

Forensic Thermal Analysis: Topic, Object, Tasks, Main Research Directions

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Formation procedure of thermal engineering researches as a separate species of forensic engineering based on principles of genesis in forensic science is considered. The latest research in the field of specific expertise use during production, distribution, transmission and consumption of energy resources is analyzed. A review of the results performed at National Scientific Center «Hon. Prof. M. S. Bokarius Forensic Science Institute» multidisciplinary forensic researches on violations of accounting and theft of natural gas by interfering with operation of accounting devices, on determining the scope of performed works on installation, testing and operation of heating equipment. Purpose: formulate definition of the concepts of the topic and object of the forensic thermal analysis; compile a list of areas of forensic thermal research and form typical tasks for this type of forensic science based on. In order to achieve the goal, the methods of scientific cognition are applied: observation, comparison, abstraction, analysis, synthesis, modeling, etc. Abbreviated and expanded definition of topic of forensic thermal analysis is proposed. On the basis of general structure of the tasks of forensic engineering a, as well as the results of the analysis of the requests of the pre-trial investigation bodies and the court regarding the conduct of forensic examinations in the thermal direction, a general list of tasks of the forensic heat engineering examination with structuring into four groups was developed. A list of the main areas of research in forensic thermal analysis has been compiled.

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Keywords: object, topic, tasks, issues of forensic thermal analysis; praxeological approach; thermal engineering; thermal power equipment.

Research Problem Formulation

In the previous research paper, we noted, *“that on a praxeological basis there is a development of all kinds and species of forensic science (in particular: forensic engineering), that is, there is a path that can be considered as a “classical” way of genesis of new species of forensic examinations:*

a) first, investigator / court draws up a decision/ decision on appointment of forensic examinations/ involvement of forensic experts;

b) in the decision / decision, investigator / court forms a range of issues that need to be resolved within the framework of forensic examinations;

c) forensic experts of various specializations conduct a number of examinations, often multidisciplinary ones;

d) scientists generalize forensic expert practice, which results in offer to initiate a new type of forensic examination at the regulatory level.”¹

M. Shcherbakovskiy² considers the praxeological approach to be the most important principle of forensic science phenomenon cognition, methodological significance of which lies in orientation of forensic science theory to solve its immediate issues as an applied science. Practical recommendations developed in accordance with principles of praxeology make it possible to use theoretically established patterns to build algorithms

for solving specific problems in typical expert situations that can be implemented, in forensic thermal engineering researches (on the example of forensic multidisciplinary examinations performed by professionals of National Scientific Center «Hon. Prof. M. S. Bokarius Forensic Science Institute» of the Ministry of Justice of Ukraine, hereinafter referred to as NSC «Hon. Prof. M. S. Bokarius FSI»).

Initiation of a new engineering in the forensic specialization 10.30: *Forensic thermal researches* is a typical example of genesis in forensic science activity. Increase in the number of violations of regulatory requirements recorded by energy supply companies at heat engineering and energy facilities has increased the number of investigative proceedings on these issues and, accordingly, requests from pre-trial investigation bodies and courts to professionals of forensic science institutions knowledgeable in research on hydronics, metering devices, sources and verification of thermal energy consumption calculations, etc., that ultimately led to separation of thermal engineering research into a separate forensic science species. Determining the topic and object of Forensic thermal analysis, formulating the tasks of thermal engineering research is an urgent issue at the current stage of the formation of this forensic science species.

1 Богданюк І. Загальна система завдань інженерно-технічних судових експертиз. *Теорія та практика судової експертизи і криміналістики*. 2022. Вип. 4 (29). С. 110—123. DOI: 10.32353/khrife.4.2022.05 (date accessed: 16.02.2023).

2 Щербаківський М. Г. Методологія дослідження феномена судових експертиз. *Вісник Луганського державного університету внутрішніх справ ім. Е. О. Дідоренка*. 2016. № 3 (75). С. 140. URL: <https://journal.lduvs.lg.ua/index.php/journal/article/view/496/434> (date accessed: 16.02.2023).

Analysis of Essential Researches and Publications

Interesting researches on engineering and technical aspects of violations of the Code of Gas Distribution Systems of Ukraine³ are research papers of D. Khomych and A. Husak⁴ (on specific expertise use of during investigation of theft of natural gas by training in the work of metering devices). At the same time, violations of technical and organizational requirements for commercial metering of thermal energy, hot and drinking water, as well as unauthorized dismantling, deliberate destruction, damage, dismantling, and other unauthorized interference with the operation of commercial metering units of thermal energy, hot or drinking water did not find appropriate coverage in the special literature on forensic expert studies.

