Formal Expert Examination of Welded Joints Quality at Oil and Gas Industry Construction Projects

Olga V. Didkovskaya¹, Olga A. Mamaeva¹, Marina V. Ilyina¹
¹1443001, Molodogvardeyskaya str., 194, Samara, Russia
kafedra_cen@mail.ru

Abstract. Now construction engineering and engineering research set much store by determination of completed works and building structures quality. At the same time, there are no special approved methods of quality determination. In this paper the authors are going to draw up a methodology of assessing the quality of welded joints of pipeline structures in case these works have to be examined forensically. The researchers analyse legislation requirements on forensic examinations technical regulations and practical experience and offer a methodology which makes it possible to conduct a formal expert examination in a proper legitimate way.

1. Introduction
Determination of welded joints quality while assessing the volume and quality of works on oil and oil products pipelines installation is an important question in judicial construction and technical researches.

The answer to this question is almost always complicated by the fact that at the time of the formal expert examination all welded joints are hidden by subsequent works (painting and insulation). At the same time, welded joints are of crucial importance in pipeline structures as they can affect the safety of pipeline maintenance, especially at hazardous industrial facilities.

When there is a formal expert examination of welded joints of pipeline structures the expert has to retrospectively assess if technological production processes of organization and control are compatible with welding production processes and welding results control.

The legal basis for a formal expert examination (regardless of the types of examinations performed) is the Federal law of 31.05.2001 № 73-FZ "On state forensic activities in the Russian Federation". According to Art. 41, Provision № 73-FZ are also applied to forensic activities of persons who are not state forensic experts [1].

At the same time, this law establishes only the procedural order of carrying out judicial examinations (construction and technical examination including) [3]. Today, neither state nor non-state experts have a definite methodological basis for the implementation of specific construction and technical expert studies.

The purpose of this work is to analyze existing regulations as well as theories and applications of judicial construction and technical expertise in the field of structures quality control and to introduce a methodology for solving a specific expert problem.

2. Theoretical and practical analysis of existing methodological approaches and forensic studies
Construction and technical expertise are based, as a rule, on some scientific and methodological approaches to these procedures in general. During such a procedure, experts specify the peculiarities of this construction and technical expertise and provide regulatory documents which are further applied to a particular issue raised by the court before the expert.

2.1. Scientific analysis of the procedure of construction and technical formal expert examination
Let us define the term 'the expertise methodology' (expert research) from the point of view of scientific terminology. Here, the expertise methodology is set of methods, techniques and technical means used in a certain sequence while studying objects of expertise to establish some facts related to the subject of a certain
kind, type and subspecies of expertise. The main methods used by an expert during the process of a formal expert examination can be described as, on the one hand, empirical and, on the other, theoretical. Empirical methods include measurement, simulation study and comparison [2]. Theoretical methods include analysis, synthesis, abstraction, extrapolation, induction and deduction. All these methods are used in the process of formal expert examination of construction projects, building structures and engineering systems as well as the expertise of their parts and components.

Table 1 demonstrates the process of construction and technical expertise on a phased basis. This is the authors' version of the classical methodology of an expert research applied to the field of construction and technical research.

Table 1. Stages and methods of construction and technical expert research

| №  | Examination stage                     | Main characteristics of the stage                                                                 | Methods of research   |
|----|--------------------------------------|--------------------------------------------------------------------------------------------------|-----------------------|
| 1  | Laboratory analysis of the case materials | Study of materials provided to experts and related to the subject of expertise, understanding of the task, determination of initial data sufficiency | Analysis, Comparison, Synthesis |
| 2  | Full-scale examination of the object of expertise | Expert examination organization and performance Assessment implementation (that is a set of measures to determine and evaluate actual values of the controlled parameters characterising the operational condition, suitability and performance of the objects of the assessment which determine the possibility of their further operation or the need for their restoration and strengthening) | Measurement, Simulation |
| 3  | Results processing and analysis       | Stationary study of the object, comparative analysis of field and desk studies                    | Comparison, Abstracting, Extrapolation |
| 4  | Final reckoning (conclusion)         | Comparison with documentary source data, drawing conclusions                                      | Induction, Deduction   |

Formal expert examination of welded joints quality at oil and gas industry construction projects as a subtype of construction and technical expertise includes all the stages listed in Table 1, and also involves the use of all the research methods listed above.

