Quality Supervision Practice of NDT Subcontractors in Power Plant Boiler Inspection

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Abstract—The quality supervision on subcontractors is the important part in the overall quality supervision of special equipment inspection and testing. This paper explains the importance of quality supervision of nondestructive testing by introducing cases of different testing conclusions caused by the difference of nondestructive testing standards, and then discusses the practical cases of quality supervision of nondestructive testing conducted by power plant boiler inspection institutions.

Keywords: quality supervision; NDT subcontractors; proficiency testing

1 Introduction

In recent years, with the development of national energy strategy and the optimization and upgrading of industrial structure, power station boilers, as one of the three main equipment of thermal power stations, are constantly upgrading towards high parameters and large capacity. Power station boilers shall be subject to supervision and inspection, periodic inspection and design document appraisal by power station boiler inspection institutions in different stages such as manufacturing, installation, repair, renovation and inspection according to the requirements of relevant laws, regulations and safety technical specifications for special equipment[1-2].Non-destructive testing technology plays an important role in the inspection process of power station boilers[3-4], and the results of non-destructive testing affect the conclusions of inspection reports. In some special cases, the inspection organization entrusts nondestructive testing to a qualified nondestructive testing organization during the inspection process, so the quality supervision of the entrusted nondestructive testing organization becomes an important part of the overall quality supervision of power plant boiler inspection. In this paper, the importance of quality supervision of nondestructive testing is illustrated by introducing cases in which different nondestructive testing standards lead to different testing conclusions, and then the practical cases of outsourcing quality supervision of nondestructive testing by inspection institutions in power plant boiler inspection are discussed in order to achieve the purpose of helping the high-quality development of power plant boiler industry.

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2 A case of the influence of the difference of nondestructive testing standards on the conclusion in the inspection of power station boilers

As an important inspection method, X-ray inspection is widely used in manufacturing, installation, inspection and other links[5-6]. During the boiler renovation of a power station, the inspection unit conducted X-ray inspection on the pipes and headers, and 30 negatives were taken, all of which were qualified above Grade II. However, when the inspectors of the inspection agency checked the negatives, they found that two of them should be judged as Grade IV and failed. Another two films of Grade I should be judged as Grade II and qualified. [7]

The reason is that the renovation and inspection unit adopts DL/T 821-2017 <Radiographic examination and quality classification of welded butt joints inmetallic materials> [8] (hereinafter referred to as DL/T 821) for evaluation, while the inspectors adopt NB/T47013.2-2015 <Nondestructive testing of pressure equipment-Part2: Radiographic testing>[9] according to the requirements of TSG G0001-2020 < Regulation on Safety Technology for Boiler> (hereinafter referred to as "Boiler Regulation). The different standards adopted lead to different final judgment results, the comparative information are seen in Table 1.

TABLE 1 THE DIFFERENCE BETWEEN DL/T 821 AND NB/T 47013.2

<table>
<tr><td colspan="3">Item</td><td>DL/T 821</td><td colspan="2">NB/T 47013.2</td></tr>
<tr><td rowspan="3">Evaluation scope</td><td colspan="2">Double Sided welding</td><td rowspan="3">≤200</td><td>For pipe and tube: /</td><td>For pressure equipments:≤400</td></tr>
<tr><td rowspan="2">Single side welding</td><td>With backing plate</td><td>For pipe and tube: ≥2</td><td>For pressure equipments:≤400</td></tr>
<tr><td>Without backing plate</td><td>For pipe and tube:≥2</td><td>For pressure equipments: /</td></tr>
<tr><td rowspan="2">Irradiation technology</td><td colspan="2">Dual-film transmittance technology</td><td>Use two films with different photosensitive speeds for one-time transmittance</td><td colspan="2">none</td></tr>
<tr><td colspan="2">The length of a transmittance</td><td>Transmittance thickness ratio K have nothing to do with the level of ray detection technology.</td><td colspan="2">Transmittance thickness ratio K has different values according to the different classes.</td></tr>
</table>