Unfortunately, modern scientific publications in this area of research are rather limited and non-systematic in nature. Thus, M. Toporkova⁵ studied thermal energy as an object of civil rights, but did not pay attention to mechanisms and methods of committing offenses that nullify these rights. V. Kuts and Yu. Kyrychenko⁶ examined in detail the object of criminal encroachment in matters of application of Art. 188-1 of the Criminal Code of Ukraine regarding the consumption of energy resources. Criminal law characteristics of the offense provided for in Art. 188-1 of the Criminal Code of Ukraine⁷ as a subject of scientific research, was in the center of attention of T. Chumachenko⁸ (in particular, theft of thermal energy through its arbitrary use), O. Avdieieva⁹ and other scientists. O. Honcharenko¹⁰ noted that the energy sector functions in the form

- 3 Кодекс газорозподільних систем : затв. Постановою Нацком. енергетики, ком. послуг України від 30.09.2015 р. № 2494 (зі змін. та допов.). URL: <https://zakon.rada.gov.ua/laws/show/z1379-15#Text> (date accessed: 16.02.2023).
- 4 Хомич Д. Порухення та крадіжки при споживанні природного газу. *Історико-правовий часопис*. 2017. № 2 (10). С. 186—190. URL: http://nbuv.gov.ua/UJRN/ipch_2017_2_39 (date accessed: 16.02.2023) ; Гусак А., Хомич Д. Тактика слідчого огляду під час розслідування викрадень природного газу в газових лічильниках. *Ibid*. 2018. № 1 (11). С. 114—118. URL: <https://evnuir.vnu.edu.ua/handle/123456789/15138> (date accessed: 16.02.2023).
- 5 Топоркова М. М. Теплова енергія як об'єкт цивільних прав. *Право і Безпека*. 2010. № 5. С. 274—276. URL: http://nbuv.gov.ua/UJRN/Pib_2010_5_66 (date accessed: 16.02.2023).
- 6 Куц В., Кириченко Ю. Об'єкт незаконного використання електричної та теплової енергії. *Вісник Національної академії прокуратури України*. 2008. № 3. С. 49—54. URL: http://nbuv.gov.ua/UJRN/Vnapu_2008_3_9 (date accessed: 16.02.2023).
- 7 Кримінальний кодекс України від 05.04.2001 р. № 2341-III (зі змін. та допов.). URL: <https://zakon.rada.gov.ua/laws/show/2341-14#Text> (date accessed: 16.02.2023).
- 8 Чумаченко Т. А. Предмет викрадення електричної та теплової енергії шляхом її самовільного використання: проблеми визначення. *Вісник Верховного Суду України*. 2007. № 8. С. 41—44 ; Eadem. Викрадення електричної або теплової енергії шляхом її самовільного використання (ст. 188-1 КК України): кримінально-правова характеристика : автореф. дис. ... канд. юрид. наук. Київ, 2008. С. 18.
- 9 Авдеев О. О. Кримінально-правова характеристика злочину, передбаченого статтею 188-1 Кримінального Кодексу України. *Вісник Кримінологічної асоціації України*. 2014. № 6. С. 25—35. URL: https://dspace.univd.edu.ua/xmlui/bitstream/handle/123456789/665/kriminal_no_pravova_harakteristika_zlochinu_peredbachenogo_statteyu_188_1_kriminal_nogo_kodeksu_ukrayini.pdf?sequence=2&isAllowed=y (date accessed: 16.02.2023).
- 10 Гончаренко О. А. Об'єкт викрадення електричної або теплової енергії шляхом її самовільного використання. *Вісник Одеського національного університету. Правознавство*. 2009. Вип. 1. Т. 14. С. 72—77. URL: <http://dspace.onu.edu.ua:8080/handle/123456789/711> (date accessed: 16.02.2023).

of a peculiar mechanism that subjects are interconnected. The mechanism of production, distribution, transmission and consumption of energy is uninterrupted and creates conditions for the reliable operation of fuel and energy complex in general that should be taken into account while investigating the theft of electrical or thermal energy through its arbitrary use. It is worth noting that a certain number of researches in expert proceedings regarding the arbitrary use of electric energy were carried out comprehensively until recently, solving the tasks of forensic electrical engineering and forensic economics.

Specialists of Hon. Prof. M. S. Bokarius Kharkiv Research Institute of Forensic Examinations (nowadays NSC «Hon. Prof. M. S. Bokarius FSI») as early as 2017 offered an appropriate forensic technique ¹¹. However, direct application of its best practices (certain principles) in forensic electrotechnical examinations for research on arbitrary use of thermal energy is impossible, although the use of some provisions of the mentioned methodology is expedient, requiring at the same time some refinement. The issue of expert practice regarding conducting research into the actual condition of gas, thermal energy, drinking water, etc. metering nodes requires separate consideration. The main publication devoted to the construction of gas meters and their operation is the handbook by M. Andriishyn and O. Karpash

with co-authors ¹², as well as the internet publication by V. Maksymchuk ¹³.

