

OCCUPATIONAL SAFETY MANAGEMENT SYSTEM IN MANUFACTURING ENTERPRISES: A PROGRAM FOR CREATING A CONCEPTUAL MODEL FOR RISK ASSESSMENT AND ANALYSIS***Sulaymanov Sunnatulla Sulaymanovich****Doctor of technical sciences, professor, Tashkent State Transport University
+99897775-51-79 ssulayman@mail.ru**Orcid number <https://orcid.org/0000-0001-5275-5200>****Saidov Doston Nuriddin ugli****PhD candidate of Tashkent State Transport University
+99890 167-96-00**doston.saidov.1996@mail.ru**Orcid number <https://orcid.org/0009-0004-4803-6026>****Batirova Mavluda Mirxadiyevna****Senior teacher of Tashkent State Transport University
+998 91 191 46 56**movludabotirova0@gmail.com**Orcid number <https://orcid.org/0009-0006-8542-003>*

Abstract: This article describes the conceptual model for creating a program for creating a conceptual model of a labor protection management system at manufacturing enterprises and examples of the created program. A conceptual model for assessing and analyzing risks is proposed for developing a labor protection management system at manufacturing enterprises. The model uses modern approaches and digital technologies aimed at minimizing production risks based on the requirements of the ISO 45001 standard. Also, accidents are analyzed and safety measures are determined based on the Heinrich theory, Domino theory and the human factor model. As part of the model creation, a Python software model was developed to increase production safety, which allows monitoring and assessing the level of worker safety. The results indicate the need to apply innovative approaches to minimizing risks and increasing labor productivity at enterprises.

Keywords: Labor protection, risk assessment, ISO 45001, production safety, digital technologies, python model

Introduction. The effective organization of occupational safety and the establishment of a safety culture in manufacturing enterprises are among the most crucial aspects of modern industrial development. Various risk factors exist in production processes, and the ability to identify, assess, and effectively manage them in advance is an integral part of occupational safety. Ensuring safe working conditions not only protects employees' health and lives but also plays a vital role in increasing productivity and ensuring the sustainable development of enterprises.

The following theoretical models are utilized to ensure occupational safety in the management of labor protection: Heinrich's Theory (which suggests that behind every major accident, there are 29 minor incidents and 300 near-misses) [1], Domino Theory (which explains that accidents occur as a result of a chain reaction of interrelated events) [2], and Human Factor Theory (which states that workers' skills and behavior directly impact safety) [3].

Methodology. ISO 45001 is an international standard for occupational health and safety management systems, encompassing elements such as development, implementation, monitoring, and continuous improvement [4].

To successfully implement a practical model of an occupational safety management system, the following stages are developed: assessment phase, planning phase, implementation phase, and analysis and monitoring phase.

The scientific and theoretical foundations of occupational safety management focus on ensuring safety in production processes, preventing workplace accidents, and safeguarding employees' health. To adapt this system to industrial conditions, it is necessary to develop a comprehensive management system based on modern risk analysis methods, digital technologies, and international standards [5].

The organization and management of occupational safety in manufacturing enterprises consist of the following stages:

Formulating Occupational Safety Policy – The company's management develops a general safety and occupational health policy, ensuring compliance with international (ISO 45001) and national standards while defining commitments to protect employees' health and safety.

Risk Identification and Assessment – Potential hazards in workplaces are identified, risk assessment methods such as FMEA, HAZOP, and SWOT analysis are applied, and measures are developed to reduce risks based on workplace condition assessments.

Implementation of Regulatory and Legal Documents – Internal occupational safety regulations are established, workplace safety standards are created, and compliance with labor codes and legal regulations is ensured.

Training and Education in Occupational Safety – Regular training sessions for employees and managers are conducted on workplace safety, emergency response procedures, and the correct use of personal protective equipment (PPE) [6].

Implementation of Control and Monitoring Systems – Work conditions are continuously monitored, employee compliance with safety requirements is checked, and accident and occupational disease statistics are maintained regularly.

Emergency Preparedness – Plans for fire, explosion, and chemical hazards are developed, rapid response teams are formed, evacuation routes are designated, and drill exercises are conducted.

Continuous Improvement of the Occupational Safety System – The system is regularly updated based on employee feedback, innovative technologies, and automated management systems. Internal and external audits are conducted to assess the effectiveness of the safety system.

The sequential processes outlined above contribute to ensuring a safe working environment in industrial enterprises, reducing workplace accidents, and increasing labor productivity.

