Energy Industry Standard of the People’s Republic of China

NB/T 47002.1-XXXX

Replace NB/T 47002.1-2009

Clad Plate for Pressure Vessel
Part 1: Stainless Steel-Steel Clad Plate

Issued on XXXX-XX-XX

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FOREWORD

NB/T 47002-XXXX Clad Plate for Pressure Vessels is divided into 4 parts:
- Part 1: Stainless Steel-Steel Clad Plate
- Part 2: Nickel-Steel Clad Plate
- Part 3: Titanium-Steel Clad Plate
- Part 4: Copper-Steel Clad Plate

This part is the first part of NB/T 47002. Compared with NB/T 47002.1-2009, the main changes are as follows:
- The manufacturing method of the rolled clad plate was added, and the total thickness of the rolled clad plate, the thickness ratio of the base metal to the cladding metal, the thickness tolerance, the grade and the code were specified;
- The relevant requirements for stress relieving heat treatment processes and equipment for clad plates were added;
- The relevant requirements for the detection of cladding metal phase ratio in the delivery condition of the clad plate with ferritic-austenitic stainless steel as cladding metal were added;
- The side bend test was added;
- The test method in 《NB/T 47013.7 Nondestructive Testing of Pressure Equipments Part 7: Visual Examination》 was added;
- The scope of the internal bend test was expanded, from grade 1 to grades 1 and 2;
- A test method for intergranular corrosion in cladding metal of clad plate was added with reference to GB/T 4334 standard.

This part is proposed and managed by the China Standardization Committee on Boilers and Pressure Vessels (SAC/TC 262).

Drafting Committee of this part:
Main drafters of this part:
The previous versions of the standards replaced by this part are:
NB/T 47002.1-2009;
JB 4733-1996.
Clad Plate for Pressure Vessels
Part 1: Stainless Steel-Steel Clad Plate

1 Scope

1.1 This standard specifies terms and definitions, ordering contents, the type, dimension and weight, grade, mark, technical requirements and test methods, inspection rules, packaging, marking and quality certificates of clad plates made by explosive welding method or rolled compounding method with stainless steel as the cladding metal and with carbon steel, low alloy steel or stainless steel as the base metal.

1.2 This part applies to stainless steel - steel clad plates for pressure vessels with a total thickness of not less than 8 mm (hereinafter referred to as clad plates).

2 Normative Reference

The following documents are indispensable for the application of this document. For dated references, only the dated version applies to this document. For undated references, the latest version (including all amendments) applies to this document.

GB/T 150 Pressure vessels
GB/T 228.1 Metallic materials - Tensile Testing - Part 1: Method of Test at Room Temperature
GB/T 229 Metallic Materials-Charpy Pendulum Impact Test Method
GB/T 247 General Rule of Packaging, Marking and Quality Certificate for Steel Plates(Sheets) and Strips
GB/T 709 Dimension, Shape, Weight and Tolerances for Hot-Rolled Steel Plates and Sheets
GB/T 713 Steel Plates for Boilers and Pressure Vessels
GB/T 3531 Steel Plates for Low Temperature Pressure Vessels
GB/T 4334 Corrosion of Metals and Alloys-Test Methods for Intergranular Corrosion of Stainless Steels
GB/T 6396 Clad Steel Plates-Mechanical and Technological Test
GB/T 13305 Micrographic Method for Determining Area Content of the Α-Phases in Stainless Steels
GB/T 24511 Stainless Steel and Heat Resisting Steel Plate, Sheet and Strip for Pressure Equipments
GB/T 30583 Specification for Post Weld Heat Treatment of Pressure Equipment
NB/T 47008 Carbon and Alloy Steel Forgings for Pressure Equipment
NB/T 47009 Alloy Steel Forgings for Low Temperature Pressure Equipment
NB/T 47010 Stainless and Heat-Resisting Steel Forgings for Pressure Equipment
NB/T 47013.3 Nondestructive Testing of Pressure Equipment - Part 3: Ultrasonic Testing
NB/T 47013.5-2015 Nondestructive Testing of Pressure Equipment - Part 5: Penetrant Testing
NB/T 47013.7 Nondestructive Testing of Pressure Equipment - Part 7: Visual Examination
NB/T47014 Welding Procedure Qualification of Pressure Equipment
JB 4732 Steel Pressure Vessels - Design by Analysis

3 Terminology and Definitions

The following Terminology and definitions apply to this document.
3.1 Compound contact interface
The bonded surface of the base metal and the cladding metal of the clad plate.

3.2 Percentage of unbonded area
The ratio of the sum of the unbonded area of the compound contact interface to the total area of the clad plate, expressed as a percentage.

3.3 Base metal
A matrix material in a composite metal.

3.4 Cladding metal
A cladding material in a composite metal.

3.5 \( R_y \) yield strength
Generic name of the upper yield strength \( R_{yH} \), lower yield strength \( R_{yL} \), specified plastic elongation strength \( R_{p0.2} \), specified total elongation strength \( R_{t0.5} \) and specified residual elongation strength \( R_{r0.2} \) in GB/T 228.1. When determining the standard value of the yield strength of the clad plate, select one of the above five standard values as the basis for calculation according to the corresponding material standards for base metal and cladding metal, respectively.

3.6 Explosive welding
The welding compound between the cladding metal and the base metal is realized during the explosion process.

3.7 Rolled compounding
Metallurgical bonding between the cladding metal and the base metal is realized during the rolling process.

4 Ordering Information
Order contracts or orders should include the following information:
a) Standard number;
b) Product name;
c) Steel specification of cladding metal and base metal;
d) Manufacturing method and grade;
e) Delivery condition;
f) Dimensions;
g) Weight;
h) Additional technical requirements, such as intergranular corrosion test, etc.

5 Type, Dimension and Weight

5.1 Type
5.1.1 The cladding metal may clad one or both sides of the base metal to form a single-clad or double-clad clad plate.
5.1.2 The shape of the clad plate is agreed upon by the supplier and the buyer and may include rectangular, square and circular shapes.

5.2 Dimensions
5.2.1 The thickness of the cladding metal should be 2 mm-16 mm.
5.2.2 The minimum thickness of the base metal should be 6 mm, and the ratio of the thickness of
the base metal to the thickness of the cladding metal should not be less than 2 for the rolled compounding method, and should not be less than 3 for the explosive welding method.

5.2.3 The maximum thickness of the clad plates produced by the rolled compounding method generally does not exceed 100 mm; the maximum area of the clad plates produced by the explosive welding method generally does not exceed 25 m². The clad plates exceeding the above dimensions can be supplied according to the agreement between the supplier and the buyer.

5.3 Weight

The clad plates can be delivered according to the theoretical weight, and the weight calculation of the cladding and base metals should meet the requirements of the steel standards. See Appendix A for the density of stainless steel of each type of steels.

6 Grade and Mark

6.1 Grade and Code

The grade and code of the clad plates shall comply with the provisions of Table 1. The grades of both sides of a double-clad clad plate should be marked respectively.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Code</th>
<th>Explosive welding method</th>
<th>Rolled compounding method</th>
<th>Unbonded rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>B1</td>
<td>R1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Grade 2</td>
<td>B2</td>
<td>R2</td>
<td>≤2</td>
<td></td>
</tr>
<tr>
<td>Grade 3</td>
<td>B3</td>
<td>R3</td>
<td>≤5</td>
<td></td>
</tr>
</tbody>
</table>

6.2 Mark

The product mark shall be composed of the cladding metal steel specification, base metal steel specification, dimensions, manufacturing method, grade code, and standard number in order. For an approximate comparison of the uniform digital code of the stainless steel and the old type of steels, refer to Appendix A.

Example 1: The grade 2 clad plate with the 3 mm thick S32168 plate as the cladding metal, the 16 mm thick Q345R plate as the base metal, at a width of 2,500 mm and a length of 8,000 mm, produced by the rolled compounding method is marked as:

(S32168+Q345R)-(3+16) ×2500×8000-R2-NB/T 47002.1-20XX

Example 2: The grade 1 clad plate with the 8 mm thick S30408 plate as the cladding metal, the 150 mm thick 16MnIII forgings as the base metal, at a diameter of 4,000 mm and produced by the explosive welding method is marked as:

(S30408+16Mn III)-(8+150)×D4000-B1-NB/T 47002.1-20XX

Example 3: The grade 2 clad plate with the 3 mm thick S31603 plate as one side of cladding metal, the 20 mm thick Q345R plate as the base metal, the 2 mm thick S30408 plate as the other side of cladding metal, at a width of 2,000 mm and a length of 6,000 mm and produced by the explosive welding method is marked as:

(S31603+Q345R+S30408)-(3+20+2)×2000×6000-B2-NB/T 47002.1-20XX

7 Technical Requirements

7.1 Cladding Metal and Base Metal

7.1.1 The cladding and base metal standards and steel specifications should comply with the requirements of Table 2. The technical requirements of the base metal (such as delivery condition, mechanical properties inspection, nondestructive testing, etc.) should also comply with the provisions of GB/T 150 or JB 4732. When forgings are used as the base metal, grade III or IV forgings...
should be used.

7.1.2 The clad plate with the lower limit of the standard tensile strength of the base metal greater than 540 MPa can be used only after technical review.

7.1.3 The cladding metal and the base metal other than those listed in Table 2 may also be used if agreed by the supplier and the buyer, but the technical requirements should not be lower than the provisions of 7.1.1. When the base metal other than the standard steel in Table 2, the steel specification selected should have similar chemical composition to the steel specification in Table 2, and the technical requirements of the steel (such as P and S contented in steel, impact test temperature and impact energy absorption index) should not be lower than the relevant provisions of the similar steel specification in Table 2.

Table 2  Cladding Metal and Base Metal

<table>
<thead>
<tr>
<th>Cladding metal</th>
<th>Base metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard No.</td>
<td>Standard No.</td>
</tr>
<tr>
<td>GB/T 24511</td>
<td>GB/T 713</td>
</tr>
<tr>
<td></td>
<td>NB/T 47008</td>
</tr>
<tr>
<td></td>
<td>NB/T 3531</td>
</tr>
<tr>
<td></td>
<td>NB/T 47009</td>
</tr>
<tr>
<td></td>
<td>GB/T 24511</td>
</tr>
<tr>
<td></td>
<td>NB/T 47010</td>
</tr>
</tbody>
</table>

Note: Other steel specification in the various standards listed above may also be used for the cladding and base metals.

