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项目: **山东莱阳核电项目 1、2 号机组**

部件: **反应堆压力容器**

Reactor Pressure Vessel

标题/Title:

埋弧焊用低合金钢焊丝焊剂采购规范

**PROCUREMENT SPECIFICATION FOR LOW-ALLOY STEEL WIRE- FLUX
COMBINATION FOR SUBMERGED ARC WELDING**

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1. 范围/ Scope

本文件规定了用于莱阳 1/2 核电项目反应堆压力容器埋弧焊用低合金钢焊丝焊剂制造和验收的要求。

This specification prescribes requirements for manufacture and acceptance of low-alloy steel wire-flux combination for submerged arc welding for reactor pressure vessel of Laiyang Nuclear Power Project Unit 1 & 2.

2. 引用标准和文件/ Referenced Documents

未注明版本号的，其最新版适用于本文件。

For undated references, the latest edition of the referenced document (including any amendments) applies.

ASME BPVC 2007 edition through 2008 addendum.

ASME BPVC Section II Material Specifications Part C Specifications for Welding Rods ,Electrodes ,and Filler Metals.

ASME BPVC Section III Subsection NCA-General Requirements Division 1&Division2.

ASME BPVC SECTION III Div 1 Subsection NB Class 1 Componaents.

ASME Section V Nondestructive Examination.

ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

ASTM A751 Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products.

ASTM E21 Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials

ASTM E208 Standard Test Methods for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic steels.

AWS A4.3 Standard Test Method for Determination of the Diffusible Hydrogen

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Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding.

AWS B4.0M Standard Methods for Mechanical Testing of Welds.

3. 通用要求 /General Requirements

3.1 标准及类别/ Standard and Classification

埋弧焊焊丝/焊剂组合应满足SFA 5.23的规定。焊材类别号为F9P4-EGN-GN。当使用G类别焊材时，还应满足本技术条件第9节的规定。

The combination of submerged arc welding wire and flux shall comply with the provisions of SFA 5.23. The classification number of the welding consumable is F9P4-EGN-GN. When using welding consumables of Category G, the provisions of Section 9 of this technical specification shall also be met.

3.2 批的定义/Definition of lots

每批焊丝应为同一热处理炉次、同一规格尺寸在同一制造周期内生产同一交货状态的材料。

A lot of solid wires is the quantity of one size produced in one production schedule from one heat and delivered in the same condition.

每批焊剂应为同批号的原材料、按同一配方在同一制造周期内生产的材料。

A lot of flux is the quantity produced from the same combination of raw materials under one production schedule.

另外，炉/批的定义应符合NB-2420的要求。

Besides, the definition of furnace/lot shall comply with the requirements of NB-2420.

4. 制造/Manufacture

4.1 焊丝/WIRES

4.1.1 焊丝规格尺寸/Size and Shapes

焊丝的尺寸应该满足表 1 要求。

The size of wire and coil and shall satisfy the requirements of table 1 below.

表1 焊丝及焊丝盘规格尺寸

Table 1 Size of Wire and Coil

焊丝直径和公差 (mm) Solid Wire diameter and tolerance (mm)	盘内径 (mm) Coil Inside Diameter (mm)	焊丝盘宽度 (mm) Coil Width (mm)	盘重 (Kg) Coil weigh(Kg)
Φ4±0.05	Φ600 (0, +20)	120 (-5, +10)	75-100
	Φ300 (0, +15)	100 (-5, +10)	25

4.1.2 焊丝表面质量/ Surface Quality of Welding Wire

焊丝表面应光滑、均匀、不应有锈蚀和氧化皮或其他对焊丝的焊接特性以及设备操作有不利影响的外来物质。焊丝表面不允许镀铜。

The wire surface should be smooth and uniform without rust-eaten and scale or other material that would probably affect the welding characteristic of wire and equipment operation. Copper facing should not be allowed.

4.1.3 焊丝的弹射度和螺旋度/Ejection Degree and Helix Degree of Welding Wire

焊丝的弹射度和螺旋度应使焊丝能在自动焊设备上能连续、均匀的送进而不影响焊接过程的质量。

Ejection degree and helix degree of welding wire should be sure enough to make continuous and even wire feeding in the automatic welding equipment and not affect the quality of welding process.

焊丝缠绕不得有硬弯和折点，焊丝在无约束状态下应能自由松开，起焊一

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端的焊丝应该固定并加标记。焊丝的每一个连续长度应由同一炉号或批号的材料组成。

Winding of wire should avoid twisting and sharply curving, leaving the wire free to unwind without restriction. Outside end of wire should be marked and be fastened firmly. Each continuous length of the welding wire shall be composed of materials from the same heat number or lot number.