Below, we develop a conceptual model for organizing and managing occupational safety in industrial enterprises. This model includes all key stages of occupational safety and is built on a systematic approach.

The proposed model represents the step-by-step process of organizing and managing occupational safety in industrial enterprises. It can be utilized to enhance industrial safety management and establish a structured control system.

A Python-based program has been developed to implement this occupational safety management model, with a corresponding code structure prepared for automation.

```
from graphviz import Digraph
# Mehnat muhofazasini tashkil etish va boshqarish jarayoni modeli
dot = Digraph('Mehnat Muhofazasi Boshqaruv Modeli')
# Tugunlar (bosqichlar)
dot.node('A', '1. Mehnat muhofazasi siyosatini shakllantirish')
dot.node('B', '2. Risklarni aniqlash va baholash')
dot.node('C', '3. Mehnat muhofazasi bo'yicha normativ-huquqiy hujjatlar')
dot.node('D', '4. Mehnat muhofazasi bo'yicha trening va o'qitish')
dot.node('E', '5. Nazorat va monitoring tizimini joriy etish')
dot.node('F', '6. Favqulodda vaziyatlarga tayyorgarlik')
dot.node('G', '7. Mehnat muhofazasi tizimini takomillashtirish')
# Bog'lanishlar
dot.edge('A', 'B')
dot.edge('B', 'C')
dot.edge('C', 'D')
dot.edge('D', 'E')
dot.edge('E', 'F')
dot.edge('F', 'G')
dot.edge('G', 'B', label='Tahlil natijalariga asoslanib qayta ko'rib chiqish')
dot.render('mehnat_muhofazasi_modeli', format='png', cleanup=False)
```

Result. An algorithmic model of labor protection organization and management processes was developed using the Python program. For this, the Python program and the Jupyter Notebook (.ipynb) platform must be installed on the computer. To launch this platform, perform the following steps:

For Windows OS:

1. Press Win + R to open cmd (Command Prompt).
2. Enter the following command “jupyter notebook” and press Enter.
3. The Jupyter interface opens in the browser.

