

Fabrication of Steel Structures in Accordance with the Requirements of the New ZTV-ING Regulations – Selected Issues

Abstract: The fabrication of steel structures imposes on the manufacturer obligations to comply with requirements of appropriate standards and regulations. This article discusses examples of German market requirements applying to the fabrication of civil engineering structures (made of steel) in accordance with the German ZTV-ING regulations [1]. In addition, the article provides examples of requirements concerning materials, design, welded joints, fabrication and acceptance documentation of steel structures described in ZTV-ING Part 4, Chapter 1. The article also discusses requirements concerning the corrosion protection of structures described in Chapter 3. Particular attention is paid to the necessity of meeting requirements concerning the competence of personnel involved in the fabrication of structures and the corrosion protection of the latter. Because of the fact that many Polish manufacturers fabricate civil engineering structures for the German market, the knowledge of the new issue of the ZTV-ING regulations (2022) is essential.

Keywords: ZTV-ING Regulations, Civil engineering structures

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Introduction

Depending on types of structures, their manufacturer is obliged to comply with appropriate standards and regulations. In terms of the European market, steel and aluminium building structures are governed by Regulation of the European Parliament and of the Council (UE) 305/2011 [2]. The above-named regulation requires that a building product entering the market should be provided with a declaration of performance and CE marking. In addition, the above-named requirement entails the necessity of complying with the DIN EN 1090 standard [3] (because of the fact that Part 1 of the aforesaid standard is harmonised with Regulation of the European Parliament and of the Council (UE) 305/2011). The manufacturer launching a building product on the market should implement (in their organisation) and certify the principles of the Company Production Control in accordance with the requirements specified in the DIN EN 1090 standard. In addition, different regulations may apply to such structures depending on

the location of their operation (e.g. bridges, road infrastructure, etc.). The aforesaid structures are governed by regulations contained in ZTV-ING – *Additional Technical Contract Conditions and Guidelines for Civil Engineering Works*. The ZTV-ING regulations contain nine chapters, i.e. 1. General information, 2. Foundation work, 3. Solid construction, 4. Steel construction, composite steel construction, 5. Building methods, building aids, 6. Building systems, 7. Tunnel construction, 8. Other buildings and 9. Annexes. Steel structures are addressed in Part 4 *Steel construction, composite steel construction*. Chapter 1 of the above-named part contains requirements concerning the fabrication of steel structures, whereas Chapter 3 *Corrosion protection of steel structures* contains requirements concerning corrosion protection. The knowledge of requirements specified in ZTV-ING is essential to companies making civil engineering structures (such as roads, etc.) for German customers. The article refers to some aspects specified in the latest issue of ZTV-ING (2022).

Requirements specified in ZTV-ING Part4, Chapter 1 – Steel construction

Manufacturers

The manufacturer of structures governed by regulations specified in ZTV-ING must be in possession of a related factory production control certificate (in accordance with the DIN EN 1090-1 standard) as well as a related welding certificate (in accordance with the DIN EN 1090-2 standard), corresponding to a related structure execution class (EXC). In terms of execution class EXC3, welding coordination specialist should possess entire technical knowledge, i.e. level C in accordance with the DIN EN ISO 14731 standard [4]. Class EXC3 applies, among other things, to all load-bearing elements of bridges. Class EXC2 (less restrictive) applies to remaining elements.

Materials

Structures should only be made of steels representing strength classes S235, S355 and S460, and consistent with the DIN EN 10025-1, -5 [5], DIN EN 10210 [6] and DIN EN 10219 [7] standards. Closed sections (shapes) must be consistent with the DIN EN 10210 standard; the thickness of their walls must be ≥ 30 mm. An additional requirement concerning closed sections is their state after normalising (NH or NLH). Load-bearing structures of bridges must not be made of steels having guaranteed toughness at a temperature of +20 and of 0°C (JR and J0). In addition, materials used in load-bearing structures of bridges must satisfy requirements of technical conditions DBS 918. It is often necessary to identify steel properties in the direction perpendicular to the surface (Z15, Z25 and Z35). The satisfaction of the above-named requirements is confirmed in acceptance certificate 3.2 in accordance with the DIN EN 10204 standard [8] (approved by a body recognised by the ordering party). In terms of all structures other than load-bearing ones it is possible to accept certificates consistent with the requirements of the DIN EN 1090-2 standard. Acceptance documents concerning materials must be presented to the ordering party before the fabrication of a structure. It should be noted that regulations of ZTV-ING also specify information which should be contained in acceptance certificates. The information should include, among other things, the chemical composition in relation to 15 chemical elements, i.e. C, Si, Mn, P, S, Al, N, Cr, Cu, Mo, Ni, Nb, Ti, V and B

and the value of carbon equivalent (CEV). In turn, in relation to 30 mm thick steel S355 it is necessary to confirm the satisfaction of requirements related to test SEP 1390 [9]. Usually, acceptance certificates only contain information concerning the chemical composition in relation to 14 elements, whereas test SEP 1390 or the Z-test in accordance with DIN EN 10164 [10] are performed as additional tests. Upon placing an order for steel it is necessary to precisely specify all requirements [11].

