Standardization of food smoking production within the framework of environmental engineering

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Abstract. Currently, there is a fairly large number of methods and systems of production management that are successfully applied all over the world. Their use in the modern enterprise management is due to the fact that in its daily activities it must ensure not only the production of high-quality and safe products, but also take into account the environmental aspects of production, ensure the safety of workers, and look for ways to improve their production activities. This situation contributes to the convergence and unification of controls among different management systems. The development of a methodological approach to the standardization of production activities based on the integration of the requirements of general management systems, which is the basis for documenting the elements of these systems at the enterprise, undoubtedly corresponds to modern trends in production management.

1. Introduction

One of the main tasks of the economic activity of enterprises in modern conditions is the introduction of environmental engineering, which makes it possible to implement the idea of sustainable development of any industrial enterprise that can simultaneously reduce the harmful impact on the environment and increase the efficiency of technological processes.

As an effective means of implementing the company's strategy to improve the quality of production processes, it is necessary to highlight the quality management system (hereinafter QMS), the food safety management system (hereinafter FSMS), the internal quality control system based on the Hazard Analysis and Critical Control Points principles (hereinafter HACCP), the lean production management system (hereinafter LPMS), as well as the use of modern quality management methods as tools to ensure the performance of these systems. In addition, the specificity of the production activities of enterprises producing food products determines the development and implementation of an environmental management system (hereinafter EMS) at enterprises.

It is obvious that the development and implementation at the enterprise of each of the above management systems (hereinafter referred to as the general management systems) solves very important issues of conducting effective activities. However, taking into account the specifics of the functioning of general management systems, the requirements for their documentation, the issue of "information overload" of the enterprise with internal documentation that regulates its activities, bearing in mind the implemented systems, arises. An analysis of the requirements for the functioning of general management systems showed a significant convergence among their management methods. The use of the systematic approach to the implementation of the requirements of general management
systems based on the principles and methods of standardization, will ensure the development and implementation of an integrated quality management system at the enterprise that meets modern requirements for enterprise management. All of the above is especially relevant for enterprises producing smoked food products, this is due to the fact that:

- production of smoked food products is regulated by the requirements of the Technical Regulations of the Customs Union (TR CU), Technical Regulations of the Eurasian Economic Union (TR EAEU);
- the production of smoked food products is a multistage one, which determines the conduct, accounting and adjustment of production operations that do not form the value of the product for the consumer;
- the production of smoked food products implies the identification of environmental aspects and the presence of an environmental policy and strategy at the enterprise, since the emission of an air-smoke mixture into the atmosphere has an extremely negative effect on the environment due to the high content of hazardous carcinogenic and mutagenic compounds in it, including polyaromatic hydrocarbons (PAH) and nitroso compounds [1];
- production of smoked food products is characterized by ineffective consumption of smoke fume, since during the smoking process about 90% of the total amount of generated smoke is emitted into the atmosphere and only 10% of smoking smoke is effectively used [2];
- the workplace of the operator of the smoking production is characterized by high potential risks, due to excessive contact with the smoke-air mixture, leading to the corresponding occupational diseases - oncology of the skin and respiratory system.

Summarizing all of the above, as a solution to the above problems, taking into account the specifics of smoking production, the nomenclature of indicators characterizing the quality and safety of smoked food products, requirements for the safety of working conditions and environmental protection, it is proposed to develop a methodological approach to standardizing the working space of the operator of smoking installations based on integration elements of general management systems. In this regard, the purpose of this work was a system for standardizing the working space of the operator of smoking installations based on the integration of elements of general management systems. For this, the following tasks were solved:

- a model of the working space of the operator of the smoking installation was built;
- objects of general management systems among the elements of the working space of the operator of the smoking installation were identified and systematized;
- a methodological approach to standardization of the working space of the operator of a smoking installation based on the integration of the requirements of general management systems was developed;
- technical solutions to improve the efficiency of the elements of the working space of the operator of the smoking installation based on the developed methodological approach were proposed.

