

Integrated Environment Assessment at Work Station of a Specialist

N.A. Nazarenko, S.S.S. Nasser, P.I. Paderno and N.I. Kurakina

Saint Petersburg Electrotechnical University "LETI"

Abstract: Environment assessment at work station, based on measuring of particular environment indices (gas, dust concentration, etc.) and comparing acquired data to standard values, does not provide an objective answer: to what extent working environment is detrimental to the specialist's health, how heavy the labour is at a certain work station of a specialist. A certain approach to integrated quantitative environment assessment at work station (WS) of a specialist is examined. The suggested approach is based on a two-stage procedure. At the first stage conversion of particular indices of separate environmental characteristics at WS into quantitative indices is performed. At the second stage acquired values of particular indices are integrated into a singular criterion. Implementing the suggested method allows decreasing the time required for an integral assessment of working environment at work station and helps to increase its accuracy. Solving the given tasks based on expert examination might provide a methodological basis for designing and inflation of an automated decision support system for assessment of a working environment at work station of a specialist or work station as a whole.

Key words: Environment assessment • Work station • Indices • integration

INTRODUCTION

Assessment of particular environment indices at a work station is usually carried out by measuring their values (gas, dust concentration, etc.) and comparing acquired data to figures given in standardized documents (national and international standards). According to the results of comparison a decision is made about classifying the analyzed index into a certain category. Such an approach does not provide an objective answer: to what extent working environment is detrimental to the specialist's health, how heavy the labour is at a certain WS, as it usually evaluates environment conditions according to different indices. Quantitative integrated environment evaluation at WS is not carried out.

Integrated approach to environment evaluation at WS is suggested, based on solving the following tasks [1-3]:

- Transforming all acquired values of particular indices at WS to one scale (0 to 1 or 0 to 100%), i.e. acquiring particular grades.

- Acquiring integral index value (evaluation of the whole complex of environmental indices at WS) based on correct integration of particular grades.

Solution of the tasks stated above:

Task 1: Transforming values of the analyzed index to one scale is performed based on the results of expert survey.

i-index model, according to expert opinion, is as follows:

$$\Delta_i = [\Delta_{ibottom}, \Delta_{itop}], \Delta_i = \bigcup_{k=1}^{n_i} G_{ik}, \text{ with } G_{ik} \cap G_{ij} = \emptyset$$

If *i*-index has a certain value in a certain state, then an expert might identify its condition as good, acceptable, medium, poor, extremely poor. Number of these conditions might be identified differently depending on an expert which increases the chance of a mistake (increases the margin of error) in environment evaluation at WS. It is suggested to introduce a step function, whose values are situated in the interval 0 to 1 and enable one to doubtlessly identify enlarged state (index interval).

Hence under the expression “a specific index value is acquired according to the results of measurement” should be understood that the value prescribed by the expert opinion to the interval where it is situated.

In order to solve the task 1, it is necessary to solve subsidiary problems:

- Determine relative qualification (competence) of all (each) expert for each analyzed index.
- Set a multitude of subranges for each analyzed index, where index values should be considered equal (indistinguishable).
- Set a grade (v_i) (standardized) for each of subrange values for analyzed index (w_i).
- Design a dependence which allows setting a numeric (standardized) grade for each value of the analyzed index.

Following basic approaches are suggested in order to solve the problems mentioned above.

Expert Relevance (Competence): In order to analyze expert competence approaches based on texts, documents, cross- and self-evaluation data, the latter can also include previous expert examination results [4]. In reality experts are usually considered equal and that their relevance (competence) coefficient is the same and equals 1. This approach is not entirely correct, as, for example, expert experience and knowledge might differ, therefore we presume that γ_i is relevance of i -expert.

Setting Subranges for Initial Indices: Using the following single method is suggested in order to set subranges where index values can be considered the same [5, 6]:

- Amount of subranges is defined by the specialists analyzing expert opinions based on preparatory study of special literature and documents
- Experts are to set the subrange limits within which index value changes are not fundamental. As a result each expert provides a set of subrange limits:

$$W_{ji} = (w_{ji1}, w_{ji2}, \dots, w_{jim+1})$$

where j is the number of index to be examined, m is the number of recognizable index values, i is the number of an expert.

For each expert and index the following inequations hold:

$$\Delta_{jbottom} = w_{ji1} < w_{ji2} < \dots < w_{jim+1} = \Delta_{jtop} \quad i = 1, 2, \dots, k$$

The values of the ends of the intervals where each expert believes the analyzed index to be constant.