4.2 焊剂/Flux

4.2.1 焊剂类型为低氢烧结型,焊剂碱度系数 $B \geq 2$ 。碱度系数根据以下公式计算:

$$\text{碱度系数 (B)} = \frac{\text{Ca} + \text{MgO} + \text{BaO} + \text{CaF} + \text{Na}_2\text{O} + \text{K}_2\text{O} + 0.5(\text{MnO} + \text{FeO})}{\text{SiO}_2 + 0.5(\text{Al}_2\text{O}_3 + \text{TiO}_2 + \text{ZrO}_2)}$$

The type of flux is low-hydrogen sintered, basic index $B \geq 2$. Basic index is calculated by the formula:

$$\text{Basic index (B)} = \frac{\text{Ca} + \text{MgO} + \text{BaO} + \text{CaF} + \text{Na}_2\text{O} + \text{K}_2\text{O} + 0.5(\text{MnO} + \text{FeO})}{\text{SiO}_2 + 0.5(\text{Al}_2\text{O}_3 + \text{TiO}_2 + \text{ZrO}_2)}$$

4.2.2 焊剂应成颗粒状,有一定的颗粒强度,并能顺利通过标准焊接设备的焊剂输送管、阀门和焊嘴。

Flux shall be granular in form and shall be capable of flowing freely through the flux feeding tubes, valves, and nozzles of standard submerged arc welding equipment.

4.2.3 焊剂中的机械夹杂物(碳粒、铁屑、铁合金凝珠及其他杂物)的重量百分含量不得大于 0.20%;焊剂含水量不得大于 0.10%;焊剂中的硫磷含量应足够低,以确保熔敷金属中硫磷含量要求。

Weight percentage of mechanical inclusion in flux (carbon granule, iron chips, ferroalloy bead and other inclusion) shall not exceed 0.20%. Moisture content in flux shall not exceed 0.10%. Sulfur and phosphorus content shall be low enough in flux to ensure the content of sulfur and phosphorus of deposited metal to meet the

requirements.

4.2.4 焊剂出厂时含水量不得大于0.10%。

Moisture content should not more than 0.10% before delivery.

4.2.5 焊剂中的硫磷含量应足够低，确保熔敷金属中硫磷含量符合规定。

Sulfur and phosphorus content of flux should be low enough to ensure the sulfur and phosphorus content of deposit metal meet the requirements.

4.2.6 焊剂应能产生成型均匀良好的焊道，保证焊道之间及焊道与母材之间熔合良好，平滑过渡，深坡口焊接时，焊剂应具有良好的脱渣性。若其中一项不合格，认为此批焊剂未通过焊接工艺性检验，不允许进行复验。

The flux can make uniform and good formation of bead, ensure good fusion and smooth transition of inter-bead and bead with base metal. The flux should have good detachability in deep groove welding. If one item of above is unqualified, this lot of flux is failed to pass welding processing property inspection, rechecking is not permitted.

5. 检验项目/ Test

对每一批号的焊丝和每一批焊剂的所有组合都必须进行下列试验。

The series of tests on each lot of wires and flux combination shall be performed as specified below.

(1) 焊丝及熔敷金属化学成分分析

Chemical analysis of wires and undiluted weld metal.

(2) 熔敷金属拉伸试验

Tensile Properties for weld metal.

(3) 落锤试验

Drop-weight test .

(4) 焊缝金属的冲击韧性试验

Impact test for weld metal.

(5) 熔敷金属扩散氢含量的测定

Diffusible Hydrogen Test for weld metal.

(6) 弯曲性能

Bend Tests

(7) RT_{NDT} 试验

Tests for RT_{NDT} Determination

(8) 冲击转变曲线

Kv Transition Curve

6. 焊接试板/Weld Plates

6.1 母材/Base Metal

用于制造试板(包括垫板)的母材应是试验用焊接填充材料牌号相当材料, 或者是用堆焊隔离层的碳钢。隔离层须按 SFA-5.23 的相应要求执行。

The base metal used to make the test plate (including the backing strip) shall be either the grade corresponding to the grade of the filler material under test, or a carbon steel buttered with a filler material. The buttering shall meet the corresponding requirements of SFA-5.23.

隔离层应遍布所有与熔敷金属接触的部分。隔离层试板坡口和表面经机械加工后, 隔离层应至少堆焊三层且厚度不少于 5mm。

Buttering shall extend over all parts which may come into contact with the weld metal deposited by welding. After machining of the bevels and surfacing of the test-plate buttering, the buttering shall comprise at least 3 layers and have a thickness of not less than 5mm.

试板尺寸应符合 SFA-5.23 以及本采购规范文件的规定, 满足所有试验的取样要求。

The dimension of test plates should conform to the specification in SFA-5.23 and this document, the size of the test piece should be enough for the tests and retests.

6.2 焊接参数/Welding Parameters

试板可采用表 2 推荐的参数进行焊接。

The welding parameters for the welding plates as specified in Table2.