2. Results and discussion
In accordance with the first research task, a model of the working space of the operator of the smoking installation was developed. The development of the model was carried out in accordance with the terms and definitions contained in GOST R 56906-2016 “Lean production. Organization of workspace (5S)” , intended for use in the FSMS and other management systems and applied to organizations, regardless of their size, ownership and type of activity.
As the first contour of the structural model, the contour of the working space was presented, it included: the working table of the operator of the smoking installation, fuel (sawdust, shavings, wood chips, etc.) and the equipment necessary for performing the technological operation of smoking and the ventilation system. As the second contour of the model, the contour of the workplace is presented, equipped with the necessary technical means: a smoking chamber, a smoke generator, control and measuring devices (hereinafter instrumentation).

A model of the working space of the smoker operator is shown in figure 1.

![Diagram of working space and workplace](image)

**Figure 1.** Model of the working space of the operator of the smoking installation

The identification of control objects of general management systems among the elements of the working space of the operator of the smoking installation was carried out for each element of a working space:

- smoke generator;
- smoking chamber;
- instrumentation;
- ventilation;
- fuel;
- desktop;
- fixtures

The following were identified as the general management systems in accordance with which the identification was carried out:

- QMS;
- LPMS
- FSMS / HACCP;
• EMS;
• occupational health and safety assessment series (hereinafter OHSAS).

The identified control objects of the general management systems in the elements of the working space of the operator of the smoking installation are presented in tables 1-7.

**Table 1. Smoke generator as an element of the working place.**

| Process name                                | Code | Safety control elements | LPMS control elements | FSMS, HACCP control elements | EMS control elements |
|---------------------------------------------|------|-------------------------|-----------------------|------------------------------|----------------------|
| Visual inspection for defects               | D1   | Prohibited:             | - generation of smoke | Possible risks:              | compliance with the   |
| Checking connections                        | D2   | - start the smoke       | with low carcinogenic   | -electric shock;            | recommended smoke     |
| Switching on                                | D3   | generator when the      | potential;             | -smoke-air mixture in the    | generation parameters |
| Setting the heating temperature             | D4   | connections are faulty; | -generation of smoke    | working room;               | ensures a decrease in  |
| Setting the air excess ratio                | D5   | -load fuel until the    | containing compounds    | -production of products     | the PAH content in     |
| Waiting for reaching the set temperature    | D6   | set temperature is      | that provide high       | with high carcinogenic      | smoke emissions.      |
| Fuel loading as needed                      | D7   | reached;                | organoleptic            | potential;                  |                      |
| Switching off                               | D8   | -disconnect connections | characteristics of the  | -fire.                      |                      |
| Waiting for the end of fuel smoldering      | D9   | during operation;       | product;               |                             |                      |
| Cleaning from combustion products           | D10  | -remove the glowing     | -maintaining the        |                             |                      |
|                                            |      | fuel;                   | required optical density|                             |                      |
|                                            |      | -touch heating and      | of the air-smoke         |                             |                      |
|                                            |      | metal parts;            | mixture.                |                             |                      |
|                                            |      | -repair the switched    |                         |                             |                      |
|                                            |      | smoke generator         |                         |                             |                      |

**Table 2. Instrumentation as an element of the working place**

| Process name                                | Code | Safety control elements | LPMS control elements | FSMS, HACCP control elements | EMS control elements |
|---------------------------------------------|------|-------------------------|-----------------------|------------------------------|----------------------|
| Visual inspection for defects               | P1   | Prohibited:             | - reliable measurement| Possible risks:              | Compliance with the   |
|                                             |      | -open the body of the   | results lead to           | -violation of technological  | recommended smoke     |
| Instrumentation maintenance                 | P2   | checked instrumentation;| obtaining products       | parameters. Leading to      | generation parameters |
| Measurement                                 | P3   | - calibrate instrumentation;| that meet customer | decrease in product          | ensures decrease in the |
|                                            |      | without proper          | requirements.            | quality;                    | PAH content in smoke  |
|                                            |      | qualification.          |                        | -violation of technological  | emissions.            |
|                                            |      |                         |                        | parameters, leading to the  |                      |
|                                            |      |                         |                        | production of unsafe         |                      |
|                                            |      |                         |                        | products                      |                      |