Design

The design process should be performed in accordance with the requirements specified in the DIN EN ISO 12944-3 [12] standard. Regulations indicate how much attention in ZTV-ING is paid to the corrosion protection of structures. It is necessary to agree (with the ordering party) all the fixing and auxiliary elements of a given structure. Such elements must be presented in production drawings and it is the ordering party that must take a decision concerning the use of such elements in the structure. It is possible to leave internal surfaces of tightly closed sections (shapes) without corrosion protection. Obviously, in the aforesaid case it is necessary to perform a leak test, where initial overpressure should amount to 2.2 bar, whereas an acceptable pressure drop within 24 hours should be 10%. It is possible to omit leak tests as regards secondary elements. It should be noted that the performance of a leak test, in addition to necessitating the welding of additional pipe connectors/nozzles, requires additional time during the fabrication process (min. 24 hours). At the design stage it is necessary to take into account the minimum requirements concerning the thickness of materials used in the structure. In terms of footbridges it is necessary to satisfy the requirements of the DIN EN 1993-2 [13] Eurocode, whereas as regards road bridges it is necessary to satisfy additional requirements specified in ZTV-ING and presented in Table 4.1.2.

Welded joints

Welders must be in possession of a valid licence (in accordance with the DIN EN ISO 9606-1 standard [14]), whereas operators must be in possession of a valid licence in accordance with the DIN EN ISO 14732 [15]. The welding company is obliged to ensure that welders satisfy welded joint-related quality requirements (where welders should have appropriate welding specimens before starting

their work). The manufacturer can start welding works only after welding coordination personnel has approved required welding procedure specifications (WPS), developed on the basis of welding procedure qualifications. The qualification process should be performed on the basis of the DIN EN ISO 15613 [16] or DIN EN ISO 15614 [17] standards. Welds should represent quality level B in accordance with the DIN EN ISO 5817 [18] standard in relation to load-bearing elements and quality level C in relation to elements of secondary importance. In cases where it was necessary to weld auxiliary elements, cutting off the latter should be followed the inspection of the surface for cracks (if any). Table 4.1.3 of ZTV-ING contains the scope of required tests in relation to structures of class EXC3.

Fabrication

The fabrication of steel structures should be consistent with principles specified in the DIN EN 1090-2 standard. During production, in addition to internal inspection (performed by the manufacturer), it is necessary to conduct external inspection (performed by the ordering party). The aforesaid inspection should include both the fabrication and corrosion protection of a given structure. It is also necessary for the manufacturer to submit a written declaration of conformity before the shipment of structural elements to the construction site. During the fabrication process, areas at risk of being exposed to fatigue loads must not be marked by imprinting and plasma marking.

Documentation

The acceptance of a given structure is based on related documentation. Regulations contained in ZTV-ING specify minimum documentation-related requirements. The documentation should contain, among other things, qualification certificates of the manufacturer and their subcontractors in accordance with the DIN EN 1090 standard, welding personnel qualification certificates in accordance with the DIN EN ISO 9606 and DIN EN ISO 14732 standards, NDT personnel qualification certificates in accordance with the DIN EN ISO 9712 standard [19], corrosion personnel qualification certificates in accordance with ZTV-ING as well as conformity certificates and declarations for all materials, verified production and assembly/mounting documentation, welding procedure specifications (WPS) and welding procedure

qualification records (WPQR), schemes for control and corrosion protection instructions, reports concerning works and their supervision (such as lists of welders, NDT reports, corrosion protection reports and measurement reports).

