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Ergonomic Diagnosis of the Driver's Workplace in an Electric Locomotive

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This paper deals with research aimed at developing a method for ergonomic analysis of the driver's workplace in an electric locomotive. It presents the structure of the diagnosis and its assumptions, and includes a re-evaluation of the questionnaire-expert method in ergonomic research. The article presents research data on weights and evaluations including their standard deviations for particular priority features. Ergonomic levels of the studied operator's cabin in locomotives are compared.

ergonomic diagnosis driver's workplace electric locomotive questionnaire-expert method weights of priority features

1. INTRODUCTION

Ergonomic diagnosis is derived from the general concept of diagnosis, defined as the ascertainment of a particular state of affairs within a given scope. Diagnosis is relatively dependent on the state of knowledge, on its purpose, and on the quality of the used benchmarks or standards of reference. According to the literature of the subject, judging from the viewpoint of evaluation of human work, the praxeological definition (Pszczołowski, 1978, pp. 48–49) seems to be closest to the mark in its description of diagnosis as an "... examination of a specific event in view of a planned action" (my translation).

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Diagnosis can include different areas in an ergonomic study, and it is not concerned with either man or machine treated separately, because its essence is in their mutual interrelations. It can therefore be assumed that the characteristic and specific feature of ergonomic analysis, as opposed to other types of analysis, is its subject, that is, the interrelations within the system of man and technical object.

As an interdisciplinary science, ergonomics utilises the methods of physiology, psychology, anthropology, organisation of labour, and technology, in addition to its own specific methods. The choice of method depends on the following factors:

- the level of automation in the man-machine-environment system;
- the "life stages" of the machine (e.g., phases of design, prototype study, production, operation);
- the scope of the diagnosed problem (requiring appropriate methods for various subdisciplines).

An overview of the world literature (Drury, 1997; Luczak, Schlich, & Springer, 1999; Salvendy, 1997; Stanton, 1998; Stanton & Young, 1999, 2001; Wilson & Corlett, 1995) points to a recent advancement of research methods developed and used in ergonomics. According to the most recent data, today's ergonomics uses some 60 different methods (Stanton & Young, 1998, 2001). Some of those methods are not widely known, as these are usually original methods tailored to the requirements of specific man-machine--environment systems (aviation, sea transport, road transport). However, despite their limited potential for general application, such methods still enrich the methodology of ergonomics. Some research (Stanton & Barber, 1996) has shown that the most typical methods used include questionnaires, interviews, observation, checklists, and heuristic methods, as these are easy to use and can be conveniently combined into different sets to suit particular requirements. Checklists are the most universal method (Kogi, 2001); they can be used in all man-machine-environment systems or they can be tailor-made for a specific system. In general, there are types of two checklists:

- a list of factors evaluated in view of their compliance with ergonomic requirements,
- a list of actions to be taken to enhance the existing design solutions or working conditions.

The best known checklists include PAQ (Position Analysis Questionnaire) dealing with the body position at work (McCormick, 1979), AET (Ergonomic

Job Analysis) for ergonomic analysis of work (Rohmert & Landau, 1985), and ESAC (Ergonomic System Analysis Checklist) or the so-called Dortmund Checklist, which has been the basic tool of practical and theoretical studies in ergonomic analysis for a number of years. Owing to the considerable size of that checklist (some 350 items) and the related problems of practical application, a number of its abridged and topically arranged versions were created (e.g., the Control Ergonomic Test II—CET II). Publications in that area include Burger and Boer (1968), Murell (1965), Grandjean (1978), and in Poland primarily Ogiński and Krasucki (1972) and Pacholski (1977).

The so-called evaluation sheets are a variation on the checklist. These include either open questions or quantitative data based on statutory norms. In Poland, examples include Głuski and Gierasimiuk (1974), Pacholski (1977), Hansen (1970).

In practice, the aforementioned evaluation sheets are mostly used for ergonomic evaluation of the workplace and they differ in the extent of detail dealt with in the questions.

An analysis of methods for ergonomic diagnosis served as a basis for defining the diagnostic assumptions in the driver-locomotive-environment (D-L-E) system. The system contains interrelations that can be objectively and repeatedly measured and expressed in terms of units (the so-called measurable features). In addition to such measurable features, some features are non-measurable. These are basically evaluated using grades to assess the compliance of the system (or of one of its elements) with ergonomic requirements (or lack of such compliance). In ergonomic diagnosis it is necessary to take into account the specific nature of the studied workplace as this has a crucial impact on the type of interrelations in a given system.