**Table 3. Smoking chamber as an element of the working place.**

| Process name                                | Code | Safety control elements | LPMS control elements | FSMS, HACCP control elements | EMS control elements |
|---------------------------------------------|------|-------------------------|-----------------------|------------------------------|----------------------|
| Visual inspection for defects               | K1   | Prohibited:             | - degree of drying     | Possible risks:              | -contamination of     |
| Checking connections                        | K2   | - start the smoking     | affects the integrity  | -electric shock;            | drains with           |
|                                            |      | chamber when external   | of the smoked products | -smoke-air mixture;         | carcinogenic smoking  |
|                                            |      | defects                 | cover and availability;|                             | components;           |


Loading the chamber with raw materials being processed

- start the smoking chamber when the connections are faulty;
- disconnect the connections while the smoke generator is running;
- open the heated chamber;
- open the chamber while the smoke generator is running;
- touch heating and metal parts;
- repair the smoking chamber while it is working;

Switching on

- open the heated chamber;
- open the chamber while the smoke generator is running;
- repair the smoking chamber while it is working;

Setting parameters for drying raw materials

- open the heated chamber;
- disconnect the connections while the smoke generator is running;

Waiting for the end of drying

- disconnect the connections while the smoke generator is running;

Setting parameters for cooking raw materials

- open the chamber while the smoke generator is running;

Waiting for the end of cooking

- touch heating and metal parts;
- repair the smoking chamber while it is working;

Switching off

- open the heated chamber;

Waiting for the chamber cooling and complete removal of smoke-air mixture from it

- touch heating and metal parts;

Unloading products from the chamber

- repair the smoking chamber while it is working;

Chamber washing

- repair the smoking chamber while it is working;

Possible risks:

- smoke-air mixture in the working room;
- products with high carcinogenic potential;
- non-compliance of products with consumer requirements;
- violations in accounting of material assets.

Table 4. Desktop as an element of the working space.

| Process name | Code | Safety control elements | LPMS control elements | FSMS, HACCP control elements | EMS control elements |
|--------------|------|--------------------------|-----------------------|-------------------------------|----------------------|
| Keeping a protocol of technical inspection of instrumentation | R1   | It is prohibited: - refusal to document smoking production is prohibited; - it is prohibited to keep records in an inappropriate form; | - generation of smoke with a low carcinogenic potential; - generation of smoke containing compounds that provide high organoleptic characteristics of products; - production of products that meet consumer requirements; | - possible risks: - smoke-air mixture in the working room; - products with high carcinogenic potential; - non-compliance of products with consumer requirements; - violations in accounting of material assets. | - observance of the recommended parameters of smoke generation ensure a decrease in the PAN content in smoking emissions. |
| Keeping a protocol of technical inspection of the smoking chamber | R2   | | | | |
| Keeping a protocol of technical inspection of the smoke generator | R3   | | | | |
| Keeping a protocol of technical inspection of ventilation | R4   | | | | |
| Documentation of the availability and number of tools, workwear, fuel | R5   | | | | |
| Control of technological parameters of smoking production for compliance with the requirements of regulatory documents | R6   | | | | |
| Documentation of the smoking process at all stages, indicating the time and technological parameters | R7   | | | | |
### Table 5. Ventilation as an element of the working space.

| Process name                                      | Code | Safety control elements                                                                 | LPMS control elements                                                                 | FSMS, HACCP control elements                                                                 | EMS control elements                                                                 |
|--------------------------------------------------|------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Visual inspection for defects                    | V₁   | Prohibited: -switch off the extractor while the smoke generator is running; -switch off the extractor until the smoke chamber and smoke generator are completely free from the smoke-air mixture. | Timely removal of products of primary pyrolysis of wood makes it possible to obtain a product with a low carcinogenic potential | Possible risks: -smoke-air mixture in the working room; -products with high carcinogenic potential. | Smoke emissions significantly pollute the environment with carcinogenic components. |
| Connection's checking                             | V₂   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
| Switching on                                     | V₃   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
| Cleaning from fuel combustion products as it gets dirty. | V₄   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
|                                                   | V₅   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |

### Table 6. Fixtures as an element of the working space.

| Process name                                      | Code | Safety control elements                                                                 | LPMS control elements                                                                 | FSMS, HACCP control elements                                                                 | EMS control elements                                                                 |
|--------------------------------------------------|------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Visual inspection for defects                    | I₁   | Prohibited: -contact by unprotected skin areas with smoke fume and fuel combustion products; -be in the working place without respiratory protection. |                                                                                       | Possible risks: - systematic contact of the skin and / or respiratory tract with fuel pyrolysis products leads to carcinogenic and mutagenic effects on the operator's body. | Negative impact on the safety of workers in smoking industries.                     |
| Use of special clothes                           | I₂   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
| Use of fixtures to clean gadgets                 | I₃   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
| Washing fixtures to clean gadgets                | I₄   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
| Removal and processing of workwear               | I₅   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |

### Table 7. Fuel as an element of the working space.

| Process name                                      | Code | Safety control elements                                                                 | LPMS control elements                                                                 | FSMS, HACCP control elements                                                                 | EMS control elements                                                                 |
|--------------------------------------------------|------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Bringing in compliance with the moisture requirements for smoking fuel | T₁   | Prohibited: -soaking fuel in water; - fuel storage in humid environment                   | -generation of smoke with a low carcinogenic potential; - generation of smoke containing compounds that provide high organoleptic characteristics of products | Possible risks: -products with high carcinogenic potential; -products with low quality indicators. | Compliance with the recommended moisture content parameters ensures a decrease in the PAH content in smoking emissions. |
| Storage at appropriate humidity or in vacuum     | T₂   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
| Determination of the volume of a portion of fuel, sufficient, but not redundant for the smoke generation cycle | T₃   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
| Loading into the smoke generator as the previous portion is removed | T₄   |                                                                                          |                                                                                       |                                                                                              |                                                                                     |
The data presented in tables 1-7 show the areas of unification and integration of general management systems into the elements of the operator's working space of a smoker.

To systematize the identified areas of unification and integration of general management systems into the elements of the working space of the operator of the smoker, the data obtained in the course of the research were systematized and presented in the form of Table 1. For ordering and visual representation when structuring the data in the cells of the table, the following color indicators were used:

- red cell - the QMS control element, highlighted in red, means the potential for making technological decisions related to saving resources, since, in accordance with the LPMS methodology, it does not generate added value for the consumer;
- green cell - the QMS control element, highlighted in green, means, in accordance with the LPMS methodology, the place where the added value of the product is formed at the consumer;
- yellow cell - the EMS control element highlighted in yellow means the need to implement the EMS requirements for this stage of the operation of the operator of the smoking installation and the control element (s) of the QMS;
- blue cell - the FSMS / HACCP control element highlighted in blue means the need to implement the FSMS / HACCP requirements for this stage of the operation of the smoking installation and the QMS control element (s);
- lilac cell - a OHSAS control element highlighted in lilac means the need to implement the OHSAS requirements for this stage of the operator of the smoking installation and the QMS control element (s).

The systematization of the identified areas of unification and integration of general management systems into the elements of the working space of the operator of the smoking installation is presented in table 1.

**Table 8.** Systematization of the identified areas of unification and integration of general management systems into the elements of the working space of the operator of a smoker.

| Name of the smoker's operator work stage | QMS control element | LPMS control element | EMS control element | FSMS/ HACCP control element | OHSAS control element | Duration of the QMS control element, minutes | Possibility to improve the elements of the working space |
|----------------------------------------|---------------------|----------------------|---------------------|----------------------------|----------------------|---------------------------------------------|--------------------------------------------------|
| Preparation of personal protective equipment, measuring instruments and ventilation for work | I₁ | I₂ | V₁ | V₂ | V₃ | P₁ | P₂ | T₁ | T₂ | R₁ | R₂ | R₃ | Duration of the QMS control element, minutes | Possibility to improve the elements of the working space |
| Smoke generator check | D₁ | D₂ | | | | | | | | | | | | |