	Double-wall single-shadow transmittance		The minimum number is given according to the difference in the distance f from the radiation source to the surface of the work piece: When f ≤ 15mm, N = 3; when f > 15mm, N = 4	The number of transmittances of the double-wall single-shadow transmittance method is obtained by looking up the chart, and the minimum is 2 transmittances.	
	Blackness of negatives	-	-	Single Film	Dual Film
		A	1.5≤D≤4.5	1.5≤D≤4.5	2.7≤D≤4.5 Among them, the single negative D ≥ 1.3
		AB	2.0≤D≤4.5	2.0≤D≤4.5	
		B	2.3≤D≤4.5	2.3≤D≤4.5	
Quality grade evaluation	Double side welding		Crack, lack of fusion, incomplete penetration, stripy flaw, round flaw, root concave	For pipe and tube: /	For Pressure Equipment: Crack, lack of fusion, incomplete penetration, stripy flaw, round flaw
	Single side welding (with/without backing plate)		Crack, lack of fusion, incomplete penetration, stripy flaw, round flaw, root concave	For pipe and tube: Crack, lack of fusion, incomplete penetration, stripy flaw, round flaw, root concave, root undercut	For Pressure Equipment: /
	Incomplete penetration		Evaluated for grades II, III and IV according to the incomplete penetration of different lengths and depths.	Allows grading of non-penetration in some cases;	

There are differences [10-11] between DL/T 821 and NB/T 47013.2 in terms of evaluation scope, irradiation technology and quality grade evaluation. The judgment result of quality grade will directly affect the qualification of test results, so quality grading plays a decisive role in whether the products are qualified or not. For single-sided welded pipe sub-pipes, NB/T 47013.2 class I evaluation does not allow the root to be concave, while DL/T 821 does. For Grade II and below, the two assessments are basically the same. Therefore, according to NB/T 47013.2, two I-level films in the preface were changed to II; According to the "Boiler Regulation", it was finally judged as Grade II qualified.

Incomplete penetration is the most divergent part in the quality grading judgment of the two standards. In NB/T 47013.2,except for single-sided welding without backing plate, incomplete

penetration is allowed to be graded, and all other welded joints with incomplete penetration are rated as Grade IV defects. While according to DL/T 821that is evaluated as Grade II, III and IV according to the incomplete penetration of different lengths and depths. For example, the header mentioned in the preface is made of 20G carbon steel with a specification of φ273*8, which is welded by one side. As a result, the root with a length of 4mm is not fully welded. According to the evaluation of DL/T 821, it is judged as Grade II; However, according to NB/T 47013.2, it is Grade IV. According to the "Boiler Regulation", it was finally judged to be unqualified at Grade IV.

Through this case, it can be seen that the uncertainty and complexity of nondestructive testing conclusion judgment are extremely necessary for the quality supervision of nondestructive testing. "Boiler Regulation" is a safety technical specification for the design, manufacture, installation, modification, repair, inspection and supervision of domestic boilers, and its clauses explicitly cite NB/T 47013 as the coordination standard, and the cited part is mandatory and has legal effect. At present, due to traditional habits, some power plant boiler installation, repair and transformation enterprises still use DL/T 821. Although DL/T 821 has its own advantages, enterprises should apply this standard on the premise of meeting laws and regulations.

3 Requirements of various qualifications of inspection institutions for outsourcing

Among the various qualifications obtained by special equipment inspection and testing institutions, in addition to the approval of special equipment inspection institutions, the qualifications of some large-scale inspection institutions also include CMA and CNAS inspection institutions. The rules, norms and standards of all kinds of qualifications have made specific provisions on outsourcing.

3.1Requirements for accreditation

TSG Z7001-2022 <Accreditation Criteriaon Special Equipment Inspection Agencies>stipulates that inspection work shall not be outsourced except nondestructive testing. The entrusting party for nondestructive testing shall obtain the corresponding qualification for nondestructive testing of special equipment. The special equipment inspection agency is responsible for the inspection results of the outsourcing. The inspection institution shall supervise the quality of the work of the outsourcing. When the inspection report (certificate) contains the inspection results provided by the outsourcing party, it shall be indicated in the inspection report.