7.1.4 When the cladding metal should be tailor welded, the relevant technical requirements are determined by the agreement between the manufacturer and the buyer, shall be indicated in the contract.

7.1.5 The cladding and base metals should be accompanied by the quality certificates (original) of the material manufacturer. The contents of the material quality certificates should be complete, clear and stamped with the quality inspection seals of the material manufacturer. In the absence of the original quality certificate, the clad plate manufacturer should obtain a copy stamped with the inspection official seal of the business unit and the signature (seal) of the person in charge of the handling of the materials, and should be responsible for the authenticity and consistency of the materials and the material quality certificate used.

7.1.6 The stress relieving heat treatment processes and equipment for clad plates should refer to the relevant requirements in GB/T 30583.

Note: It is generally believed that the stress relieving heat treatment processes of the clad plate at a temperature lower than the tempering temperature of the base metals will not change the heat treatment delivery condition of the base metals.

7.2 Delivery condition

The clad plate should be leveled and sheared (or cut) before delivered, and the hot-rolled or heat treated condition of the clad plate should comply with the provisions for the corresponding base metal in GB/T 150 or JB 4732. According to the requirements of the purchaser stated in the contract, the surface of the cladding metal can be treated by shot blasting, polishing or pickling.

7.2.1 The clad plate shall be delivered after heat treatment, levelling and shearing (or cutting). The hot rolling or heat treatment condition of the clad plates shall be in accordance with the provisions of the base metal in GB/T 150 or JB 4732.
7.2.2 According to the requirements of the buyer, and the negotiation between the buyer and the manufacturer that indicated in the contract, other heat treatment condition can be adopted for delivery.

7.2.3 According to the requirements of the buyer, in the contract, sand blasting, polishing or acid cleaning may be carried out for the surface of the cladding metal.

7.3 Bonded Condition

7.3.1 The clad plate should be examined by 100% ultrasonic examination. The bonded condition should be performed in accordance with the provisions of Table 3.

7.3.2 Repair welding may be carried out for the unbounded area exceeding the requirements in Table 3. Before repair welding, the cladding metal in the unbounded area should be polished and levelled to the surface of the base metal. The penetrant examination is performed to confirm that the unbounded area has been removed, and passing the qualification according to the provisions of NB/T 47014, then the welder with the valid certificate performs repair welding. Ultrasonic test and penetrant test should be performed after welding and mending. The results of ultrasonic testing should comply with the requirements of Table 3. The results of the penetrant test should comply with grade I specified in NB/T 47013.5-2015. The repair welding record (including the position of the repair welding zone on the clad plate, the area of each welding zone, the welding material and the welding process factor) should be attached to the product quality certificate.

Table 3 Bonded Condition

<table>
<thead>
<tr>
<th>Grade</th>
<th>Indication length of a single unbounded area/mm</th>
<th>Area of a single unbounded area/cm²</th>
<th>Unbonded rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>$R_e \geq \frac{R_{e1}t_1 + R_{e2}t_2}{t_1 + t_2}$</td>
<td>$R_m \geq \frac{R_{m1}t_1 + R_{m2}t_2}{t_1 + t_2}$</td>
<td>0</td>
</tr>
<tr>
<td>Grade 2</td>
<td>(\leq 50)</td>
<td>(\leq 20)</td>
<td>(\leq 2)</td>
</tr>
</tbody>
</table>

7.4 Mechanical Properties

7.4.1 The bonded shear strength of the compound contact interface of the clad plate should not be less than 210 MPa. For double-clad clad plates, different side cladding metals should be retained for shear testing.

7.4.2 The tensile testing results of the clad plate should comply with the requirements of Table 4. For double-clad clad plates, generally only one type of cladding metal is retained for tensile testing, and the cladding metal to be retained is indicated by the purchaser in the contract. When the thickness of the base metal is greater than 40 mm or specified by the purchaser, only the tensile testing of the base metal should be carried out, and the test results should comply with the requirements of the base metal standard.

Table 4 Results of Tensile Testing

<table>
<thead>
<tr>
<th>Yield strength $R_e$ /MPa</th>
<th>Tensile strength $R_m$ /MPa</th>
<th>Elongation at break $A$%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Not less than the standard value of the base metal.
Note 1: \( R_{c1} \) - The yield strength of the cladding metal in standard, MPa;

\( R_{c2} \) - The yield strength of the base metal in standard, MPa;

\( R_{m1} \) - The tensile strength of the cladding metal in standard, MPa;

\( R_{m2} \) - The tensile strength of the base metal in standard, MPa;

\( t_1 \) - Thickness of the cladding metal, mm;

\( t_2 \) - Thickness of the base metal, mm;

Note 2: When the standard value of the elongation of the cladding metal is less than that of the elongation of the base metal, the elongation of the clad plate is allowed to be less than the standard value of the base metal, but should not be less than the standard value of the cladding metal. At this time, a tensile testing of a base metal specimen should be supplemented, and the elongation at break should be not less than the standard value of the base metal.

7.4.3 The clad plate is only subjected to the impact test of the base metal, and the impact test temperature and the impact energy absorption should meet the requirements of the base metal standard. If there is no impact test in the base metal standard, the clad plate may not be subjected to the impact test.

7.5 Bending Performance

The results of the internal bend (compressing the surface of the cladding metal) and external bend (stretching the surface of the cladding metal) tests, the side bend (stretching and compressing the cross section of the clad plate) test of a single-clad clad plate and the external bend (stretching the surfaces of the two cladding metals) test of the double-clad clad plate should comply with the requirements of Table 5. The clad plate with forgings or stainless steel as the base metal may not be subjected to a bending test.

<table>
<thead>
<tr>
<th>Bending angle</th>
<th>Bending diameter</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>180°</td>
<td>Internal bend according to the standard of the base metal, external bend ( d=4a ) (( d ) is bending diameter, and ( a ) is specimen thickness), side bend ( d=40 ) mm</td>
<td>There must be no cracks on the outside of the bended part and the compound contact interface must not be laminated.</td>
</tr>
</tbody>
</table>

7.6 For the clad plate with the cladding metal as ferritic-austenitic stainless steel, the ferrite content of the cladding metal in the delivery condition should be tested. The ferrite content should be 40%-60%.

7.7 Intergranular Corrosion Test

According to the requirements of the purchaser, the supplier can perform the intergranular corrosion test for the cladding metal of the clad plate based on the agreement between the supplier and the buyer. The test requirements and the qualification standards are agreed by the supplier and the buyer.

7.8 Dimensional Tolerance and Flatness

7.8.1 The thickness tolerance of the clad plate should comply with the requirements of Table 6. For the clad plate with forgings as base metal, the thickness tolerance of the base metal is agreed by both the supplier and the buyer.

| Table 6 Thickness Tolerance |
Thickness tolerance of cladding metal & Thickness tolerance of base metal & Total thickness tolerance

±10% of nominal thickness of cladding metal, and within the range of ±1.0 mm

Base metal standard
The values of positive and negative tolerances are reduced by 0.5 mm

Tolerance of cladding metal + Tolerance of base metal

<table>
<thead>
<tr>
<th>Thickness tolerance of cladding metal</th>
<th>Thickness tolerance of base metal</th>
<th>Total thickness tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10% of nominal thickness of cladding metal, and within the range of ±1.0 mm</td>
<td>Base metal standard</td>
<td>Tolerance of cladding metal + Tolerance of base metal</td>
</tr>
</tbody>
</table>

8.1 The bonded condition of the clad plate should be determined by ultrasonic testing method, and the testing method is as specified in NB/T 47013.3.

8.2 Penetrant testing is as specified in NB/T 47013.5.

8.3 The shear test, tensile test and bend test of the clad plate are as specified in GB/T 6396.

8.4 The tensile test for the base metal of the clad plate complies with the provisions of GB/T 228.1.

8.5 The impact test for the base metal of the clad plate complies with the provisions of GB/T 229.

8.6 The ferrite content of the cladding metal of the duplex steel clad plate is tested according to GB/T 13305.

8.7 The intergranular corrosion test of the cladding metal of the clad plate should be in accordance with the provisions of the agreement between the supplier and the buyer, and may refer to the relevant requirements of GB/T 4334.

9.1 The clad plate is inspected by the supplier quality inspection department.

9.2 The clad plates should be delivered in batches, and each batch should consist of clad plates of the same material combination (the cladding metal and the base metal are respectively the
same steel specification, the same thickness, and the same delivery condition), the same explosive welding or rolling and heat treatment processes.

9.3 The inspection items of the clad plate are as specified in Table 7. Ultrasonic testing, dimensions (except for the thickness of the cladding metal) and surface quality should be tested sheet by sheet, and the remaining items should be inspected by batch. The items required to be inspected by the buyer in the table should be performed in accordance with the provisions of the contract. Other items can be inspected after agreed by the supplier and the buyer.

<table>
<thead>
<tr>
<th>Inspection item</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Shear testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Tensile testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Impact testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Internal bend testing</td>
<td>○</td>
<td>○</td>
<td>△</td>
</tr>
<tr>
<td>External bend testing</td>
<td>△</td>
<td>△</td>
<td>△</td>
</tr>
<tr>
<td>Side bend testing</td>
<td>△</td>
<td>△</td>
<td>△</td>
</tr>
<tr>
<td>Ferrite content testing (duplex stainless steel cladding metal)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

9.4 A sample is taken from each batch of the products, and the sample can also be taken from the test pieces prepared under the same batch conditions as the product. The sampling method is as specified in the corresponding base metal standard. The number of samples is as follows: one shear specimen, one tensile specimen, three impact specimens, one internal bend specimen, one external bend specimen, one side bend specimen, one ferrite content specimen, two intergranular corrosion specimen, and one cladding metal thickness specimen. For the double-clad clad plate, one specimen is taken respectively for shear, external bend, side bend, and thickness tests of cladding metals at different sides.

