BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXVII No. 4/2015	21 – 34	Seria Tehnică

Technological Features of Valves Installation on the Natural Gas Transmission Pipelines – Part II

Gheorghe Zecheru*, Ilie Laţa**, Andrei Dumitrescu*

* Universitatea Petrol-Gaze din Ploieşti, Bd. Bucureşti 39, 100680, Ploieşti
e-mail: gzecheru@upg-ploiesti.ro

** SNTGN "TRANSGAZ" S.A., P-ța Constantin I. Motaş 1, 551130, Mediaş
e-mail: ilie.lata@transgaz.ro

Abstract

This paper presents the main requirements regarding the technical features of the valves intended to be used as equipment components for the natural gas transmission systems. The main technological problems regarding the valves installation on the pipelines belonging to these transmission systems are analysed, commented and answered. The paper, due to its topic, constitutes a practical guide extremely useful for those dealing with the design, construction, testing and quality inspection of some new natural gas transmission pipelines, and also for those who design or perform maintenance, rehabilitation or modernisation works for such pipelines.

Key words: *natural gas transmission pipelines, pipeline valves, valves installation and testing*

The Technological Process of Valves Installation

For the installation of the valves onto the pipelines intended for natural gas transmission, several technological procedures technically possible (applicable with the available elements of logistics) can be conceived. The main issues that shall be taken into consideration for the elaboration of the technological process for the installation of a valve are the followings:

- as a function of the type of pipeline on which the valve is installed (new pipeline, pipeline that is rehabilitated etc.) and of the initial / basic data regarding the installation, the type of the technological installation process can be selected: with the intercalation / insertion of the valve on the pipeline – TIV or with the serial installation of the valve on the pipeline – TSV;
- in all cases (new pipeline or a pipeline which is repaired) the valve installation is performed on the pipeline taken out of service and cleaned (without containing natural gas, liquid hydrocarbons, water or mechanical impurities);
- the installation of the valve is performed in "field" conditions and, as a consequence, the technological process of installation shall not contain operations that are difficult to perform in such conditions (preheating, post-weld heat treatments etc.);
- the most important technological operations (upon which depend the mounting quality and the operational safety of the pipeline on which the valve has been installed) are the operations of execution of the welded joints and/or of the flanged joints;
- the technological process of installation that is applied in a given case must be selected among the technological processes technically possible conceived for that case, by applying a

pertinent technical and economical criterion: maximum installation efficiency; minimum cost of the installation works; maximum mounting quality and the uppermost operating performances etc.

A. The technological process of TIV type for the installation of a valve with welding ends comprises the operations presented in Figure 13 (where point *O* is the reference / main marker for the valve positioning); during the execution of the operations of tack welding and of welding of the valve to the pipeline, the valve weight must be unloaded (on the supporting elements of the valve) and it shall not generate mechanical stresses in the joints area.

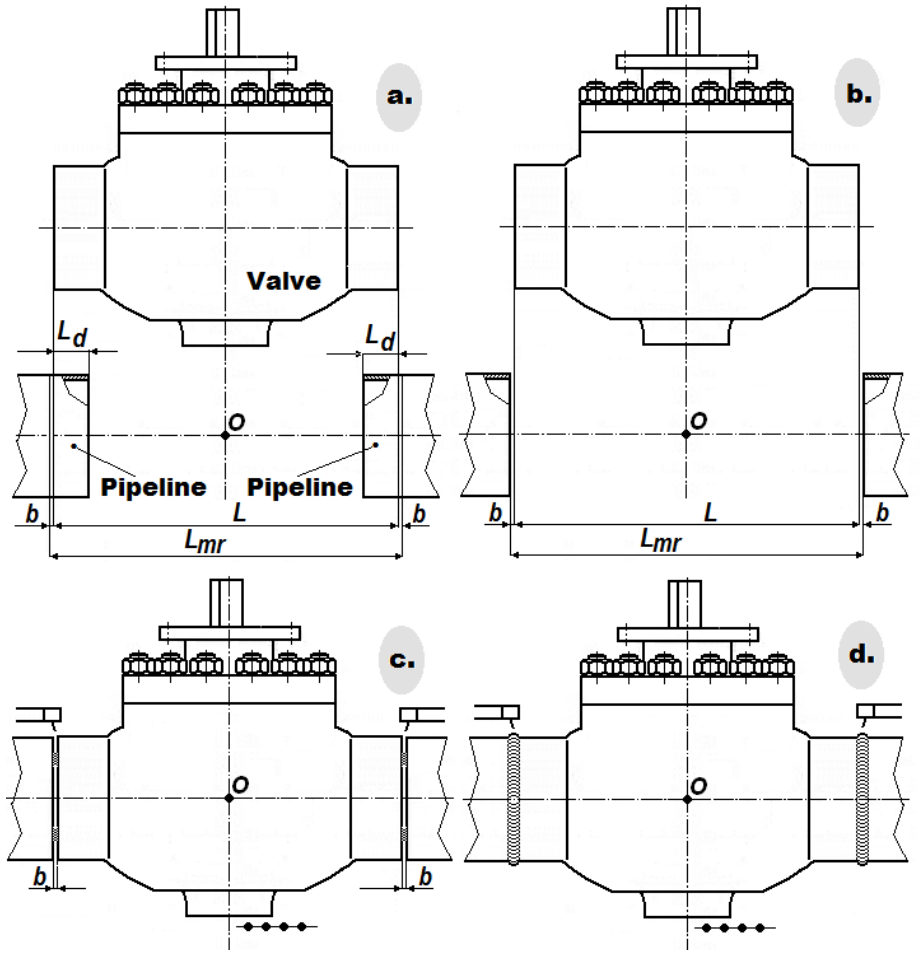


Fig. 13. Technological process of TIV type for the installation of a valve with welding ends: a. positioning the valve and marking the ends of the pipes between which the valve is intercalated / inserted; b. machining the pipes ends and securing the mounting distance $L_{mr} = L + 2b$, *L* being the "end-to-end" dimension of the valve; c. tack welding the valve on the pipeline; d. performing the circular welded joints between the valve and the pipeline.

B. The technological process of TSV type for the installation of a valve with welding ends includes the operations shown in Figure 14; as for the previous case, during the execution of the operations of tack welding and of welding of the valve to the pipeline, the valve weight shall be unloaded (on the supporting elements of the valve) and it must not generate mechanical stresses in the joints area.

If it is assessed that the execution of the welded joints can determine the inacceptable heating and the damage or deterioration of some components of the closure system of the valve, the manufacturer can be required to deliver the valve with extended welding ends, obtained by welding (in factory conditions, using suitable welding processes and regimes) some pipe segments at the two ends of the valve body (see fig. 8.b). In order to install such a valve, the same technological processes of installation as described above are used (alternatives A or B).