The aim of this article is to present a new approach to diagnose the driver's workplace in an electric locomotive.

2. SPECIFIC NATURE OF DRIVER'S WORK

One significant element of the driver's work is an analysis of information received both from in-cabin signals and track observation. This information is processed by the driver and used to control the whole D-L-E system. Driving, that is, correct vehicle movement, is the final effect of the system's functioning depending on the driver's orientation, decision making, and performance processes (Grabarek, 2001).

The specific nature of the work poses to the driver some specific requirements in terms of psychological and physical abilities to enable instant signal reception and its processing into action. A certain measure of psychophysical ability in the driver is not only a precondition for safe driving but also for passenger safety. As a result, drivers are recruited to the job based on the so-called negative psychological selection, that is, no-one can be admitted to the profession unless she or he can demonstrate a suitable level of ability in terms of certain psychophysical features, which are evaluated in detail during periodic control tests. However, this does not mean that the psychophysical condition of the driver remains constant throughout the work, which has some impact on the interrelations between the driver and the other elements of the system.

The driver's workplace is physically limited by the size of the cabin. Its most important factors include the working area and space, the height and shape of the working field, the shape of the field of vision, the situation of different work elements and means, the design and situation of the seat, and the material working conditions.

From the viewpoint of adapting the machine and the material environment for the man in the locomotive cabin, the most important factors include

- the workplace spatial structure,
- the distribution of elements within the working field,
- the visibility of high and low track signals,
- the material working environment.

The analysis of existing ergonomic methods and of the driver's workplace made it possible to create a specific method adapted for the diagnosis of the driver's workplace in electric locomotives. In terms of structure, it also includes other well-known methods, such as questionnaire and survey, interview, observation, evaluation sheet, and the expert method. The assumptions of the ergonomic diagnosis are presented in section 3.

3. CONCEPT OF ERGONOMIC DIAGNOSIS FOR DRIVER'S WORKPLACE

The methodology of the proposed ergonomic diagnosis makes the following assumptions (Grabarek, 2000b):

- The diagnosis includes an analysis of human, construction-technological, and material environment factors, with each factor carrying a general evaluation weight of Q_j ($j = 1, 2, 3$);

- All factors have the same weight of 1 in the evaluation of the global diagnosis rate;
- Each factor is described using features determining its ergonomic level;
- The number and type of features describing particular factors is determined by the specific nature of the diagnosed workplace;
- In terms of quantity and quality, the features (referred to as priority features) make up a set sufficient both to evaluate the selected factors and to perform the final ergonomic diagnosis;
- The features of each factor are differentiated by weight;
- Priority features and their specific weights are defined using questionnaire-expert research results;
- The weights of particular features are arrived at as the average value obtained form survey studies:

$$a_i = \frac{\sum_{j=1}^{m} a_{ij}}{m} \quad , \tag{1}$$

where a_i—feature weight, m—number of surveys used to evaluate the average value;

- The weights are random variables with an average value within the range of 1–5; the standard deviation of the weight is calculated as follows:

$$SD(a_i) = \sqrt{\frac{\sum_{j=1}^{m} (a_i - a_{ij})^2}{m(m-1)}} \quad ; \tag{2}$$

- Each feature is evaluated in accordance with its ergonomic criterion;
- The following 4-grade division was used for evaluation criteria: 2—*unacceptable* (unacceptable feature status resulting in unacceptably arduous work, work-disruptive, and posing a risk); 3—*acceptable* (feature status causing work arduousness but posing no risk); 4—*good* (feature status causing minimum work arduousness but lacking work comfort); 5—*very good* (feature status causing no negative comment, providing a sense of comfort);
- Each factor is evaluated through calculating a generalised weight rate:

$$Q_{j\ \ j=1,2,3} = \frac{\sum_{i=1}^{n} a_i M_i}{\sum_{i=1}^{n} a_i} \quad , \tag{3}$$

where Q_j—generalised evaluation weight rate of a factor, a_i—feature weight, M_i—feature evaluation;

- Calculated generalised weight rates for each factor will serve as the basis for the global ergonomic diagnosis rate expressed using the following formula:

$$Q_{\text{glob}} = \frac{Q_1 + Q_2 + Q_3}{3} \quad , \tag{4}$$

where Q_1—generalised evaluation weight rate for the human factor, Q_2—generalised evaluation weight rate for the construction-technological factor, Q_3—generalised evaluation weight rate for the material environment factor;