ZTV-ING requirements Part 4, Chapter 3 – Corrosion protection of steel structures

In terms of anticorrosion solutions it is necessary to comply with the requirements of the DIN EN ISO 12944 standard. When designing new structures it is also necessary to take into account activities aimed to ensure environmental protection in cases of corrosion protection repairs (if any). In addition, in cases of galvanised structures it is necessary to comply with guidelines DAST 022 [20] and the DIN EN ISO 14713-2 standard [21]. An important requirement concerning new structures which should be subjected to corrosion protection through panting is the obtainment of preparation level P3 in accordance with the DIN EN ISO 8501-3 standard [22] (or the obtainment of preparation level P2 in terms of welds). In cases of edges, an alternative to a requirement imposed by preparation level P3 (rounding of all edges to obtain minimum radius minimum $R = 2$) is three-sided collapse. Structures to be subjected to hot galvanising or thermal spraying should be prepared in accordance with preparation level P2. Preparation level P3 requires additional amount of work, which should be remembered as early as during the overview of requirements. Regulations specified in ZTV-ING are also concerned with environmental requirements and specify the necessity of complying with related regulations as regards the emission of volatile substances (i.e. necessity of reporting the emission or obtaining permission for the emission of volatile substances). During the removal of old coatings with harmful substances performed by means of reusable abrasive materials, the equipment used in the process must allow the separation of harmful substances from the abrasive material. The regulations also indicate the necessity of the removal and the disposal of waste in accordance with related regulations. Regulations contained in ZTV-ING state that abrasive materials used for surface preparation should be sharp-edged and consistent with the DIN EN ISO 11124 [23] and DIN EN ISO 11126 [24] standards. Surfaces prepared for painting should represent

minimum purity class Sa 2½ (in accordance with the DIN EN ISO 8501-1 standard [25]), whereas the surface profile should be at least average Grit in accordance with the DIN EN ISO 8503-1;-2 standard [26]. The cleaning of the surface should be followed by inspection for dust (acceptable class 2 in accordance with the DIN EN ISO 8502-3 standard [27] and contamination with salt amounting to a maximum of 80 mg/m² (in accordance with the DIN EN ISO 8502-6 standard [28]). An important requirement concerns the manner of preparing galvanised surfaces for painting. Regulations specified in ZTV-ING require the performance of sweeping, yet the removal of a maximum of 15 µm of the zinc coating is permitted. Prepared surfaces must be released for the painting process by the ordering party or an inspection body designated by the former. The performance of corrosion protection requires the development of corrosion protection schemes. Schemes and technical specifications of applied materials must be available in the work area. The application of paint coatings should take place on the same day after cleaning or, if purity level Sa3 is required, immediately. Before the application of another layer, each paint coating should be approved by the ordering party. Individual layers should be of different colours. The thickness of paint coatings should be measured using the 80/20 principle, where the maximum thickness must not exceed the double or, in individual cases, the triple nominal thickness. The thickness of priming paints containing zinc must be restricted to 150 µm. It should also be noted that priming paints must not be applied using the roller. After the deposition of the priming paint it is necessary to additionally paint edges and welds, where the width and thickness of the layer is often identified in specifications. When planning the painting process, the painting of edges should be treated as the deposition of an additional layer. In relation to hot galvanising, zinc coatings are assessed using the requirements of DASt 022 and those of the DIN EN ISO 1461 standard [29]. In terms of thermal spraying, coatings are assessed on the basis of the requirements specified in the DIN EN ISO 2063-1;-2 standard [30]. All the corrosion protection-related works must be appropriately documented (in accordance with Annex B), where the documentation should be transferred to the ordering party. Corrosion protection-related requirements in accordance with the previous issue of ZTV-ING are presented in publication [31].

Personnel

Requirements contained in ZTV-ING concerning personnel can be divided into two groups. The first group is concerned with requirements related to personnel involved in welding processes and that involved in non-destructive tests. Such personnel should possess appropriate qualifications (citing appropriate standards). Different requirements apply to corrosion protection personnel. In terms of thermal spraying, ZTV-ING refers to the DIN EN ISO 2063-1;-2 standard, which, in turn, refers to the ISO 12690 standard [32]. The above-named standards contain requirements concerning metalisers, whose qualifications should be consistent with the ISO 14918 standard [33]. In turn, personnel supervising the process of thermal spraying should have qualifications consistent with the ISO 12690 standard. Qualifications of personnel supervising thermal spraying depend on their knowledge; the standard specifies three levels of knowledge, i.e. extensive technical knowledge sufficient for the planning, performing, supervising and the testing of all the tasks as well as for assuming responsibility for spraying, specialist technical knowledge sufficient for the planning, performing, supervising and the testing of all the tasks as well as for assuming responsibility for spraying within a given technical sub-area and basic technical knowledge sufficient for the planning, performing, supervising and the testing of all the tasks as well as for assuming responsibility for spraying within a limited technical area. Regulations specified in ZTV-ING state that personnel performing the deposition of paint coatings should also be appropriately qualified. For instance, in terms of German contractors, foremen should confirm their qualifications by holding a KORSchein certificate. Foreign contractors should hold an equivalent qualification certificate, yet ZTV-ING regulations do not specify what qualifications can be recognised as such. It should be noted that a KORSchein course lasts 3 weeks and finishes with an examination. To the best knowledge of the authors of this article, in many cases holding a FROSIO inspector certificate is sufficient. However, such a fact should always be agreed between the parties to a contract. A foreman with appropriate qualifications must be present at all times during the performance of works. Other personnel should also hold appropriate certificates, e.g. of a successfully completed (anti)corrosion course

(of a minimum 2 weeks' duration); personnel performing abrasive blasting should have completed a course in shot blasting (of a minimum 1 week's duration), whereas painters should have completed a coating deposition course (of a minimum 1 week's duration).