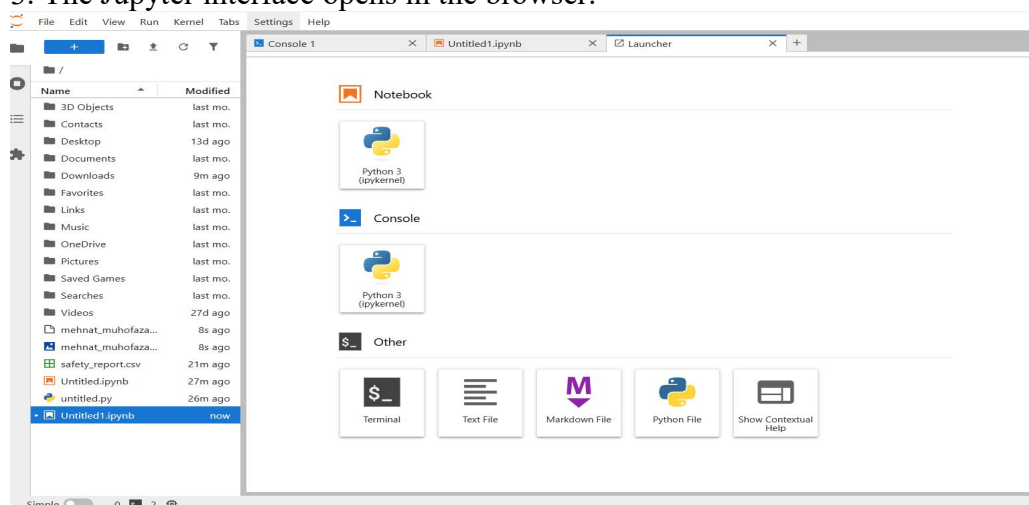
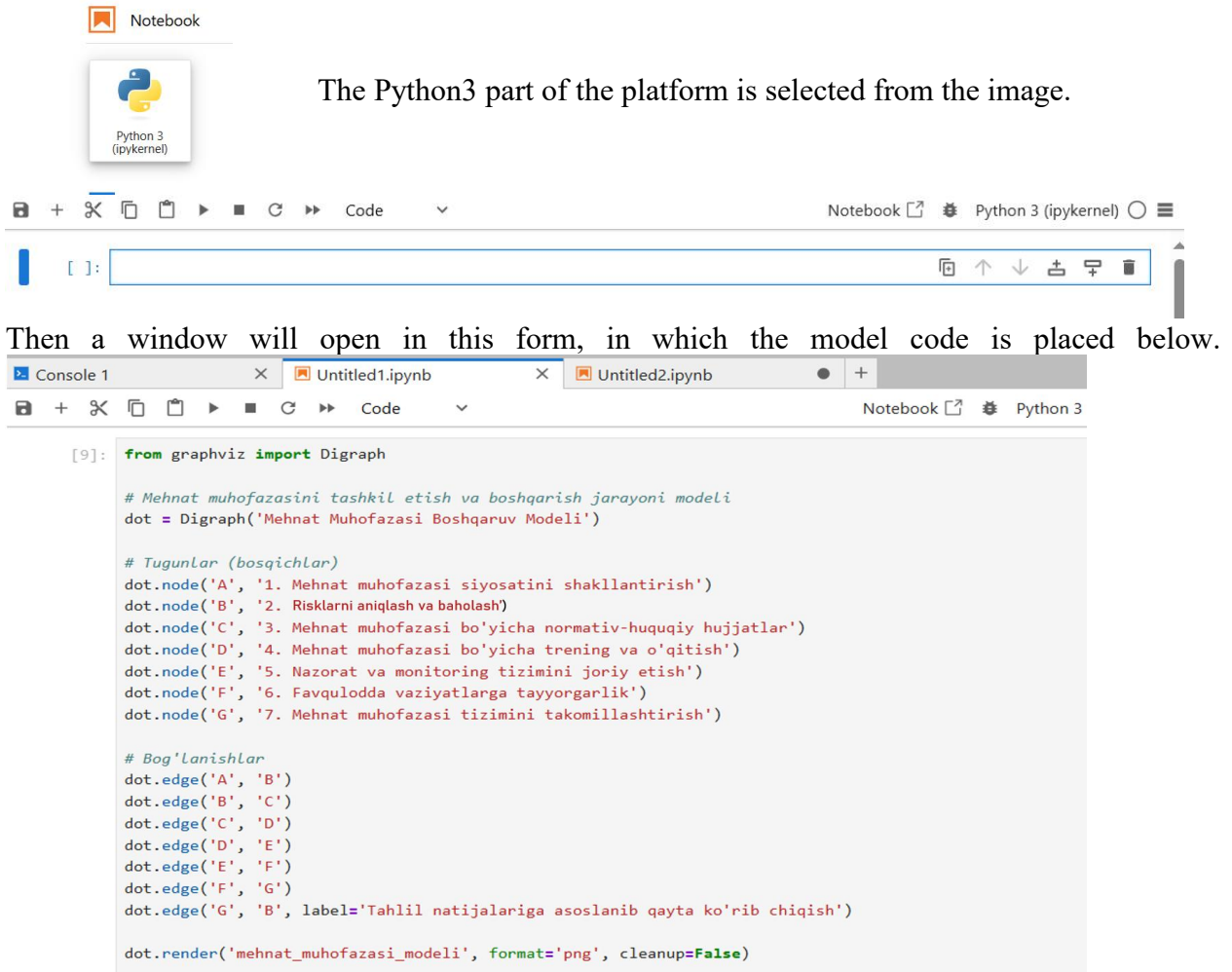


Figure 1. Overview of the Jupyter interface in the browser

**Figure 2. Model view in Jupyter window**

After pasting the model code, pressing Shift+Enter will display the answer in a window like this.

This response will appear in the window. Now, to open this file, a command is given to the code part of the Jupyter interface.

```
from IPython.display import Image
Image('mehnat_muhofazasi_modeli.png')
```

When this command is given, the model drawing below will open in the Jupyter interface (Figure 2).

During this program, a simple small code is written that also demonstrates the "Safety Monitoring System for Workers". This code is also written using Python and the response is received through the Jupyter interface. The model performs the following functions: Assessing the risk level of workers, Checking compliance with safety rules, and Generating a Report.

This code is written to assess the safety rating of workers and determine the level of risk.