- In accordance with the assumed evaluation criteria, workplaces graded 2 (*unacceptable*) in any feature will be considered ergonomically unacceptable. In that case, both the generalised weight rate and the global diagnosis rate will equal 2 (*unacceptable*). Hypothetically, grade 2 results in barring the workplace from use until the feature has been improved;
- Evaluations of 3 or more mean that the ergonomic level of the studied workplace is within the *acceptable* to *very good* band. The global diagnosis rate will be used to compare the ergonomic level of the driver's cabin in different locomotives, and to define the order of modernisation based on weight rates;
- Creating a modernisation schedule with regard to a particular workplace will be preceded by a detailed analysis of the generalised weight rates.

4. QUESTIONNAIRE-EXPERT METHOD AS DATA SOURCE IN ERGONOMIC DIAGNOSIS

The accumulated knowledge of experts in a given field plays a key role in creating an ergonomic diagnosis of the workplace. There exist numerous methods for obtaining expert knowledge characterised by varying degrees of formality. One of them is the questionnaire method.

The questionnaire is a set of written questions aimed at obtaining responses to solve a scientific problem. The main aim of the questions posed in the questionnaires was to select priority features and to weigh them. The obtained questionnaire responses were then processed statistically to allow problem interpretation and explanation. The quality of questionnaire responses, which determines its cognitive value, depends mainly on the person queried and on the kind of questions posed. In order to avoid the typical errors and shortcomings of the questionnaire as a research method, certain specific requirements were accepted as to the questionnaire's structure and the choice of respondents. The scope of questions was determined on the basis of an analysis of pilot research aimed at a preliminary definition of the set of factors and their features in diagnosing the workstation. It was accepted that the experts would be drivers, Polish State Railways (PKP) supervision officers, rolling stock designers, and suitably specialised academic researchers.

The research was conducted in two stages (Grabarek, 2000a). The aim of stage 1 was for experts to define the priority features for the aforementioned three factors. The following were considered to be priority features:

- the human factor: psychophysical condition, adaptation to work, mental effort, job experience, physical effort;
- the construction-technological factor: track visibility, seat design, visibility of steering and signalling equipment, workplace spatial structure, distribution of other equipment;
- the material environment factor: noise, vibration, microclimate, lighting, dust pollution.

Table 1 lists the definitions of the priority features.

The aim of stage 2 of the research was for the experts to assign individual weights to particular features and to valuate their ergonomic level (Grabarek, 2001). This evaluation was done according to particular locomotive types. The set of locomotives included most types operated by the Polish State Railways.

In accordance with prior assumptions, expert knowledge was obtained through responses to questions in parts A and B of the questionnaire.

The task of part A was for the experts to weigh the particular features of ergonomic diagnosis. The questionnaire was presented to drivers and to rolling stock maintenance personnel, who evaluated each feature in terms of its significance at work. The experts had at their disposal a 1–5 scale where 1 meant a feature was *almost insignificant* in driving a locomotive, whereas 5 meant a feature was *extremely significant* in driving a locomotive. The values of 2, 3, and 4 were equivalent to intermediate states. Feature weights were assigned through averaging the results within a given factor.

The task of questionnaire B was to evaluate the ergonomic level of the currently operated locomotives. The questionnaire contained the same

TABLE 1. Definitions of Priority Features

Concept	Definition
Adaptation to work	Adaptation to requirements stemming from the working environment, achievement of highly effective activity, work satisfaction. Adaptation slows down the increase of tiredness under the same kind strain.
Psychophysical condition	The psychological and physical condition of the human body that makes it possible to carry out the various job functions.
Mental effort	Effort resulting from cognitive overload of information, decisions, operations, and monotony during work.
Physical effort	Effort to the human body during work resulting from expenditure of energy, static load, and monotypical movement patterns.
Job experience	Number of years spent working in a given job.
Seat design	Shape and size of the seat resulting from the user's anthropometric dimensions and from the type of work.
Visibility of steering and signalling equipment	The location of steering and signalling equipment in the human field of vision.
Workplace spatial structure	Set of points in space that must be perceived and interacted with by the working person.
Track visibility	Visibility of the track, high, and low symbols from the driver's cabin.
Distribution of other equipment	Location of other equipment according to man's anthropometric requirements relative to space.
Noise	Each sound that may lead to loss of hearing or pose a health hazard or any other danger.
Vibration	Set of phenomena occurring in workplaces consisting in the transmission of energy during work from the source of vibrations to the human body through those body parts that are in contact with the source of vibration.
Lighting	Parameter of the working environment that preconditions the functioning of the organs of sight.
Microclimate	Set of climatic elements characterising enclosed spaces. It is consciously shaped to ensure optimum working conditions to the human body and it is defined using the following air parameters: pressure, temperature, humidity, and movement.
Dust pollution	Chemical and physical substances occurring in the workplace that affect people through the respiratory system, the mucous membranes, and the skin.