The systematization of the identified areas of unification and integration of general management systems into the elements of the working space of the operator of the smoking installation is presented in table 1.
| Name of the smoker’s operator work stage | QMS control element | LPMS control element | EMS control element | FSMS/HACCP control element | OHSAS control element | Duration of the QMS control element, minutes | Possibility to improve the elements of the working space |
|-----------------------------------------|---------------------|---------------------|--------------------|---------------------------|----------------------|----------------------------------|-----------------------------------------------|
| Loading of semi-finished products of the smoking chamber | R₃ | | | | | 2 |  |
| Drying | K₃ | | | | | 5-10 |  |
| | K₄ | | | | | 2 |  |
| | K₅ | | | | | 2 |  |
| | K₆ | | | | | 25-30 |  |
| | P₃ | | | | | 5 |  |
| | R₆ | | | | | 25-30 |  |
| Cooking | K₇ | | | | | 2 |  |
| | K₈ | | | | | 30-60 |  |
| | P₃ | | | | | 5 |  |
| | R₆ | | | | | 30-60 |  |
| Preparation of the smoke generator | D₃ | | | | | 1 |  |
| | D₄ | | | | | 2 |  |
| | D₅ | | | | | 5 |  |
| | D₆ | | | | | 10 |  |
| | P₃ | | | | | 5 |  |
| | T₃ | | | | | 5 |  |
| | R₆ | | | | | 10 |  |
| Smoking | D₇ | | | | | 30-60 |  |
| | D₈ | | | | | 1 |  |
| | D₉ | | | | | 5-10 |  |
| | D₁₀ | | | | | 5 |  |
| | K₉ | | | | | 2 |  |
| | K₁₀ | | | | | 30-60 |  |
| | P₃ | | | | | 5 |  |
| | T₄ | | | | | 30-60 |  |
| | R₆ | | | | | 30-60 |  |
| Cooling | K₁₁ | | | | | 1 |  |
| | K₁₂ | | | | | 10 |  |
| | P₃ | | | | | 5 |  |
| | R₆ | | | | | 10 |  |
| Unloading of finished products | K₁₃ | | | | | 5-10 |  |
| Sanitization | K₁₄ | | | | | 10 |  |
| | V₄ | | | | | 1 |  |
| | V₅ | | | | | 5 |  |
| | I₃ | | | | | 10 |  |
| | I₄ | | | | | 5 |  |
| | I₅ | | | | | 5 |  |
| | P₃ | | | | | 5 |  |
| Documentation of technical process parameters | R₇ | | | | | 10 |  |

* indicate elements of the working space of the operator of the smoker, determined for the implementation of technical solutions to improve the efficiency of activities.
The data set and their structure, presented in Table 1, represent a methodological approach to the sequence of implementation and the content of measures to standardize the working space of the operator of smokers based on the integration of the requirements of general management systems. The possibility of simultaneous implementation of the requirements of general management systems in the production process based on standardization in the development of internal documentation, as well as the ability to realistically understand the places of the process for which it is possible to develop and implement technical solutions to improve the efficiency of work should be noted as an advantage of the proposed methodological approach.

In accordance with the next research task, based on the data presented in Table 1, technical solutions were proposed to increase the efficiency of the elements of the working space of the operator of the smoker based on the developed methodological approach:

• at the pre-drying stage (K₄), the switching on of the smoking chamber can be improved by automating the process of switching on when the chamber is closed, which will reduce the time for its implementation to zero;
• the stage of preparation of the smoke generator (D₃) can be improved by automatically switching it on after a specified period of time from switching on the smoking chamber, which will reduce the time for its implementation to zero;
• It is proposed to automate the smoking stage (D₇) by installing a fuel dispenser equipped with a timer, which will reduce the time for its implementation to zero;
• during the period of the end of the smoking stage (D₉, D₁₀), it is possible to eliminate waiting for the end of fuel smoldering and cleaning the smoke generator from fuel combustion products by using an external mobile sealed bunker, into which fuel combustion products are placed through the pipeline for further cooling, which will reduce the time for its implementation up to 1-2 minutes.

3. Conclusion
The developed methodological approach to standardization of the working space of the operator of the smoker based on the integration of the requirements of the general management systems, including the construction of a model of the working space of the operator of the smoker the identification of control areas, identified areas of integration and integration of the general management systems into the elements of the working space of the operator of the smoker, the standardization of management elements of the working space of the operator of the smoker, allows to reduce the risks of environmental pollution by smoke emissions and increase the level of safety of the working space of the operator of the smoker.

References
[1] Kim I N 2016 Carcinogenic polycyclic aromatic hydrocarbons and nitroso compounds in smoking environments and smoked products (Vladivostok: Dalrybvtuz)
[2] Kim E N, Kim I N and Radakova T N 1989 Obtaining a smoking preparation during the purification of smoke emissions from smoking chambers Fish industry 3, 80-4