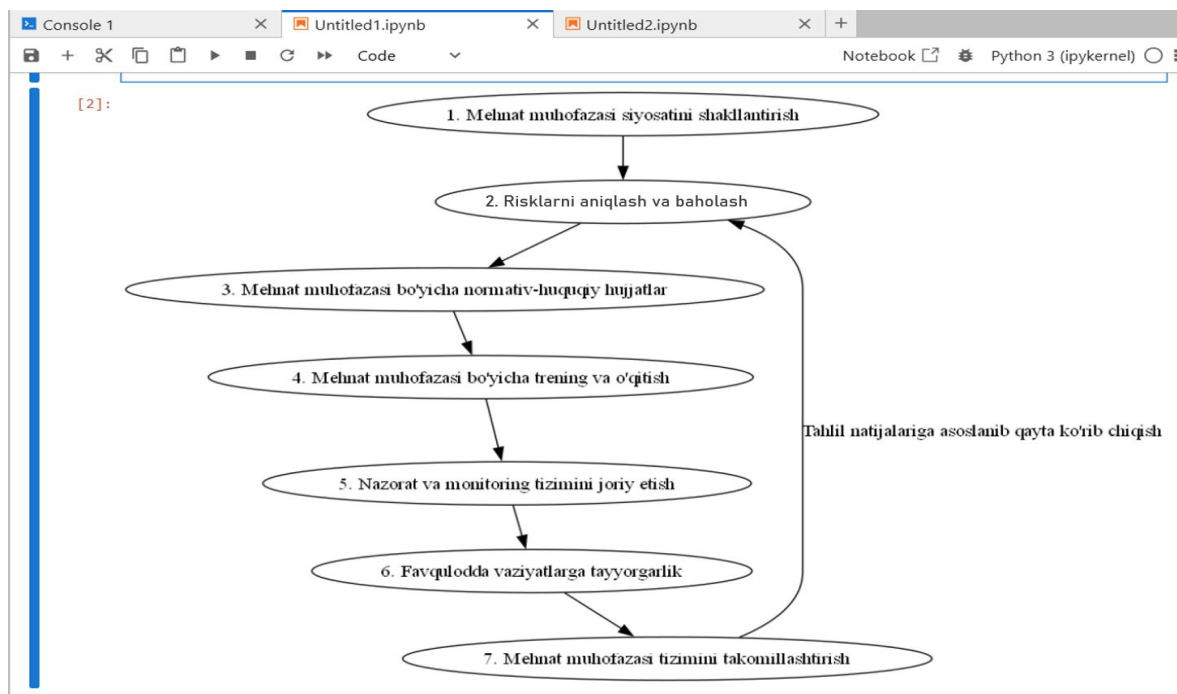


Figure 3. Model of the processes of organizing and managing labor protection in manufacturing enterprises

The purpose of writing the code is:

Analyze the safety score of workers

Assign a risk level for each worker (Safe, Medium risk, High risk)

Create a table of results and save it to a CSV file

How the code works

List of workers

Each worker is given an ID, Name, and Safety score (safety_score).

For example: {"id": 1, "name": "Ali", "safety_score": 95}

assess_risk(worker) function

Evaluates the risk level based on the worker's safety score:

80 and above → "Safe"

50-79 → "Medium risk"

Below 50 → "High risk"

generate_report(workers) function

```

# Ishchilar ro'yxati
✓ workers = [
    {"id": 1, "name": "Ali", "safety_score": 95},
    {"id": 2, "name": "Vali", "safety_score": 80},
    {"id": 3, "name": "Sardor", "safety_score": 60},
    {"id": 4, "name": "Jamshid", "safety_score": 30},
]

# Xavf darajasini baholash funksiyasi
✓ def assess_risk(worker):
    ✓ if worker["safety_score"] >= 80:
        return "Xavfsiz"
    ✓ elif 50 <= worker["safety_score"] < 80:
        return "O'rtacha xavf"
    ✓ else:
        return "Yuqori xavf"

# Hisobot yaratish
✓ def generate_report(workers):
    data = []
    ✓ for worker in workers:
        risk_level = assess_risk(worker)
        data.append([worker["id"], worker["name"], worker["safety_score"], risk_level])

    df = pd.DataFrame(data, columns=["ID", "Ism", "Xavfsizlik reytingi", "Xavf darajasi"])
    df.to_csv("safety_report.csv", index=False)
    print("Hisobot yaratildi: safety_report.csv")
    print(df)

# Hisobotni ishga tushiramiz
generate_report(workers)