9.5 If the items inspected by batch are unqualified, then double-quantity specimens are taken from the same batch to re-test the unqualified items. The re-inspection of the impact test is in accordance with the standards of the base metal. If any one result of the re-inspection (including any of the indicators required by the test) is unqualified, the batch of products should not be delivered. At this point, the supplier can test sheet by sheet and deliver sheet by sheet; or after the entire batch of steel plates is heat treated, it can be submitted as a new batch for inspection.

10 Packaging, Marking and Quality Certificate

10.1 Each clad plate should be marked with the product mark, batch No., manufacturer's name (or trademark), production date, etc. on the surface of the cladding metal at the end of the steel plate.

10.2 A clad plate product quality certificate (original) should be provided upon delivery and a copy of the purchased cladding metal and/or base metal quality certificate should be provided.

10.3 The surface of the cladding metal should be effectively protected against scratches.

10.4 The rest of the requirements are in accordance with the provisions of GB/T 247.
The density of stainless steel is listed in Table A.1.

<table>
<thead>
<tr>
<th>Steel specification</th>
<th>Density/(kg/dm$^3$) 20℃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unified digital code</td>
<td>Type of Steels</td>
</tr>
<tr>
<td>S11306</td>
<td>06Cr13</td>
</tr>
<tr>
<td>S11348</td>
<td>06Cr13Al</td>
</tr>
<tr>
<td>S11972</td>
<td>019Cr19Mo2NbTi</td>
</tr>
<tr>
<td>S30408</td>
<td>06Cr19Ni10</td>
</tr>
<tr>
<td>S30403</td>
<td>022Cr19Ni10</td>
</tr>
<tr>
<td>S32168</td>
<td>06Cr18Ni11Ti</td>
</tr>
<tr>
<td>S31603</td>
<td>022Cr17Ni12Mo2</td>
</tr>
<tr>
<td>S31608</td>
<td>06Cr17Ni12Mo2</td>
</tr>
<tr>
<td>S31688</td>
<td>06Cr17Ni12Mo2Ti</td>
</tr>
<tr>
<td>S31703</td>
<td>022Cr19Ni13Mo3</td>
</tr>
<tr>
<td>S39042</td>
<td>015Cr21Ni26Mo5Cu2</td>
</tr>
<tr>
<td>S22053</td>
<td>022Cr23Ni5Mo3N</td>
</tr>
<tr>
<td>S25073</td>
<td>022Cr25Ni7Mo4N</td>
</tr>
</tbody>
</table>
People’s Republic of China Energy Industry Standard

NB/T 47002.2-20XX

In substitution of NB/T 47002.2-2009

Clad Plate for Pressure Vessels
Part 2: Nickel-Steel Clad Plate

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6 Grade and Mark

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8 Test Methods

9 Inspection Rules

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Appendix A (Nonmandatory Information) Density Of Nickel and Nickel Alloy
PREFACE

NB/T 47002-XXXX Clad Plate for Pressure Vessels is divided into 4 parts:
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This part is the second part of NB/T 47002. Compared with NB/T 47002.2-2009, the main changes are as follows:
- The manufacturing method of the rolled clad plate was added, and the total thickness of the rolled clad plate, the ratio of the thickness of the base metal to the thickness of the cladding metal, the thickness tolerance, the grade and the code were specified;
- The relevant requirements for stress relieving heat treatment processes and equipment for clad plates were added;
- The cladding metal should mainly use various type of steels of nickel and nickel alloy plates specified in NB/T 47046 Nickel –Nickel Alloy Plate for Pressure Equipment;
- The side bend test was added;
- The test method from NB/T 47013.7 Non-Destructive Testing of Pressure Equipment Part 7: Visual Examination was added
- The range of the internal bend test was expanded, from grade 1 to grades 1 and 2;

This part is proposed and managed by the China Standardization Committee on Boilers and Pressure Vessels (SAC/TC 262).

Drafting Committee of this part:
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NB/T 47002.2-2009;
Clad Plate for Pressure Vessels
Part 2: Nickel-Steel Clad Plate

1 Range

1.1 This standard specifies the type, dimension and weight, grade, mark, technical requirements and test methods, inspection rules, packaging, marking and quality certificates of clad plates made by explosive welding method or rolled compounding method, with nickel and nickel alloy as the cladding metal and carbon steel, low alloy steel or stainless steel as the base metal.

1.2 This standard applies to nickel-steel clad plates for pressure vessels with a total thickness of not less than 8 mm (hereinafter referred to as clad plates).

2 Normative Reference

The following documents are indispensable for the application of this document. For dated references, only the dated version applies to this document. For undated references, the latest version (including all amendments) applies to this document.

GB/T 150 Pressure vessels
GB/T 228.1 Metallic materials-Tensile Testing - Part 1: Method of Test at Room Temperature
GB/T 229 Metallic Materials-Charpy Pendulum Impact Test Method
GB/T 247 General Rule of Packaging, Marking and Quality Certificate for Steel Plates(Sheets) and Strips
GB/T 709 Dimension, Shape, Weight and Tolerances for Hot-Rolled Steel Plates and Sheets
GB/T 713 Steel Plates for Boilers and Pressure Vessels
GB/T 2054 Nickel and Nickel Alloy Plate and Sheet
GB/T 3531 Steel Plates for Low Temperature Pressure Vessels
GB/T 6396 Clad Steel Plates-Mechanical and Technological Test
GB/T 15260 Corrosion of Metals and Alloys-Test Methods for Intergranular Corrosion of Nickel Alloys
GB/T 24511 Stainless Steel and Heat Resisting Steel Plate, Sheet and Strip for Pressure Equipments
GB/T 30583 Specification for Post Weld Heat Treatment of Pressure Equipment
NB/T 47008 Carbon and Alloy Steel Forgings for Pressure Equipment
NB/T 47009 Alloy Steel Forgings for Low Temperature Pressure Equipment
NB/T 47010 Stainless and Heat-Resisting Steel Forgings for Pressure Equipment
NB/T 47013.3 Nondestructive Testing of Pressure Equipment - Part 3: Ultrasonic Testing
NB/T 47013.5-2015 Nondestructive Testing of Pressure Equipment - Part 5: Penetrant Testing
NB/T 47013.7 Nondestructive Testing of Pressure Equipment - Part 7: Visual Examination
NB/T 47046 Nickel-Nickel Alloy Plate for Pressure Equipments
JB 4732 Steel Pressure Vessels-Design by Analysis

3 Ordering Information

Order contracts or orders should include the following information:

a) Standard number;
b) Product name;
c) Type of steels of cladding metal and base metal;
d) Manufacturing method and grade;

(e) Delivery status;

(f) Dimensions;

(g) Weight;

(h) Additional technical requirements, such as intergranular corrosion test, etc.

4 Terminology and Definitions

The following Terminology and definitions apply to this document.

4.1 Compound contact interface

The bonded surface of the base metal and the cladding metal of the clad plate.

4.2 Percentage of unbonded area

The ratio of the sum of the unbonded area of the compound contact interface to the total area of the clad plate, expressed as a percentage.

4.3 Base metal

A matrix material in a composite metal.

4.4 Cladding metal

A cladding material in a composite metal.

4.5 Re yield strength

Generic name of the upper yield strength \( R_{eH} \), lower yield strength \( R_{eL} \), specified plastic elongation strength \( R_{p0.2} \), specified total elongation strength \( R_{t0.5} \) and specified residual elongation strength \( R_{r0.2} \) in GB/T 228.1. When determining the standard value of the yield strength of the clad plate, select one of the above five standard values as the basis for calculation according to the corresponding material standards for base metal and cladding metal, respectively.

4.6 Explosive welding

The welding compound between the cladding metal and the base metal is realized during the explosion process.

4.7 Rolled compounding

The rolled compounding between the cladding metal and the base metal is realized during the rolling process.

5 Type, Dimension and Weight

5.1 Type

5.1.1 The cladding metal may clad one or both sides of the base metal to form a single-clad or double-clad clad plate.

5.1.2 The shape of the clad plate is agreed upon by the supplier and the buyer and may include rectangular, square and circular shapes.

5.2 Dimensions

5.2.1 The thickness of the cladding metal should be 2 mm-16 mm.

5.2.2 The minimum thickness of the base metal should be 6 mm, and the ratio of the thickness of the base metal to the thickness of the cladding metal should not be less than 2 for the rolled compounding method, and should not be less than 3 for the explosive welding method.

5.2.3 The maximum thickness of the clad plates produced by the rolled compounding method generally does not exceed 100 mm; the maximum area of the clad plates produced by the explosive welding method generally does not exceed 25 m². The clad plates exceeding the
above dimensions can be supplied according to the agreement between the supplier and the buyer.

5.3 Weight

The clad plates can be delivered according to the theoretical weight, and the weight calculation of the cladding and base metals should meet the requirements of the corresponding metal standards. See Appendix A for the density of the cladding metal of each type of steels.

6 Grade and Mark

6.1 Grade and Code

The grade and code of the clad plates shall comply with the provisions of Table 1. The grades of both sides of a double-clad clad plate should be marked respectively.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Code</th>
<th>Explosive welding method</th>
<th>Rolled compounding method</th>
<th>Unbonded rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>B1</td>
<td>R1</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Grade 2</td>
<td>B2</td>
<td>R2</td>
<td></td>
<td>≤2</td>
</tr>
<tr>
<td>Grade 3</td>
<td>B3</td>
<td>R3</td>
<td></td>
<td>≤5</td>
</tr>
</tbody>
</table>

6.2 Mark

The product mark shall be composed of the cladding metal type of steels, base metal type of steels, dimensions, manufacturing method, grade and code, and standard number in order.

