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加氢反应器用 2.25Cr-1Mo 钢
焊丝/焊剂、焊条订货技术条件
PURCHASE SPECIFICATION
OF SOLID WIRE/FLUX AND COVERD ELECTRODES
FOR 2.25Cr-1Mo HYDROGENANT REACTOR

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文件修改记录表
Revision Status Sheet

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1 范围 Scope

本文件规定了用于 2.25Cr-1Mo 钢加氢反应器埋弧焊焊丝和焊剂、焊条订货和验收技术要求。

This specification prescribes requirements for the purchase and acceptance for submerged-arc welding wire & flux and covered electrodes matching for 2.25Cr-1Mo steel hydrogenation reactor.

2 参考规范 Applicable Code

ASME 锅炉及压力容器规范，第Ⅱ卷 C 篇 SFA-5.01/SFA-5.01M，最新版。

ASME B&PVC, Sec. Ⅱ Part C SFA-5.01/SFA-5.01M, latest edition.

ASME 锅炉及压力容器规范，第 II 卷 C 篇 SFA-5.23/SFA-5.23M、SFA-5.5/ SFA-5.5M，最新版；埋弧焊焊丝和焊剂组合类别号为 F9P2-EG-B3 或 F9P2-EB3R-B3R；焊条类标号为 E9016-B3 或 E9018-B3。

ASME B&PVC, Sec. Ⅱ Part C SFA-5.23, SFA-5.5, latest Edition; Classification of combination of SAW wire and flux shall be F9P2-EG-B3 or F9P2-EB3R-B3R; Classification of covered of electrode shall be E9016-B3 or E9018-B3.

ASME 锅炉及压力容器规范，第Ⅷ卷 D2 分册，3.4 条，最新版

ASME B&PVC, Sec. Ⅷ Division 2, item 3.4, latest Edition

ASME 锅炉及压力容器规范，第Ⅸ卷，最新版

ASME B&PVC, Sec. Ⅸ, latest edition

API 推荐规范 934-A，最新版. API RP 934-A, latest edition

除符合上述规范要求外，还应符合本订货技术条件的规定。

Except for applicable code above, the requirement of this specification also shall be met by the manufacturer.

3 技术要求 Technical Requirements

埋弧焊焊丝/焊剂、焊条的制造可采用任何能使产品符合规范和本技术条件要求的方法进行。每批焊材的生产量尽量满足一次订货的要求。

SAW wire/fluxes and covered electrodes can be manufactured with any method of which products meet the requirements of applied code and this specification. To

the best of manufacturer's ability, the quantity of each batch production shall meet the ordering required as possible.

4 试验要求 Test Requirements

供方需对每一炉批号组合的埋弧焊焊丝/焊剂、每一炉批号的焊条按如下要求进行检验:

Supplier shall test each batch of combination of SAW wire/flux and each batch of covered electrodes required as follows:

4.1 熔敷金属的化学成分 Chemical analysis of weld metal

4.2 熔敷金属室温拉伸试验 Tension test of weld metal at room temp.

4.3 熔敷金属高温拉伸试验 Tensile test of weld metal at elevated temp.

4.4 熔敷金属冲击试验 Impact test of weld metal

4.5 熔敷金属硬度试验 Hardness test of weld metal

4.6 熔敷金属回火脆化试验 Temper embrittlement test of weld metal

4.7 弯曲试验 Bend test

4.8 应力持久试验 Stress-rupture test

4.9 熔敷金属扩散氢含量 Diffusible hydrogen content of weld metal

4.10 焊条药皮含水量 Moisture content of coating

4.11 焊剂含水量 Moisture content of flux

4.12 焊剂的硫、磷含量及机械夹杂物 Content of S and P element in flux and mechanical impurity of flux

5 焊接条件 Welding Condition

5.1 焊接试验用母材 Base Metal for Welding Test

焊接试验用母材应符合 ASME 规范第 II 卷 A 篇相关标准要求的 SA-387 Gr.22 CL.2 或 SA-182 F22 CL.3/SA-336 F22 CL.3 轧材或锻件，或按照 SFA-5.23/ SFA-5.23M 和 SFA-5.5/ SFA-5.5M 规定的形式进行。

The base metal to be used for welding tests shall be SA-387 Gr.22 CL.2, or SA-182 F22 CL.3/SA-336 F22 CL.3 rolling or forging specified in ASME code Sec. II, Part A or type specified in SFA-5.23/ SFA-5.23M and SFA-5.5/ SFA-5.5M.