表2 焊接参数

Table2 Welding Parameters

焊丝规格 (mm)	Φ4
Size (mm)	
焊接方法	埋弧焊
Welding process	SAW
焊接位置	平焊 (PA)
Welding position	Flat (PA)
预热温度	≥150℃
Preheat Temperatures	
道间温度	≤250℃
Interpass Temperatures	
后热	250~400℃, 至少 4 小时
post-weld heat treatment	250~400℃ for a minimum of 4 hours
电流种类	直流
Welding type	DC
极性	正极性
Polarity	DCEP
电流 (A)	580~640
Welding Current (amperes)	
电压 (V)	28~34
arc Voltage (volts)	
焊速(mm/min)	280~400
Travel Speed(mm/min)	

6.3 试板检验/ Examination of the Test Plates

焊接试件在取样前应进行射线检测和渗透检测。射线检验按照 SFA-5.23 执行，结果应满足 NB-5320 的要求。渗透检测应按 ASME 第 V 卷第 6 章执行，结果应满足 NB-5350 的要求。

Before sampling, the welded test piece shall undergo radiographic detection and penetrant detection. Radiographic detection shall be carried out in accordance with

SFA-5.23, and the results shall meet the requirements of NB-5320. Penetrant detection shall be carried out in accordance with Section 6 of Volume V of ASME, and the results shall meet the requirements of NB-5350.

6.4 热处理/ Heat Treatment

对于热处理态试验的试板应进行一次模拟热处理，热处理在无损检验之前或之后进行均可。模拟焊后热处理的规范应满足以下要求：

A simulated stress relieving heat treatment shall be applied to the test plates for Post weld heat treatment condition accepted test. The heat treatment shall be applied to the welding plates before specimens are removed. This heat treatment may be applied either before or after the nondestructive examination. Post weld heat treatment shall be applied according to the requirements as specified below.

(1) 热处理保温温度 600~620℃，热处理保温时间 40 (0, +1) 小时。

Holding temperature for the post weld heat treatment shall be 600-620℃, and holding time shall be 40(0,+1) hours.

(2) 炉温在 300℃ 以上时，加热和冷却速率不得超过 55℃/h。

Heating rate (and cooling) shall not exceed 55℃/h in the range above 300℃.

7. 试验要求/Tests Requirements.

7.1 化学分析/Chemical Analysis

每一盘圆焊丝中最多只能有一个接头，每盘圆焊丝必须进行化学分析。对每盘圆焊丝的两端取样进行化学成分分析，但对没有接头的盘圆只要求在每一盘圆的一端取样进行化学分析。

There shall be at most one splice in each coil of wire rod. Each coil of wire rod shall undergo chemical analysis. Samples shall be taken from both ends of each coil of wire rod for chemical composition analysis. However, for coils without splices, it is only required to take samples from one end of each coil for chemical composition anal

ysis.

熔敷金属化学分析试样应取自纵向拉伸试样的延长部分，确保没有被母材稀释。

The sample of chemical analysis for deposited metal is taken from extension part of the longitudinal tensile samples, make sure no dilution from base metal.

化学分析方法应符合 ASTM A751 规定。

The sample shall be analyzed according to ASTM A751.

焊丝及熔敷金属化学分析结果应符合表 3 的规定。

Chemical composition for wires and weld deposit metal should conform to the requirements in table 3.

表3 焊丝及其熔敷金属化学成分 (Wt%)

Table 4 Chemical Composition Requirements for Wires And Weld Deposit Metal (Wt%)

元素 Elements	C	S	P	Si	Mn	Ni	Cr
焊丝 Wire	0.07~0.17	≤0.005	≤0.006 ⁽¹⁾	≤0.25	1.60-2.20	0.55~0.75	≤0.15
熔敷金属 Deposit Metal	≤0.100	≤0.008	≤0.010 ⁽¹⁾	0.15~0.40	1.25~1.80	0.60~0.80	≤0.20
元素 Elements	Mo	Cu	Co	V	N	Sb	Sn
焊丝 Wire	0.42~0.55	≤0.050	≤0.02	≤0.009	≤0.0100	≤0.005 ⁽¹⁾	≤0.008 ⁽¹⁾
熔敷金属 Deposit Metal	0.40~0.65	≤0.050	≤0.02	≤0.010	提供数据 for Information	≤0.002 ⁽¹⁾	≤0.010 ⁽¹⁾
元素 Elements	Bi	As	B	Al	Pb/Ti/W/Zr/O	Nb	
焊丝 Wire	≤0.002	≤ 0.010 ⁽¹⁾	提供数据 for Information	提供数据 for Information	提供数据 for Information	≤0.01	
熔敷金属 Deposit Metal	≤0.002	≤ 0.010 ⁽¹⁾	≤0.0005	≤0.04	提供数据 for Information	≤0.01	

注：（1）P、Sb、Sn、As 含量按 Bruscato 公式应满足下列要求： $(10P+5Sb+4Sn+As)/100 \leq 15\text{ppm}$ 。

（2）报告出含量>0.001%的元素。

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Note: (1) P, Sb, Sn, As content according to Bruscato formula should meet the following requirements: $(10P+5Sb+4Sn+As)/100 \leq 15\text{ppm}$.