3.2Qualification determination

There is no mention of subcontracting management requirements in the Measures for the Administration of Qualification Certification of Inspection and Testing Institutions (promulgated by Order No.163 of the General Administration of Quality Supervision, Inspection and Quarantine on April 9, 2015 and revised according to the Decision of the State Administration of Market Supervision on Abolishing and Amending Some Rules on April 2, 2021). At present, it is mentioned in the <Evaluation Criteria for Qualification Recognition of Inspection and Testing Institutions> that inspection and testing institutions should subcontract inspection and testing projects to inspection and testing institutions that have obtained

qualification recognition according to law and have the ability to complete the subcontracted projects. The specific subcontracted inspection and testing projects should obtain the written consent of the client in advance, and the inspection and testing report or certificate should reflect the subcontracted projects and mark them. RB/T214-2017 <Competence assessment for inspection body and laboratory mandatory approval –General requirements for inspection body and laboratory>also makes similar provisions. When inspection and testing institutions need to subcontract inspection and testing projects, they should subcontract them to inspection and testing institutions that have obtained the qualification certification of inspection and testing institutions and are capable of completing the subcontracted projects. The specific subcontracted inspection and testing projects and inspection and testing institutions that undertake the subcontracted projects should obtain the consent of the client in advance. When issuing inspection reports or certificates, the subcontracted projects shall be distinguished. Inspection and testing institutions shall not subcontract projects prohibited by laws, regulations, technical standards and other documents.

3.3Inspection organization approval

CNAS-CI01-A001<Guidance on the Application of Inspection Body Competence Accreditation Criteria in the Field of Boilers, Pressure Vessels (including Gas Cylinders) and Pressure Pipes> mentions that inspection institutions shall not subcontract the inspection of boilers, pressure vessels and pressure pipes to other inspection institutions. CNAS-CI01-A002 < Guidance on the Application of Inspection Body Competence Accreditation Criteria in the Fieldof Elevators, Cranes, Ropeway, Large Recreation Facilities and Powered Vehicles on the place used for a Particular Purpose> mentions that inspection institutions shall not subcontract the inspection of elevators, lifting machinery, passenger transport ropeways, large amusement facilities and vehicles in factories to other inspection institutions. However, special inspection items such as nondestructive testing can be subcontracted, and subcontractors shall have corresponding inspection qualifications.

4 Non-destructive testing outsourcing quality supervision practice

4.1Mode of Capability Verification

Ability verification refers to the evaluation of participants' ability according to pre-established criteria by laboratory comparison [12]. As an important external quality evaluation activity, capability verification can objectively evaluate the capabilities of inspection and testing institutions [13]. In order to further improve the quality of the inspection agency's NDT outsourcing work and ensure the effectiveness and reliability of the inspection and testing work, the agency has conducted a follow-up assessment of the data reliability of the NDT outsourcing party through a third-party competency verification provider for three consecutive years. The distribution of samples and comparison reports are independently completed by the third-party competency verification provider, and then one comparison report is sent to the outsourcing unit participating in the comparison and the other to the relevant departments of the agency. In the process of capability verification, each outsourcing party independently completes the testing of samples within the specified time in strict accordance with the time node, and delivers the testing samples and submits the result data. Through the supervision and

assessment in 2020, 2021 and 2022, our institution found that there were many problems and unsatisfactory results in the outsourcing projects of ultrasonic testing and radiographic testing; For magnetic particle testing and penetrant testing, the data results are more accurate and stable, and the data tracking is as follows, see Figure 1 to Figure 4.