Example 1: The grade 2 clad plate with the 3 mm thick NCu30 plate as the cladding metal, the 16 mm thick Q345R plate as the base metal, at a width of 2,000 mm and a length of 6,000 mm, produced by the rolled compounding method is marked as:

(NCu30+Q345R)-(3+16)×2000×6000-R2-NB/T 47002.2-20XX

Example 2: The grade 1 clad plate with the 8 mm thick N5 plate as the cladding metal, the 150 mm thick 16MnIII forgings as the base metal, at a diameter of 3,000 mm, and produced by the explosive welding method is marked as:

(N5+16Mn III)-(8+150)×D3000-B1-NB/T 47002.2-20XX

7 Technical Requirements

7.1 Cladding Metal and Base Metal

7.1.1 The cladding and base metal standards and type of steels should comply with the requirements of Table 2. The cladding metals N5, N7 and NCu30 should be annealed. The technical requirements of the base metal (such as delivery status, mechanical properties inspection, nondestructive testing, etc.) should also comply with the provisions of GB/T 150 or JB 4732. When forgings are used as the base metal, grade III or IV forgings should be used.

7.1.2 The clad plate with the lower limit of the standard tensile strength of the base metal greater than 540 MPa can be used only after technical review.

7.1.3 The cladding metal and the base metal other than those listed in Table 2 may also be used if agreed by the supplier and the buyer, but the technical requirements should not be lower than the provisions of 7.1.1. When the base metal other than the standard steel in Table 2, the type of steels selected should have similar chemical composition to the type of steels in Table 2, and the technical requirements of the steel (such as P and S contents in steel, impact test temperature and impact energy absorption index) should not be lower than the relevant provisions of the similar type of steels in Table 2.
Table 2  Cladding Metal and Base Metal

<table>
<thead>
<tr>
<th>Cladding metal</th>
<th>Base metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard No.</td>
<td>Example of type of steels</td>
</tr>
<tr>
<td>GB/T 2054</td>
<td>N5</td>
</tr>
<tr>
<td>NB/T 47046</td>
<td>N7</td>
</tr>
<tr>
<td></td>
<td>NCu30</td>
</tr>
<tr>
<td></td>
<td>NS1101</td>
</tr>
<tr>
<td></td>
<td>NS1102</td>
</tr>
<tr>
<td></td>
<td>NS1402</td>
</tr>
<tr>
<td></td>
<td>NS3102</td>
</tr>
<tr>
<td></td>
<td>NS3203</td>
</tr>
<tr>
<td></td>
<td>NS3304</td>
</tr>
<tr>
<td></td>
<td>NS3305</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Other type of steels in the various standards listed above may also be used for the cladding and base metals.

7.1.4 When the cladding metal should be tailor welded, the relevant technical requirements are determined by the agreement between the supplier and the buyer and are indicated in the contract.

7.1.5 The cladding and base metals should be accompanied by the quality certificates (original) of the material manufacturer. The contents of the material quality certificates should be complete, clear and stamped with the quality inspection seals of the material manufacturer. In the absence of the original quality certificate, the clad plate manufacturer should obtain a copy stamped with the inspection official seal of the business unit and the signature (seal) of the person in charge of the handling of the materials, and should be responsible for the authenticity and consistency of the materials and the material quality certificate used.

7.1.6 The stress relieving heat treatment processes and equipment for clad plates should refer to the relevant requirements of GB/T 30583;

7.2 Delivery Status

The clad plate should be leveled and sheared (or cut) before delivered, and the hot-rolled or heat treated status of the clad plate should comply with the provisions for the corresponding base metal in GB/T 150 or JB 4732. According to the requirements of the purchaser stated in the contract, the surface of the cladding metal can be treated by shot blasting, polishing or pickling.

7.3 Bonded Status

7.3.1 The clad plate should be ultrasonically tested using a 100% scanning method. The bonded status should comply with the provisions of Table 3.

7.3.2 Welding and mending are allowed for unbonded areas beyond those specified in Table 3. Before welding and mending, the cladding metal in the unbonded area should be polished and levelled to the surface of the base metal. The penetrant test is performed to confirm that the unbonded area has been removed, and then the welder with the valid certificate performs welding and mending in accordance with an approved welding procedure. Ultrasonic test and penetrant test should be performed after welding and mending. The results of ultrasonic testing should comply with the requirements of Table 3. The results of the penetrant test should comply with grade I specified in NB/T 47013.5-2015. The welding and mending record (including the position of the welding and mending zone on the clad plate, the area of each welding and mending zone, the welding material and the welding process parameters) should be attached to the product quality certificate.

Table 3  Bonded Status

<table>
<thead>
<tr>
<th>Grade</th>
<th>Indication length of a single unbonded area/mm</th>
<th>Area of a single unbonded area/cm²</th>
<th>Unbonded rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grade 2</td>
<td>≤50</td>
<td>≤20</td>
<td>≤2</td>
</tr>
<tr>
<td>Grade 3</td>
<td>≤75</td>
<td>≤45</td>
<td>≤5</td>
</tr>
</tbody>
</table>
7.4 Mechanical Properties

7.4.1 The bonded shear strength of the compound contact interface of the clad plate should not be less than 210 MPa. For double-clad clad plates, different side cladding metals should be retained for shear testing.

7.4.2 The tensile testing results of the clad plate should comply with the requirements of Table 4. For double-clad clad plates, generally only one type of cladding metal is retained for tensile testing, and the cladding metal to be retained is indicated by the purchaser in the contract. When the thickness of the base metal is greater than 40 mm or specified by the purchaser, only the tensile testing of the base metal should be carried out, and the test results should comply with the requirements of the base metal standard.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Results of Tensile Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield strength $R_y$ /MPa</td>
<td>$R_y \geq \frac{R_{c1}t_1+R_{c2}t_2}{t_1+t_2}$</td>
</tr>
<tr>
<td>Tensile strength $R_m$ /MPa</td>
<td>$R_m \geq \frac{R_{m1}t_1+R_{m2}t_2}{t_1+t_2}$</td>
</tr>
<tr>
<td>Elongation at break $A$/%</td>
<td>Not less than the standard value of the base metal</td>
</tr>
</tbody>
</table>

Note:
- $R_{c1}$ - Standard value of the yield strength of the cladding metal, MPa;
- $R_{c2}$ - Standard value of the yield strength of the base metal, MPa;
- $R_{m1}$ - Standard lower limit of the tensile strength of the cladding metal, MPa;
- $R_{m2}$ - Standard lower limit of the tensile strength of the base metal, MPa;
- $t_1$ - Thickness of the cladding metal, mm;
- $t_2$ - Thickness of the base metal, mm;

7.4.3 The clad plate is only subjected to the impact test of the base metal, and the impact test temperature and the impact energy absorption should meet the requirements of the base metal standard. If there is no impact test in the base metal standard, the clad plate may not be subjected to the impact test.

7.5 Bending Performance

The results of the internal bend (compressing the surface of the cladding metal) and external bend (stretching the surface of the cladding metal) tests, the side bend (stretching and compressing the cross section of the clad plate) test of a single-clad clad plate and the external bend (stretching the surfaces of the two cladding metals) test of the double-clad clad plate should comply with the requirements of Table 5. The clad plate with forgings as the base metal is not subjected to a bending test.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Bending Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending angle</td>
<td>Bending diameter</td>
</tr>
<tr>
<td>180°</td>
<td>Internal bend according to the standard of the base metal, external bend $d=4a$ ($d$ is bending diameter, and $a$ is specimen thickness), side bend $d=40$ mm</td>
</tr>
</tbody>
</table>

7.6 Intergranular Corrosion Testing

According to the requirements of the purchaser, the supplier can perform the intergranular corrosion test for the cladding metal of the clad plate based on the agreement between the supplier and the buyer. The test requirements and the qualification standards are agreed by the supplier and the buyer.

7.7 Dimensional Tolerance and Flatness

7.7.1 The thickness tolerance of the clad plate should comply with the requirements of Table 6. For the clad plate with forgings as base metal, the thickness tolerance of the base metal is
agreed by both the supplier and the buyer.

Table 6  Thickness Tolerance

<table>
<thead>
<tr>
<th>Thickness tolerance of cladding metal</th>
<th>Thickness tolerance of base metal</th>
<th>Total thickness tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10% of nominal thickness of cladding metal, and within the range of ±1.0 mm a</td>
<td>Base metal standard</td>
<td>Tolerance of cladding metal + Tolerance of base metal</td>
</tr>
<tr>
<td>±1.0 mm</td>
<td>The values of positive and negative tolerances are reduced by 0.5 mm</td>
<td></td>
</tr>
</tbody>
</table>

a  For the rolled clad plate, when the thickness of the cladding metal is less than 5 mm, its positive tolerance is not more than 1.0 mm.

7.7.2  The allowable tolerances of the length and width of the clad plate comply with the corresponding provisions of the base metal standard, and the allowable tolerance of the diameter of the circular clad plate is as agreed between the supplier and the buyer.

7.7.3  The flatness of the clad plate is as specified in GB/T 709. When the standard value of the yield strength of the base metal is greater than 460 MPa, the flatness is 1.5 times the value specified in GB/T 709. For the clad plate used for the heat-exchanger tube/sheet, the flatness is agreed by the supplier and the buyer.

7.8  Surface quality

The surface of the cladding metal of the clad plate should not have defects such as scars, cracks, inclusions and pleats. If the above defects are present, the removal is allowed, but after the removal, the minimum thickness of the cladding metal should be ensured, otherwise the welding and mending should be performed, and the welding and mending should comply with the corresponding provisions of 7.3.2. The surface quality of the base metal should comply with the requirements of the base metal standard.

8  Test Methods

8.1  The bonded status of the clad plate should be determined by ultrasonic testing method, and the testing method is as specified in NB/T 47013.3.

8.2  Penetrant testing is as specified in NB/T 47013.5.

8.3  The shear test, tensile test and bend test of the clad plate are as specified in GB/T 6396.

8.4  The tensile test for the base metal of the clad plate complies with the provisions of GB/T 228.1.

8.5  The impact test for the base metal of the clad plate complies with the provisions of GB/T 229.

8.6  The intergranular corrosion test of the cladding metal of the clad plate complies with the relevant provisions of GB/T 15260.