factors and their features as part A. However, the evaluation followed a 4-grade scale where 2 meant *unacceptable* (an unacceptable feature status causing inadmissible arduous working conditions, posing a risk, and disrupting work); 3 meant *acceptable* (feature status causing some work arduousness but posing no risk); 4 meant *good* (feature status compliant with standards, but failing to provide work comfort); 5 meant *very good* (feature status leaving no reservations, causing minimum work arduousness, and providing a sense of comfort).

5. RESEARCH RESULTS

The research was carried out among drivers and rolling stock maintenance personnel employed at four rolling stock maintenance facilities, that is, in Cracow, Warsaw, Lublin, and Szczecin, Poland, who operated electric locomotives of the same types, that is, EP, EU, ET, and EN. Data was collected from 843 respondents. According to the results of part A, particular weights were assigned to features of human, construction-technological, and material environment factors. The weights were determined by the experts based on their own appraisal of their significance. The results of part B served as the basis for calculating the global rate of ergonomic diagnosis.

5.1. Analysis of Questionnaire Part A

Figures 1–3 illustrate form the weights of particular features in particular factor groups and different locomotive types.

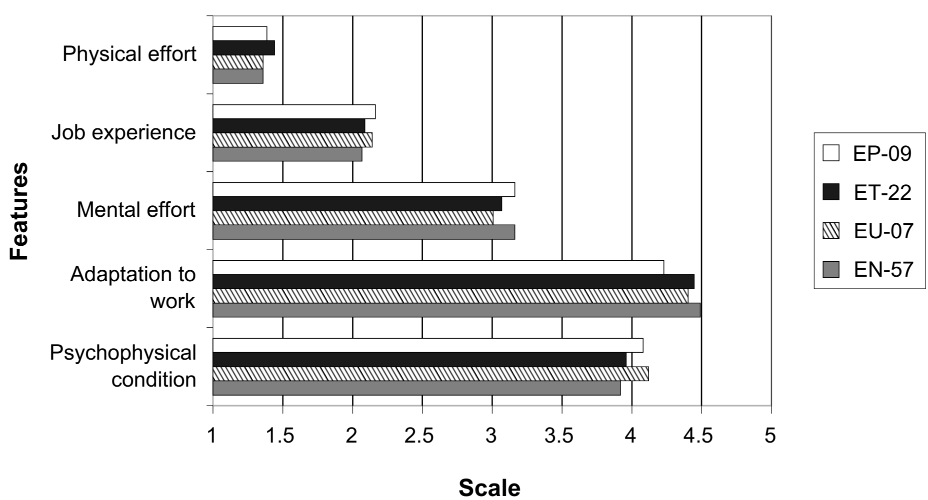

Figure 1. Weights for human factor features using the example of four types of locomotives (EP-09, ET-22, EU-07, EN-57).

