number of cycles will be enhance.

Presented concepts are concentrated mainly on the loading process in storing area. There is a shortage of concepts in which, in the phase of unloading, automatization can be used. Such a concept is presented in the article "Physical Work Intensity of In-Plant Milk Run Operator. Part II – Case study".

4 Energy Expenditure Assessment Procedure for In-Plant Milk Run Operator

While conducting the energy expenditure assessment for in-plant milk run operator in first stage it is necessary to prepare job description that includes:

- milk run characteristics such as:
  - material sources – storage system, including: height of shelves, angle of shelves, access to shelves, manner of handling, etc.,
  - handling units including: type of unit, numbers of unite per tour, size of unit, weight of unit, handles, manner of caring, etc.,
  - replenishment principles,
  - route including: its shape, duration, numbers of stops,
  - assignment of vehicle to route,
  - milk-run control principle,
  - integration of loading process,
  - integration of empty bins process,
- responsibilities and performed activities (typical for milk runner and additional operators tasks),
- workers (age, anthropometric characteristics, work experience, health, physical activity connected with lifestyle,
- type of the milk run train, carts, etc.,
- tools and additional item that operator is using,
- Personal Protective Equipment, clothing,
- ambient conditions,
- worktime, shifts, number of rest brakes, number of overtime.

To realize second stage "measurement, analysis and assessment of energy expenditure" it is necessary to:

- choose the method of measurement,
- plan the measurement,
- choose employees who will be tested,
- prepare tools: forms for notes and findings, camera, etc.,
- conduct measurement,
- compare results with physiological and legal requirement (presented in point 2).

Second stage should be terminated with conclusions that leads to recommendations of adjustments to reduce energy expenditure both per minute and per shift.

In some cases it may be necessary to assess if a worker (especially mature worker) is physically capable of performing the required job/task safely without undue levels of physical strain and fatigue.

5 Summary

According to the concept of milk runs, work of in-plant milk run operator can differs significantly and different physical work intensity can be noticed. It is supposed that the highs energy expenditure can be in the work process organized according to first concept. Studies of the authors' show that in all concepts the energy expenditure per work shift (for men) can be high and may exceed legal requirements. Research findings presented in paper "Physical Work Intensity of In-Plant Milk Run Operator. Part II – Case study" and in further articles which are going to be published proves that.

Proper work organization of internal transport workers is crucial in relation to aging society process. Labor market demands will determinate taking under consideration mature workers in work process designing. Employers who establish age-friendly workplaces that promote and support the work ability of employees as they age are likely to be more successful in maintaining worker safety and productivity, ultimately optimizing their competitiveness and sustainability. However, in many occupations, especially those requiring high sustained physical efforts (for example milk run operator), it may not be possible to accommodate the work demands with the capacities of the workers. In such situations it will be necessary to assess if a worker is "fit for duty" and therefore physically capable of performing the required job/task safely without undue levels of physical strain and fatigue [23].

The occupational medicine specialists are responsible for identifying whether an older worker may be able or not to perform a given job. This task is difficult by the fact that there is high degree of diversity in the jobs performed within a given occupation. That is why the cooperation between employer and occupational medicine specialists is very important.

References

1. Mácsay, V., Bányai, T.: Toyota production system in Milkrun based In-Plant supply. J. Prod. Eng. **20**(1), 141 (2017)
2. Bielecki, M., Szymonik, A.: Total logistics management – as condition for the functioning of the logistically efficient company. In: Carpathian Logistics Congres 2013, Congress Proceedings, Tanger, Ostrava, pp. 212–217 (2014)
3. Baudin, M.: Lean logistics. The Nuts and Bolts of Delivering Materials and Good, p. 67. Productivity Press, New York (2004)
4. Meusel, W.: Realisierung eines Logistikberater-Arbeitsplatzes für das Frachtkostencontrolling mit wissensbasierten Elementen. Nürnberg, Univ., Diss.–Erlangen, 1995. Frankfurt am Main, Berlin: Lang (Europäische Hoch-schulschriftenReihe 5, Volks- und Betriebswirtschaft, 1755) (1995)
5. Takeda, H.: Das System der Mixed Production. Verlag Moderne Industrie, Landsberg (1996)
6. Klenk, E., Galka, S.: Analysis of parameters influencing In-Plant milk run design for production supply. In: 12th International Material Handling Research Colloquium. Technishe Universitat Munich, pp. 25–28 (2012)