8.7  Dimension Inspection Method

8.7.1  The total thickness of the clad plate is measured with a micrometer or caliper at a distance of not less than 40 mm from the edge of the steel plates.

8.7.2  The thickness of the cladding metal of the clad plate is measured according to the provisions of GB/T 6396.

8.7.3  The length, width or diameter of the clad plate is measured with a steel tape measure.

8.7.4  The flatness of the clad plate is measured according to the provisions of GB/T 709.

8.8  The surface quality of the clad plate is generally visually inspected, with reference to the relevant requirements of NB/T 47013.7.

9  Inspection Rules

9.1  The clad plate is inspected by the supplier quality inspection department.

9.2  The clad plates should be delivered in batches, and each batch should consist of clad plates of the same material combination (The cladding metal and the base metal are respectively the same type of steels, the same thickness, and the same delivery status), the same explosive
welding or rolled compounding and heat treatment processes.

9.3 The inspection items of the clad plate are as specified in Table 7. Ultrasonic testing, dimensions (except for the thickness of the cladding metal) and surface quality should be tested sheet by sheet, and the remaining items should be inspected by batch. The items required to be inspected by the buyer in the table should be performed in accordance with the provisions of the contract. Other items can be inspected after agreed by the supplier and the buyer.

<table>
<thead>
<tr>
<th>Inspection Item</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Shear testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Tensile testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Impact testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Internal bend testing</td>
<td>Δ</td>
<td>Δ</td>
<td>Δ</td>
</tr>
<tr>
<td>External bend testing</td>
<td>Δ</td>
<td>Δ</td>
<td>Δ</td>
</tr>
<tr>
<td>Side bend testing</td>
<td>Δ</td>
<td>Δ</td>
<td>Δ</td>
</tr>
<tr>
<td>Intergranular corrosion</td>
<td>Δ</td>
<td>Δ</td>
<td>Δ</td>
</tr>
<tr>
<td>Internal bend testing</td>
<td>○</td>
<td>○</td>
<td>Δ</td>
</tr>
<tr>
<td>Surface quality</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: ○ - Item to be inspected; Δ - Items required to be inspected by the buyer.

9.4 A sample is taken from each batch of the products, and the sample can also be taken from the test pieces prepared under the same batch conditions as the product. The sampling method is as specified in the corresponding base metal standard. The number of samples is as follows: one shear specimen, one tensile specimen, three impact specimens, one internal bend specimen, one external bend specimen, one side bend specimen, two intergranular corrosion specimens, and one cladding metal thickness specimen. For the double-clad clad plate, one specimen is taken respectively for shear, external bend, side bend, and thickness tests of cladding metals at different sides.

9.5 If the items inspected by batch are unqualified, then double-quantity specimens are taken from the same batch to re-test the unqualified items. The re-inspection of the impact test is in accordance with the standards of the base metal. If any one result of the re-inspection (including any of the indicators required by the test) is unqualified, the batch of products should not be delivered. At this point, the supplier can test sheet by sheet and deliver sheet by sheet; or after the entire batch of steel plates is heat treated, it can be submitted as a new batch for inspection.

10 Packaging, Marking and Quality Certificate

10.1 Each clad plate should be marked with the product mark, batch No., manufacturer's name (or trademark), production date, etc. on the surface of the cladding metal at the end of the steel plates.

10.2 A clad plate product quality certificate (original) should be provided upon delivery and a copy of the purchased cladding metal and/or base metal quality certificate should be provided.

10.3 The surface of the cladding metal should be effectively protected against scratches.

10.4 The rest of the requirements are in accordance with the provisions of GB/T 247.
Appendix A
(Nonmandatory Information)
Nickel and nickel alloy density

The density of nickel and nickel alloys is listed in Table A.1.

<table>
<thead>
<tr>
<th>China type of steels</th>
<th>US ASME type of steels</th>
<th>Density/(kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N5</td>
<td>N02201</td>
<td>8.890</td>
</tr>
<tr>
<td>N7</td>
<td>N02200</td>
<td>8.890</td>
</tr>
<tr>
<td>NCu30</td>
<td>N04400</td>
<td>8.830</td>
</tr>
<tr>
<td>NS1101</td>
<td>N08800</td>
<td>7.940</td>
</tr>
<tr>
<td>NS1102</td>
<td>N08810</td>
<td>7.940</td>
</tr>
<tr>
<td>NS1402</td>
<td>N08825</td>
<td>8.140</td>
</tr>
<tr>
<td>NS3102</td>
<td>N06600</td>
<td>8.420</td>
</tr>
<tr>
<td>NS3203</td>
<td>N10675</td>
<td>9.220</td>
</tr>
<tr>
<td>NS3304</td>
<td>N10276</td>
<td>8.870</td>
</tr>
<tr>
<td>NS3305</td>
<td>N06455</td>
<td>8.640</td>
</tr>
<tr>
<td>NS3311</td>
<td>N06059</td>
<td>8.800</td>
</tr>
</tbody>
</table>
People’s Republic of China Energy Industry Standard

NB/T 47002.3-20XX

In substitution of NB/T 47002.3-2009

Clad Plate for Pressure Vessels
Part 3: Titanium-Steel Clad Plate

Issued on XXXX-XX-XX

Implemented on XXXX-XX-XX

Issued by National Energy Administration
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PREFACE

NB/T 47002-XXXX Clad Plate for Pressure Vessels is divided into 4 parts:
- Part 1: Stainless Steel-Steel Clad Plate
- Part 2: Nickel-Steel Clad Plate
- Part 3: Titanium-Steel Clad Plate
- Part 4: Copper-Steel Clad Plate

This part is the third part of NB/T 47002. Compared with NB/T 47002.3-2009, the main changes are as follows:
- The manufacturing method of the rolled clad plate was added, and the total thickness of the rolled clad plate, the ratio of the thickness of the base metal to the thickness of the cladding metal, the thickness tolerance, the grade and the code were specified;
- The relevant requirements for stress relieving heat treatment processes and equipment for clad plates were added;
- The side bend test was added;
- The test method from NB/T 47013.7 Non-Destructive Testing of Pressure Equipment Part 7: Visual Examination was added
- The range of the internal bend test was expanded, from grade 1 to grades 1 and 2;

This part is proposed and managed by the China Standardization Committee on Boilers and Pressure Vessels (SAC/TC 262).

Drafting Committee of this part:
Main drafters of this part:
The previous versions of the standards replaced by this part are:
NB/T 47002.3-2009;
Clad Plate for Pressure Vessels  
Part 3: Titanium-Steel Clad Plate

1 Range

1.1 This part specifies the type, dimension and weight, grade, mark, technical requirements and test methods, inspection rules, packaging, marking and quality certificates of clad plates made by explosive welding method or rolled compounding method, with titanium and titanium alloy as the cladding metal and carbon steel, low alloy steel or stainless steel as the base metal.

1.2 This part applies to stainless titanium-steel clad plates for pressure vessels with a total thickness of not less than 8 mm (hereinafter referred to as clad plates).

2 Normative Reference

The following documents are indispensable for the application of this document. For dated references, only the dated version applies to this document. For undated references, the latest version (including all amendments) applies to this document.

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NB/T 47013.3 Nondestructive Testing of Pressure Equipment - Part 3: Ultrasonic Testing
NB/T 47013.5-2015 Nondestructive Testing of Pressure Equipment - Part 5: Penetrant Testing
NB/T 47013.7 Nondestructive Testing of Pressure Equipment - Part 7: Visual Examination
JB 4732 Steel Pressure Vessels - Design by Analysis
GB/T 30583 Specification for Post Weld Heat Treatment of Pressure Equipment

3 Ordering Information

Order contracts or orders should include the following information:

a) Standard number;
b) Product name;
c) Type of steels of cladding metal and base metal;
d) Manufacturing method and grade;
e) Delivery status;
f) Dimensions;
g) Weight;
h) Additional technical requirements.

4 Terminology and Definitions

The following Terminology and definitions apply to this document.

4.1 Compound contact interface
The bonded surface of the base metal and the cladding metal of the clad plate.

4.2 Percentage of unbonded area
The ratio of the sum of the unbonded area of the compound contact interface to the total area of the clad plate, expressed as a percentage.

4.3 Base metal
A matrix material in a composite metal.

4.4 Cladding metal
A cladding material in a composite metal.

4.5 Explosive welding
The welding compound between the cladding metal and the base metal is realized during the explosion process.

4.6 Rolled compounding
The rolled compounding between the cladding metal and the base metal is realized during the rolling process.

5 Type, Dimension and Weight

5.1 Type
5.1.1 The cladding metal may clad one or both sides of the base metal to form a single-clad or double-clad clad plate.

5.1.2 The shape of the clad plate is agreed upon by the supplier and the buyer and may include rectangular, square and circular shapes.

5.2 Dimensions
5.2.1 The thickness of the cladding metal should be 1.0 mm-12 mm.

5.2.2 The minimum thickness of the base metal should be 6 mm, and the ratio of the thickness of the base metal to the thickness of the cladding metal should not be less than 2 for the rolled compounding method, and should not be less than 3 for the explosive welding method.

5.2.3 The maximum thickness of the clad plates produced by the rolled compounding method generally does not exceed 100 mm; the maximum area of the clad plates produced by the explosive welding method generally does not exceed 25 m². The clad plates exceeding the above dimensions can be supplied according to the agreement between the supplier and the buyer.

5.3 Weight
The clad plates can be delivered according to the theoretical weight, and the weight calculation of the cladding and base metals should meet the requirements of the corresponding material standards. The density of each type of steels of the cladding metal is as follows: TA1, TA2, TA3, and TA9 are 4.51g/cm³, and TA10 is 4.54g/cm³.