2.2. Analysis of the regulatory and methodological basis for welded joints of oil pipelines quality control

Ring welded joints of oil products transportation pipelines are an integral part of critical structures of hazardous production facilities and are subject to strict quality control of their performance.

Quality control of welded joints is a set of measures aimed at determining the quality of welded joints in various ways through the control of workers qualification; materials, equipment and devices used in the course of construction, the control of the welding technology and its compliance with the presence or absence of defects in welded joints (as stated in construction documents).

In court disputes on the quality of welded joints it is also important for the expert to assess their quality control results officially stated during the construction process.

The regulatory framework establishing the requirements for the organization and control of compliance with the technological processes of welding, design and welding results control is given in the following documents:

- the order of Rostekhnadzor of 26.12.2006 No. 1128 "On validation and introduction of requirements to scope of documentation and rules of procedure for executive documentation at construction, reconstruction, capital repairs of capital construction projects and of requirements imposed to examination certificates for construction works and networks of engineering infrastructure" [4];
the order of Rostekhnadzor of 14.03.2014 No. 102 "On the approval of Federal regulations and rules in the field of industrial safety "Requirements to production of welding works on hazardous industrial facilities" [5];
- GOST (All Union State Standard) 7512-82 Non-destructive evaluation. Welded joints. Radiographic method [6].

Welding works shall be performed according to the engineering and manufacturing documentation on welding including production instructions and technological charts on welding approved in accordance with the established procedure. All requirements applicable to welding technologies, welding practice, welding consumables and welding equipment as well as to weld inspection should be registered in the engineering and manufacturing documentation. Welded joints control should be carried out in the scope and according to methods provided by the standard process documentation or project documentation.

During welding works it is necessary to provide:
- identification of production documentation and forms, the use of basic materials, the use of welding materials, the proper location of welds in the structure;
- registration of information about welders performing welds, places and results of corrections of welded joints;
- control of compliance of the welding process with the welding process charts.

Welded connections of elements with wall thickness more than 6 mm are subject to marking with indication of codes of brand marks of welders which make it possible to identify the welders who carried out welding.

While carrying out of welding works, the executive documentation, including logs of welding works, conclusions on the control, test reports of welded joints providing the ability to identify records of the completed welded joints for ciphers brand marks of welders and welds should be issued in timely manner.

If all regulatory documents mentioned above are properly followed, it makes it easier for the expert to assess the quality of welded joints. More precisely, there might be no need to assess the quality of welded joints at all due to the absence of the subject-matter of the judicial case. However, the practice of judicial construction and technical expertise demonstrates otherwise, proving the need for a coherent methodology of such studies.

2.3. Scientific and practical analysis of examination of welded joints of oil pipelines quality control
In this part the authors analyse the procedure of practical examination of welded joints quality. This analysis is based on a real expert study with the following characteristics:
- the object of expertise – the pipeline pumping trap oil at the refinery;
- the questions put by the court to the expert - whether pipelines installation works are in accordance with as-built documentation, whether the materials which have been actually used correspond to project documentation, whether the brand marks of welded joints indicated in the production of welding works correspond to those stated in construction documents;
- the purpose of the expert study is to assess the quality of welding works performed during the installation of the pipeline on the basis of the actual contractor's answers to the questions posed by the court.

Table 2 shows step-by-step results and identified problems in the process of performing this examination.
Table 2. Stages and problems of expert research of quality of pipeline welded joints

| №   | Examination stage                              | Stage results and problems                                                                 |
|-----|-----------------------------------------------|------------------------------------------------------------------------------------------|
| 1   | Laboratory analysis of the case materials     | Executive documentation includes only general lay-outs of welding joints (no customer approval)  |
|     |                                               | Additional request for the following missing documentation: logs of welding works, acts of visual and (or) measuring control of welded connections, conclusions about the quality of welded connections by results of radiographic control |
|     |                                               | No executive documentation confirming welding works progress and quality as required by existing normative documents |
| 2   | Full-scale examination of the object of expertise | Welded connections of assembled pipelines 89×6, 159×6, 219×6 mm are hidden under their painting and insulation |
|     |                                               | Branding of welding joints with indelible paint                                             |
|     |                                               | Hidden nature of works, no possibility of measurement and photofixation of the examination object |
| 3   | Results processing and analysis               | No possibility to compare the compliance of brand marks of welders with the results of the inspection and desk audit of the submitted documentation |
| 4   | Final reckoning (conclusion)                  | The fact that welded connections were made by the claimed contractor is not established        |

Thus, the most important and at the same time problematic issues in the process of examination of the quality of welded joints and the proof that they were made by the definite of welding works are as follows:

1. The welding joints of oil products pipelines are hidden by subsequent works. As a result, neither the joint itself nor the welder's brand mark can be investigated without the disturbance of insulating layers (see Figures 1, 2).