5.2 试件规格和形式 Weld Coupon Dimension and Shape

试件规格和形式应满足检验项目的需要或按照 SFA-5.23/SFA-5.23M 和 SFA-5.5/ SFA-5.5M 规定的形式进行。

The weld coupon dimension and shape shall meet requirements of examination items or meet requirements specified in SFA-5.23/SFA-5.23M and SFA-5.5/ SFA-5.5M.

5.3 焊接位置 Welding position

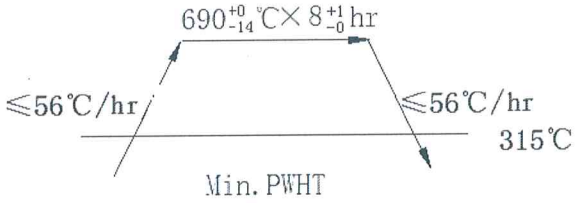
焊接位置为平焊位。

Welding position is flat.

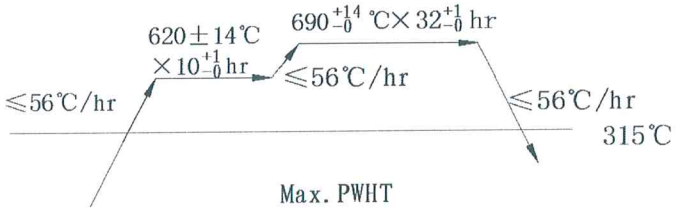
5.4 焊后热处理 Post Weld Heat Treatment

试件焊后热处理按 Min.PWHT:690^{+0}_{-14} ℃×8^{+1}_{-0} hrs 和 Max.PWHT:620±14℃×10^{+1}_{-0} hrs +690^{+14}_{-0} ℃×32^{+1}_{-0} hrs 的热处理工艺执行。

Post weld heat treatment of weld coupon shall be done with the following conditions.



Min.PWHT



Max.PWHT

6 熔敷金属化学成份 Chemical Analysis of Weld Metal

熔敷金属化学成份如表 1 所示。

Chemical analysis of weld metal shall be as shown in table 1.

表 1 熔敷金属化学成分（wt %）

Table 1 Chemical Composition of Weld Metal (wt%)

	C	Si	Mn	P *	S *	Cr	Mo	Cu	Ni
焊丝/焊剂 Wire/Flux	0.05～0.15	0.05～0.35	0.30～0.95	≤0.010	≤0.010	2.00～2.50	0.90～1.20	≤0.15	≤0.25

目标值 Target	--	--	--	≤ 0.008	≤ 0.005	--	--	--	--
焊条 Covered electrode	0.05～ 0.12	0.20～ 0.50	≤0.90	≤ 0.010	≤ 0.010	2.00～ 2.50	0.90～ 1.20	≤ 0.20	≤0.25
目标值 Target	--	--	--	≤ 0.008	≤ 0.005	--	--	--	--
	Nb	Ti	Sb	Sn	As	B	O * ppm	N * ppm	Si+Mn
焊丝/焊剂 Wire/Flux	≤ 0.010	≤ 0.030	≤ 0.005	≤ 0.005	≤ 0.005	≤ 0.002	≥ 300	实测 report	≤1.20
目标值 Target	--	--	--	--	--	--	300～ 350	≤ 100	--
焊条 Covered electrode	≤ 0.010	≤ 0.030	≤ 0.004	≤ 0.010	≤ 0.010	≤ 0.002	实测 report	实测 report	≤1.20
目标值 Target	--	--	--	--	--	--	≤ 350	≤ 100	--

X=（10P+5Sb+4Sn+As）/100≤12， 目标值 Target value≤10

式中元素以 ppm 含量代入。The elements are in ppm.

J=（Si+Mn）×（P+Sn）×10^4≤120，目标值 Target value≤100

式中元素以质量百分含量代入。The elements are in wt%.

7 熔敷金属的力学性能 Mechanical Property of Weld Metal

7.1 熔敷金属的力学性能如表 2 所示。

Mechanical Property of weld metal shall be as shown in table 2.

表 2 熔敷金属的力学性能

Table 2 Mechanical Property of weld metal

项目 item	单位 unit	数值 Required value	热处理状态 HT condition
室温拉伸强度 Rm RT tensile strength Rm	MPa	515～690	620±14℃×10^{+1}_{-0} hrs & 690^{+14}_{-0} ℃×32^{+1}_{-0} hrs
室温屈服强度 Rp0.2 RT yield strength Rp0.2	MPa	≥310	
室温延伸率 A RT elongation A	%	≥20	
室温断面收缩率 Z RT reduction of area Z	%	≥45	
454℃高温屈服强度 Rp0.2 Yield strength at 454℃ Rp0.2	MPa	≥231	