C. The technological process of TIV type for the installation of a valve with flanged ends consists of the operations presented in Figure 15; during the execution of the operations of tack welding, of welding – on the pipes of the transmission line – the flanges between which the valve is installed and of achieving the assemblies with flanges, the valve weight must be unloaded (on the supporting elements of the valve) and it shall not generate mechanical stresses in the area of the welded joints or of the flanged assemblies.

If the installation conditions allow it, after tack welding the flanges between which the valve is placed, the flanged assemblies are disconnected and the valve is removed, and after welding the flanges at the ends of the pipeline, the valve is reinstalled, restoring the flanged joints; by acting in this way, the hazard of damage or deterioration of the elements of the valve closure system due to excessive heating during the execution of the welding operation is eliminated.

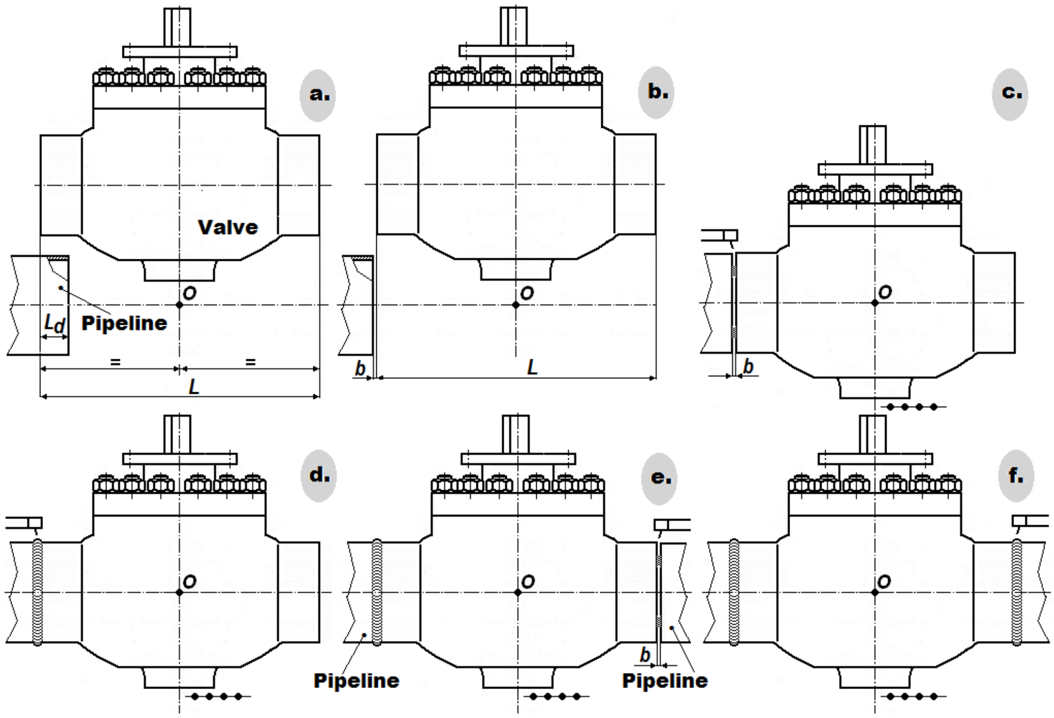


Fig. 14. Technological process of TSV type for the installation of a valve with welding ends: a. positioning the valve and marking the pipe end to which the first end of the valve is welded; b. machining the pipe end and securing the correct position of the mark *O*; c. tack welding the first end of the valve to the pipe on which it is mounted; d. executing the circular welded joint between the first end of the valve and the pipe of the transmission line; e. machining the end of the second pipe with which the valve is assembled and tack welding the second end of the valve with the pipe end; f. performing the circular welded joint between the second end of the valve and the pipe of the transmission line.

D. The technological process of TSV type for the installation of a valve with flanged ends comprises the operations shown in Figure 16; as for the previous case, when applying such a technology, the necessary measures will be taken in order for the loads due to the own weight of the components that are assembled not to generate mechanical stresses in the welded or flanged joints.

One of the important conditions that must be fulfilled when applying any of the installation technologies described is constituted (as it has been previously stated) by securing the placement in the correct reciprocal position of the components that are assembled by welding when installing the valve: the pipes and flanges which are welded at the pipes ends, if the valve that is to be installed is provided with flanged ends, respectively the pipes and welding ends of the valve, if the valve that must be installed is of the type with welding ends; the main requirements regarding the placement in the correct reciprocal position of the components and the preservation of their correct location by using tack welds are the followings:

- the components that are joined by butt welding shall be aligned adequately, the maximum allowable misalignment Δ_{ac} having to correspond to the indications from Figure 17; by analysing the drawing from Figure 17, it can be observed that the misalignment of the components that are to be joined by butt welding (which has to be inferior to the value Δ_{ac} in any point on the circumference of the components ends) is complex, depending on several factors: the non-coaxial positioning of the components; the effective deviation of the reference diameter of the components; the out-of-circularity of the components ends etc.;