Analysis results of forensic examinations carried out at the NSC «Hon. Prof. M. S. Bokarius FSI» in this direction indicates that professionals most often examine gas meters for the purposes of forensic examination without taking into account general condition of the entire equipment (all measuring equipment) and its operating conditions. Trace evidence researches are primarily aimed at establishing the process of trace formation as a result of tampering with meters (in particular, examinations of locking and protective (control) devices, seals, etc.), instead to find out the facts of intentional destruction, damage, disassembly, other unauthorized interference in the work of a commercial node of thermal energy accounting, hot or drinking water, gas meters is impossible without specific expertise of the structure of these measuring equipment and specific expertise in the field of fluid and gas dynamics and technical thermodynamics that does not belong to competence of forensic trace evidence analyst. Science and technology literature on thermal engineering researches, where these physical processes are studied, described and explained, in scientific and engineering (applied) field, currently, is represented either by an outdated theoretical work (*Hydrodynamics* by L. Landau and E. Lifshitz ¹⁴), or by separate

11 Методика дослідження засобів обліку електричної енергії та схем їх підключення з метою вирішення діагностичних завдань (реєстр. код 0.1.21). Харків : ХНДІСЕ Мін'юсту України, 2017 / Реєстр методик проведення судових експертиз Мін'юсту України : офіц. сайт. URL: <http://rmpse.minjust.gov.ua/page/1> (date accessed: 16.02.2023).

12 Андріішин М. П., Карпаш О. М., Марчук Я. С., Петришин І. С., Середюк О. Є., Чеховський С. А. Облік природного газу : довідник. Івано-Франківськ, 2008. 180 с. : іл.

13 Максимчук В. Прилади обліку газу: основні типи та особливості експлуатації. *Журнал головного енергетика*. 2021. № 05. URL: <http://jge.techmedia.com.ua/zhurnal-golovnego-energetika-2021-5/prylady-obliku-hazu-osnovni-typy-ta-osoblyvosti-ekspluatatsiyi> (date accessed: 16.02.2023).

14 Ландау Л. Д., Лифшиц Е. М. Теоретическая физика. В 10 т. Т. VI: Гидродинамика. 3-е изд., перераб. Москва, 1986. 736 с.

research papers of Ukrainian scientists (*Fluid and gas dynamics* by S. Vasylenko with co-authors ¹⁵ and O. Husak with co-authors ¹⁶).

The next direction in conducting research, demanded by the bodies of pre-trial investigation and the court, is to resolve the issue of compliance of specific thermal equipment with the regulatory requirements and the requirements of the manufacturer, as well as the issue of the amount of performed work on installation, testing and operation of thermal equipment. Since heat engineering equipment is common in the modern world (both in industrial and domestic use), and differs in purpose, structure and principles of work, it is problematic to review the latest publications on these issues due to their diversity and significant volume.

In our opinion, on the territory of Ukraine, the *Power and heat engineering processes and equipment* ¹⁷ electronic news is currently the most authoritative in the field of heat engineering research; *East European Journal of Physics* ¹⁸ (in the part of publications on technical thermal physics and industrial thermal energy); *Thermophysics and Thermal Power Engineering* ¹⁹ (in the part of industrial thermal energy, conversion of renewable types of energy, measuring devices and methods of measuring thermal quantities, etc.).

The analysis results of scientific publications allow us to state that scientific developments in forensic thermal analysis require theoretical structuring, generalization and methodological concretization of individual cases under research that primarily involves determining the topic and object of forensic thermal analysis, formulating the tasks of thermal engineering research and developing typical issues that should be solved by forensic thermal analysis.

Article Purpose

This research purpose is to:

- 1) formulate concept definitions of: *forensic thermal analysis topic* and *forensic thermal analysis*;
- 2) compile a list of directions of forensic thermal engineering research in forensic examination (based on the results of analysis of requests of pre-trial investigation bodies, courts and appeals of individuals and legal entities);
- 3) identify typical tasks in certain areas of thermal engineering research.

Research methods

For achieving the goal, such methods of scientific cognition as observation, comparison, abstraction, analysis, synthesis, modeling, etc. were used.

15 Василенко С. М., Кулінченко В. Р., Шевченко О. Ю., Піддубний В. А. Гідрогазодинаміка : монографія. Київ, 2016. 676 с.

16 Гусак О. Г., Шаропов С. О., Ратушний О. В. Гідрогазодинаміка : навч. посіб. Суми, 2022. 296 с.

17 Енергетичні та теплотехнічні процеси й устаткування / Вісник Національного технічного університету «Харківський політехнічний інститут». URL: <http://vestnik.kpi.kharkov.ua/etpo/uk/pro-zhurnal/> (date accessed: 16.02.2023).

18 Східно-європейський фізичний журнал / Вид-во ХНУ ім. В. Н. Каразіна. URL: <https://periodicals.karazin.ua/eejp/issue/view/1185> (date accessed: 16.02.2023).

19 Теплофізика та теплоенергетика / Вид-во Інституту технічної теплофізики НАН України. URL: <http://ittf.kiev.ua/vidavnicha-diyalnist/> (date accessed: 16.02.2023).

Main Content Presentation

In order to determine forensic thermal analysis topic, you need to refer to the formulation of the subject of forensic expertise as a science. We consider the wording: *“Forensic science topic is the factual data and circumstances of the case (proceedings), established by the forensic expert on the basis of specific expertise use through the use of appropriate means (methods) in the study of material and materialized media for the purpose of solving the tasks of forensic examination”* presented in the: *Forensic science fundamentals: Tutorial for professionals who intend to obtain or confirm forensic expert qualification book* ²⁰.