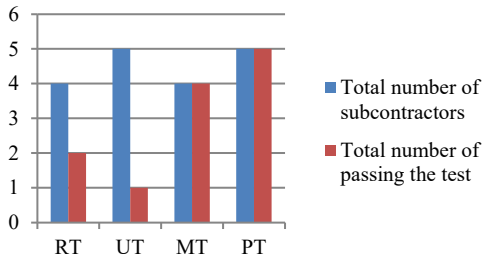

Figure 1 Quality Supervision Data in 2020

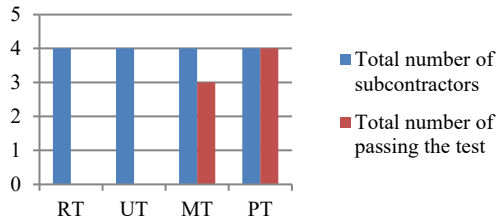

Figure 2 Quality Supervision Data in 2021

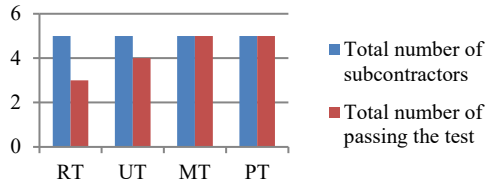

Figure 3 Quality Supervision Data in 2022

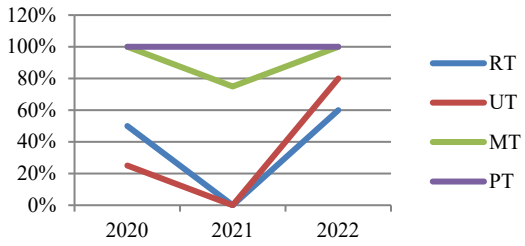

Figure 4 Comparison of passing rate for three consecutive years.

It can be seen that, after three years' continuous competence verification, the passing rate of competence verification of the outsourcing party is the highest in recent years. Taking competence verification as a way to supervise the quality of the outsourcing party's work has obvious supervision and warning functions.

For the unit whose assessment conclusion is problematic or unsatisfactory, it must complete the capability verification or measurement audit organized by the capability verification provider within two months from the date of obtaining the conclusion, and report the conclusion to the relevant departments of this institution for the record. During this period, the outsourcing unit should analyze the reasons and take corresponding measures to ensure the quality of nondestructive testing, and the personnel responsible for nondestructive testing in the outsourcing department should strengthen the spot check; If the unit is still dissatisfied with the conclusion of capability verification or measurement audit, the relevant departments of this institution will advise the relevant outsourcing business departments to suspend the NDT-related business of this project until the conclusion of capability verification or measurement audit is satisfactory.

4.2Mode of on-site assessment of personnel of outsourcing units

In addition to the ability verification supervision and assessment by unit, the supervision and assessment can also be carried out by inspectors. Assess the NDT capability of the on-site NDT certified personnel engaged in the outsourcing business of the outsourcing unit, and only qualified NDT certified personnel can complete the NDT work within the outsourcing business scope. Before on-site assessment, the outsourcing unit shall report the list of NDT certified personnel engaged in on-site operation to the entrusting unit, and the reported personnel materials shall be accompanied by NDT qualification certificate, registration certificate and social security payment record.

Organize internal and external experts to assess the actual operation of the reported NDT certified personnel, and report the assessment results to the quality supervision and management department of the outsourcing party, which will inform all outsourcing units and relevant business departments of the institute after summarizing the results. NDT ability assessment activities can be arranged twice a year, once in the first half of the year, and the certified personnel who pass the ability assessment will no longer arrange assessment during the period of the unit, and there will be no make-up examination for this assessment.

5 Summary

For the way that the inspection organization will commission nondestructive testing in the process of boiler inspection in power plant, the content of quality supervision in boiler inspection in power plant will increase accordingly. The ultimate goal is to ensure the quality of outsourced work and control the factors affecting the quality of outsourced work to a minimum. The inspection organization can comprehensively consider the quality supervision mode according to the personnel, equipment, samples, testing methods and environmental factors in boiler inspection in power plant[14], and carry out capacity verification and commissioned nondestructive testing through a third party. By continuously monitoring the technical ability and data reliability of the non-destructive testing outsourcing party, potential risks can be found

and corrected in time, which is a powerful guarantee for the sustained and high-quality development of the power plant boiler inspection industry.

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