(2) If there are other elements with content $> 0.001\%$, detection and recording shall be carried out.

7.2 力学性能试验/ Mechanical Properties

7.2.1. 熔敷金属拉伸试验/Tensile test for All-Weld Metal

每批焊丝和焊剂应在焊态和热处理状态的条件下进行熔敷金属拉伸试验，每一试验状态下，室温和 350℃ 各两个试样。拉伸试样中心线位于距试板上表面 10mm 位置，按 AWS B4.0M 要求进行试验。试验结果见表 4 所示。

Tension tests shall be performed for each lot of wires and flux in the post weld heat-treated condition and as-welded conditions. Two specimens for room temperature and two specimens for 350℃ shall be tested in each condition. Tension test specimens center shall be 10mm from the finished weld surface, and the tests shall be performed in accordance with AWS B4.0M. The results of tension tests shall conform to table 4.

表4 熔敷金属拉伸性能

Table 4 Tension Properties of All-Weld Metal

温度 Temperature	拉伸强度 (MPa) Tensile Strength (MPa)	0.2%屈服强度 (MPa) Yield Strength at 0.2% offset (MPa)	延伸率(%) Elongation (%)	断面收缩率 (%) Reduction of Area (%)
室温 Room Temperature	580~700	≥460	≥22	≥50
350℃	≥520	≥380	≥17	≥45

7.2.2. 冲击试验/ Impact tests.

每批焊丝焊剂的熔敷金属在焊态和焊后热处理态下进行夏比 V 型缺口冲击试验，KV 冲击每组 3 个试样。试验尺寸应符合 ASTM A370 图 11A 型的要求，试样中心线位于距试板上表面 10mm 位置。依据 AWS B4.0M 要求进行夏比 V 型

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缺口冲击试验。试验温度及试验结果应满足表 5 所示。

KV Impact test for each lot of wires and flux should be performed in as-welded and postweld heat treated conditions. Three specimens shall be tested for each series. Specimens shall be in accordance with SA-370, Figure 11, Type A, and specimens center shall be 10mm from the finished weld surface. The Charpy V-notch test shall be performed in accordance with AWS B4.0M. The test temperature and result of KV Impact tests shall conform to table 5.

表5 全焊缝金属冲击性能

Table 5 Impact Toughness of All-Weld Metal

温度 Temperature	冲击吸收功 Absorbed Energy		侧向膨胀量 (mm) Lateral Expansion (mm)
	单个最小值 (J) Individual value (J)	平均值 (J) Average value (J)	
	3℃	≥80	
18℃	≥80	≥112	≥0.90
-15℃	≥34 ⁽¹⁾	≥41	≥0.85
-30℃	≥34 ⁽¹⁾	≥41	≥0.85

注：（1）一组(三个)试样中只允许有一个试样低于平均值。

Note (1): Only one result below the minimum average value may be accepted per series of three test specimens.

7.2.3. 落锤试验/ Drop-weight test

在焊态和热处理状态下对焊缝金属进行落锤试验。每一试验状态各两个试样。试样类型为ASTM E208中的P3型，试样中心线位于距试板上表面10mm位置。

Drop weight test shall be carried out in as welded and post weld heat treated conditions for the deposited metal. Two test specimens shall taken for each condition. Test specimens shall be of type P3 in compliance with ASTM E208, and specimens center shall be 10mm from the finished weld surface.

试验温度应不高于-25℃，验收标准为两个试样不断裂。

The test temperature shall be not higher than -25℃, and two specimens show

no-break performance.

7.2.4. 确定 RT_{NDT} 试验/ Tests for RT_{NDT} Determination

试验分别在焊态和热处理状态下进行。每个试验温度下，每一试验状态各两个试样。应准备足够数量的落锤试样，试样类型为ASTM E208中的P3型。

Drop weight test shall be carried out in as welded and post weld heat treated conditions for the deposited metal. Two test specimens shall taken for each temperature and each condition. Test specimens shall be of type P3 in compliance with ASTM E208.

根据 7.2.3 的试验结果，以每次 5°C 为单位降低试验温度，直至得到两个试样都不断的结果。并且在低于该温度 5°C 的试验温度下，至少有一个试样断裂。实际的 T_{NDT} 即为该温度减去 5°C 的温度值。

According to the test results of 7.2.3, the test temperature is reduced by 5°C each time until the result that both specimens do not break is obtained. And at the test temperature 5°C lower than this temperature, at least one specimen is fractured. The actual T_{NDT} is the temperature value obtained by subtracting 5°C from this temperature.