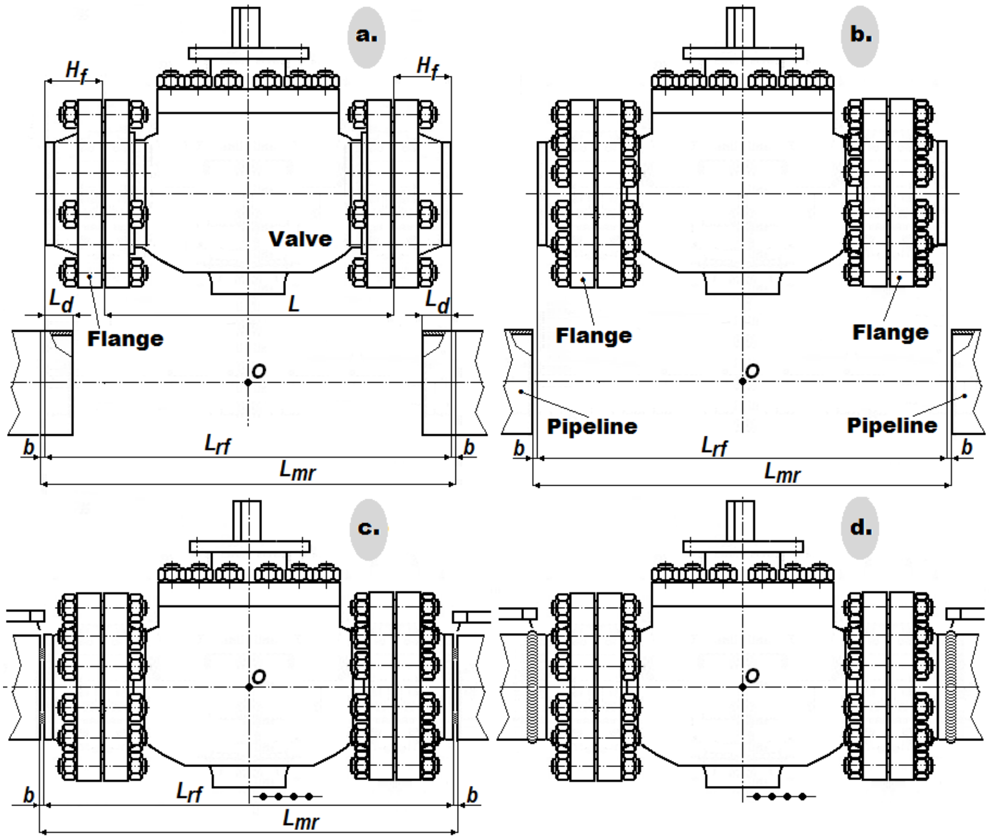


Fig. 15. Technological process of TIV type for the installation of a valve with flanged ends: a. positioning the valve and marking the pipes ends between which the valve is intercalated / inserted; b. machining the pipes ends and securing the mounting distance $L_{mr} = L + 2H_f + 2b = L_{rf}+2b$, L being the “face-to-face” dimension of the valve, and H_f the height of the flanges between which the valve is mounted; c. tack welding, on the pipes ends between which the valve is inserted, of the flanges on which the valve is installed, the joints between these flanges and the end flanges of the valve being completely achieved (with the bolts or studs screwed adequately in order to secure the mechanical strength and tightness of the joints); d. performing the circular welded joints between the flanges amid which the valve is mounted and the pipes of the transmission line.

- the ends of the components that are joined by butt welding shall be machined suitably to achieve between them a weld groove with the geometry (described by the: root opening b; root face c; groove angle $2\alpha_t$) precisely defined, as a function of the thickness of the components that are welded, of the adopted welding process, of the used welding position (defined in accordance with [13]: vertical up PF or vertical down PG welding on the pipeline with horizontal axis; horizontal PC welding on the pipeline with vertical axis; up H-L045 or down J-L045 welding on the pipeline with inclined axis – see fig. 9), of the type of filler materials (electrodes, wires etc.) which are used etc.; for the typical case of metal – arc welding with covered electrodes (process 111 according to [14]), using PF and PG positions, the following all-purpose requirements shall be applied (which are correlated with the recommendations made by the valve manufacturers or by the standards in the field, such as [12] – see figs. 10 and 11): when welding in the PF position: $b = 2.0^{+0.5}$ mm; $c = 2.4^{+0.8}$ mm and $2\alpha_t = 75^o \pm 5^o$, and when welding in the PG position: $b = 1.2^{+0.5}$ mm; $c = 1.6^{+0.8}$ mm and $2\alpha_t = 60^{o+10}$;

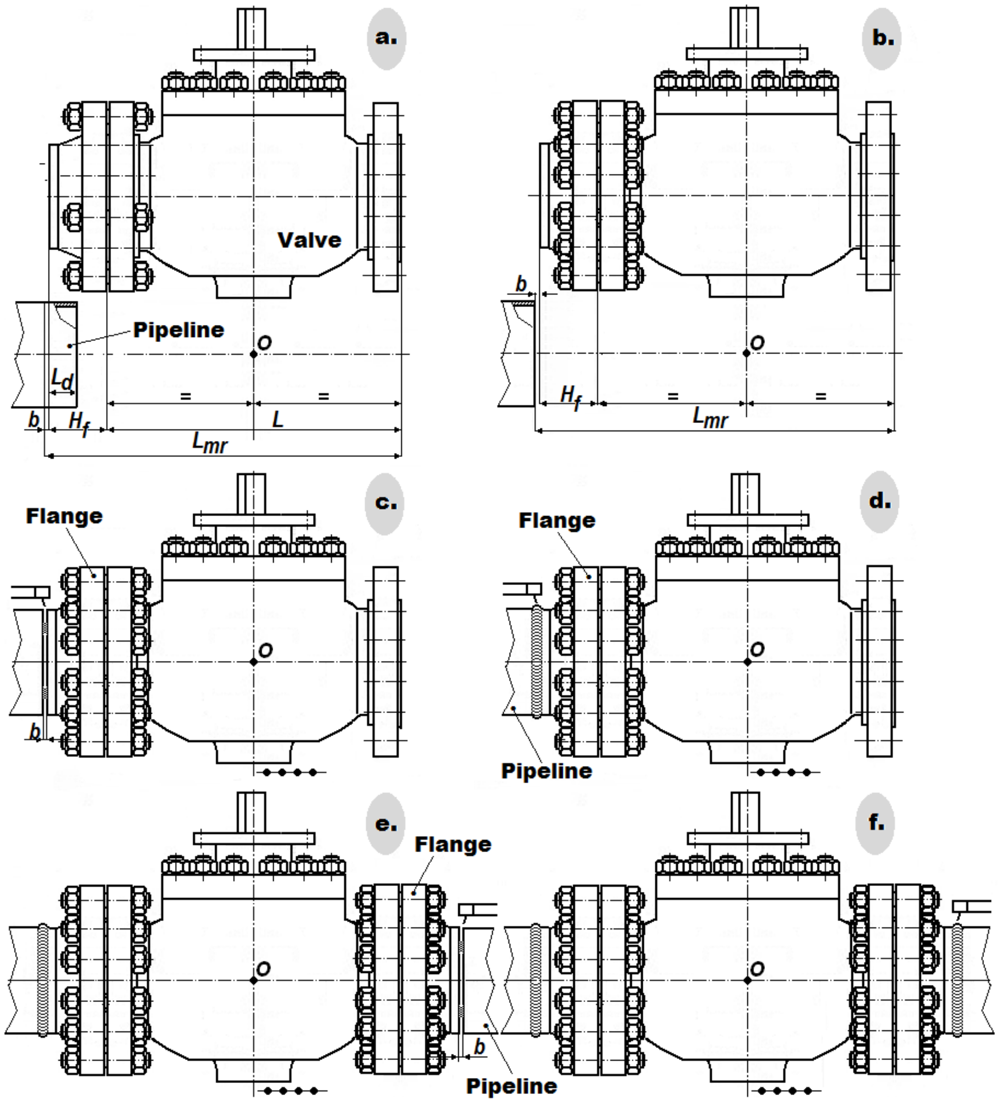


Fig. 16. Technological process of TSV type for the installation of a valve with flanged ends: a. positioning the valve and marking the pipe end to which the first flange for the valve installation is welded; b. machining the pipe end and securing the correct position of the mark *O*; c. tack welding the first flange for the installation of the valve on the pipe with which it is assembled; d. performing the circular welded joint between the flange and the pipe of the transmission line and final tightening of the joint between this flange and the first end flange of the valve; e. machining the end of the second pipe with which the valve is assembled, tightening the assembly between the second end flange of the valve and the second flange for the valve installation and tack welding the second flange for the valve installation with the pipe end; f. executing the circular welded joint between the second flange for the valve installation and the pipe of the transmission line.