Summary

In view of the above-presented ZTV-ING regulations it is particularly important to get to know related requirements before signing a contract. When starting to perform a given order, the manufacturer must be aware of additional requirements imposed by ZTV-ING in terms of materials, fabrication process and works-related documentation. A particularly important requirement is concerned with anticorrosion personnel's competence and qualifications. It is important to agree with the counterparty what personnel's qualifications will be acceptable as equivalent to those stipulated in ZTV-ING. In cases where the supplementation of qualifications is required it is necessary to take into account the availability of related courses on the Polish market. Companies planning to fabricate structures for the German market should take into account the necessity of satisfying requirements specified in ZTV-ING. In such a case it is necessary to plan the satisfaction of requirements concerning technical possibilities involving the fabrication of related structures and requirements involving anticorrosion personnel (along with necessary training, if any). The above-named FROSIO inspector certificate can be obtained in related courses conducted in Poland (with Polish as the language of instruction). It is also possible to employ external personnel, yet, in such a case, it is necessary to take into account additional costs related to that fact and properly assess the availability of such personnel on the market.

Prior to agreeing contractual provisions the manufacturer should be aware of the necessity of satisfying various requirements concerning both personnel performing a given contract and materials used during the performance of the contract.

When discussing ZTV-ING requirements it is necessary to note that nearly all the aforementioned standards are described as DIN. The foregoing means that the analysis of contractual provisions necessitates reference to German issues of related standards. It might happen that a

national annex to the German issue of a given standard will contain additional requirements.

References

- [1] ZTV-ING:2022 – Dodatkowe warunki techniczne umów i wytyczne dla konstrukcji inżynierskich.
- [2] Rozporządzenie Parlamentu Europejskiego i Rady (UE) nr 305/2011 z dnia 9 marca 2011.
- [3] DIN EN 1090-1,-2,-3+A1:2012 Wykonanie konstrukcji stalowych i aluminiowych Część 1: Zasady oceny zgodności elementów konstrukcyjnych; Część 2: Wymagania techniczne dotyczące konstrukcji stalowych; Część 3: Wymagania techniczne dotyczące wykonania konstrukcji aluminiowych.
- [4] DIN EN ISO 14731:2006 Nadzorowanie spawania. Zadania i odpowiedzialność.
- [5] DIN EN 10025:2004 Wyroby walcowane na gorąco ze stali konstrukcyjnych.
- [6] DIN EN 10210:2006 Kształtowniki zamknięte wykonane na gorąco ze stali konstrukcyjnych niestopowych i droбноziarnistych.
- [7] DIN EN 10219:2006 Kształtowniki zamknięte ze szwem wykonane na zimno ze stali konstrukcyjnych niestopowych i droбноziarnistych.
- [8] DIN EN 10204:2004 Wyroby metalowe. Rodzaje dokumentów kontroli.
- [9] SEP 1390 próba spawalności poprzez zginanie próbki napawanej.
- [10] DIN EN 10164:2004 Wyroby stalowe o podwyższonych własnościach plastycznych w kierunku prostopadłym do powierzchni. Warunki techniczne dostawy.
- [11] Kozłowski J., Krawczyk R.: Wymagania dodatkowe do wytwarzania spawanych konstrukcji budowlanych wg normy EN 1090. Biuletyn Instytutu Spawalnictwa, 2023, vol. 67, no. 1, pp. 26–31.
- [12] DIN EN ISO 12944-1–8:1998 Farby i lakiery – Ochrona przed korozją konstrukcji stalowych za pomocą ochronnych systemów malarskich.
- [13] DIN EN 1993-2:2019 Eurokod 3. Projektowanie konstrukcji stalowych. Część 2: Mosty stalowe.
- [14] DIN EN ISO 9606-1:2017 Egzamin kwalifikacyjny spawaczy. Spawanie. Część 1: Stale.
- [15] DIN EN ISO 14732:2014 Personel spawalniczy. Egzaminowanie operatorów spawania oraz nastawiaczy zgrzewania dla zmechanizowanego i automatycznego spawania/zgrzewania metali.
- [16] DIN EN ISO 15613:2006 Specyfikacja i kwalifikowanie technologii spawania metali. Kwalifikowanie na podstawie przedprodukcyjnego badania spawania/zgrzewania.
- [17] DIN EN ISO 15614-1:2017 Specyfikacja i kwalifikowanie technologii spawania metali. Badanie technologii spawania. Część 1: Spawanie łukowe i gazowe stali oraz spawanie łukowe niklu i stopów niklu.
- [18] DIN EN ISO 5817:2014 Spawanie. Złącza spawane ze stali, niklu, tytanu i ich stopów (z wyjątkiem spawanych wiązek). Poziomy jakości według niezgodności spawalniczych.

