IT-Based Systematic Monitoring of the Disposal of Associated Petroleum Gas

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Abstract. The paper substantiates the necessity of implementing information technology-based systematic monitoring for studying environmental pollutions induced by the flaring of associated petroleum gas. It proposes approaches to creating information software for monitoring using the existing analysis and control technologies that are necessary for finding the correlations between the controlled and uncontrolled factors in the gas-flaring process. We have developed an information software suite for real-time monitoring of environmental pollutions caused by the flaring of associated petroleum gas; using a wireless sensor network, the software can visualize the obtained data. We have experimentally measured the concentrations of nitrogen, hydrocarbon, and carbohydrate compounds in soil at various distances from the emission source. There has been established a strong correlation between the flaring process parameters and the emission concentrations. The paper proposes mechanisms for using this software in the analysis of the environmental safety of territories.

1. Introduction
The use of associated petroleum gas is a recognized problem of Russia's oil-and-gas industry. According to the Ministry of Nature, Russia produces 55 billion m³ of petroleum gas per annum, 26% of which is sent to refineries, 47% is consumed on-the-spot for industrial needs, while 27% is flared [1–4]. Russia's oil-and-gas network has fields that are so remote from gas refineries and transport infrastructures that traditional gas refining methods are not an option. The share of associated petroleum gas to be flared is dropping very slowly due to its volatile composition and the impurities it contains. This is why a large number of oil-and-gas companies still prefer to use stationary gas flares to dispose of associated petroleum gas. Flaring results in the atmospheric emissions of acid-forming components ( NOₓ, HₓS, COₓ ). Thermal destruction of soils is observed within 25 meters of the flare, while vegetation is inhibited within 150 meters. Data on the produced hydrocarbons and the amount of flared gas prove the necessity of monitoring this process in order to evaluate the environmental effects [5–7]. The age of information technology implies the creation of state-of-the-art research tools and methods. This is why a good option consists in developing information software for systematic remote monitoring of the flaring of associated petroleum gas [8–12, 15].

Data inputs may include the following:
– characteristics and differentiation of associated petroleum gases to flare by chemical composition;
– flaring process type;
– flaring equipment type;
– meteorological parameters of the flaring process.
The information software suite consists of three modules: a data module, a visualization (graph and chart) module, and a data management module for quick entry-making and reporting. Software modules are coded in Visual Basic for Applications (VBA), an object-oriented programming language; field measurements data are obtained by means of an SQL query builder.

The algorithm for studying the concentrations of chemical compounds deposited during flaring is implemented as a Windows 2007 program running in the Builder environment (with conventional VBA programming languages); it also includes manuals on the substantive content of the program, calculation toolsets, and graphical components.

The dialog in this software is organized as follows. First, the user selects an area to analyze as well as the flaring process type; then they are shown the list of chemical compounds to study; then they specify the flaring equipment for a given type of combustion chamber and enter the weather conditions of flaring. After the system is called, it loads the main interface, see Figure 1. In that interface, the user selects a function or a job type. The main option in the software database in the measurement table; other tables are for reference only, see Figure 2.

![Figure 1. Main interface.](image1)

![Figure 2. Structure of the information software suite.](image2)

Primary data is obtained from piezoelectric transducers placed in the soil at a certain distance away from the emission source to form a wireless sensor network [13, 14].

Wireless sensor networks consist of small computing-communication devices. Each device comes with a processor, some memory, digital-to-analog and analog-to-digital converters, an RF transceiver, a power source, and sensors. Sensors are selected on the basis of the chemical composition of the studied substance and are connected through digital and analog converters [16–19], see Figure 3.

For this research, we have studied the content of nitrogen oxides, hydrocarbon oxides, and carbon dioxide in the emissions. Concentration of other chemical contaminants deposited in the soil can be analyzed by replacing the adsorbents on the sensor surface [20–24].
Figure 3. Layout of gas-flaring process analysis equipment: DS₁, DS₂, and DSₙ are sensors placed within 10 meters of the emission source; DS₂₁, DS₂₂, and DSₙ are sensors placed 15 meters or farther from the emission source.

Measurements produce a measurement table which contains the concentrations of sensor-deposited chemicals generated by flaring associated petroleum gas with special markers that indicate the measurement date and time, the lot # where measurements were taken, the wind speed, the environmental humidity and temperature.

The analysis of chemical contained in the flared associated petroleum gases can be visualized in real time, Figure 4.