- the frontal surfaces of the ends of the components which are joined by butt welding shall be parallel, the allowable value for the lack-of-parallelism being defined by means of the opening *b*, which has to be maintained within the field of tolerance (defined above) in any point on the circumference of the components ends; in addition, as a function of the welding position, the following recommendations regarding the placement of the areas with the minimum opening of the weld groove on the circumference of the components ends shall also be fulfilled: for PF welding, the groove with the minimum opening must be positioned (defined using the conventional method of the o'clock position) at 6 o'clock, while, for PG welding, the groove with the minimum opening has to be located at 12 o'clock;

- the maintenance in the correct position of the components which are butt joined is secured by executing 4 tack welds, whose edges are subsequently grinded with a round shaped abrasive disc and which shall have the following geometrical characteristics (see fig. 18): length l_{ps} = 12...22 mm, penetration p_{ps} = 1.6 ± 0.3 mm and root reinforcement e_{rp} = 1.3 ± 0.3 mm; the tack welds will be located (in diametrically opposed pairs) at 2, 5, 8 and 11 o'clock, if PF position is to be use for welding, and at 3, 6, 9 and 12 o'clock, if PG position will be used for welding.

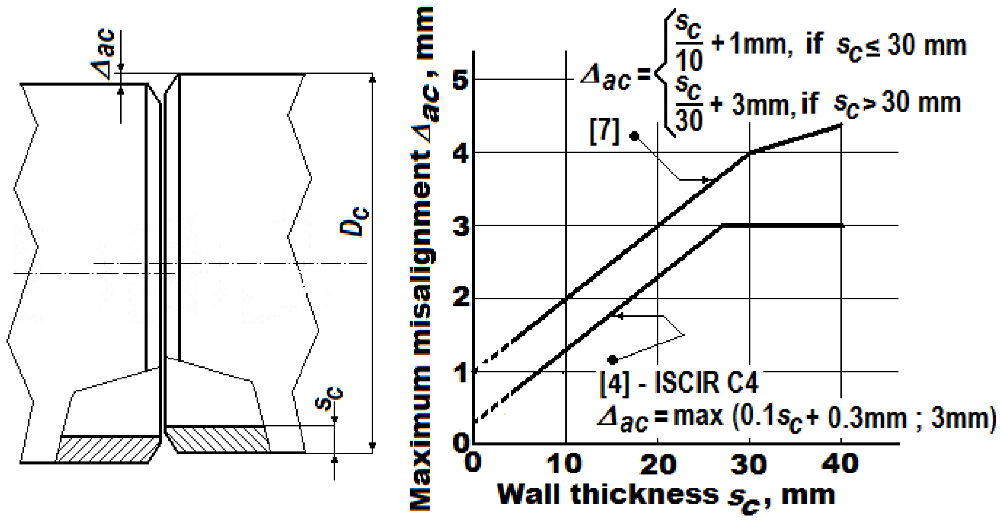


Fig. 17. The allowable misalignments of the components that are joined by butt welding when installing valves

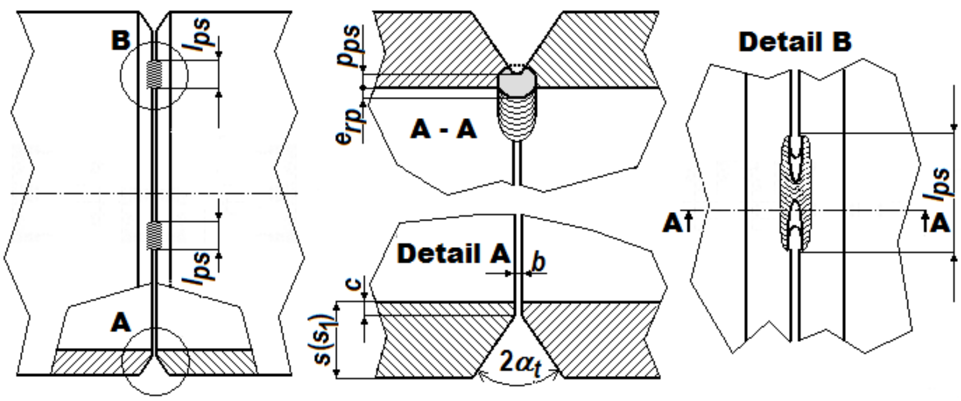


Fig. 18. The correct positioning and tack welding of the ends of the components that are joined by butt welding when installing valves

Welding Technologies Used for Valves Installation

The welding operations are involved in all the technological processes of valves installation on the natural gas transmission pipelines, the functionality and reliability of the valves, as well as the operational safety of the pipeline on which the valves have been installed, depending to an essential extent on the quality of their execution. Therefore, the welding operations from the technological processes of installation of the valves on pipelines shall be performed only with qualified procedures, the welding procedure being defined as a "specified course of action to be followed in making a weld, including the welding process or processes, reference to materials, welding consumables, preparation, preheating (if necessary), method and control of welding and post-weld heat treatment (if relevant) and necessary equipment to be used". Any welding procedure is documented by: a) a Welding Procedure Specification – WPS, document that stipulates in detail the variables corresponding to a specific application in order to ensure the repeatability; b) a recommended practice, which represents a simplified specification of the welding procedure, suitable for the direct practical usage, where values are defined for all the essential variables which are under the direct control of the welder, values that must be used by the welder when performing the welding operation.

Each welding procedure (and its specification – WPS) has to be qualified. The qualification of a welding procedure has as basis a preliminary Welding Procedure Specification – pWPS, which is a draft of the specification for a welding procedure, assumed adequate by the user, but which has not been qualified; welding of the specimens required for the qualification of a welding procedure shall be executed on the basis of a pWPS. The qualification of a welding procedure is performed on the basis of a Welding Procedure Approval Record – WPAR, which contains all the relevant data about welding the specimens required for the qualification of the procedure and all the results obtained when examining and testing these specimens.