Regarding the definition of subject of forensic science topic, scientists are in one of two positions:

- 1) I. Aliiev, N. Klymenko and M. Sehai believe that forensic expertology topic should include patterns due to forensic science, since the theory of forensic examinations is formed in its depths and is largely based on its methodology. This requirement applies to the didactic component containing professional training of experts in various specializations;
- 2) F. Dzhavadov, S. Bychkova and I. Pyrih deny possibility of legal and organizational principles belonging to forensic expertology topic.

The research object and topic are categories of scientific process and are related to each other as basic and detailed, general and partial, primary

and secondary ones. Certainly, these concepts are not identical ones: for example, research topic can be common to different sciences, and the subject can be characteristic of only one science. The object concept is broader: it covers external world phenomena that are subject to knowledge and practical influence of subjects, persons. On the other hand, the topic is a component, a specific aspect of the object studied by this science, it is embodiment of the circle of the most essential studying issues. In order to simplify the difference perception between a topic and an object, it is advisable to apply the constructions *topic — goal* and *object — means* to these concepts. It may be stated that subject is the most essential, leading properties of the researched object (phenomenon), to which cognitive activity is directed. The topic concept of and the forensic examination task (if the task is not understood in a broad sense — as specific questions posed to the expert by the person or body that appointed the forensic examination, and in a narrow sense — as achievement of what the expert's cognitive activity is aimed at) are identical ones. Thus, the forensic examination topic is determined by its tasks, objects and methods of cognition. A constant connection between the topic and tasks is important for achieving our goal.

At the preparation stage for initiation of forensic thermal analysis, forensic experts of NSC «Hon. Prof. M. S. Bokarius FSI» prepared necessary changes to the Research guidelines on preparation and

20 Головченко Л. М., Лозовий А. І., Сімакова-Єфремян Е. Б. та ін. Основи судової експертизи: навчальний посібник для фахівців, які мають намір отримати або підтвердити кваліфікацію судового експерта. Харків, 2016. С. 25. URL: <https://expertize-journal.org.ua/attachments/article/924/ose.pdf> (date accessed: 09.11.2022).

appointment of forensic examinations and researches ²¹ (hereinafter referred to as RG). By order of the Ministry of Justice dated on 15.08.2022 No. 3430/5 ²² Sec. II RG supplemented Ch. 17, which clause 17.2 sets out the following main tasks of forensic thermal analysis:

- *determination of characteristics and parameters of objects related to production, transportation, supply and use (consumption) of thermal energy;*

- *compliance determination of district heating thermal engineering equipment, heating system, ventilation and air conditioning systems with requirements established in technical conditions, norms, standards and rules;*

- *determination of the technical condition of heat engineering equipment, heat power plants, pipelines of heating system with heating devices, heat exchangers and shut-off and control valves;*

- *establishment of causes and consequences of accidents and failures of thermal equipment of thermal power plants that led to violation of heat supply regimes of consumers;*

- *establishing causes and consequences of accidents and failures of the equipment under research, during which operation thermal processes occur with deviation of the parameters of this process from the standard one;*

- *establishment of operating modes of thermal installations and the mechanism of thermal processes during technical operation*

of thermal equipment and components of district heating;

- *establishing actual circumstances of the occurrence and course of thermal processes in thermal equipment, machines and mechanisms and/or their components;*

- *setting use volume of heat and/or fuel for heating, ventilation, water supply, technological, production needs.*

Other tasks can be assigned to thermal engineering research if specific expertise in the field of thermal engineering and energy-efficient technologies is required for their solving. Specific expertise use in the field of thermal engineering can also be applied in the complex solution of issues where it is necessary to apply specific expertise in other forensic expert specializations ²³.

The object of forensic examination is understood as “material (materialized) sources of information (objects, formations, etc.) that are investigated (recognized) by forensic expert on the basis of the of specific expertise application , within the framework of subject of expert research by certain methods and means in order to solve the tasks (issues) set by the authorized person (body)” ²⁴.

Systematizing the above, we can offer the following definition: **object of forensic thermal analysis** is a reflection in the form of material and materialized sources of material evidence information (thermal engineering equipment and equipment which energy transformation takes place in accompanied

21 Науково-методичні рекомендації з питань підготовки та призначення судових експертиз та експертних досліджень : затв. наказом Мін'юсту України від 08.01.1998 р. № 53/5 (зі змін. та допов.). URL: <https://zakon.rada.gov.ua/laws/show/z0705-98#Text> (date accessed: 16.02.2023).

22 Зміни до деяких нормативно-правових актів з питань судово-експертної діяльності : затв. наказом Мін'юсту України від 15.08.2022 р. № 3430/5. URL: <https://zakon.rada.gov.ua/laws/show/z0922-22#n24> (date accessed: 16.02.2023).