夏比（V形缺口）冲击功 -30℃ Charpy V-notch impact energy at -30℃	J	三个试样平均值≥54 Average Energy≥54 允许其中一个试样≥48 Only one minimum value ≥48	690^{+0}_{-14} ℃×8^{+1}_{-0}hrs
焊接接头硬度 Weld joint hardness	HB	焊缝硬度≤225 Weld metal hardness≤225	

7.2 熔敷金属回火脆化试验 Temper embrittlement test of weld metal

试样经分步冷却脆化处理后（英文简写S.C.，见图1）应满足下式要求：VTr54+3ΔVTr54≤0℃。式中VTr54—经Min.PWHT后夏比冲击功为54J时相应的转变温度；ΔVTr54—Min.PWHT+S.C.后冲击功为54J时相应的转变温度增量，如图2所示。图中曲线A和曲线B分别由8个适当的温度点所组成，但必须包括-30℃。在每个温度下各取3个试样进行夏比冲击试验，共需48个试样。曲线应完整，应有上下平台值。

After the Charpy test specimen sets are step cooling heat treated(abbreviation S.C., see figure 1) ,the impact properties shall meet the following requirement: VTr54+3ΔVTr54≤0℃. Where, VTr54 is 54J transition temperature subjected to the minimum PWHT only; ΔVTr54 is the shift of 54J transition temperature subjected to the minimum PWHT plus the step cooling heat treatment, See figure 2. A and B transition curve are made up of eight selected test temperatures. One of the test temperatures shall be performed at -30℃. Three specimens shall be tested at each test temperature. And forty-eight test specimens shall be prepared. The temperature curve shall be integrated and include both the upper and lower shelf.

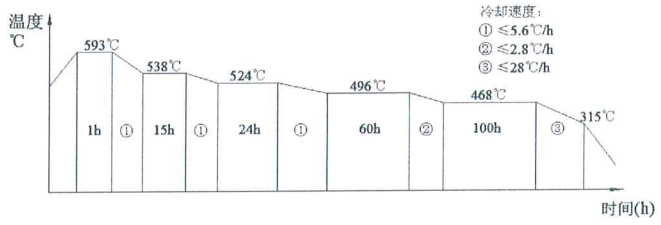


图1 阶冷脆化处理程序

Figure 1 the procedure of step cooling heat treatment

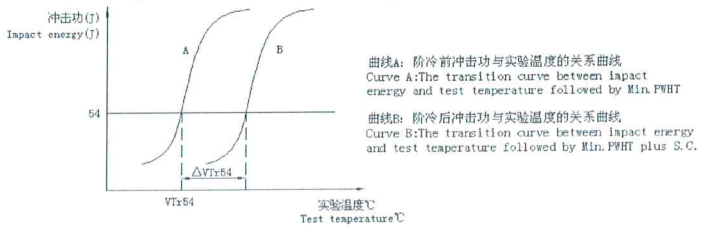


图 2 冲击功与试验温度关系曲线

Figure 2 The transition curve between impact energy and test temperature

8 弯曲试验 Bend Test

每一炉批号的埋弧焊焊丝和焊剂组合以及焊条的熔敷金属应进行纵向弯曲试验。面弯和背弯试样各取 1 个。熔敷金属纵向弯曲试样弯曲到表 3 规定的角度后，其拉伸面上的熔敷金属沿任何方向不应有单条长度大于 3mm 的开口缺陷，试样熔敷金属的棱角开口缺陷可不计，但由未熔合、夹渣或其他内部缺欠引起的棱角开口缺陷长度应计入。

Each batch of combination of SAW wire & flux and covered electrodes shall carry out longitudinal bend test. One face bend specimen and one root bend specimen shall be prepared. After the specimen is bent to the specified angle according to the requirements of Table 3, the single length of the tensile surface shall not have the cracks or faults of more than 3 mm in any directions. The edge cracks of the specimen can be ignored, but the length of the edge cracks caused by slag inclusion, lack of fusion, or other defects shall be counted.