Any welding procedure must be reset with a new WPS and shall be completely requalified when the essential variables modify themselves. The changes of the other variables does not imply the elaboration and requalification of new welding procedures. The essential variables are:

- the welding process or the method of application of this process;
- the parent material (of the components that are welded); for the development of the qualified procedures, the parent materials are divided in the following categories: a) steels with the specified minimum yield strength smaller than or equal to 290 MPa; b) steels with the specified minimum yield strength greater than 290 MPa, but smaller than 448 MPa; c) steels with the specified minimum yield strength greater than or equal to 448 MPa, with the specification that, for the steels from each mechanical strength grade that fits within this last category, specific welding procedures shall be developed and qualified;
- the joint configuration; the small changes of the angle of the weld groove are not considered as changes of this essential variable, while the basic configuration of the groove (V, U, I etc.) defines this essential variable, the transition from one shape of the groove to another implying the qualification of a new welding procedure;
- the welding position; a change of position (for instance, passing from welding with the rotation of the components that are welded to welding with the components maintained in a fixed position or passing from vertical down welding to vertical up welding) imposes the qualification of a new welding procedure;
- the wall thickness of the components that are joined by welding; the range of the wall thicknesses of the components for which a qualified procedure is valid (using welded specimens with the wall thickness s_p) can be defined by applying the methodology recommended in [15] or using the recommendations from Table 2, obtained by processing the information from this standard;
- the filler material; the followings constitute modifications of this essential variable (which imply the qualification of a new welding procedure): a) the conversion of the filler material from one group to another (the groups are defined in Table 3); b) any change of the strength grade of the filler material, for the pipes and components with the specified minimum yield strength greater than 448 MPa; the main groups of filler materials recommended by [16] for welding pipes and components of the natural gas transmission pipelines using the process 111 (metal – arc welding with covered electrode) are presented in Table 3;

Table 2. Definition of the range of the wall thicknesses (of the components that are welded) for which a qualified welding procedure is valid

Wall thickness of the components of the welded specimens used for the procedure qualification s_p, mm	Wall thicknesses range (s_c, mm, of the components which are welded) for which the qualified welding procedure is valid	
	Single run welding	Multi run welding
$s_p \leq 3$	$0.7s_p \leq s_c < 1.3s_p$	$0.7s_p \leq s_c < 2.0s_p$
$3< s_p \leq 12$	$\max[0.5s_p; 3] \leq s_c <1.3s_p$	$3 \leq s_c < 2.0s_p$
$12 < s_p \leq 30$	$0.5s_p \leq s_c < 1.1s_p$	$0.5s_p \leq s_c < 2.0s_p$

Table 3. Groups of filler materials recommended for the execution of the welding operations when installing valves

AWS Group	AWS Specification	AWS covered electrodes	Equivalent electrodes [17]
1	A5.1 A5.5	E6010; E6011 E7010; E7011	E35 3 C 21 E42 2 MoC21
2	A5.5	E8010; E8011	E46 31 MiMoC21
3	A5.1/A5.5 A5.5	E7015; E7016; E7018 E8015; E8016; E8018	E42 5 B 32H5; E42 2 B 12H10 E46 6 1Ni B 42H5

- the electrical parameters; changing the polarity when using direct current or switching from direct current to alternating current, the use of values of the arc welding current I_s outside the range [$0.9I_{sp}$; $1.1I_{sp}$] or the range [$0.85I_{sp}$; $1.15I_{sp}$], if cellulosic electrodes are used, as well as welding with values of the arc voltage U_a outside the range [$0.9U_{ap}$; $1.1U_{ap}$] (I_{ap} being the value of the welding current and U_{ap} – the value of the arc voltage when welding the specimens with which the procedure qualification has been performed) constitute modifications of this essential variable;
- the inter-pass time; increasing the maximum value of the time between the completion of the root pass and the execution of the following layer constitutes a modification of this essential variable;
- the shielding gas and its flow rate; changing the shielding gas or the shielding gas mixture, as well as increasing or decreasing noticeably the flow rate of the shielding gas or of the shielding gas mixture constitute modifications of this essential variable;
- the welding speed; changing the recommended range for the welding speed constitutes a modification of this essential variable and imposes the qualification of a new welding procedure; the welding speed range for which a qualified procedure is valid is [$0.9v_{sp}$; $1.1v_{sp}$), v_{sp} being the welding speed used for the execution of the specimens with which the procedure qualification has been performed;
- the preheating; diminishing the minimum specified value of the preheating temperature t_{pr} constitutes a modification of this essential variable;
- the post-weld heat treatment; introducing a post-weld heat treatment or changing the regime parameters of the existent treatment constitute modifications of this essential variable and imposes the qualification of a new welding procedures.

For the development of the procedures required for the execution of the welding operations when installing the valves, the following important issues shall be taken into account:

- the parent materials, from which the components that are joined by butt welding are manufactured, that is the pipes of the transmission line and the valve body, for the case of installing the valves with welding ends, or the pipes and the flanges between which the valve is installed, for the case of installing the valves with flanges at the ends, are non-alloy steels or low-alloy steels or micro-alloy steels, with fine grains and high mechanical strength, from the grades and groups summarized in Tables 4 and 5; it has to be mentioned that in these tables:

a) the groups from [18] comprise the steels: Group 1 – Steels with a specified minimum yield strength R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ ≤ 460 MPa and with the analysis in %: %C ≤ 0.25; %Si ≤ 0.60; %Mn ≤ 1.70; %Mo ≤ 0.70*; %S ≤ 0.045; %P ≤ 0.045; %Cu ≤ 0.040*; %Ni ≤ 0.5*; %Cr ≤ 0.3 (0.4 for castings); %Nb ≤ 0.05; V ≤ 0.12*; %Ti ≤ 0.05, with the remark that, for the components marked with *, a higher value is accepted provided that %Cr + %Mo + %Ni + + %Cu + %V ≤ 0,75; Group 2 – Thermomechanically treated fine grain steels and cast steels with a R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ > 360 MPa; Group 3 – Quenched and tempered steels and precipitation hardened steels (except stainless steels) with a R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ > 360 MPa; b) the groups from [19] comprise the steels: unalloyed steels without guaranteed properties at elevated temperature – 2E0 or with guaranteed elevated temperature properties – 3E0 or with specified properties up to 400 °C, R_{eH} > 265 MPa; low-temperature-tough fine-grain steels with R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ > 275 MPa at room temperature – 7E0 or with R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ > 355 MPa at room temperature – 7E1; fine-grain steels with yield strength at room temperature R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ > 285 MPa – 8E2 or R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ > 355 MPa – 8E3;

Table 4. The main grades and groups of steels used to manufacture the pipes for transmission lines