依据NB-2331试验程序确定熔敷金属的 RT_{NDT} 。熔敷金属 RT_{NDT} 应 $\leq -30^{\circ}\text{C}$ 。

The test to determine RT_{NDT} shall be performed according NB-2331. The temperature RT_{NDT} shall not higher than -30°C .

用于确定熔敷金属的 RT_{NDT} 的试板厚度应为225mm，试样中心线位于试板内表面或外表面的T/4部位。试板的焊接及热处理应满足第6章的要求。

The thickness of the test plate for determining the RT_{NDT} of the deposited metal shall be 225mm, and the centerline of the specimen shall be located at the T/4 position of the inner or outer surface of the test plate. The welding and heat treatment of the test plate shall meet the requirements of section 6.

7.2.5. 冲击转变曲线/Kv Transition Curve

要提供完整焊态和焊后热处理态的KV冲击转变曲线。上平台能量值应不小

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于 130J，对应侧膨胀值应不小于 1.3mm。同时应记录剪切面积为 50%对应的温度。

KV transition curves at both as-welded condition and post weld heat treatment are required. The KV energy in upper shelf must be greater than or equal to 130 J and the minimum lateral expansion is 1.3mm. The temperature at 50% shear fracture should be recorded.

确定 KV 冲击转变曲线应包含至少在 6 个温度下进行试验，每一温度试验 3 个试样。应选取试验温度以提供一条完整光滑的曲线。转变曲线应包括断裂能量和侧向膨胀量两条曲线。

The minimum requirements to establish the KVJ curve shall consist of testing series of three (3) specimens at a minimum of six(6) temperatures. Test temperatures shall be selected to provide a full smooth curve. The transition curve shall be developed in terms of both fracture energy and lateral expansion.

试验尺寸应符合 ASTM A370 图 11A 型的要求。依据 AWS B4.0M 的要求进行夏比 V 型缺口冲击试验。试验至少应包含下列四个温度：

Specimens shall be in accordance with SA-370, Figure 11, Type A. The Charpy V-notch test shall be performed in accordance with AWS B4.0M. The following four (3) temperatures shall be included as a minimum.

(1) 显示下平台能量的温度（剪切面积不大于 10%）

Temperature showing lower energy shelf(10% shear fracture or less).

(2) $T_{NDT}+33^{\circ}\text{C}$

(3) 0°C

(4) 显示上平台能量的温度（100%剪切面积）。

Temperature showing upper energy shelf (100% shear fracture).

用于制作KV冲击转变曲线的试板厚度应为225mm，试样中心线位于试板内表面或外表面的T/4部位。试板的焊接及热处理应满足第6章的要求。

For test plates used to prepare KV impact transition curves, the thickness shall be 225mm, and the centerline of the specimen shall be located at the T/4 position of

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the inner or outer surface of the test plate. The welding and heat treatment of the test plate shall comply with the requirements of section 6.

7.2.6. 弯曲性能/Bend Tests

试件经焊后热处理后须进行弯曲性能试验。试样种类、数量、规格尺寸及试验条件应符合表 6 的规定。

Bend test shall be carried out at after post weld heat-treated for the test plates. Test type, size, quantity and condition should conform to table 6.

试验方法按 AWS B4.0M 的规定执行。验收标准为：试样弯曲后，在拉伸面上不允许出现具有特征性的裂纹，单个裂纹、气孔和夹渣等缺陷的长度不得超过 3mm。

The bend test shall be performed in accordance with AWS B4.0M. Acceptance criterion: characteristic crack and any defects with dimension over 3mm in the tensile surface are not allowed after bending.

表6 弯曲性能

Table 6 Bend Test

弯曲种类 Type	试样尺寸 (mm) Size (mm)	数量 quantity	试验条件 Test Condition
横向侧弯 Transverse side bending	10×25×200	2	D=4a $\alpha=180^\circ$ P=6.2a
横向面弯 Transverse face bending	10×38×200	2	D=4a $\alpha=180^\circ$ P=6.2a
横向背弯 Transverse root +bending	10×38×200	2	D=4a $\alpha=180^\circ$ P=6.2a

注：D 为弯曲试验机的芯棒直径；a 为弯曲试样的厚度；P 为支承辊距离。

Note: D is the plunger diameter of the bend test machine, a is the thickness of the bend specimens, and P is the distance between the shoulders.