表 3 弯曲试验规定

Table 3 Bending Test Requirements

试验温度 Test Temp.	类型 Type	尺寸(mm) Dimension(mm)	数量 Quantity	弯心直径(mm) Bending Plunger Diameter(mm)	弯曲角度 Bend Angle
室温 Room Temp.	(a)纵向面弯 Longitudinal Face Bend	10×38×200	1	40	180°
	(b)纵向背弯 Longitudinal Root Bend	10×38×200	1	40	180°

9 应力持久试验 Stress-rupture test

用于 2.25Cr-1Mo 埋弧焊（SAW）的每一炉批号的焊丝和焊剂组合均应进行两个试样的应力持久试验，满足 ASME 锅炉及压力容器规范，第Ⅷ卷第 2 分册 3.4 条要求。其中一个试样轴线平行于焊缝轴线（全焊缝金属试样），一个试样轴线垂直于焊缝轴线。试验要求如下：

a. 标距内试样直径等于 13mm，试样中心线位于试验件厚度的 T/2 处。

b. 横向试样的标距应包括焊缝和邻近熔合线至少 19mm 的母材。

c. 试验材料应按模拟最大焊后热处理进行。

d. 试验条件是在 510℃、210MPa 下持久试验时间超过 650h。

For 2.25Cr-1Mo material, each batch of combination of SAW wire & flux shall carry out stress-rupture test with two specimens meeting the requirements specified in ASME B&PVC, Sec. Ⅷ D2 item 3.4. One specimen is machined parallel (all weld metal specimen) to the weld axis and one transverse to the weld axis in accordance with the following:

a. The specimen diameter within the gage length shall be 13 mm. The specimen centerline shall be located at the 0.5-t thickness location of weld coupon.

b. The gage length for the transverse specimen shall include the weld and at least 19 mm of base metal adjacent to the fusion line.

c. The test material shall be postweld heat treated to maximum PWHT.

d. The condition of the stress-rupture test shall be 210 MPa at 510℃. The time of failure shall exceed 650hr.

10 熔敷金属扩散氢含量 Diffusible Hydrogen content of weld metal

埋弧焊焊丝/焊剂组合、焊条的熔敷金属的扩散氢含量采用水银法或气相色谱法测定，要求扩散氢含量小于等于 5ml/100g. 参考标准 AWS A4.3 或 ISO 3690-2000.

The diffusible hydrogen content of weld metal for combination of SAW wire/ flux and covered electrodes shall be carried out by mercury or gas chromatography methods which results meet the following requirements: H≤5ml/100g, referring to AWS A4.3 or ISO 3690-2000.

11 焊材制造要求 Manufacture Requirements of Welding Consumables

11.1 焊丝 Welding Wire

a. 焊丝的椭圆度不应超过直径允许偏差的 75%。

Ellipticity of the welding wire shall not exceed 75% of its diameter tolerance.

b. 每盘焊丝应是一根整丝。焊丝盘的重量和尺寸由供需双方商定，具体由需方采购技术规格书的要求规定。

Each coil shall consist of one continuous length of wire. Weight and size of each coil shall be consulted between buyer and seller, the details shall be

specified by purchaser in their procurement specification.

c.焊丝外观质量 Welding Wire Appearance Quality

① 焊丝表面应光滑、均匀，不应有锈蚀和氧化皮，不允许有超出直径偏差之半的划伤和局部缺陷存在。

The wire shall have a smooth and uniform finish which shall be free from rust, scale, local scratch over half of diameter allowance, and local defects.

② 成盘焊丝不允许存在接头，焊丝在标准设备中应能连续、均匀地送进而不影响焊接过程质量。焊丝应为半硬状态，焊丝包装打开后不应出现炸盘、散盘现象。

Joint is not been allowed for whole coil wire, wire shall be able to deliver continuously and equably in standard equipment so as to assure welding qualities. Wire shall be semirigid so that loose and blast coil won't happen after opening package.

d.缠绕焊丝不得有硬弯和折点，焊丝展开后不应重叠交错。起焊一端的焊丝应固定并加标记。

The wire shall be wound so that kinks, sharp bends are not encountered, leaving the covered electrode free to unwind without restriction. The outside end of the electrode shall be identified so it can be readily located.

e.其余制造要求参见 ASME CODE Sec. Ⅱ Part C SFA5.23 的有关规定执行。

Other requirements shall be in accordance with ASME CODE Sec. Ⅱ Part C SFA5.23.

11.2 焊剂 Flux

a.焊剂粒度应均匀，具有较高的颗粒强度，并能流畅地在焊剂给送系统中输送。

Flux granule shall be uniform and strong enough to flowing freely through flux feeding system.

b.出厂焊剂的含水量不得大于 0.10%。

Moisture of delivered flux shall be less than 0.10%.

c.焊剂中的磷、硫含量应足够低，以确保熔敷金属中磷、硫含量的限值。焊剂中的硫含量不大于 0.035%,磷含量不大于 0.040%.