```

Figure 4. Code for the safety monitoring system for workers

Calculates the risk level for each worker and adds it to the table

Displays the table on the screen

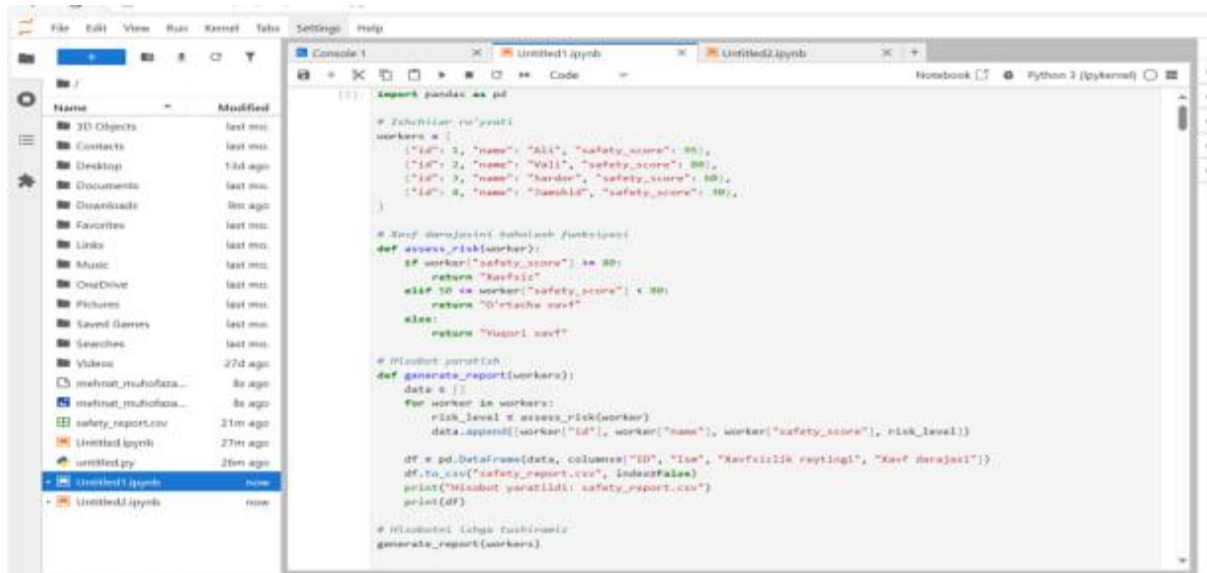
Saves it to a CSV file (safety_report.csv), which can then be used for analysis or monitoring.

Result (output report)

The table that appears on the screen:

ID	Name	Security Rating	Risk Level
1	Ali	95	Safe
2	Vali	80	Safe
3	Sardor	60	Moderate risk
4	Jamshid	30	High risk

This code can be used to automatically assess, monitor, and report on the safety level of workers, identify potential hazards in advance, and take action. When the code runs, a safety_report.csv file is created that can be opened in Excel or other programs. Each worker in the system has a safety rating. If he or she engages in unsafe behavior, his or her rating is lowered and the system issues a warning.



The response is obtained by running the following code in Python.

Figure 5. The view of the safety monitoring system for workers in Jupyter

The report was created by pressing Shift+Enter to run the code in this window.

To use the worker safety monitoring system code, you can run the following code in Python and get the following result. First, the code looks like this, and it is placed on the Jupyter platform.

```
Hisobot yaratildi: safety_report.csv
```

ID	Ism	Xavfsizlik reytingi	Xavf darajasi
0	1	Ali	95
1	2	Vali	80
2	3	Sardor	60
3	4	Jamshid	30

This code is designed to create a simple model for a worker safety monitoring system. Its purpose is to do the following:

1. Monitor worker

safety status – The data is created in a table format, which contains the following indicators for each worker:

Protective clothing (X) (1 – present, 0 – absent)

Safety compliance (Y) (as a percentage)

2. Calculate safety rating (Z) – The overall safety rating of each worker is calculated based on the following formula: $Z = X \cdot Y \cdot 100$

This rating helps determine how well an employee is following safety rules.

1. Output safety results – The results are displayed on the screen so that they can be easily reviewed.

2. Save results in CSV format – The results are saved in the safety_report.csv file for further analysis or use in other systems.