6 Grade and Mark
6.1 Grade and Code

The grade and code of the clad plates should comply with the provisions of Table 1. The grades of both sides of a double-clad clad plate should be marked respectively.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Explosive welding method</th>
<th>Rolled compounding method</th>
<th>Unbonded rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>B1</td>
<td>R1</td>
<td>0</td>
</tr>
<tr>
<td>Grade 2</td>
<td>B2</td>
<td>R2</td>
<td>≤2</td>
</tr>
<tr>
<td>Grade 3</td>
<td>B3</td>
<td>R3</td>
<td>≤5</td>
</tr>
</tbody>
</table>

6.2 Mark

The product mark should be composed of the clad metal type of steels, base metal type of steels, dimensions, manufacturing method, grade code, and standard number in order.

Example 1: The grade 2 clad plate with the 3 mm thick T3 plate as the cladding metal, the 16 mm thick Q345R plate as the base metal, at a width of 1 500 mm and a length of 6 000 mm, produced by the rolled compounding method is marked as:

(TA3+Q345R) - (3+16)×1500×6000-R2-NB/T 47002.3-20XX

Example 2: The grade 1 clad plate with the 8 mm thick TA2 plate as the cladding metal, the 150 mm thick 16MnIII forgings as the base metal, at a diameter of 2 000 mm, and produced by the explosive welding method is marked as:

(TA2+16Mn III) - (8+150)×D2000-B1-NB/T 47002.3-20XX

7 Technical Requirements

7.1 Cladding Metal and Base Metal

7.1.1 The cladding and base metal standards and type of steels should comply with the requirements of Table 2. The cladding metal should be annealed. The technical requirements of the base metal (such as delivery status, mechanical properties inspection, nondestructive testing, etc.) should also comply with the provisions of GB/T 150 or JB 4732. When forgings are used as the base metal, grade III or IV forgings should be used.

7.1.2 The clad plate with the lower limit of the standard tensile strength of the base metal greater than 540 MPa can be used only after technical review.

7.1.3 The cladding metal and the base metal other than those listed in Table 2 may also be used if agreed by the supplier and the buyer, but the technical requirements should not be lower than the provisions of 7.1.1. When the base metal other than the standard steel in Table 2, the type of steels selected should have similar chemical composition to the type of steels in Table 2, and the technical requirements of the steel (such as P and S contents in steel, impact test temperature and impact energy absorption index) should not be lower than the relevant provisions of the similar type of steels in Table 2.

7.1.4 When the cladding metal should be tailor welded, the relevant technical requirements are determined by the agreement between the supplier and the buyer and are indicated in the contract.

7.1.5 The cladding and base metals should be accompanied by the quality certificates (original) of the material manufacturer. The contents of the material quality certificates should be complete, clear and stamped with the quality inspection seals of the material manufacturer. In the absence of the original quality certificate, the clad plate manufacturer should obtain a copy stamped with the inspection official seal of the business unit and the signature (seal) of the person in charge of the handling of the materials, and should be responsible for the authenticity and consistency of the materials and the material quality certificate used.
Table 2 Cladding Metal and Base Metal

<table>
<thead>
<tr>
<th>Cladding metal</th>
<th>Base metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard No.</td>
<td>Type of Steels</td>
</tr>
<tr>
<td>GB/T 3621</td>
<td>TA1</td>
</tr>
<tr>
<td></td>
<td>TA2</td>
</tr>
<tr>
<td></td>
<td>TA3</td>
</tr>
<tr>
<td></td>
<td>TA9</td>
</tr>
<tr>
<td></td>
<td>TA10</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Other type of steels in the various standards listed above may also be used for the base metal.

7.1.6 The stress relieving heat treatment processes and equipment for clad plates should refer to the relevant requirements of GB/T 30583;

7.2 Delivery Status

The clad plate can be hot rolled or heat treated, leveled and sheared or cut, and the surface of the cladding metal can be descaled before delivered, and the hot-rolled or heat treated status of the clad plate should comply with the provisions for the corresponding base metal in GB/T 150 or JB 4732. According to the requirements of the purchaser and otherwise stated in the contract, the surface of the cladding metal can be treated by shot blasting, polishing or pickling.

7.3 Bonded Status

The clad plate should be ultrasonically tested using a 100% scanning method. The bonded status should comply with the provisions of Table 3.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Indication length of a single unbonded area/mm</th>
<th>Area of a single unbonded area/cm²</th>
<th>unbonded rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grade 2</td>
<td>≤50</td>
<td>≤20</td>
<td>≤2</td>
</tr>
<tr>
<td>Grade 3</td>
<td>≤75</td>
<td>≤45</td>
<td>≤5</td>
</tr>
</tbody>
</table>

7.4 Mechanical Properties

7.4.1 The bonded shear strength of the compound contact interface of the clad plate should not be less than 140 MPa. For double-clad clad plates, different side cladding metals should be retained for shear testing.

7.4.2 The clad plate is only subjected to the tensile testing of the base metal, and the test results should comply with the requirements of the base metal standard.

7.4.3 The clad plate is only subjected to the impact test of the base metal, and the impact test temperature and the impact energy absorption should meet the requirements of the base metal standard. If there is no impact test in the base metal standard, the impact test is not performed.

7.5 Bending Performance

The results of the internal bend (compressing the surface of the cladding metal) and external bend (stretching the surface of the cladding metal) tests, the side bend (stretching and compressing the cross section of the clad plate) test of a single-clad clad plate and the external bend (stretching the surfaces of the two cladding metals) test of the double-clad clad plate should comply with the requirements of Table 4. The clad plate with forgings as the base metal is not subjected to a bending test.
Table 4  Bending Performance

<table>
<thead>
<tr>
<th>Bending angle</th>
<th>Bending diameter</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>180°</td>
<td>Internal bend according to the standard of the base metal, external bend $d=4a$ ($d$ is bending diameter, and $a$ is specimen thickness), side bend $d=40$ mm</td>
<td>There must be no cracks on the outside of the bended part and the compound contact interface must not be laminated.</td>
</tr>
</tbody>
</table>

7.6  Dimensional Tolerance and Flatness

7.6.1  The thickness tolerance of the clad plate should comply with the requirements of Table 5. For the clad plate with forgings as base metal, the thickness tolerance of the base metal is agreed by both the supplier and the buyer.

Table 5  Thickness tolerance

<table>
<thead>
<tr>
<th>Thickness tolerance of cladding metal</th>
<th>Thickness tolerance of base metal</th>
<th>Total thickness tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10% of nominal thickness of cladding metal, and within the range of ±1.0 mm $^a$</td>
<td>Base metal standard</td>
<td>Tolerance of cladding metal $^+$ Tolerance of base metal</td>
</tr>
<tr>
<td>The values of positive and negative tolerances are reduced by 0.5 mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ For the rolled clad plate, when the thickness of the cladding metal is less than 5 mm, its positive tolerance is not more than 1.0 mm.

7.6.2  The allowable tolerances of the length and width of the clad plate comply with the corresponding provisions of the base metal standard, and the allowable tolerance of the diameter of the circular clad plate is as agreed between the supplier and the buyer.

7.6.3  The flatness of the clad plate is as specified in GB/T 709. When the standard value of the yield strength of the base metal is greater than 460 MPa, the flatness is 1.5 times the value specified in GB/T 709. For the clad plate used for the heat-exchanger tube/sheet, the flatness is agreed by the supplier and the buyer.

7.7  Surface Quality

The surface of the cladding metal of the clad plate should not have defects such as scars, cracks, inclusions and pleats. If the above defects are present, the removal is allowed, but after the removal, the minimum thickness of the cladding metal should be ensured. The surface defects beyond the minimum thickness of the cladding metal but not penetrating the base metal can be welded and mended. The welding and mending shall be performed by a welder with a valid certificate in accordance with an approved welding procedure. The surface after welding and mending should be levelled with the surface of the cladding metal and inspected by penetrant test. The results should comply with grade I of NB/T 47013.5-2015. The surface quality of the base metal should comply with the requirements of the base metal standard.

8  Test Methods

8.1  The bonded status of the clad plate should be determined by ultrasonic testing method, and the testing method is as specified in NB/T 47013.3.

8.2  Penetrant testing is as specified in NB/T 47013.5.

8.3  The shear test and bend test of the clad plate are as specified in GB/T 6396.

8.4  The tensile testing for the base metal of the clad plate complies with the provisions of GB/T 228.1.

8.5  The impact test for the base metal of the clad plate complies with the provisions of GB/T 229.

8.6  Dimension Inspection Method

8.6.1  The total thickness of the clad plate is measured with a micrometer or caliper at a distance of not less than 40 mm from the edge of the steel plates.

8.6.2  The thickness of the cladding metal of the clad plate is measured according to the provisions of GB/T 6396.
8.6.3 The length, width or diameter of the clad plate is measured with a steel tape measure.
8.6.4 The flatness of the clad plate is measured according to the provisions of GB/T 709.
8.7 The surface quality of the clad plate is generally visually inspected, with reference to the relevant requirements of NB/T 47013.7.

9 Inspection Rules

9.1 The clad plate is inspected by the supplier quality inspection department.
9.2 The clad plates should be delivered in batches, and each batch should consist of clad plates of the same material combination (the cladding metal and the base metal are respectively the same steel specification, the same thickness, and the same delivery status), the same explosive welding or rolling and heat treatment processes.
9.3 The inspection items of the clad plate are as specified in Table 6. Ultrasonic testing, dimensions (except for the thickness of the cladding metal) and surface quality should be tested sheet by sheet, and the remaining items should be inspected by batch. The items required to be inspected by the buyer in the table should be performed in accordance with the provisions of the contract. Other items can be inspected after agreed by the supplier and the buyer.

<table>
<thead>
<tr>
<th>Inspection Item</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Shear testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Tensile testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Impact testing</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Internal bend testing</td>
<td>○</td>
<td>○</td>
<td>△</td>
</tr>
<tr>
<td>External bend testing</td>
<td>△</td>
<td>△</td>
<td>△</td>
</tr>
<tr>
<td>Side bend testing</td>
<td>△</td>
<td>△</td>
<td>△</td>
</tr>
<tr>
<td>Dimensions</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Surface quality</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: ○ - Item to be inspected;
△ - Items required to be inspected by the buyer.