7. Konarska, M., Kurkus-Rozowska, B., Krokosz, A., Furmanik, M.: Application of pulmonary ventilation measurements to assess energy expenditure during manual and massive muscular work. In: Proceedings of the 12th Congress of IEA, Toronto, Human Factor Association of Canada, pp. 316–317 (1994)
8. Koradecka, D., Bugajska, J.: Physiological Instrumentation. In: Karwowski, W., Marras, W. S. (eds.) The occupational ergonomics handbook, pp. 525–547. CRC Press, Boca Raton (1999)
9. Koradecka, D.: Handbook of occupational safety and health. CRC Press, Taylor & Francis Group, Boca Raton (2010)
10. Job design for the aged with regard to decline in their maximal aerobic capacity: Part I - Guidelines for the practitioner Int. J. Ind. Ergon. **10**, 53–63 (1992a)
11. Job design for the aged with regard to decline in their maximal aerobic capacity: Part II – The scientific basis for the guide. Int. J. Ind. Ergon. **10**, 65–77 (1992b)
12. Makowiec-Dąbrowska, T., Koszada-Włodarczyk, W., Jóźwiak, Z.: Energy expenditure at work: assessment guidelines. (Koszt energetyczny pracy: wytyczne dotyczące określania). Oficyna Wydawnicza IMP, Lodz, pp. 21–23 (1999)
13. McGill, S.M.: The biomechanics of low back injury: implications on current practice in industry and the clinic. J. Biomech. **30**, 465–475 (1997)
14. Makowiec-Dąbrowska, T.: Zasady oceny obciążenia fizycznego podczas pracy zawodowej. Zesz. Metod-Org. IMP Łódź **22**, 29 (1988)
15. Kozłowski S., Nowakowska A., Kirschner H., Obuchowicz-Łożyńska z.: Ocena wyliczania wysokości pułapu tlenowego człowieka (nomogram Astrand-Ryhming) jako pomiaru zdolności do pracy w warunkach aerobowych. Wych. Fiz. Sport, pp. 4–12 (1968)
16. Makowiec-Dąbrowska T.: Occupational physiology. In: Indulski, J.A. (eds.) Occupational Hygiene. Oficyna Wydawnicza IMP, Lodz, s. 71–152 (1999)
17. http://legislacja.rcl.gov.pl/docs//525/12292452/12393379/12393380/dokument258140.pdf
18. Regulation of the Minister of Labor and Social Policy of March 14, 2000 on occupational safety and health of manual handling and other physically demanding work tasks. Journal of Law No. 26, Item 313 as amended; No. 82, Item 930; No. 56, Item 462; No. 0 Item 854
19. The Regulation of the Council of Ministers of April 3, 2017 on the catalogue of jobs that are arduous, hazardous and/or harmful to the health of pregnant and breastfeeding women (Journal of Laws of 2017, Item 796)
20. 'Practical guidelines on periodic medical evaluation of workers' included in the Regulation of the Minister of Health and Social Welfare of May 30, 1996 on periodic medical evaluation of workers, the scope of worker medical prevention and medical opinions issued for purposes specified in the labor code. Journal of Laws of 1996, No. 69, Item. 332 as amended
21. The Regulation of the Council of Ministers of May 28, 1996 on prophylactic meals and beverages. Journal of Laws of 1996, No. 60, Item 279
22. Meyer, A.: Milk Run Design Definitions, Concepts and Solution Approaches. KIT Scientific Publishing, Karlsruhe (2017)
23. Kenny, G.P., Groeller, H., McGinn, R., Flouris, A.D.: Age, human performance, and physical employment standards. Appl. Physiol. Nutr. Metab. **41**(6), 92–107 (2016)