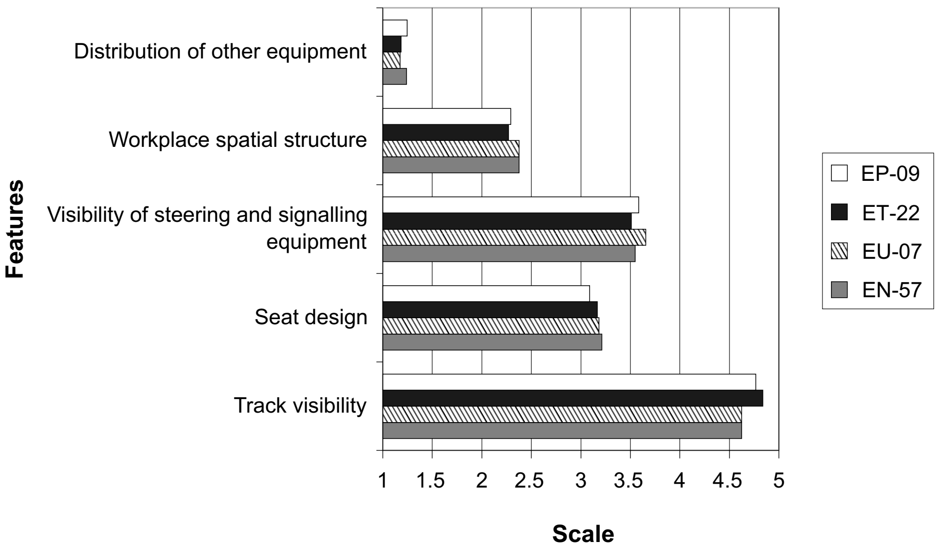

Figure 2. Weights for construction-technological factor features using the example of four types of locomotives (EP-09, ET-22, EU-07, EN-57).

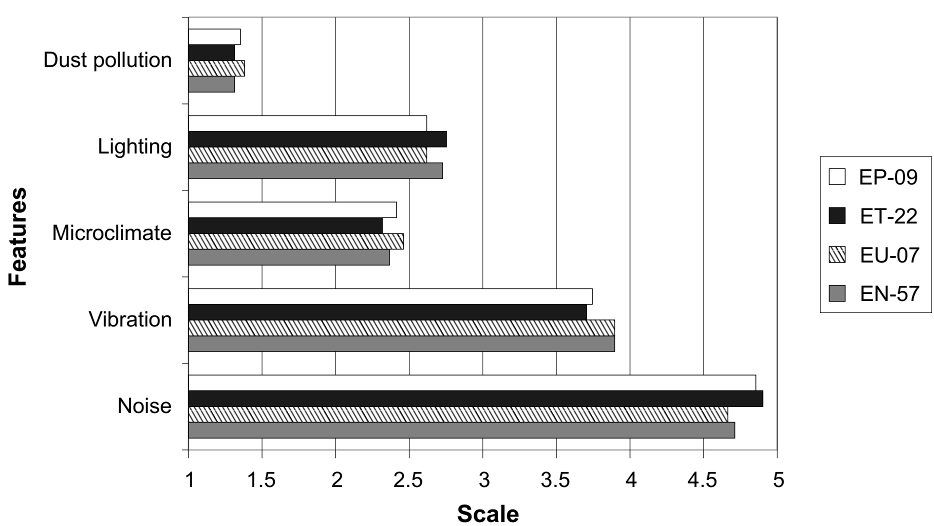

Figure 3. Weights for material environment factor features using the example of four types of locomotives (EP-09, ET-22, EU-07, EN-57).

Tables 2 and 3 for the set of the studied locomotives and for particular locomotive types show that the weights of particular features are similar. This proves that the respondents agreed about the importance of the features influencing the ergonomic level.

TABLE 2. Weights and Standard Deviations of Priority Features for the Entire Set of the Studied Locomotives

Factor	Priority Feature	Average Value of Weight	Random Variable
H F	psychophysical condition	4.04	0.0303
	adaptation to work	4.36	0.0349
	mental effort	3.10	0.0279
	job experience	2.11	0.0148
	physical effort	1.40	0.0126
C-T F	track visibility	4.72	0.0354
	seat design	3.12	0.0265
	visibility of steering and signalling equipment	3.62	0.0326
	workplace spatial structure	2.34	0.0192
	distribution of other equipment	1.21	0.0094
ME F	noise	4.76	0.0381
	vibration	3.82	0.0363
	microclimate	2.39	0.0206
	lighting	2.70	0.0211
	dust pollution	1.34	0.0127

Notes. HF—human factor, C-T F—construction-technological factor, ME F—material environment factor.

Within the human factor, the top-weighing feature was "adaptation to work," whose significance is also confirmed in the research literature. Within the construction-technological factor, "track visibility" was considered to be the most important. In locomotives operated in Poland, track information is received directly by the driver without any computer support, as such solutions appear in high-speed locomotives (in excess of 200 kmph). In the case of Polish rolling stock, this feature is undoubtedly very significant for correct train driving. "Noise" is the most important feature within the material environment factor. Keeping this feature's parameters at an acceptable level or better ensures greater working comfort and decreases the risk of driver error.

The obtained weights can be therefore accepted as the basis for the ergonomic diagnosis of the driver's workplace.