7.3 扩散氢含量的测定/Diffusible Hydrogen Test

熔敷金属扩散氢含量的测定应按 AWS A4.3 的规定执行。采用气相色谱法或

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其他更精确的方法测量，熔敷金属扩散氢含量 $\leq 4\text{ml}/100\text{g}$ 。

The determination of the diffusion hydrogen content in weld metal shall be carried out in accordance with the provisions of AWS A4.3. Measurement shall be performed using gas chromatography or other more accurate methods, and the diffusion hydrogen content in weld metal shall be $\leq 4\text{ml}/100\text{g}$.

8. 复验/Retest

8.1 如某一不合格的结果是由于试验的实施过程中的问题或由于试样存在缺陷引起有关结果不予认可，并应重新进行试验。

8.1 If an unqualified result is caused by issues in the test implementation process or defects in the specimen, the relevant result shall not be recognized, and the test shall be retested.

8.2 当下列任何一项试验结果不合格时，不合格试验项目按下述要求进行复试：下列以外的试验项目不允许复试。

8.2 If any test fails to meet its requirements for the first time, that test must be repeated twice as required below. Retests for other items are not allowed.

8.2.1 化学成分：只需要对不符合要求的元素进行双倍复试；

8.2.1 Chemical composition: For chemical analysis, retest shall be only for those elements which fail to meet the requirements.

8.2.2 拉伸性能：抗拉强度、规定强度及断后伸长率同时作为复试项目，进行双倍复试；

8.2.2 Tensile properties: Tensile strength, specified strength, and elongation after fracture shall be retested as a set in double quantity;

8.2.3 冲击性能：应在规定温度下作两组复试，两组试样的复试结果均应合格。

8.2.3 Impact properties : Two groups of retests shall be conducted at the specified temperature, and the results of both groups shall be qualified.

8.2.4 弯曲性能：应作两组复试，两组试样复试的结果均合格。

8.2.4 Bend properties: Two groups should be retest, the results of the two groups are

qualified.

8.3 复试试样应在原试件上切取；若不能满足此要求，应重新制备试件进行全套试验，在焊接参数保持不变的条件下，在重新制备的试件上可以仅对不合格的试验项目进行复试。

8.3 Specimens for retest shall be taken from the original test coupon. ; if this requirement cannot be met, a new test coupon shall be prepared for a full set of tests. If the welding parameters remain unchanged, only the unqualified test item may be retested on the newly prepared test piece.

8.4 所有的复试结果均应满足本技术条件规定的要求，复试只允许一次。

8.4 All retest results shall meet the requirements specified in this technical document, and only one retest is allowed.

9. 首次使用的焊材和 G 类别焊材的附加要求 / Additional requirements for filler metal for first application or with a “G” suffix

对于首次用于三代核电厂的焊接材料商业牌号或者 G 类别的焊材，须增加以下要求：

For trade designation of welding materials used for the first time in third-generation nuclear power plants or the filler metal with a “G” suffix, the following requirements shall be added:

(1) 焊接材料制造商的业绩证明 / Experiences of welding material Manufacturer

焊接材料制造商需提供证据表明，证明该焊接材料具有在核电领域或相似质量要求的其他工业中的应用业绩。

The welding material manufacturer shall provide information to prove the application experience of the welding material in the field of nuclear power or other industries with similar quality requirements.

(2) 焊接材料的使用性能证明 / Proof of the performance of welding

materials

焊接材料制造商需提供证据表明,焊接材料至少已经过三个炉/批号的试验,证明该焊接材料在采用生产中使用的焊接变素范围的情况下,其焊缝化学成分和力学性能可以满足规定的要求。提供的证明应属于由相同的焊接材料制造商生产,具有相同的商业牌号,相同的型号且在配方中没有重大变化的焊接材料。

The welding material manufacturer shall provide evidence that welding material have through at least three furnace/batch number of the test, show that the welding material using the welding variable used in production, its chemical composition and mechanical properties of weld can satisfy the requirement of regulations. Certificates provided shall be of the same welding material manufactured by the same welding material manufacturer, of the same trade designation, of the same type and without significant changes in the formula.

(3) 焊接材料使用性能证明的另一种方法/Another method of proving the performance of the welding material

如果焊接材料制造商提供 9.2 节中的证据,需进行试验证明该焊接材料在不同的条件下,其化学成分和力学性能满足规定的要求。至少应对三种不同的炉/批号和至少两种直径(如果在生产中使用的直径超过一种)的焊接材料进行试验。试验需证明在生产中使用高和低的冷却速度和相似的焊接工艺(即薄板使用高热输入、高道间温度、低冷却速度和厚板使用低热输入、低道间温度、高冷却速度)的条件下,都能满足化学成分和力学性能的要求。

If the welding material manufacturer is unable to provide the evidence in Section 9.2, tests shall be carried out to prove that the chemical composition and mechanical properties of the welding material meet the specified requirements under different conditions. At least three different furnace/lot numbers and at least two sizes (if more than one is used in production) shall be tested for welding materials. The tests shall prove that the requirements of chemical composition and mechanical properties can be met in production using high and low cooling rates and similar welding processes (i.e., high heat input, high inter-pass temperature, low cooling rate for thin plates and

low heat input, low inter-pass temperature, high cooling rate for thick plates).