- [19] DIN EN ISO 9712:2022 Badania nieniszczące. Kwalifikacja i certyfikacja personelu badań nieniszczących.
- [20] DAST 022 Deutscher Ausschuß für Stahlbau (Cynkowanie ogniowe nośnych elementów stalowych).
- [21] DIN EN 14713:2010 Powłoki cynkowe – Wytyczne i zalecenia dotyczące ochrony przed korozją konstrukcji ze stopów żelaza.
- [22] DIN EN 8501-3:2007 Przygotowanie podłoża stalowych przed nakładaniem farb i podobnych produktów – Wzrokowa ocena czystości powierzchni. Część 3: Stopnie przygotowania spoin, krawędzi i innych obszarów z wadami powierzchni.
- [23] DIN EN ISO 11124:2018 Przygotowanie podłoża stalowych przed nakładaniem farb i podobnych produktów. Wymagania techniczne dotyczące metalowych ścierni stosowanych w obróbce strumieniowo-ściernej.
- [24] DIN EN ISO 11126:2018 Przygotowanie podłoża stalowych przed nakładaniem farb i podobnych produktów. Wymagania techniczne dotyczące niemetalowych ścierni stosowanych w obróbce strumieniowo-ściernej.
- [25] DIN EN ISO 8501-1:2008 Przygotowanie podłoża stalowych przed nakładaniem farb i podobnych produktów. Wzrokowa ocena czystości powierzchni. Część 1: Stopnie skorodowania i stopnie przygotowania niepokrytych podłoża stalowych oraz podłoża stalowych po całkowitym usunięciu wcześniej nałożonych powłok.
- [26] DIN EN ISO 8503-1;-2:2012 Przygotowanie podłoża stalowych przed nakładaniem farb i podobnych produktów. Charakterystyki chropowatości powierzchni podłoża stalowych po obróbce strumieniowo-ściernej. Część 1: Wyszczególnienie i definicje wzorców ISO profilu powierzchni do oceny powierzchni po obróbce strumieniowo-ściernej. Część 2: Metoda stopniowania profilu powierzchni stalowych po obróbce strumieniowo-ściernej – Sposób postępowania z użyciem wzorca.
- [27] DIN EN ISO 8502-3:2012 Przygotowanie podłoża stalowych przed nakładaniem farb i podobnych produktów. Badania służące do oceny czystości powierzchni. Część 3: Ocena pozostałości kurzu na powierzchniach stalowych przygotowanych do malowania (metoda z taśmą samoprzylepną).
- [28] DIN EN ISO 8502-6:2020 Przygotowanie podłoża stalowych przed nakładaniem farb i podobnych produktów. Badania służące do oceny czystości powierzchni. Część 6: Ekstrakcja rozpuszczalnych w wodzie zanieczyszczeń do analizy (Metoda Bresle’a).
- [29] DIN EN ISO 1461:2023 Powłoki cynkowe nanoszone na wyroby stalowe i żeliwne metodą zanurzeniową. Wymagania i metody badań.
- [30] DIN EN ISO 2063 Natryskiwanie cieplne. Cynk, aluminium i ich stopy. Część 1: Uwagi dotyczące projektowania i wymagania jakościowe dla systemów ochrony przed korozją. Część 2: Prowadzenie systemów ochrony przed korozją.
- [31] Czysch M., Kozłowski J., Kozłowski J.: Wybrane zagadnienia z zakresu antykorozji stalowych konstrukcji spawanych na podstawie niemieckich przepisów ZTV-ING i VGB/BAW. Przegląd Spawalnictwa, 2017, vol. 89, no. 5, pp. 71–74.
- [32] DIN EN ISO 12690:2010 Powłoki metalowe i inne nieorganiczne. Nadzór nad natryskiwaniem cieplnym. Obowiązki i odpowiedzialność.
- [33] DIN EN ISO 14918:1998 Natryskiwanie cieplne. Egzamin dla metalizatorów.