TABLE 3. Weights and Standard Deviations of Priority Features for Particular Types of Locomotives

Factor	Priority Feature	EN-57		EU-07		ET-22		EP-09	
		a_i	$SD(a_i)$	a_i	$SD(a_i)$	a_i	$SD(a_i)$	a_i	$SD(a_i)$
H F	psychophysical condition	3.92	0.0333	4.12	0.0391	3.96	0.0356	4.08	0.0351
	adaptation to work	4.49	0.0404	4.40	0.0352	4.45	0.0430	4.23	0.0389
	mental effort	3.16	0.0316	3.00	0.0257	3.07	0.0273	3.16	0.0240
	job experience	2.07	0.0199	2.14	0.0169	2.09	0.0209	2.16	0.0184
	physical effort	1.36	0,0106	1.36	0.0118	1.44	0.0123	1.39	0.0123
C-T F	track visibility	4.63	0.0347	4.63	0.0347	4.84	0.0377	4.77	0.0453
	seat design	3.21	0.0273	3.18	0.0255	3.17	0.0253	3.09	0.0278
	visibility of steering and signalling equipment	3.55	0.0312	3.66	0.0311	3.51	0.0299	3.58	0.0319
	workplace spatial structure	2.38	0.0226	2.38	0.0228	2.27	0.0179	2.29	0.0181
	distribution of other equipment	1.24	0.0105	1.17	0.0102	1.19	0.0110	1.25	0.0111
ME F	noise	4.71	0.0358	4.66	0.0364	4.90	0.0382	4.86	0.0388
	vibration	3.90	0.0308	3.90	0.0335	3.71	0.0319	3.74	0.0292
	microclimate	2.37	0.0237	2.46	0.0236	2.32	0.0202	2.41	0.0241
	lighting	2.73	0.0259	2.62	0.0233	2.75	0.0207	2.62	0.0257
	dust pollution	1.31	0.0112	1.38	0.0135	1.31	0.0105	1.35	0.0115

Notes. HF—human factor; C-T F—construction-technological factor; ME F—material environment factor; a_i—feature weight; EN-57, EU-07, ET-22, EP-09—types of locomotives.

5.2. Analysis of Questionnaire Part B

Figures 4–6 illustrate the evaluations of features within particular factor groups and in different locomotive types.

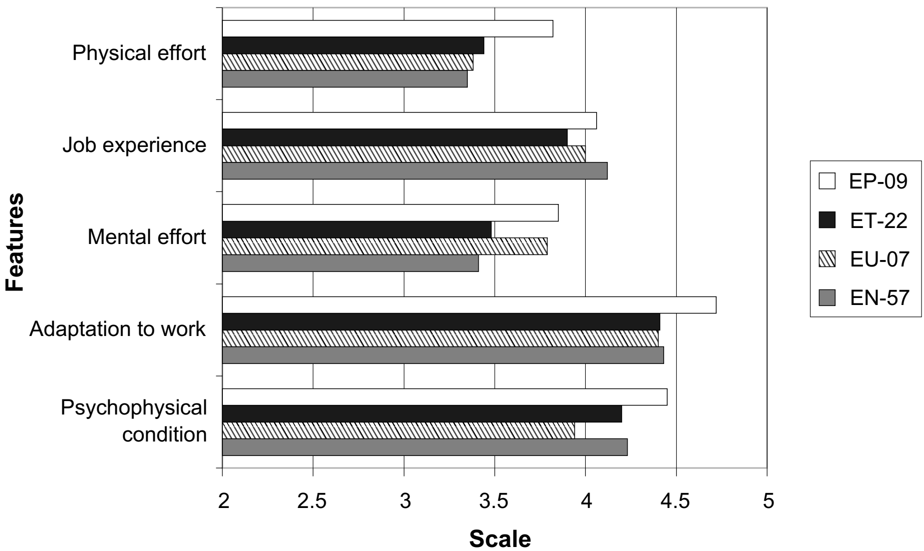

Figure 4. Expert-assigned evaluations of human factor features using the example of four types of locomotives (EP-09, ET-22, EU-07, EN-57).