10. 包装和标识/ Packing and Marking

10.1 包装/ Packing

焊丝和焊剂要按照 ASME 规范第 II 卷 C 篇 SFA-5.23 以密封包装供货。需防止由于大气潮湿或其他污染所造成的破坏，或者是通常情况下的机械破坏。

The welding wires and fluxes shall be supplied in sealed packages in accordance with SFA-5.23 of Section C, Volume II of ASME Code. It is necessary to prevent damage caused by atmospheric moisture, other contaminations, or normal mechanical damage.

焊丝盘应用绷带从内径到外径缠绕焊盘捆扎好。焊丝的缠绕应无扭结、波折、锐弯或嵌住，使焊丝在无拘束的状态下能自由松开。焊丝的外端(开始焊接的一端)应加识别标记，使能容易找到，并应固定牢，以防止松脱。

Each coil shall be banded with bands around coil from inside diameter to outside diameter. Electrodes shall be wound so that kinks, waves, sharp bends or wedging are not encountered, leaving the filler metal free to unwind without restriction. The outside end of the filler metal (the end with which welding is to begin) shall be identified so it can be readily located and shall be fastened to avoid unwinding.

焊剂的包装应保证焊剂在正常贮存条件下存放二年不变质，焊剂的焊接工艺性和不锈钢堆焊层各项性能符合本技术条件的规定。

Packing of flux should ensure quality constant in two-year normal storage. The welding performance of flux and the properties of stainless steel deposited metal should meet the technical requirements.

在运输过程中，托盘上焊丝盘应加以遮盖保护。

All coils on pallet shall be covered to protect coils during shipment.

在一个托盘上的所有焊丝盘应具有相同的批号

All coils placed on one pallet shall be of the same lot number.

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运输托盘尺寸和重量应该满足表 7 规定

The shipping pallet size and weight should conform to table 7:

表7 托盘规格尺寸

Table 7 Size of Pallet

托盘类型 Pallet type	尺寸 (mm) ⁽¹⁾ Size (mm)	重量 (Kg) ⁽²⁾ Weight (Kg)
Pallet for wire (wooden box)	Max.960H×1100W×1200L	Max.1200/Pallet

注：

(1) 尺寸包括木质支承材料。

The size is including wooden support material.

(2) 托盘的重量近似为 1200kg (允许公差+0/-10%)。

The weight of pallet is approximately 1200kg.(tolerance +0/-10%).

10.2 标识/ Marking

9.2.1 焊丝标识/ Marking of Wires

(1) 每一箱焊丝必须编有识别标志，可查出焊丝的批次、生产日期、生产班次、生产线以及制造焊丝所用的焊芯化学成分范围。

Each box of wire shall be identified to trace back to the lots, production date, shifts, production line of wire and chemical composition of mixture and bars used to produce wire.

(2) 每盘焊丝都应按 SFA-5.23 的要求标识，其上至少包括以下信息，标签应标在焊盘的内径上：

Each coils shall be identified with the information required by SFA-5.23, it contains the following information. The label shall be placed on the inside diameter surface of coil.

—材料的分类号和牌号。

—Classification and trade designation.

—制造商名称和商标。

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—Name of manufacture and trade mark.

—规格尺寸和净重。

—Size and net weight.

—批号、炉号。

—Lot number and heat number.

—生产日期。

—Making date.

(3) 焊丝表面不准涂油或其它有害的防护涂层

The surface of welding wires shall not be covered with oil or other harmful protective agents.

(4) 焊丝盘箍紧带不许锈蚀

The steel belt to be fasten the coil shall not be rusted.

(5) 焊丝盘外面应使用具有一定韧性且防潮的包装,防止在运输和储存过程中受到损坏和污染

The coil shall be wrapped with tough and moisture-proof material for prevention of damage and dirt during transportation and preservation

(6) 焊丝盘外应缠绕牛皮纸,牛皮纸两端应使用塑料带固定

Each coil shall be spirally wrapped with kraft paper and the end of paper shall be fixed with vinyl tape.

9.2.2 焊剂标识/Marking of Flux

焊剂的容器应以打印记或贴上标签,其上至少包括以下内容:

Each flux container shall have a stamped, printed label which shall contain the following information as minimum

—制造商名称和商品名称

—Name of manufacture and trade designation.

—颗粒尺寸

—Particle size

—净重

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—Net weight

—焊材规格号

—Welding material spec. No.