23 Науково-методичні рекомендації URL: <https://zakon.rada.gov.ua/laws/show/z0705-98#Text> (date accessed: 16.02.2023).

24 Головченко Л. М., Лозовий А. І., Сімакова-Єфремян Е. Б. та ін. *Op. cit.* С. 27. URL: <https://expertise-journal.org.ua/attachments/article/924/ose.pdf> (date accessed: 16.02.2023).

by heat processes; equipment for recording parameters; documents about phenomena and processes, schemes, drawings, etc.), placed in the case materials (proceedings). The given definition is quite concise, convenient for delineating the limits of the of specific expertise application, but it does not fully correspond to the constructions: *subject – goal and object – means*. It is worth noting that the objects of heat engineering research include: *heat engineering equipment and its components that produce heat energy by converting mechanical, electrical, and chemical energy; thermal energy equipment that uses thermal energy for heating, ventilation, water supply, technological, production or communal household needs; thermal power plants that convert heat into work or, conversely, work into heat; fuel and heat supply systems and other engineering and technical equipment or systems for converting any type of energy into thermal energy; components of such equipment where heating occurs; systems of cooling and heat-mass exchange of substances in solid, liquid and gaseous aggregate states; heat energy transmission (transportation, supply) systems, gas, heat, and water supply systems (gas pipelines, steam pipelines, hot water pipelines) along with auxiliary equipment that ensures transportation and control of these processes; equipment for accounting of energy resources (fuel, thermal energy, natural gas, water), measuring equipment for technical implementation of such accounting, other components and auxiliary equipment of accounting units; systems of utilization (recovery), accumulation (accumulation)*

of thermal energy; systems for registering operating parameters of heating equipment; operation modes (normal and emergency) of heating equipment; direct thermal processes as physical phenomena in all forms of their detection and impact on materials, substances, machines, mechanisms, equipment, etc.; drawings, technological schemes, instructions, instructions, regulations for the operation of heating equipment, etc.

Taking into account the above and the general system of tasks of forensic Engineering initiated by us earlier ²⁵, as well as analysis results of the requests of pre-trial investigation bodies and the court to conduct forensic examinations of the heat engineering direction, we propose to differentiate the tasks of forensic thermal analysis into the same four groups as the tasks of forensic engineering ²⁶:

- *First group* is research on the state of objects;
- *Second group* is establishment of compliance / non-compliance of the object state with certain requirements;
- *Third group* is determination of the mechanism of occurrence of investigated situation;
- *Fourth group* is clarification of cause-effect relation in the situation (event) under research.

Synthesizing the main tasks of heat engineering expertise fixed in RG ²⁷ and the general system of tasks of engineering and technical forensic examinations proposed by us ²⁸, we can characterize the general tasks of Forensic thermal analysis.

25 Богданюк І. О. цит. С. 120—121. DOI: [10.32353/khrife.4.2022.05](https://doi.org/10.32353/khrife.4.2022.05) (date accessed: 16.02.2023).

26 Ibid. С. 121.

27 Див. п. 17.2 гл. 17 розд. II Науково-методичних рекомендацій ... URL: <https://zakon.rada.gov.ua/laws/show/z0705-98#Text> (date accessed: 16.02.2023).

28 Богданюк І. О. цит. С. 120—121. DOI: [10.32353/khrife.4.2022.05](https://doi.org/10.32353/khrife.4.2022.05) (date accessed: 16.02.2023).

General tasks of forensic thermal analysis

1. Investigation of the state of objects with definition of:

1.1. Designation of the object with identification of performed functions, identification of the object (type, brand, model, design, modification, etc.);

1.2. Characteristic parameters:

a) technical and operational indicators (temperature, pressure, concentration, density, speed, acceleration, current, flow, etc.), specific characteristics and parameters of objects related to production, transportation, supply and use (consumption) of thermal energy;

b) technical indicators (level, group, complexity, configuration, limits of application / use, etc.);

1.3. Actual condition of heat engineering equipment, heat power plants, heating pipelines with heating devices, heat exchangers, shut-off and control valves, metering units, measuring equipment and control, gas, heat, water supply systems (gas pipelines, steam pipelines, hot water pipelines) and air conditioning, heating and cooling systems:

a) integrity (complete, partial, set of fragments, fragment);

b) functionality (operable / inoperable, critical / limit state, etc.);

c) list of actual defects with their identification and

establishment of the of object malfunction type (partial, complete, critical, etc.) by defects recorded in the research;

d) type of malfunction by the method of detection (obvious / hidden);

1.4. Operation mode / mode of operating conditions; (change of mode in time);

1.5. Identification of operation mode (normal / abnormal / emergency);

1.6. Identification of the state with determination of type of the studied state (primary / changed). Determination of changes in the state (what they were);

1.7. Identification of the studied thermal process;

1.8. The type (nature) of malfunctions (loss of integrity; wear; destruction; thermal, mechanical damage, etc.) of the object as a whole or its individual parts, elements, fragments;