Group and subgroup of steels according to [18]			Steel grades according to [20]
Group	Subgroup	Material description a)	
1	1.1	Steels with R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ ≤ 275 MPa	L245R,N,Q,M
	1.2	Steels with 275 MPa < R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ ≤ 360 MPa	L290R,N,Q,M; L360N,Q,M
	1.3	Normalized fine grain steels with R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ > 360 MPa	L415N
2	2.1	Thermomechanically treated fine grain steels and cast steels with 360 MPa < R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ ≤ 460 MPa	L415M; L450M
	2.2	Thermomechanically treated fine grain steels and cast steels with R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ > 460 MPa	L485M; L555M
3	3.1	Quenched and tempered steels with 360 MPa < R_{eH}, $R_{p0.2}$ or $R_{t0.5}$ ≤ 690 MPa	L415Q; L450Q; L485Q; L555Q

a) the values of the specified yield strength can be for the upper yield strength R_{eH}, for the proof strength, plastic extension $R_{p0.2}$ or for the proof strength, total extension $R_{t0.5}$

- the weldability of the steels indicated as parent materials is good, since they have limited mass concentrations of carbon and impurities (S and P) and they present low levels of carbon equivalent *CE*, determined with the equations recommended in [1] (CE_{IIW}, if %C > 0.12 % or CE_{Pcm}, if %C ≤ 0.12 %), but it has to be taken into account the fact that weldability is also influenced by the welding process used and by the quality of the filler materials used for welding;
- the main technological problem whose solution must be secured by the execution procedures for the welding operations when installing valves is hydrogen induced cracking (also named cold cracking or delayed cracking); in Annex B from [16] it is specified that three conditions must be simultaneously fulfilled in order for the hydrogen induced cracking to occur: a) hydrogen is present in the welded joint; b) the metallurgical structure of the welded joint is susceptible to cracking; c) tensile mechanical stresses are generated in the welded joint area;
- in order to prevent hydrogen induced cracking, technological measures shall be taken in order to minimize or to eliminate the possibility of occurrence of at least one of the three conditions stated above: a) using electrodes with a reduced content of hydrogen and making the conditions for the deployment of welding processes with low levels of diffusible hydrogen in the welded joints; b) minimizing the possibilities for the formation in the welded joint (in the weld W and in the heat / thermo-mechanically affected zone – HAZ) of some microstructures susceptible to cracking; to that purpose, one can resort to: using a large enough heat input at

welding, welding with preheating (not recommended in the case of the welding operations implicated by the valves installation, because it is difficult and costly to apply in field conditions), executing some W with multiple layers (the application of each layer having a preheating effect for the next layer and an annealing effect for the previous layer), achieving an annealing layer above the W; c) securing a low intensity of the residual stresses generated at welding and reduced effects of concentration of these stresses at the root of the welded joint performed; from this point of view, the installation technologies of TIV type are not favourable (and TSV type technologies are preferred), because – when performing the welding operations – feedback stresses of important intensities (besides the residual stresses due to welding, determined by the non-uniform temperature distribution in the areas of W and HAZ formation) are generated, being determined by the obstruction and/or limitation of the deformation of the material in the weld area due to the great stiffness of the ensemble formed by the components that are welded;

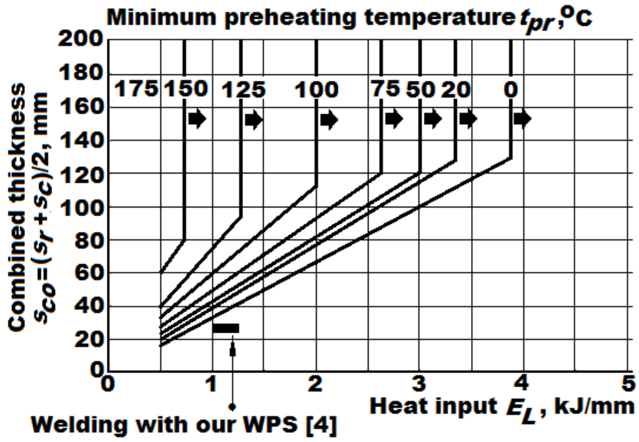
Table 5. Steels recommended for the valves bodies and for the flanges mounted on pipelines[a)]

Steel grade	Standard	Steel subgroup [18]	Steel group [19]	Utilization domain
GP240GR [c)]	[21]	1.1	2E0	CASTING Body of pipeline valves (welding ends or end flanges)
GP240GH [c),d)]		1.1	3E0	
GP280GH [c),d)]		1.2	3E0	
G17Mn5 [d)]	[22]	1.1	7E0	
G20Mn5 [d)]		1.2	7E0	
P245GH	[23]	1.1	3E0	FORGING Body of pipeline valves (welding ends or end flanges) Pipeline flanges
P280GH		1.1	3E1	
P285NH,QH	[24]	1.2	8E2	
P355NH,QH		1.2	8E3	
P420NH [b)]		1.3	8E3	
P420QH [b)]		3.1	8E3	
P235GH; P265GH	[25]	1.1	3E0	PLATE & STRIP Pipeline flanges
P295GH		1.2	3E1	
P275NL1,NL2	[26]	1.1	7E0	
P355NL1,NL2		1.2	7E1	
P275NH		1.1	8E2	
P355N,NH		1.1	8E3	
P460N,NH,NL1,NL2		1.3	8E3	
P460Q,QH,QL1,QL2	[27]	1.3	8E3	

a) the chemical composition and mechanical properties of the steels shall correspond to the requirements from the standards indicated in the table; b) these grades are not found among the steel grades selected in [19]; c) the final structural state obtained after the normalizing heat treatment (N); d) the final structural state obtained after the heat treatment of quenching + tempering (QT).

- in order to define rational welding regimes, ensuring the achievement of welded joints of good quality (with desired mechanical properties and without cracks induced by hydrogen) and cost-effective (performed with reduced costs, by using low-price filler materials and avoiding the application of preheating and/or post-weld heat treatments), the usage of the methods presented in Annex C of the standard [14] is recommended; in this manner, the authors of the present paper have elaborated and qualified a new welding procedure, whose WPS is included in [4], for which the diagram from Figure 19 confirms the validity and describes the field of usage, based on the application of the requirements from [14], with the help of the recommendations from this standard being also determined the length of the W deposited with one electrode L_{de} (with the length L_{MA} = 450 mm), which is the reference criterion for testing the welders training (before executing the welds for valves installation): L_{de} = 145...170 mm, for the case of welding with covered electrodes with the diameter d_{MA} = 3.2 mm and L_{de} = 190 ... 225 mm, for the case of welding with covered electrodes with the diameter d_{MA} = 4.0 mm;

- the procedure whose WPS is presented in [4] corresponds to the use of the metal – arc welding process with covered electrode (code 111), which is at present the welding process currently used when constructing the pipelines intended for natural gas transmission; the improvement of the quality of the welded joints that are executed when installing valves (and, in general, when laying pipelines) can be secured by using Flux – Cored wire metal – Arc Welding without gas shield – FCAW-NG (code 114) or Flux – Cored wire metal – Arc Welding with Inert Gas shield – FCAW-IG (code 137), using special equipment for orbital welding, of the type shown in Figure 20 [30], a pWPS for such applications (using the process FCAW-IG) being proposed by the authors of the present paper and included in [4].