—批号

—Lot number

—生产日期

—Manufacturing date

—烘干温度和烘干要求

—Bake temperature and other baking requirements

—焊剂类型

—Type of flux

9.2.3 托盘标识/Marking of Pallet

托盘上的标签应包括以下信息：

The label or tag with following information shall be applied to the pallet:

—焊剂和焊丝的类别和尺寸。

—Classification and size of wire or flux.

—批号。

—Lot number.

—制造商名称和商品名称。

—Name of manufacture and trade designation.

—采购规格书号。

—Purchase specification number.

—采购单号。

—Purchase order number.

—总的净重。

—Total net weight.

11. 质量要求/ Quality Requirements

10.1 质量保证要求

焊材供货商应遵循 HAF003 或 ASME BPVC Section III NCA-3800 的要求制订和实施质量保证大纲，具体要求按采购合同执行。

The electrode supplier shall formulate and implement Quality Assurance Program according to ASME BPVC Section III NCA-3800 or HAF003. The Quality Assurance Program shall conform to requirements of the purchase contract in detail.

为检查或审查采购过程的每个阶段，一重、一重的用户和一重的授权和检查时有权进入供应商的车间、接触设备和记录。

CFHI, CFHI's customer, and CFHI's authorized nuclear inspector shall have access to the supplier's plant facilities and records for inspection or audit at each tier of procurement.

发货前，当供应商确定了一项不符合项时，对于不符合项的处理办法应得到买方批准。

When a nonconformance is identified by the supplier prior to shipment, the nonconformance shall be submitted to CFHI for approval of the disposition.

10.2 材料的证明/ Certification of Material

鉴定材料试验报告（CMTR）应随焊材一起交货，并至少应包括下列内容：

The Certified Material Test Report (CMTR) shall be delivered with the welding consumable and shall include the following information as minimum:

- (1) 所有要求的化学分析、试验和检验的实际结果。

The actual results of all required chemical analysis, tests and examinations.

- (2) 进行化学分析、试验或检验的分供方的证明。对于除化学分析、试验或检验以外其它要求保留追溯性的工作，应将这些工作和进行这些工作的合格分供方列在 CMTR 上，或者将合格分供方的证明附在 CMTR 上。

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The subsupplier's certification for performing chemical analysis, tests or examinations. The operations other than chemical analysis, tests or examinations requiring maintenance of traceability, these operations and the approved subsuppliers performing them shall be listed on the CMTR or the approved subsupplier's certification for the operation may be furnished as an attachment to the CMTR.

(3) 规格、供货数量和生产日期。

Size, supply quantity and production date.

(4) 材料标识描述。

Material identification description.

(5) 材料组织的质量系统证书和有效期（适用时）；

The Material Organization's Quality System Certificate number and expiration date, as applicable.

(6) 相应的书面的质量系统大纲的版本和日期（适用时）。

The revision and date of the applicable written Quality System Program, as applicable.

(7) AWS 标准号(包括版本号)和类别号；

AWS standard number (including version number) and classification designation.

(8) 批号、 检验号或炉号；

Lot number, inspection number or heat number.

(9) 实际使用的焊接规范；

The actual welding parameters used.

(10) 采购定单号和采购规格书号；

Purchase order number and the procurement specification number.

(11) 任何不符合项及处理的记录；

Records of any nonconforming items including the disposition.

(12) 推荐的焊接工艺、电源种类、极性、焊接位置等参数。

Recommended welding process, power source type, polarity, parameter scope,

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inter-pass temperature, welding position and other welding parameters.

(13) 焊后热处理条件和焊后热处理参数，包括加热和冷却速度、保温时间。

Post-weld heat treatment conditions and parameters, including heating and cooling rates, and holding time.

(14) 性能试验报告，包括取样位置、试验方法、试验温度、试样类型以及试验结果等。

Performance test reports, including sampling locations, test methods, test temperatures, sample types, and test results, etc.

(15) 供应商的名称和商标

Supplier's name and trade designation.

(16) 焊剂类型、渣系、颗粒度、焊剂使用前烘干温度及时间；循环使用次数、混合比例；焊丝和焊剂的贮存和使用说明；空气中允许的最长暴露时间等；最大允许烘干次数和累计烘干时间。

Type of flux, method of manufactured, particle size range and flux drying procedure (temperature, hours and times), storage term, conditions for the recycling of powdered flux, etc. The maximum allowable exposure time in the air, the maximum allowable number of drying times and the cumulative drying time, etc.

(17) 如果材料的制造和供应不是在同一个公司，材料的供应商应将所有制造商的鉴定材料试验报告转移给采购商，包括材料供应商的鉴定材料试验报告。

If the material manufacturer and the material supplier are different companies, the material supplier shall transmit all material manufacturer's CMTR to the purchaser including material supplier's CMTR.

(18) 在焊材发运之前，鉴定材料试验报告应该提交给买主并得到认可。

The CMTR shall be submitted and approved by purchaser before shipping.