Figure 4. Analysis of flaring-induced nitrogen emissions at a certain distance from the source; concentration designations: hydrocarbon compounds, mg/m³ - nitrogen compounds, mg/m³ - carbon compounds, mg/m³.
2. Conclusion
The developed information software for systematic monitoring of the disposal of associated petroleum gas enables real-time monitoring of concentrations of hydrocarbon, nitrogen, and carbon compounds deposited in the soil, whereby the specifications of the flaring equipment are taken into account. Compliance with, or excess of environmental concentration norms with respect to hazardous substances is part of the administrative and legal regulation of industrial activities. If the maximum permissible values of flaring, and the dispersion of the combustion products of, associated petroleum gas are exceeded, emission fees are calculated by multiplying the normal negative environmental impact feeds by 12 as of 2013, and by 30 since 2016 [24]. The proposed system for monitoring the associated petroleum gas flaring process helps enhance the monitoring and control of greenhouse-gas emissions to improve the environmental safety of oil-and-gas facilities.

3. References
[1] Knizhnikov AYu, Ilyin AM 2017 Problems and Prospects of Using Associated Petroleum Gas in Russia WWF, Moscow 32
[2] Abukova L A, Shuster V L 2016 Strategic directions of development oil and gas complex in Russia 12–15
[3] Ilyina M N 2007 Requirements to the Preparation of Associated Petroleum Gas for Use in Small-Scale Power Engineering Bulletin of Tomsk Polytechnic University 310 2 167–171
[4] Buznik V M 2010 Innovative Technologies for Processing and Using Associated Petroleum Gas Moscow: Publication of the Federation Council 174
[5] Bazhaykin S G, Ilyasova Ye Z 2008 Analysis of Indices of Associated Gas Production and Utilization Problems of Gathering, Treatment and Transportation of Oil and Oil Products 4 54–59
[6] Frans G 2010 Remote Monitoring and Production Optimisation in Shell Society of Petroleum Engineers https://www.onepetro.org/conference-paper/SPE-136384-RU
[7] Khamidullin R D 2017 IT-Solution Development for Remote Production Management ad Control Over the Field Development Oil, Gas & Business 8 2017 26–31
[8] Cramer R 2010 Less Footprints in the Snow for Salym Field in Western Siberia Society of Petroleum Engineers https://www.onepetro.org/conference-paper/SPE-133236-MS
[9] Buzanovsky V A 2008 Informational Systems for Measuring the Physico-Chemical Composition and Properties of Substances World of Measurements 2 4–9
[10] Vendrov A M 2010 Dedevlovement of Information Software for Economics Moscow: Finansy i Kredit 323
[11] Vlasov D V New Instruments for Measuring Gas-Flow Dust Parameters Moscow: Eco-Intech 350
[12] Gaponyuk E I, Malakhov S G 2009 Comprehensive System of Indicators for Ecological Monitoring of Soils Leningrad: Gidrometeoizdat 3–10
[13] Gauzner S I, Kivilis S 2007 Weight, Volume, and Density Measurements Moscow: Izd-vs standartov 664
[14] Golitsyna O L Databases 2010 (Bazy dannyh): tutorial 2010 Moscow: FORUM: INFRA-M 55
[15] Dego S M 2011 Database Development and Use Moscow: Finansy i redit 210
[16] Dudkin N I 2013 Problems of Controlling the Mass Concentration of Aerosols Industrial Ecology 9 32–37
[17] Yegorov A A 2009 Systematization, Principles of Work and Area of Application of Sensors Journal of Radioelectronics 3 65–70
[18] Sergiyevsky M 2014 Wireless Sensor Networks Computer Press. Moscow 8 12–17
[19] Udartseva O V 2007 Information Technology for Environmental Safety Systems Information Security in Open Education Conference Proceedings 112–119
[20] Gonzalez T, Netusil M, Ditl P 2012 Raw gas dehydration on supersonic swirling separator Czech Technical University in Prague pp 76-84
[21] Schinkelshoek P, Hugh D Epsom 2008 Supersonic gas conditioning – commercialization of Twister™ technology 87th Annual Convention pp 2-7

[22] Baskakov S S 2008 Methods for Prolonging the Service Life of Distributed Wireless Data Collection Networks Technology and Software of Control and Measurement Systems 930–936

[23] Trelieven P, Neurocomputers 2009 University College

[24] Decree of the Russian Government dd 2012 On the Calculation of Fees for Negative Environmental Impact Induced by the Atmospheric Emissions in Flaring and (or) Dispersion of Associated Petroleum Gas 1148