This system can be used to monitor how employees are following safety and identify problems in advance. If an employee has a low safety rating, additional work may be needed with them.

```
# Oddiy xavfsizlik monitoring tizimi
import pandas as pd

# Ishchilar xavfsizlik holati (misol uchun)
data = {
    "Ishchi": ["Ali", "Vali", "Gulnoza", "Kamol"],
    "Himoya kiyimi": [1, 0, 1, 0],
    "Xavfsizlik qoidalariga rioya qilish": [0.9, 0.5, 0.8, 0.4],
}

df = pd.DataFrame(data)

# Xavfsizlik reytingini hisoblash
df["Xavfsizlik reytingi"] = df["Himoya kiyimi"] * df["Xavfsizlik qoidalariga rioya qilish"] *

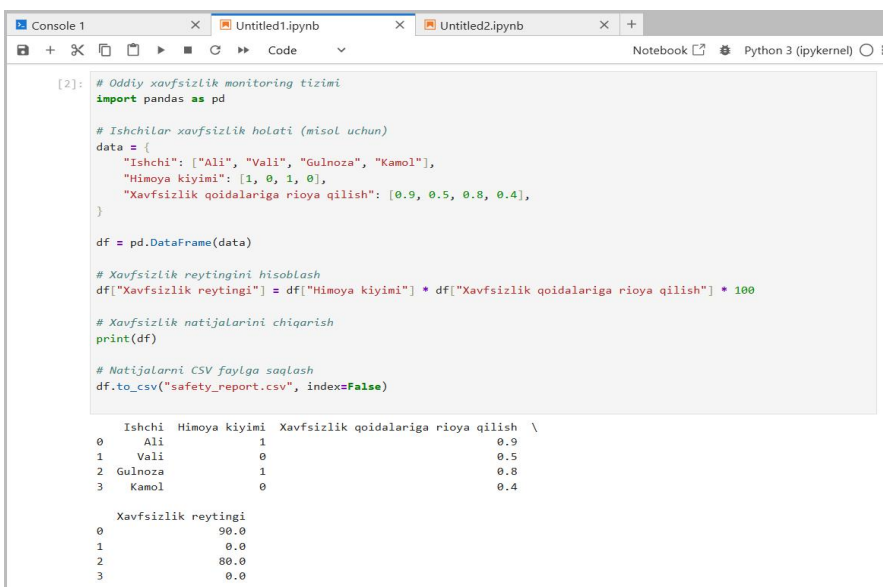
# Xavfsizlik natijalarini chiqarish
print(df)

# Natijalarni CSV faylga saqlash
df.to_csv("safety_report.csv", index=False)
```

Figure 6. Code for monitoring worker safety status

Above, a conceptual model has been developed for optimizing the labor protection management system and assessing and analyzing risks at production enterprises. The model includes important factors that allow increasing labor safety, reducing accidents, and effectively managing production processes.

Above, a conceptual model has been developed for optimizing the labor protection management system and assessing and analyzing risks at production enterprises. The model includes important factors that allow increasing labor safety, reducing accidents, and effectively managing production processes.



```
[2]: # Oddiy xavfsizlik monitoring tizimi
import pandas as pd

# Ishchilar xavfsizlik holati (misol uchun)
data = {
    "Ishchi": ["Ali", "Vali", "Gulnoza", "Kamol"],
    "Himoya kiyimi": [1, 0, 1, 0],
    "Xavfsizlik qoidalariga rioya qilish": [0.9, 0.5, 0.8, 0.4],
}

df = pd.DataFrame(data)

# Xavfsizlik reytingini hisoblash
df["Xavfsizlik reytingi"] = df["Himoya kiyimi"] * df["Xavfsizlik qoidalariga rioya qilish"] * 100

# Xavfsizlik natijalarini chiqarish
print(df)

# Natijalarni CSV faylga saqlash
df.to_csv("safety_report.csv", index=False)
```

	Ishchi	Himoya kiyimi	Xavfsizlik qoidalariga rioya qilish	Xavfsizlik reytingi
0	Ali	1	0.9	90.0
1	Vali	0	0.5	0.0
2	Gulnoza	1	0.8	80.0
3	Kamol	0	0.4	0.0

This result is obtained.

During the study, various models of labor protection were coded and analyzed using the Python programming language, and the results were evaluated practically. Algorithms for determining the level of risk were developed and their application in production processes was tested. The results obtained proved the effectiveness of digital technologies in improving

labor protection.

Conclusion. Based on the results of the analysis, innovative approaches to assessing and managing risks in manufacturing enterprises were proposed. This model is of great importance for increasing the efficiency of the labor protection system, monitoring the level of compliance with safety regulations, and preventing accidents.

In the future, there are prospects for further improving this model, using artificial intelligence technologies, and developing real-time risk monitoring systems.

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