1.9. List (scope) of works on restoration, repair, elimination of consequences.

2. Establishment of conformity or non- compliance with the state of the object:

2.1. Requirements of regulatory and technical and regulatory docu- ments (technical requirements; technical specifications; tech- nical conditions; terms of the contract of sale / provision of services/supply/storage /prop- erty management/ lease / acces- sion; requirements of technolo- gical maps regulating compliance with certain parameters: fuel

- consumption, production, consumption / use of thermal energy, etc.);
 - 2.2. Requirements of regulatory and technical documents (rules, instructions, guidelines) regarding the actions of certain persons;
 - 2.3. The scope of performed work (manufacturing, construction, installation, other work, including modernization, repair, restoration); the requirements of regulatory and technical and regulatory documents, as well as contracts, project documentation and estimates.
 3. Research on objects with mechanism establishment of occurrence of studied objects:
 - 3.1. Thermal process, event, incident, situation, accident, etc.;
 - 3.2. Actual operation mode, actual technological process;
 - 3.3. Actual condition, existing defects, malfunctions with the definition of the occurrence mechanism of malfunction type due to:
 - a) inept handling of equipment / appliance / component;
 - b) improper and inappropriate operation (maintenance), installation, storage;
 - c) overload;
 - d) weakness;
 - e) wear-and-tear
 - f) aging, degradation;
 - g) coincidence of operational resource;
 - h) constructive malfunction;
 - i) production or technological malfunction.
 4. Establishment of causal and conditionality relations:
 - 4.1. Acquisition of actual state;
 - 4.2. Occurrence of an event, incident, situation, accident;
 - 4.3. Improper operation, improper use.
- For a more complete understanding Forensic thermal analysis object, which definition is proposed above, it is important to have a good understanding of the types of heat engineering equipment and its features, for example: industrial and household; heat generating and heat using; with a developed structure in terms of the number of thermal processes in the workflow and with one type of thermal process; structurally complex and simple; systemic in composition and single-device; with the organization of the thermal process in a closed system and an open one; with the same or with different principles of work, etc. In view of infinity of this list, we will limit ourselves to analysis of the main types of thermal power equipment (only of industrial purpose and without taking into account constructive changes) as objects of forensic thermal analysis.
- Main types
of thermal power equipment
as objects of forensic researches**
- Boiler plants.
 - Combustion chambers.
 - Industrial furnaces.
 - Steam turbines.
 - Gas Turbine and Combined Units.
 - Internal combustion engine,
 - Jet engines.

- Utility blowers (pumps, fans, compressors).
- Pipeline systems and shut-off and control valves.
- Gas control points.
- Drying plants.
- Industrial heat and mass exchangers and installations.
- Refrigeration and cryogenic plants.
- Nuclear reactors.
- Steam generators.
- Other hydroelectric power stations
- Thermal power plants.
- Nuclear power plants.
- Plasma power plants.
- Heating systems
- Ventilation and air conditioning systems.
- Heating, heating, heat and power supply systems.
- Heat supply systems of industrial enterprises.
- Gas, water, steam, fuel metering units.

- Heat accumulators.

Main types of heat energy equipment include both separate types of equipment (which, although they are complete products, but according to their use or purpose are only elements, for example: boiler rooms, turbines, dryers, refrigeration units, heat and mass exchange devices), and systems containing several elements, structurally and functionally interconnected to perform system integral functions (for example: thermal and nuclear power stations; heating, ventilation and air conditioning systems; heating and heat energy supply systems). Such systems may contain the same elements (E.g., Figs. 1 and 2), but they should be considered as separate objects of study, since an incorrectly or poorly designed system cannot perform the functions assigned to it (or perform them improperly), even when individual elements fully meet the necessary quality and functional indicators.