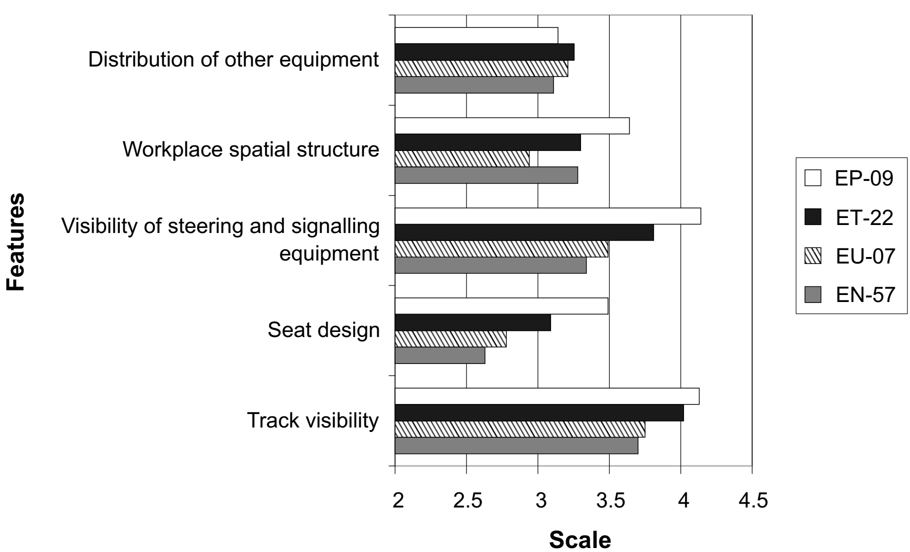

Figure 5. Expert-assigned evaluation of contruction-technological factor features using the example of four types of locomotives (EP-09, ET-22, EU-07, EN-57).

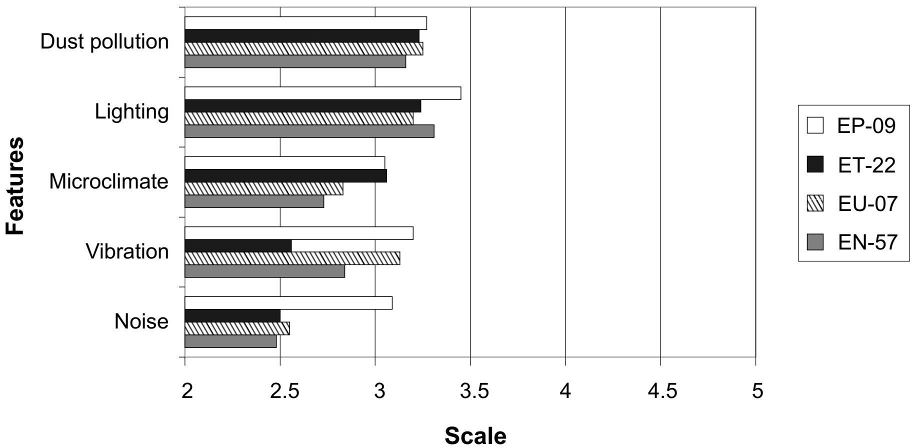

Figure 6. Expert-assigned evaluations of material environment factor features using the example of four types of locomotives (EP-09, ET-22, EU-07, EN-57).

TABLE 4. Evaluations and Standard Deviations of Priority Features for the Entire Set of the Studied Locomotives

Factor	Priority Feature	Average Value of Evaluation	Random Variable
HF	psychophysical condition	4.15	0.2075
	adaptation to work	4.44	0.2664
	mental effort	3.60	0.0360
	job experience	3.95	0.1185
	physical effort	3.39	0.1881
C-T F	track visibility	3.83	0.0766
	seat design	2.92	0.0847
	visibility of steering and signalling equipment	3.60	0.0972
	workplace spatial structure	3.24	0.0972
	distribution of other equipment	3.19	0.0925
ME F	noise	2.55	0.0561
	vibration	2.87	0.0718
	microclimate	2.87	0.0742
	lighting	3.23	0.0743
	dust pollution	3.22	0.0902

Notes. HF—human factor, C-T F—construction-technological factor, ME F—material environment factor.