9.4 A sample is taken from each batch of the products, and the sample can also be taken from the test pieces prepared under the same batch conditions as the product. The sampling method is as specified in the corresponding base metal standard. The number of samples is as follows: one shear specimen, one tensile specimen, three impact specimens, one internal bend specimen, one external bend specimen, one side bend specimen, and one cladding metal thickness specimen. For the double-clad clad plate, one specimen is taken respectively for shear, external bend, side bend, and thickness tests of cladding metals at different sides.

9.5 If the items inspected by batch are unqualified, then double-quantity specimens are taken from the same batch to re-test the unqualified items. The re-inspection of the impact test is in accordance with the standards of the base metal. If any one result of the re-inspection (including any of the indicators required by the test) is unqualified, the batch of products should not be delivered. At this point, the supplier can test sheet by sheet and deliver sheet by sheet; or after the entire batch of steel plates is heat treated, it can be submitted as a new batch for inspection.

10 Packaging, Marking and Quality Certificate

10.1 Each clad plate should be marked with the product mark, batch No., manufacturer’s name (or trademark), production date, etc. on the surface of the cladding metal at the end of the steel plates.
10.2 A clad plate product quality certificate (original) should be provided upon delivery and a copy of the purchased cladding metal and/or base metal quality certificate should be provided.

10.3 The surface of the cladding metal should be effectively protected against scratches.

10.4 The rest of the requirements are in accordance with the provisions of GB/T 247.
People’s Republic of China

NB/T 47002.4-20XX
In substitution of NB/T NB/T 47002.4-2009

Clad Plate for Pressure Vessels
Part 4: Copper-Steel Clad Plate

Issued on XXXX-XX-XX
Implemented on XXXX-XX-XX

Issued by National Energy Administration
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PREFACE

NB/T 47002-XXXX Clad Plate for Pressure Vessels is divided into 4 parts:
- Part 1: Stainless Steel-Steel Clad Plate
- Part 2: Nickel-Steel Clad Plate
- Part 3: Titanium-Steel Clad Plate
- Part 4: Copper-Steel Clad Plate

This part is the fourth part of NB/T 47002. Compared with NB/T 47002.4-2009, the main changes are as follows:
- The manufacturing method of the rolled clad plate was added, and the total thickness of the rolled clad plate, the ratio of the thickness of the base metal to the thickness of the cladding metal, the thickness tolerance, the grade and the code were specified;
- The relevant requirements for stress relieving heat treatment processes and equipment for clad plates were added;
- The side bend test was added;
- The test method from NB/T 47013.7 Non-Destructive Testing of Pressure Equipment Part 7: Visual Examination was added
- The range of the internal bend test was expanded, from grade 1 to grades 1 and 2;

This part is proposed and managed by the China Standardization Committee on Boilers and Pressure Vessels (SAC/TC 262).

Drafting Committee of this part:
Main drafters of this part:
The previous versions of the standards replaced by this part are:
NB/T 47002.4-2009;
Clad Plate for Pressure Vessels

Part 4: Copper-Steel Clad Plate

1 Range

1.1 This part specifies the type, dimension and weight, grade, mark, technical requirements and test methods, inspection rules, packaging, marking and quality certificates of clad plates made by explosive welding method or rolled compounding method, with copper and copper alloy as the cladding metal and carbon steel, low alloy steel or stainless steel as the base metal.

1.2 This part applies to stainless copper-steel clad plates for pressure vessels with a total thickness of not less than 8 mm (hereinafter referred to as clad plates).

2 Normative Reference

The following documents are indispensable for the application of this document. For dated references, only the dated version applies to this document. For undated references, the latest version (including all amendments) applies to this document.

GB/T 150 Pressure vessels
GB/T 228.1 Metallic materials-Tensile Testing- Part 1: Method of Test at Room Temperature
GB/T 229 Metallic Materials-Charpy Pendulum Impact Test Method
GB/T 247 General Rule of Packaging, Marking and Quality Certificate for Steel Plates(Sheets) and Strips
GB/T 709 Dimension, Shape, Weight and Tolerances for Hot-Rolled Steel Plates and Sheets
GB/T 713 Steel Plates for Boilers and Pressure Vessels
GB/T 2040 Copper and Copper Alloy Sheet
GB/T 3531 Steel Plates for Low Temperature Pressure Vessels
GB/T 6396 Clad Steel Plates-Mechanical and Technological Test
GB/T 24511 Stainless Steel and Heat Resisting Steel Plate, Sheet and Strip for Pressure Equipments
NB/T 47008 Carbon and Alloy Steel Forgings for Pressure Equipment
NB/T 47009 Alloy Steel Forgings for Low Temperature Pressure Equipment
NB/T 47010 Stainless and Heat-Resisting Steel Forgings for Pressure Equipment
NB/T 47013.3 Nondestructive Testing of Pressure Equipment - Part 3: Ultrasonic Testing
NB/T 47013.5-2015 Nondestructive Testing of Pressure Equipment - Part 5: Penetrant Testing
NB/T 47013.7 Nondestructive Testing of Pressure Equipment - Part 7: Visual Examination
JB 4732 Steel Pressure Vessels-Design by Analysis
GB/T 30583 Specification for Post Weld Heat Treatment of Pressure Equipment
3 Ordering Information

Order contracts or orders should include the following information:

a) Standard number;
b) Product name;
c) Type of steels of cladding metal and base metal;
d) Manufacturing method and grade;
e) Delivery status;
f) Dimensions;
g) Weight;
h) Additional technical requirements.

4 Terminology and Definitions

The following Terminology and definitions apply to this document.

4.1 Compound contact interface

The bonding surface of the base metal and the cladding metal of the clad plate.

4.2 Percentage of unbonded area

The ratio of the sum of the unbonded area of the compound contact interface to the total area of the clad plate, expressed as a percentage.

4.3 Base metal

A matrix material in a composite metal.

4.4 Cladding metal

A cladding material in a composite metal.

4.5 Explosive welding

The welding compound between the cladding metal and the base metal is realized during the explosion process.

4.6 Rolled compounding

The rolled compounding between the cladding metal and the base metal is realized during the rolling process.

5 Type, Dimension and Weight

5.1 Type

5.1.1 The cladding metal may clad one or both sides of the base metal to form a single-clad or double-clad clad plate.
5.1.2 The shape of the clad plate is agreed upon by the supplier and the buyer and may include rectangular, square and circular shapes.

5.2 Dimensions

5.2.1 The thickness of the cladding metal should be 2 mm-16 mm.

5.2.2 The minimum thickness of the base metal should be 6 mm, and the ratio of the thickness of the base metal to the thickness of the cladding metal should not be less than 2 for the rolled compounding method, and should not be less than 3 for the explosive welding method.

5.2.3 The dimensions of the clad plate should be determined by the agreement between the supplier and the buyer. The maximum thickness of the rolled clad plates generally does not exceed 100 mm; the maximum area of the clad plates produced by the explosive welding method generally does not exceed 25 m².

5.3 Weight

The clad plates can be delivered according to the theoretical weight, and the weight calculation of the cladding and base metals should meet the requirements of the corresponding material standards. See Appendix A for the density of the cladding metal of each type of steels.

6 Grade and Mark

6.1 Grade and Code

The grade and code of the clad plates should comply with the provisions of Table 1. The grades of both sides of a double-clad clad plate should be marked respectively.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Code</th>
<th>Explosive welding method</th>
<th>Rolled compounding method</th>
<th>Unbonded rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>B1</td>
<td>R1</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Grade 2</td>
<td>B2</td>
<td>R2</td>
<td></td>
<td>≤2</td>
</tr>
<tr>
<td>Grade 3</td>
<td>B3</td>
<td>R3</td>
<td></td>
<td>≤5</td>
</tr>
</tbody>
</table>

6.2 Mark

The product mark should be composed of the clad metal type of steels, base metal type of steels, dimensions, manufacturing method, grade code, and standard number in order.

Example 1: The grade 2 clad plate with the 3 mm thick T2 plate as the cladding metal, the 16 mm thick Q345R plate as the base metal, at a width of 1 500 mm and a length of 6 000 mm, produced by the rolled compounding method is marked as:

(T2+Q345R)-(3+16)×1500×6000-R2-NB/T 47002.4-20XX

Example 2: The grade 1 clad plate with the 8 mm thick BFe30-1-1 plate as the cladding metal, the 150 mm thick 16MnIII forgings as the base metal, at a diameter of 2 000 mm, and produced by the explosive welding method is marked as:

(BFe30-1-1+16MnIII)-(8+150)×D2000-B1-NB/T 47002.4-20XX
7 Technical Requirements

7.1 Cladding Metal and Base Metal

7.1.1 The cladding and base metal standards and type of steels should comply with the requirements of Table 2. The cladding metal should be annealed. The technical requirements of the base metal (such as delivery status, mechanical properties inspection, nondestructive testing, etc.) should also comply with the provisions of GB/T 150 or JB 4732. When forgings are used as the base metal, grade III or IV forgings should be used.

7.1.2 The clad plate with the lower limit of the standard tensile strength of the base metal greater than 540 MPa can be used only after technical review.

7.1.3 The cladding metal and the base metal other than those listed in Table 2 may also be used if agreed by the supplier and the buyer, but the technical requirements should not be lower than the provisions of 7.1.1. When the base metal other than the standard steel in Table 2, the type of steels selected should have similar chemical composition to the type of steels in Table 2, and the technical requirements of the steel (such as P and S contents in steel, impact test temperature and impact energy absorption index) should not be lower than the relevant provisions of the similar type of steels in Table 2.

7.1.4 When the cladding metal should be tailor welded, the relevant technical requirements are determined by the agreement between the supplier and the buyer and are indicated in the contract.

7.1.5 The cladding and base metals should be accompanied by the quality certificates (original) of the material manufacturer. The contents of the material quality certificates should be complete, clear and stamped with the quality inspection seals of the material manufacturer. In the absence of the original quality certificate, the clad plate manufacturer should obtain a copy stamped with the inspection official seal of the business unit and the signature (seal) of the person in charge of the handling of the materials, and should be responsible for the authenticity and consistency of the materials and the material quality certificate used.