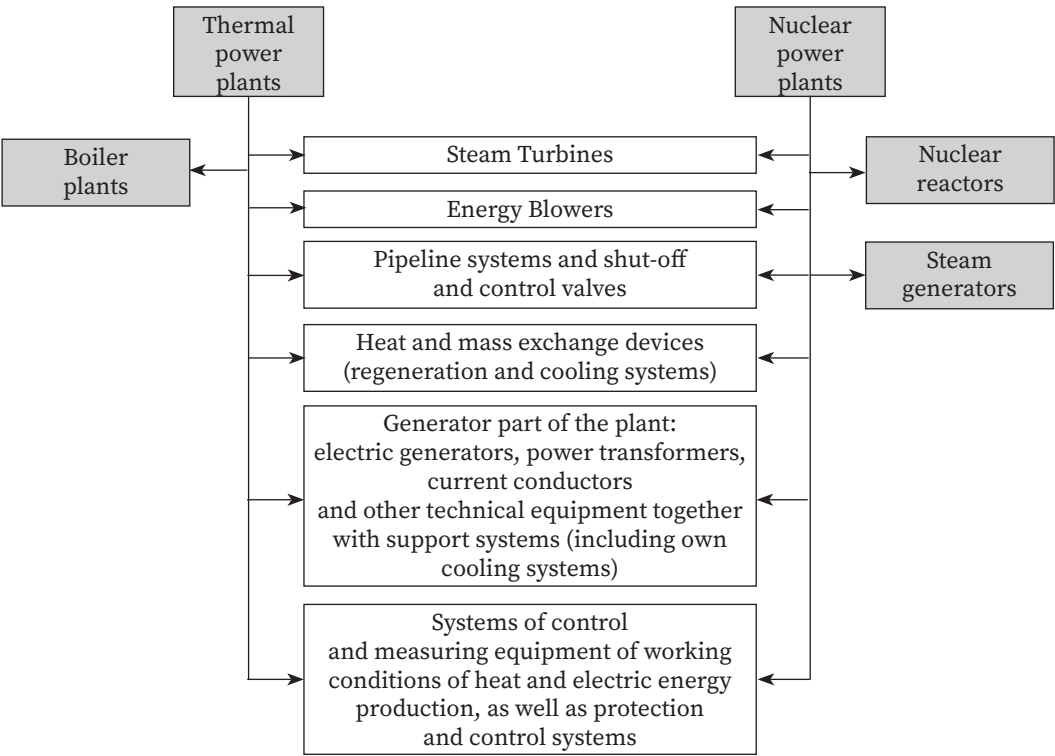


Fig. 1. Thermal and nuclear power plants as complex system objects of forensic thermal analysis

Shorthands:

-  system object
-  object that is an element of the system and can be a subsystem

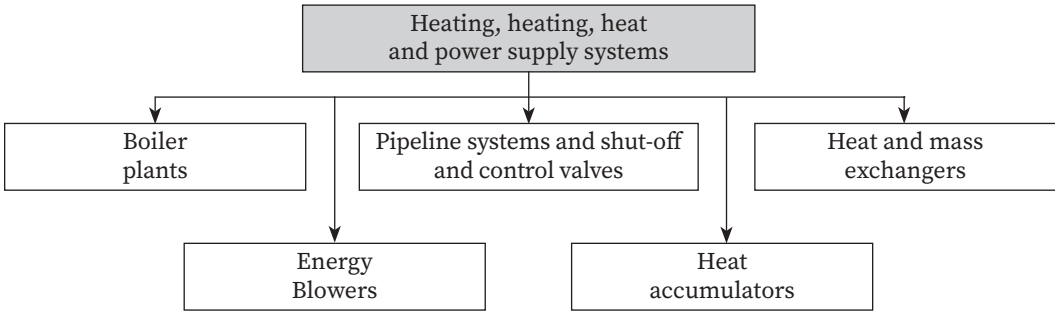


Fig. 2. Structure of a complex system object of forensic thermal expertise research

Shorthands:

-  system object
-  object that is an element of the system

Individual elements of thermal power equipment can have their own internal classifications (see, for example, Fig. 3), and individual positions of these classifications can be separate research objects.

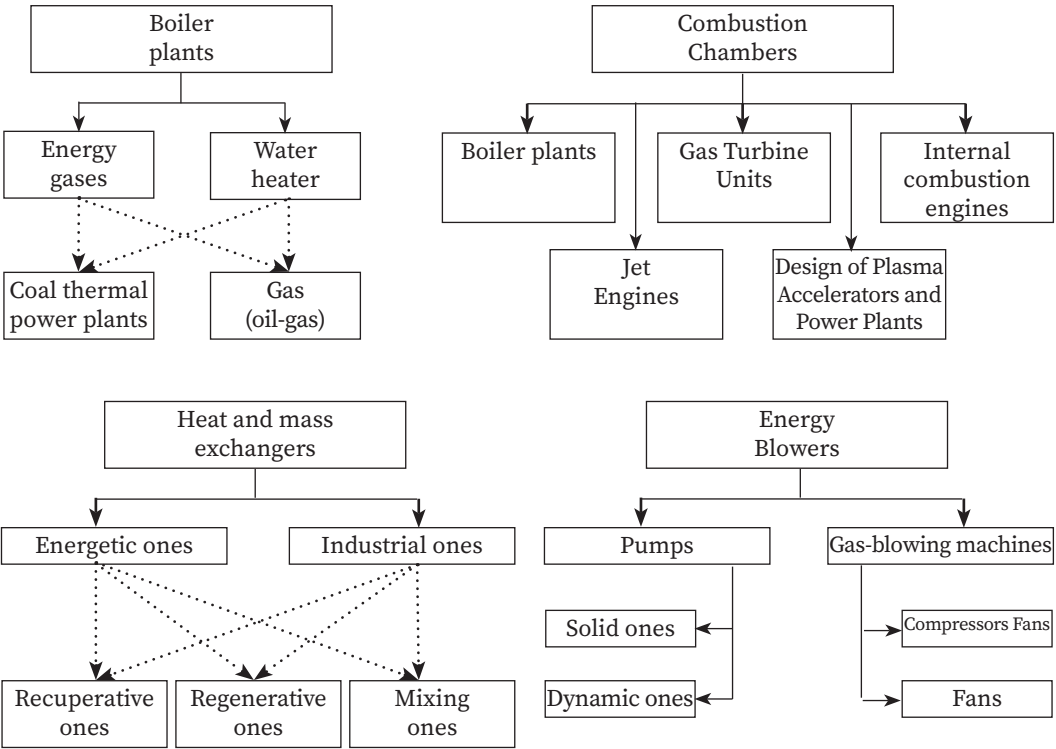


Fig. 3. Classification of elements of heating equipment systems

We should note that the same universal physical processes operate in all variety of objects of heat engineering equipment (both existing and those that can be created): mechanical, thermodynamic, fluid and gas dynamics, heat and mass exchange (Fig. 4).