TABLE 5. Evaluations and Standard Deviations of Priority Features for Particular Types of Locomotives

Factor	Priority Feature	EN-57		EU-07		ET-22		EP-09	
		M_i	$SD\ (M_i)$	M_i	$SD\ (M_i)$	M_i	$SD\ (M_i)$	M_i	$SD\ (M_i)$
HF	psychophysical condition	4.23	0.2583	3.94	0.2364	4.20	0.2310	4.45	0.2670
	adaptation to work	4.43	0.2437	4.40	0.2860	4.41	0.1764	4.72	0.2313
	mental effort	3.41	0.0887	3.79	0.1023	3.48	0.0974	3.85	0.1078
	job experience	4.12	0.1154	4.00	0.1120	3.90	0.1131	4.06	0.1137
	physical effort	3.35	0.0905	3.38	0.0879	3.44	0.0929	3.82	0.1109
C-T F	track visibility	3.70	0.0888	3.75	0.0825	4.02	0.1005	4.13	0.0950
	seat design	2.63	0.0605	2.78	0.0612	3.09	0.0742	3.49	0.0837
	visibility of steering and signalling equipment	3.34	0.0868	3.49	0.0838	3.81	0.0991	4.14	0.1076
	workplace spatial structure	3.28	0.0951	2.94	0.0823	3.30	0.0891	3.64	0.1019
	distribution of other equipment	3.11	0.0871	3.21	0.0963	3.27	0.0917	3.14	0.0879
ME F	noise	2.48	0.0521	2.55	0.0536	2.50	0.0550	3.09	0.0680
	vibration	2.84	0.0653	3.13	0.0687	2.56	0.0589	3.20	0.0768
	microclimate	2.73	0.0683	2.83	0.0821	3.06	0.0765	3.05	0.0641
	lighting	3.31	0.0794	3.20	0.0832	3.24	0.0907	3.45	0.0987
	dust pollution	3.16	0.0853	3.25	0.0975	3.23	0.0969	3.27	0.0948

Notes. HF—human factor; C-T F—construction-technological factor; ME F—material environment factor; EN-57, EU-07, ET-22, EP-09—types of locomotives; M_i—feature evaluation.

In this case, all respondent evaluations were taken into account in calculating the average results, that is, unacceptable grades too. This allowed making comparisons in terms of ergonomic levels of different locomotive types as well as of the entire set studied. The evaluations of priority features contained in Tables 4 and 5 show links between feature status and locomotive type, which result from the quality of particular construction solutions. The most recent construction solution among the studied locomotives was used in the EP-09 locomotive, and it was this locomotive that scored the highest in terms of priority feature evaluations. An analysis of particular factors points to low evaluations of the material environment priority features. Only in the case of the EP-09 locomotives none of the features was graded as *unacceptable*. Table 6 contains generalised weight rates and global ergonomic diagnosis rates for the studied set of locomotives. The EP-09 locomotive achieved the highest global ergonomic diagnosis rate of 3.77. Based on these results, a general conclusion could be made that the ergonomic levels of the studied locomotives oscillate around the value of 3, that is, *acceptable*. Using the ergonomic diagnosis method in particular individual locomotives—and using known evaluation methods for particular features—would make it possible to clearly define their ergonomic level and point to an optimal modernisation strategy.

TABLE 6. Generalised Weight Rates and the Global Ergonomic Diagnosis Rate for the Studied Locomotives

Rates of Diagnosis	Set of Studied Locomotives	EN-57	EU-07	ET-22	EP-09
Generalised evaluation weight rate for H F (Q_1)	4.02	4.02	4.00	4.00	4.29
Generalised evaluation weight rate for C-T F (Q_2)	3.44	3.27	3.31	3.61	3.84
Generalised evaluation weight rate for ME F (Q_3)	2.87	2.82	2.92	2.80	3.19
Global ergonomic diagnosis rate (Q_{glob})	3.44	3.37	3.41	3.47	3.77

Notes. HF—human factor; C-T F—construction-technological factor; ME F—material environment factor; EU-07, EN-57, ET-22, EP-09—types of locomotives.

6. CONCLUSIONS

The assumptions of the method for ergonomic diagnosis of the driver's workplace and its preliminary application made it possible to ascertain and evaluate the ergonomic level of the cabins in the studied electric locomotives.

The general ergonomic diagnosis rate Q_{glob} as defined in this paper is heuristic in its nature. It is based on expert-assigned weights and evaluations. In this way, both the values and the evaluations contain a certain subjective element, which is minimised by statistical averaging. The evaluations of priority features obtained in this way are compatible with those arrived at in different ways, that is, using measuring techniques, as evidenced in the results of research on features of the material environment obtained by the Railways Scientific and Technological Centre (commissioned by the Polish State Railways).

The conclusions of this study can be used in modernisation of the operated locomotives, and for diagnosing the rolling stock purchased abroad.

Moreover, from the methodological point of view, analysis of the gathered data confirmed the usefulness of the questionnaire in extracting expert knowledge.

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