Diffusable hydrogen content D_{HC}, ml/100g of deposited metal	(15...	(10;15]	(5;10]	(3;5]	...3]
Hydrogen scale	A	B	C	D	E
Carbon equivalent CE_{IIW}max, %	0.43	0.45	0.47	0.53	0.55

Fig. 19. Description of the field of use and of the validity of the welding procedure by applying the method recommended by SR EN 1011-2:2002

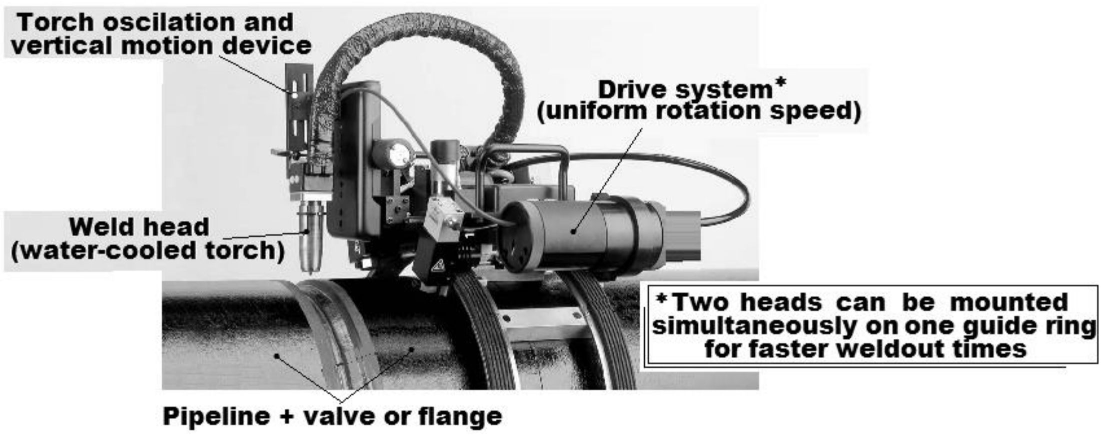


Fig. 20. Equipment for orbital welding, using the FCAW, for valves installation [30]

The quality of the welded joints related to valves installation is checked along the execution of the welding operations and after performing the welded joints. While completing the welding operations it is checked: a) the integral and rigorous fulfilment of the requirements from the Welding Procedure Specification which is used; b) the quality of each layer of the welded joint and, if the case, the complete removal of the slag after executing each layer; the inspections are performed by careful visual examination and have to be completed so that the requirements from the Welding Procedure Specification regarding the inter-pass temperature are fulfilled. After executing the welded joints, the non-destructive examination of their quality is performed. The plans for non-destructive testing of the welded joints connected to valves installation shall stipulate the inspection of all these joints (100 % inspection) using radiographic or ultrasonic testing, doubled by the magnetic particles or liquid penetrant examination, in accordance with the requirements from [16, 28].

Because when performing the welded joints linked to valves installation the risk of delayed cracking due to hydrogen can appear, according to the requirements from [14], the non-destructive examinations of the welded joints shall be scheduled after at least 16 hours from their execution.

The inspection of the welded joints quality will be performed with suitable equipment and devices, capable to unambiguously highlight the presence of the possible defects, to record and to store the information obtained following the examinations and to allow for their interpretation and for editing the documents including the inspection result. The inspection shall be performed only by authorised laboratories and by adequately qualified and authorised personnel that shall comply with all the requirements comprised in [28]. The types of imperfections and defects of the welded joints that has to be taken into account, the quality level and the acceptance criteria of the welded joints subjected to checking will be specified by using the requirements from [16, 29]; the existence in the welded joints of the discontinuities (detected by non-destructive examination using any of the methods previously mentioned) which are interpreted as lack of fusion, lack of penetration or cracks shall not be accepted in any case. All the welded joints that do not comply with the acceptance criteria shall be subjected to reparation or re-execution and shall be re-subjected to the procedure of quality inspection.

Execution of the Flanged Joints when Installing Valves

The quality of the execution of the joints with flanges influences to an essential extent the operationality and reliability of the valves with flanged ends, as well as the operational safety of the pipelines on which such valves have been installed. The execution of the flanged joints, required for the installation of the valves with flanged ends, implies the achievement of the activities and the fulfilment of the following indications:

- checking the integrity of the frontal surfaces of the flanges and of the packings;
- checking the fulfilment of the total allowable misalignment of the bolt holes (from the flanges of the valve that is installed) A – see fig. 21.a; in accordance with the requirements from [3] the condition that shall be satisfied is: $A \leq 2$ mm, if the nominal size of the valve is at the most DN100 or $A \leq 3$ mm, if the nominal size is over DN100;
- mounting the bolts or studs and tightening the nuts in a “criss-cross” pattern, based on a working scheme of the type shown in Figure 21.b, with the recommended tightening moment (recorded as initial data) in order to ensure the development, in the bolts or studs, of the axial (pre-tensioning) force needed to secure the mechanical strength and tightness properties of the flanged joint; in order to tighten the threaded connections bolt/stud – nut, adequate dynamometric keys shall be used.

Conclusions

The issues analysed, commented and resolved in this paper, regarding the technical requirements and the technological processes that must be applied when installing valves on the pipelines (for transmission and from the technological installations) belonging to the natural gas transmission systems, can be summarised under the form of the following conclusions:

- The valves are a complex equipment (made of a great number of components that functionally interact), with large sizes and weights (in correlation with the dimensions of the pipelines on which they are placed), with high acquisition and installation costs and with extremely important operational requirements (on whose fulfilment the working continuity and the operational safety of the natural gas transmission systems largely depend) and, as a result, when manufacturing them and when installing them on the pipelines, all the technical requirements that confers them high performances of reliability and maintainability shall be rigorously fulfilled.