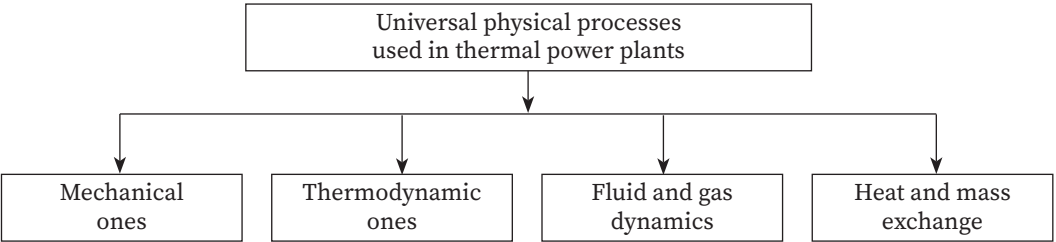


Fig. 4. Physical processes in thermal power plants

Compiling a comprehensive list of thermal energy equipment is an almost impossible task, because today mankind uses many different devices and equipment, which, moreover, are improved every day. We have provided an approximate list of such equipment for a holistic understanding of the topic, object and tasks of forensic thermal analysis and a comprehensive understanding of its methodology. Issues of the methodology of forensic thermal analysis require a separate research that is the goal of our further scientific investigations.

Conclusions

Formation procedure of thermal engineering researches as a separate type of forensic engineering and thermal analysis based on the principles of genesis in forensic expertise is considered. The latest research in the field of the use of special knowledge during the production, distribution, transmission and consumption of energy resources is analyzed. A review of the complex expert studies carried out at NSC «Hon. Prof. M. S. Bokarius FSI» on violations of accounting and theft of natural gas by interfering with the operation of accounting devices, on the determination of the scope of the completed works on installation, testing and operation of heating equipment was carried out. The need to define the concept of topic and object of forensic thermal engineering researches, formulate the tasks of thermal engineering research at the stage of formation of these species of forensic science is substantiated. Expanded definition of the subject of Forensic Thermal Analysis is proposed. On the basis of general structure of forensic tasks, as well as the results of the analysis of the requests of the pre-trial investigation bodies and the court regarding conduct

of forensic examinations in the heat engineering direction, general list of tasks of the forensic thermal analysis engineering examination structuring into four groups has been developed. A list of the main research areas of forensic thermal analysis has been compiled.

Судова теплотехнічна експертиза: предмет, об'єкт, завдання, основні напрями досліджень Ігор Богданюк

Розглянуто процес формування теплотехнічних досліджень як окремого виду судової інженерно-технічної експертизи за принципами генезису в судовій експертології. Проаналізовано останні дослідження в царині використання спеціальних знань під час виробництва, розподілу, передавання та споживання енергоресурсів. Здійснено огляд виконаних в Національному науковому центрі «Інститут судових експертиз ім. Засл. проф. М. С. Бокаріуса» комплексних експертних досліджень із порушень обліку та крадіжок природного газу шляхом утручання в роботу приладів обліку, із визначення обсягу виконаних робіт із монтажу, випробування й експлуатації теплотехнічного устаткування. Мета: сформулювати визначення понять предмета й об'єкта судової теплотехнічної експертизи; скласти перелік напрямів теплотехнічних досліджень і сформулювати за ними типові завдання для цього виду судової експертизи. Для досягнення поставленої мети застосовано методи наукового пізнання: спостереження, порівняння, абстрагування, аналіз, синтез, моделювання тощо. Запропоновано скорочене та розширене визначення предмета судової теплотехнічної експертизи. На підставі загальної структури завдань інженерно-технічних судових експертиз, а також за результатами аналізування запитів органів досудового розслідування й суду щодо проведення судових експертиз

теплотехнічного напряму розроблено загальний перелік завдань судової теплотехнічної експертизи зі структуруванням за чотирма групами. Складено перелік основних напрямів досліджень в судовій теплотехнічній експертизі.

Ключові слова: об'єкт, предмет, завдання, питання судової теплотехнічної експертизи; праксеологічний підхід; теплотехнічні дослідження; теплоенергетичне устаткування.

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Declaration of Competing Interest

The author declares that there is no conflict of interest related to this topic; although Ihor Bohdaniuk is a member of the advisory board of the collection, he did not participate in the decision to publish and this article is subject to a full process of expert verification and editing.

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