7.1.6 The stress relieving heat treatment processes and equipment for clad plates should refer to the relevant requirements of GB/T 30583.

<table>
<thead>
<tr>
<th>Cladding metal</th>
<th>Base metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard No.</td>
<td>Example of type of steels</td>
</tr>
<tr>
<td>GB/T 2040</td>
<td>T2, TU1, H68, H62, HSn62-1, QSn6.5-0.1, QA19-2, B19, BFe10-1-1, BFe30-1-1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Other type of steels in the various standards listed above may also be used for the cladding and base metals.

7.2 Delivery Status
The clad plate should be heat treated, leveled and sheared or cut, and the surface of the cladding metal can be descaled before delivered, and the heat treated status of the clad plate should comply with the provisions for the corresponding base metal in GB/T 150 or JB 4732.

7.3 Bonded Status

7.3.1 The clad plate should be ultrasonically tested using a 100% scanning method. The bonded status should comply with the provisions of Table 3.

7.3.2 Welding and mending are allowed for the unbonded area beyond those specified in Table 3. Before welding and mending, the cladding metal in the unbonded area should be polished and leveled to the surface of the base metal. The penetrant test is performed to confirm that the unbonded area has been removed, and then the welder with the valid certificate performs welding and mending in accordance with an approved welding procedure. Ultrasonic test and penetrant test should be performed after welding and mending. The results of ultrasonic testing should comply with the requirements of Table 3. The results of the penetrant test should comply with grade I specified in NB/T 47013.5-2015. The welding and mending record (including the position of the welding and mending zone on the clad plate, the area of each welding and mending zone, the welding material and the welding process parameters) should be attached to the product quality certificate.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Indication length of a single unbonded area/mm</th>
<th>Area of a single unbonded area/cm²</th>
<th>Unbonded rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grade 2</td>
<td>≤50</td>
<td>≤20</td>
<td>≤2</td>
</tr>
<tr>
<td>Grade 3</td>
<td>≤75</td>
<td>≤45</td>
<td>≤5</td>
</tr>
</tbody>
</table>

7.4 Mechanical Properties

7.4.1 The bonded shear strength of the compound contact interface of the clad plate should not be less than 100 MPa. For double-clad clad plates, different side cladding metals should be retained for shear testing.

7.4.2 The clad plate is only subjected to the tensile testing of the base metal, and the test results should comply with the requirements of the base metal standard.

7.4.3 The clad plate is only subjected to the impact test of the base metal, and the impact test temperature and the impact energy absorption should meet the requirements of the base metal standard. If there is no impact test in the base metal standard, the clad plate may not be subjected to the impact test.

7.5 Bending Performance

The results of the internal bend (compressing the surface of the cladding metal) and external bend (stretching the surface of the cladding metal) tests, the side bend (stretching and compressing the cross section of the clad plate) test of a single-clad clad plate and the external bend (stretching the surfaces of the two cladding metals) test of the double-clad clad plate should comply with the requirements of Table 4. The clad plate with forgings as the base metal is not subjected to a bending test.
Table 4 Bending Performance

<table>
<thead>
<tr>
<th>Bending angle</th>
<th>Bending diameter</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>180°</td>
<td>Internal bend according to the standard of the base metal, external bend (d=4a) ((d) is bending diameter, and (a) is specimen thickness), side bend (d=40) mm</td>
<td>There must be no cracks on the outside of the bended part and the compound contact interface must not be laminated.</td>
</tr>
</tbody>
</table>

7.6 Dimensional Tolerance and Flatness

7.6.1 The thickness tolerance of the clad plate should comply with the requirements of Table 5. For the clad plate with forgings as base metal, the thickness tolerance of the base metal is agreed by both the supplier and the buyer.

Table 5 Thickness tolerance

<table>
<thead>
<tr>
<th>Thickness tolerance of cladding metal</th>
<th>Thickness tolerance of base metal</th>
<th>Total thickness tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\pm 10%) of nominal thickness of cladding metal, and within the range of (\pm 1.0) mm</td>
<td>Base metal standard The values of positive and negative tolerances are reduced by (0.5) mm</td>
<td>Tolerance of cladding metal+Tolerance of base metal</td>
</tr>
</tbody>
</table>

7.6.2 The allowable tolerances of the length and width of the clad plate comply with the corresponding provisions of the base metal standard, and the allowable tolerance of the diameter of the circular clad plate is as agreed between the supplier and the buyer.

7.6.3 The flatness of the clad plate is as specified in GB/T 709. When the standard value of the yield strength of the base metal is greater than \(460\) MPa, the flatness is \(1.5\) times the value specified in GB/T 709. For the clad plate used for the heat-exchanger tube/sheet, the flatness is agreed by the supplier and the buyer.

7.7 Surface Quality

The surface of the cladding metal of the clad plate should not have defects such as scars, cracks, inclusions and pleats. If the above defects are present, the removal is allowed, but after the removal, the minimum thickness of the cladding metal should be ensured, otherwise the welding and mending should be performed, and the welding and mending should comply with the corresponding provisions of 7.3.2. The surface quality of the base metal should comply with the requirements of the base metal standard.

8 Test Methods

8.1 The bonded status of the clad plate should be determined by ultrasonic testing method, and the testing method is as specified in NB/T 47013.3.

8.2 Penetrant testing is as specified in NB/T 47013.5.

8.3 The shear test and bend test of the clad plate are as specified in GB/T 6396.

8.4 The tensile test for the base metal of the clad plate complies with the provisions of GB/T 228.1.

8.5 The impact test for the base metal of the clad plate complies with the provisions of GB/T 229.

8.6 Dimension Inspection Method

8.6.1 The total thickness of the clad plate is measured with a micrometer or caliper at a distance of not less than \(40\) mm from the edge of the steel plates.
8.6.2 The thickness of the cladding metal of the clad plate is measured according to the provisions of GB/T 6396.

8.6.3 The length, width or diameter of the clad plate is measured with a steel tape measure.

8.6.4 The flatness of the clad plate is measured according to the provisions of GB/T 709.

8.7 The surface quality of the clad plate is generally visually inspected, with reference to the relevant requirements of NB/T 47013.7.

9 Inspection Rules

9.1 The clad plate is inspected by the supplier quality inspection department.

9.2 The clad plates should be delivered in batches, and each batch should consist of clad plates of the same material combination (The cladding metal and the base metal are respectively the same type of steels, the same thickness, and the same delivery status), the same explosive welding or rolled compounding and heat treatment processes.

9.3 The inspection items of the clad plate are as specified in Table 6. Ultrasonic testing, dimensions (except for the thickness of the cladding metal) and surface quality should be tested sheet by sheet, and the remaining items should be inspected by batch. The items required to be inspected by the buyer in the table should be performed in accordance with the provisions of the contract. Other items can be inspected after agreed by the supplier and the buyer.

<table>
<thead>
<tr>
<th>Inspection Item</th>
<th>Grade code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B1</td>
</tr>
<tr>
<td>Ultrasonic testing</td>
<td>○</td>
</tr>
<tr>
<td>Shear testing</td>
<td>○</td>
</tr>
<tr>
<td>Tensile testing</td>
<td>○</td>
</tr>
<tr>
<td>Impact testing</td>
<td>○</td>
</tr>
<tr>
<td>Internal bend testing</td>
<td>○</td>
</tr>
<tr>
<td>External bend testing</td>
<td>△</td>
</tr>
<tr>
<td>Side bend testing</td>
<td>△</td>
</tr>
<tr>
<td>Dimensions</td>
<td>○</td>
</tr>
<tr>
<td>Surface quality</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: ○ - Item to be inspected; △ - Items required to be inspected by the buyer.

9.4 A sample is taken from each batch of the products, and the sample can also be taken from the test pieces prepared under the same batch conditions as the product. The sampling method is as specified in the corresponding base metal standard. The number of samples is as follows: one shear specimen, one tensile specimen, three impact specimens, one internal bend specimen, one external bend specimen, one side bend specimen, two intergranular corrosion specimen, and one cladding metal thickness specimen. For the double-clad clad plate, one specimen is taken respectively for shear, external bend, side bend, and thickness tests of cladding metals at different sides.
9.5 If the items inspected by batch are unqualified, then double-quantity specimens are taken from the same batch to re-test the unqualified items. The re-inspection of the impact test is in accordance with the standards of the base metal. If any one result of the re-inspection (including any of the indicators required by the test) is unqualified, the batch of products should not be delivered. At this point, the supplier can test sheet by sheet and deliver sheet by sheet; or after the entire batch of steel plates is heat treated, it can be submitted as a new batch for inspection.

10 Packaging, Marking and Quality Certificate

10.1 Each clad plate should be marked with the product mark, batch No., manufacturer's name (or trademark), production date, etc. on the surface of the cladding metal at the end of the steel plates.

10.2 A clad plate product quality certificate (original) should be provided upon delivery and a copy of the purchased cladding metal and/or base metal quality certificate should be provided.

10.3 The surface of the cladding metal should be effectively protected against scratches.

10.4 The rest of the requirements are in accordance with the provisions of GB/T 247.
Appendix A
(Nonmandatory Information)
Density of copper and copper alloys

The density of copper and copper alloys is listed in Table A.1.

Table A.1  Density of Copper and Copper Alloys

<table>
<thead>
<tr>
<th>Type of steels</th>
<th>Density/(g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>8.93</td>
</tr>
<tr>
<td>TU1</td>
<td>8.93</td>
</tr>
<tr>
<td>H68</td>
<td>8.53</td>
</tr>
<tr>
<td>H62</td>
<td>8.43</td>
</tr>
<tr>
<td>HSn62-1</td>
<td>8.45</td>
</tr>
<tr>
<td>QSn6.5-0.1</td>
<td>8.80</td>
</tr>
<tr>
<td>QA19-2</td>
<td>7.60</td>
</tr>
<tr>
<td>B19</td>
<td>8.90</td>
</tr>
<tr>
<td>BFe10-1-1</td>
<td>8.90</td>
</tr>
<tr>
<td>BFe30-1-1</td>
<td>8.90</td>
</tr>
</tbody>
</table>