2. Methods of welded joints branding contradictory to the existing regulations [3]: applying the brand marks with paint instead of the print (see Figure 3). When branding technologies are violated, it is not always possible to find the brand mark even in case when the insulation is broken for the sake of the expert study (after the structure painting).

Figure 1. Welded joints of the pipeline before insulation installation

Figure 2. Installed pipeline with broken insulation
3. No consistent and comprehensive documentation of the welding process and results.

The authors go on with further specification of technical expertise methodology typical for construction and technical examination of welded joints quality. It is based on the experience described above.

3. Development of methodological approaches to perform expert studies of the quality of welded joints of pipelines

In this part the authors follow the adapted method of construction and technical expertise (described in Part 2.1 of the article) and take into account the analysis of expert practice problems and difficulties in the study of the quality of welded joints of pipelines after the completion of construction works (described in Part 2.3 of the article). The researchers introduce here a set of new methods to improve the methodology mentioned above.

The most significant methodological additions, according to the authors, should be made to the analytical stages of the examination that is to the desk analysis of the case materials and to the analysis of research results.

The key provisions that need to be included into the methodology of examination of the quality of welded joints of pipelines are as follows:

1. Examination of the as-built documentation at the stage of desk analysis.

The executive documentation should include the following documents:

- logs of welding works;
- pipelines test certificates, the test reports of welded joints;
- certificates of installation of technological pipelines (with information on welding);
- executive schemes (drawings) of pipelines (with indication of welding joints);
- specifications of material resources used in the process of the installation of pipeline sections;
- lists of welders, heat treatment operators, welding engineers, certified by visual and measuring control (with information about their personal brand marks, assessment certificates issued by the National Agency for welding control);
- certificates of visual and (or) measuring quality control of welded joints;
- acts of input control of material resources;
- pipeline welding technological charts;
- certificates of welding materials performance evaluation;
- electrodes quality certificates.
2. Examination of photo and video recording materials at the stage of research results analysis.

As weld joints tend to be hidden by subsequent works after the completion of installation of oil products, the expert has no possibility to independently assess the quality of welded joints and identify the deposited brand marks. In addition, at the sites of hazardous production facilities, there is often a ban on photo and video.

In this case, the expert can use the results of photo and video fixation, performed earlier in the process of direct execution and control of works as the legitimate basis for expert research of determining the welding operator and the quality of welded joints (that is, in addition to the duly executed as-built welding documentation). This photo and video evidence must be formally included into the annex to the executive documentation and further presented in the case if there is a legal expertise of the issues related to welding.

4. Conclusions
The paper introduces the authors' methodology of conducting a specific construction and technical expertise study - the formal expert examination of the quality of welded joints of pipelines.

The research is based on the comprehensive analysis of the theoretical and procedural frameworks of forensic activities, normative and technical regulations, on the authors' own experience and on the identified problems which occur in the process of quality examinations of building structures and their parts.

The research results can further be used as a methodology for formal expert examination of the quality of welding works and in the organization, control and design of welding works while they are performed.

References
[1] Federal law No. 73-FZ of 31.05.2001 "On state forensic activities in the Russian Federation", access mode: http://base.garant.ru/12123142/ online: 06/2019.
[2] Yu. G. Korukhov, Dictionary of basic terms of forensic examinations, M.: Sudex publishing center, 2012.
[3] I. G. Burtsev, and Ya. I. Kondratieva, Typical errors in forensic examination, Traditions and innovations in architecture and civil engineering. Construction: collection of articles [electronic resource], Samara, pp. 384-387, 2017.
[4] The order of Rostekhnadzor of 26.12.2006 No. 1128 "On validation and introduction of requirements to scope of documentation and rules of procedure for executive documentation at construction, reconstruction, capital repairs of capital construction projects and of requirements imposed to examination certificates for construction works and networks of engineering infrastructure", 2006.
[5] The order of Rostekhnadzor of 14.03.2014 No. 102 "On the approval of Federal regulations and rules in the field of industrial safety "Requirements to production of welding works on hazardous industrial facilities", 2014.
[6] GOST (All Union State Standard) 7512-82 Non-destructive evaluation. Welded joints. Radiographic method.