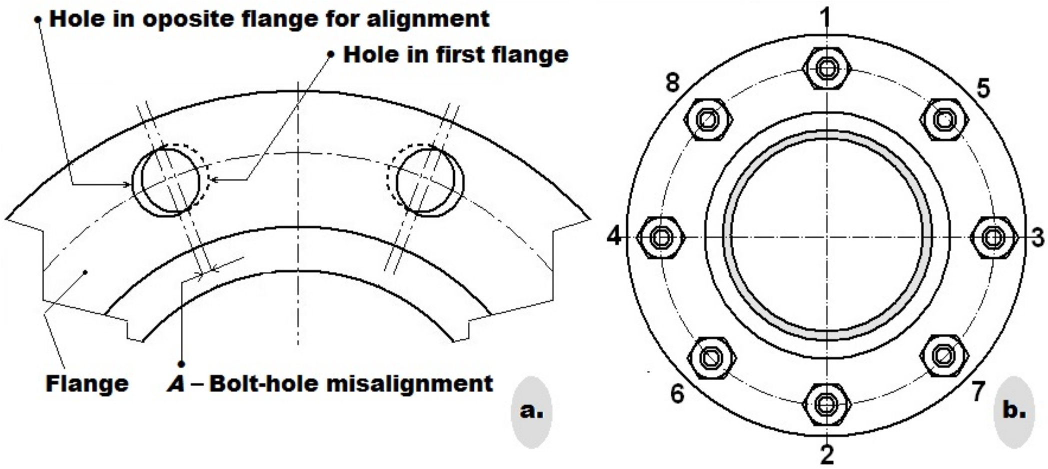


Fig. 21. Indications regarding the execution of the flanged joints when installing the valves: a. inspection scheme for the total allowable misalignment of bolt holes *A*; b. tightening scheme for the threaded connections bolt/stud – nut (1, 2...8 – working order when executing the tightening).

- The operational reliability (real reliability) of the valves can be determined to a very important extent by the component named reliability of use (which is combined probabilistically with the intrinsic reliability, determined by the manufacturing quality), with its magnitude depending on the quality of the installation, operation and maintenance of this equipment.
- The preparation of valves installation, consisting of analysing the initial / basic data needed to elaborate the technological process of installation, checking the technical state of the valves that must be installed and approving their installation (if all the constructional and operational features from the technical documentation correspond to the characteristics marked on each valve prepared for installation), settling and marking the place for the installation of the valves, preparing the ends of the pipeline on which each valve is installed and guaranteeing the mounting distance, shall be rigorously performed, fulfilling all the recommendations from the present work.
- The type of the technological process of installation (with the intercalation / insertion of the valve on the pipeline – TIV or with the serial installation of the valve on the pipeline – TSV) is selected taking into account the technical features of the pipeline on which installation is performed and of the valve that is installed.
- The welding operations related to valves installation shall be performed only based on qualified procedures, rigorously complying with the requirements from the specifications of these procedures; the recommendations from the present paper regarding the selection of the welding conditions, regimes and materials so that the unwanted phenomenon of cold cracking of the welded joints does not occur, as well as the recommendation to perform the operations of non-destructive examination of the welded joints after at least 16 hours from their execution (because cold cracking, due to hydrogen, is a phenomenon of delayed cracking) shall be fulfilled.
- The quality of the execution of the main operations when making flanged joints, consisting of checking the integrity of the frontal surfaces of the flanges and packings, and of the controlled tightening of the threaded connections bolt/stud – nut, can have important influences on the reliability of the valves installed on pipelines.

Acknowledgements

The research leading to these results has received funding from the European Union Seventh Framework Programme FP7-PEOPLE-2012-IRSES, under grant agreement n° 318874 "*INNOPIPES*" – ***Inno****vative Nondestructive Testing and Advanced Composite Repair of* ***Pipe****lines with Volumetric* ***S****urface Defects*.

References – continued from **Part I**

14. * * * – EN 1011-2:2002, *Welding. Recommendation for welding of metallic materials*.
15. * * * – EN ISO 15614-1:2004, *Specification and qualification of welding procedures for metallic materials. Welding procedure test.* Part 1: *Arc and gas welding of steel and arc welding of nickel alloys*.
16. * * * – API Standard 1104 –1994, *Welding of pipelines and related facilities*.
17. * * * – EN ISO 2560:2009, *Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels. Classification*.
18. * * * – CR ISO 15608:2000, *Welding. Guidelines for a metallic material grouping system*.
19. * * * – EN 1092-1:2001, *Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated*. Part 1: *Steel flanges*.
20. * * * – EN ISO 3183:2013, *Petroleum and natural gas industries. Steel pipe for pipeline transportation systems* (equivalent of API Specification 5L).
21. * * * – EN 10213-2:1996, *Technical delivery conditions for steel casting for purposes*. Part 2: *Steel grades for use at room temperature and at elevated temperatures*.
22. * * * – EN 10213-3:1995, *Technical delivery conditions for steel casting for purposes*. Part 3: *Steel grades for use at low temperatures*.
23. * * * – EN 10222-2:2000, *Steel forgings for pressure purposes. Ferritic and martensitic steels with specified elevated temperature properties*.
24. * * * – EN 10222-4:2000, *Steel forgings for pressure purposes. Weldable fine-grain steels with high proof strength*.
25. * * * – EN 10028-2:2003, *Flat products made of steels for pressure purposes*. Part 2: *Non-alloy and alloy steels with specified elevated temperature properties*.
26. * * * – EN 10028-32:2003, *Flat products made of steels for pressure purposes*. Part 3: *Weldable fine grain steels, normalized*.
27. * * * – EN 10028-6:2003, *Flat products made of steels for pressure purposes*. Part 6: *Weldable fine grain steels, quenched and tempered*.
28. * * * – ISO 13847:2013, *Petroleum and natural gas industries. Pipeline transportation systems. Welding of pipelines*.
29. * * * – EN ISO 5817:2014, *Welding. Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levels for imperfections*.
30. * * * – *MAGNATECH orbital welding systems*, www.magnatech-europe.com

Particularităţile tehnologice ale instalării robinetelor pe conductele destinate transportului gazelor naturale – Partea a II-a

Rezumat

În lucrare sunt prezentate principalele cerinţe privind caracteristicile tehnice ale robinetelor care trebuie utilizate ca echipamente componente ale sistemelor de transport al gazelor naturale şi sunt analizate, comentate şi soluţionate principalele probleme tehnologice privind instalarea robinetelor pe conductele aparţinând acestor sisteme de transport. Prin conţinutul său, lucrarea constituie un ghid practic deosebit de util pentru cei care se ocupă cu proiectarea, construirea, probarea şi verificarea calităţii unor noi conducte de transport al gazelor naturale, precum şi pentru cei care proiectează sau efectuează lucrări de mentenanţă, reabilitare sau modernizare a unor astfel de conducte.