- Expert opinion integration and correction of subrange limits

In order to correct subrange limits we use weighted arithmetic mean:

$$\bar{w}_{jl} = \sum_{i=1}^k \gamma_i \cdot w_{jil}, \quad l = 1, 2, \dots, m+1$$

where $(\gamma_1, \gamma_2, \dots, \gamma_k)$ is vector of expert relevance. As a result of this expert assessment of each index we obtain a set of values of the ends of the intervals where according to expert opinion index values are constant:

$$\bar{W}_j = (\bar{w}_{j1}, \bar{w}_{j2}, \dots, \bar{w}_{jm+1})$$

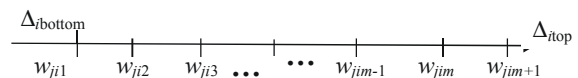
Method of Setting Index Values (Standardized) for Defined Subranges: Expert examination is used to set standardized index values in defined subranges.

- For each index experts are given defined subranges and asked to give a (generalized) grade from 0 to 1 based on their experience and knowledge. For experts' convenience information is given in a graphic form, namely in the form of a graphic presentation of index interval which is already, in order to avoid discussions, divided in subranges.

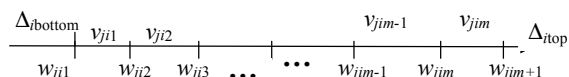
Experts are asked to give numeric values to grades as they feel to be correct, for example: excellent – 1 or 100%; very good – 0,8 to 0,9; good – 0,6 to 0,8 and so forth.

Experts turn in their sheets to the research group as in the Picture 2.

- Each of k experts provides a set of different values: $V_{ji} = (v_{ji1}, v_{ji2}, \dots, v_{jim})$, corresponding to defined intervals.



Pic. 1: Blank sheet given to an expert



Pic. 2: A work sheet turned in by an expert

- Obtaining average values. In order to obtain average value we use weighted geometric mean, which is a more pessimistic evaluation method than weighted arithmetic mean. Hence we obtain average values for each index value in the subranges:

$$\bar{v}_{jl} = \prod_{i=1}^k v_{jil}^{\gamma_i}, \quad l=1, 2, \dots, m.$$

As a result of expert assessment we obtain a set of numeric grades of an index which, according to expert opinion, are practically constant in the given intervals:

$$\bar{V}_j = (\bar{v}_{j1}, \bar{v}_{j2}, \dots, \bar{v}_{jm})$$

Transforming quantitative indices, acquired by measuring, into grades, constant in the given intervals, is finished.

Designing a Dependence Which Allows Setting a Numeric (Standardized) Grade for Each Value of the Analyzed Index: Designing a dependence can be performed by designing an analytic (in some cases linear) function, approximating the obtained step function, for example, by LS method considering input values.

Task 2: Acquiring integral index value, evaluation of the whole complex of environmental indices at WS.

This task consists of the following subsidiary problems:

- Evaluation of weight coefficient (importance coefficient) for particular indices
- Setting numeric gradation (intervals) for integral index values.

Solution for each subsidiary problem is as follows:

Evaluation of Weight Coefficient (Importance Coefficient) for Particular Indices: Expert opinion integration (considering their different competence) is provided by correct usage of a modified analytic hierarchy process [7-9]. It results in a standardized vector $\bar{\beta} = (\beta_1, \beta_2, \dots, \beta_n)$, whose elements depict the influence (input) of particular

measured environment indices at WS on the integral index, characterizing the working environment at WS as a whole.

Setting Numeric Gradation (Intervals) for Integral Index Values: Method, similar to the method described earlier, should be used for setting intervals (interval limits) to divide integral index value, which characterizes comfort (discomfort) of working environment at WS.

- The number of ranges is defined by the specialist (research group).
- Experts set the range limits for the integral assessment, in which they classify the working environment at WS accordingly. An example is given for simplification. Each of the experts has provided the following set of limits: $D_i = (d_{i1}, d_{i2}, \dots, d_{ir+1})$, where r is the number of ranges, defined for integral index; i is the number of an expert. Inequalities hold for the acquired set of limits:

$$0 = d_{i1} < d_{i2} < \dots < d_{ir} < d_{ir+1} = 1$$

Values of the ends of the intervals, where experts interpret integral index the same way, are obtained as a result.

- Obtaining average values for the ends of the intervals.

In order to obtain average values we use the weighted arithmetic mean $\bar{d}_l = \sum_{i=1}^k \gamma_i \cdot d_{il}$, $l=1, 2, \dots, r+1$, where

$(\gamma_1, \gamma_2, \dots, \gamma_k)$ is weight (competence) vector.

The result is a set of values of the ends of the intervals, where values of integral index of working environment at WS is interpreted the same way:

$$\bar{D} = (\bar{d}_1, \bar{d}_2, \dots, \bar{d}_{r+1})$$

It is possible to design a smoothing or approximating function, which allows obtaining a numeric grade for each of integral index values, but this dependence is too dependent on expert opinion and cannot give an accurate assessment.

RESULTS AND CONCLUSIONS

- Method for acquiring integral assessment of working environment at WS is given.

- Implementing the suggested method allows decreasing the time required for an integral assessment of working environment at WS and helps to increase its accuracy.
- Solving the given tasks based on expert examination might provide a methodological basis for designing and inflation of an automated decision support system for assessment of a working environment at WS of a specialist or WS as a whole.

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