The phosphorus and sulphur content of flux shall be low enough to meet chemical

analysis requirements of the weld metal. Sulphur content of flux shall be less than 0.035% and phosphorus content shall be less than 0.040%.

d.焊剂中机械夹杂物(铁屑、铁合金凝珠及其它杂物)的重量百分含量不得大于0.20%。

The weight of mechanical impurity (scrap, iron alloy globular and other impurity) of flux shall be less than 0.20%.

e.焊剂应能产生成型均匀良好的焊道，使焊道与焊道之间及焊道与母材之间应熔合良好，平滑过渡，没有咬边。

The flux shall permit the production of uniform, well-shaped beads that merge smoothly with each other and the base metal without undercut.

f.焊剂应具有深坡口脱渣性好、流动性适宜的特点。

The flux shall enable good slag-removal capability in deep groove and reasonable fluidity in molten state.

g.其余制造要求参见ASME CODE Sec. II Part C SFA5.23的有关规定执行。

Other requirements refer to ASME CODE Sec. II Part C SFA 5.23.

11.3 焊条 Covered electrode

a.焊条药皮应均匀紧密地包覆在焊芯周围，整根焊条上不应有影响焊接质量的裂纹、气泡、杂质和剥落等缺陷。

The covering shall be cover the core wire closely and uniformly, and defects, such as crack, bubble, impurity and scale-offs, which affecting welding quality shall not be allowed for the whole electrode.

b.焊条引弧端药皮应倒角，焊芯端面应露出，以保证引弧顺利。

The arc end of each covered electrode shall be sufficiently bare and the covering sufficiently tapered to permit easy striking of the arc.

c.焊条药皮应有足够的强度，保证在正常的搬运和使用过程中不损坏。

The covering of the covered electrode shall be strong enough to prevent covered electrode from damage during carrying and using.

d.焊条药皮含水量不得大于0.10%。

Moisture of covered electrodes shall be less than 0.10%.

e.焊条的偏心度要求：直径为4.0mm的焊条，偏心度不应大于4%；直径为5.0mm的焊条，偏心度不应大于3%。

Eccentricity requirements of the covered electrode: for dia. 4mm covered electrode, its eccentricity shall be less than 4%, and for dia.5mm covered electrode, its eccentricity shall be less than 3%.

f.焊条应适宜全位置焊接，具有良好的焊接工艺性能，易于脱渣。

The covered electrode shall adapt to all position welding and have a good weldability and good slag-removal capability.

g.其余制造要求参见ASME CODE Sec. II Part C SFA5.5的有关规定执行。

Other requirements refer to ASME CODE Sec. II Part C SFA5.5.

12 包装 Packaging

焊材应适当的包装，以保证在正常条件下运输和储存过程中不受损害。若在海上长时间运输，焊条包装盒应密封，保证焊条不受潮湿。

Welding consumables shall be suitably packaged to protect then from damage during shipment and storage under normal conditions. Package of cover electrode shall be sealed when a long time sea transportation during shipment, which protect covered electrode from humidity.

13 包装标识 Marking of Packages

每个单位包装件的外表应清晰地标出下述内容：

The following information shall be legibly marked on the outside of each unit package：

（1）制造厂名称 Manufacturer's name

（2）商品名称 Trade designation

（3）ASME标准号和类别号 ASME specification and classification designations

（4）规格和净重 Size and net weight

（5）批号、检验号或炉号 Lot, control, or heat number

（6）生产日期 Production date

（7）推荐烘干条件 Recommendation for baking condition

（8）焊剂颗粒尺寸 Flux particle size

（9）警示标签 Warning label

14 材料合格证书 Certified Material Test Report

供方所提供的每一批次焊丝和焊剂、焊条，都必须提供材料合格证书，其内容包括下述项目。

Each batch of welding wire & flux and covered electrodes supplied by the seller must offer the certificate material test report including the following contents:

（1）商品名称 Trade Designation

（2）ASME规范号和AWS类别号 ASME specification number and AWS classification number

（3）规格和净重 Size and net weight

（4）批号、检验号或炉号 Lot, control, or heat number

（5）生产日期 Production date.

（6）用户名称 Customer's name

（7）制造厂名称 Manufacturer's name

（8）用户规范号和版本号 Customer's Spec. No. and Rev. No.

（9）试验采用的基材名称 Material Designation of Base Metal for Acceptance Test

（10）焊接条件 Weld Conditions

（11）热处理条件 Heat Treatment Condition

（12）本技术条件规定的试验结果 Test Results required in this specification

（13）ASME SFA-5.23/SFA-5.23M和ASME SFA-5.5/SFA-5.5M要求的试验结果 Test Results required in ASME SFA-5.23/SFA-5.23M and ASME SFA-5.5/SFA-5.5M

（14）用户订单号 Customer's purchase order number

（15）QA责任人的证明声明和签字 Certification Statement and Signature by Responsible Person to QA.