



Cladding-Technology-Shanxi-Co.,-Ltd- CLADDING-ITP-019-Cladding-Thick- Wall-Pipe-ITP

科雷丁技术（山西）有限公司

Cladding-Technology-Shanxi-Co.,-Ltd

检验与试验计划

Inspection and Test Plan

文件编号	Document No.	CLADDING-ITP-019
文件名称	Document Title	厚壁管堆焊多层多道控制、稀释率检测与无损检测检验与试验计划
Inspection and Test Plan for Multi-layer Multi-pass Control, Dilution Rate Detection and Non-destructive Testing of Thick-walled Pipe Cladding		
版本号	Version	A/0



生效日期	Effective Date	2025-01-01
编制	Prepared By	质量管理部
Quality Management Department		
审核	Reviewed By	技术质量总监
Technical Quality Director		
批准	Approved By	总经理
General Manager		

1. 目的 Purpose

本检验与试验计划旨在规范科雷丁技术（山西）有限公司厚壁管堆焊作业过程中的多层多道焊接控制、稀释率检测与无损检测工作，确保堆焊层质量符合设计要求和相关标准规范，为法兰堆焊、管件堆焊、钢管堆焊、轴套管堆焊等精密堆焊服务提供可靠的质量保证。

This inspection and test plan is designed to standardize the multi-layer multi-pass welding control, dilution rate detection and non-destructive testing work during the thick-walled pipe cladding operation of CLADDING-Technology-Shanxi-Co.,-Ltd, to ensure that the cladding layer quality meets the design requirements and relevant standards and specifications, and to provide reliable quality assurance for precision cladding services such as flange cladding, pipe fitting cladding, steel pipe cladding, and shaft sleeve cladding.

2. 适用范围 Scope of Application

本计划适用于公司采用 TIG 堆焊和 MIG 堆焊工艺进行厚壁管堆焊作业的全过程质量控制，包括但不限于以下产品：

- 法兰堆焊（Flange Cladding）
- 管件堆焊（Pipe Fitting Cladding）
- 钢管堆焊（Steel Pipe Cladding）
- 轴套管堆焊（Shaft Sleeve Cladding）
- 模具堆焊修复（Mold Cladding Repair）

This plan applies to the whole process quality control of thick-walled pipe cladding operations using TIG cladding and MIG cladding processes, including but not limited to the following products:



- Flange Cladding
- Pipe Fitting Cladding
- Steel Pipe Cladding
- Shaft Sleeve Cladding
- Mold Cladding Repair

3. 职责 Responsibilities

部门/岗位	Department/Position	职责	Responsibilities
质量管理部	Quality Management Department	负责本计划的编制、修订与解释；组织实施检验与试验工作；记录检验结果并出具检验报告	Responsible for the preparation, revision and interpretation of this plan; organize and implement inspection and testing work; record inspection results and issue inspection reports
生产部	Production Department	负责按工艺要求执行堆焊作业；配合检验人员进行过程检验；对不合格项进行整改	Responsible for executing cladding operations according to process requirements; cooperate with inspectors for process inspection; rectify non-conformities
技术部	Technical Department	负责制定堆焊工艺规程；确定工艺参数；提供技术支持	Responsible for developing cladding process specifications; determining process parameters; providing technical support
设备部	Equipment Department	负责焊接设备的维护保养；确保检测设备处于良好状态	Responsible for maintenance of welding equipment; ensuring testing equipment is in good condition



4. 管理内容与程序 Management Content and Procedures

4.1 检验与试验流程 Inspection and Test Procedure

4.1.1 焊前检验 Pre-weld Inspection

序号	No.	检验项目	Inspection Item	检验内容	Inspection Content	检验方法	Inspection Method	检验时机	Inspection Timing	合格标准	Acceptance Criteria	记录文件	Record Document
1	1	母材确认	Base Material Verification	核对 厚壁 管材质、 规格、 热处理状态	Verify material grade, specification and heat treatment status of thick-walled pipe	目 视 检 查 + 材 质 证 书 核 查	Visual inspection + Material certificate verification	焊 前	Pre-weld	材质 与设 计要 求一 致， 材质 证书 齐全	Material matches design requirements, material certificates complete	焊 前 检 验 记 录 表	Pre-weld Inspection Record
2	2	焊材确认	Welding Material Verification	核对 堆焊 焊丝/ 焊条 牌号、 规格、 批次、 有效期	Verify cladding wire/rod grade, specification, batch and validity period	目 视 检 查 + 焊 材 证 书 核 查	Visual inspection + Welding material certificate verification	焊 前	Pre-weld	焊材 牌号 符合 工 艺 要 求， 在有效 期 内	Welding material grade meets process requirements, within validity period	焊 前 检 验 记 录 表	Pre-weld Inspection Record
3	3	坡口检查	Groove Inspection	检查 坡口 形	Check groove form,	量 具 测	Measuring tool + Visual	焊 前	Pre-weld	坡口 尺寸 符合	Groove dimensions meet	焊 前 检	Pre-weld Inspection



		查		式、尺寸、表面质量	dimensions and surface quality	量 + 目视检查	inspection			工艺规程要求, 表面无油污、锈蚀	process specification requirements, surface free from oil and rust	验记录表	ion Record
4	4	设备状态确认	Equipment Status Verification	检查 TIG/MIG 焊机参数设定、气体流量、导电嘴状态	Check TIG/MIG welder parameter settings, gas flow rate, contact tip condition	目视检查 + 参数核对	Visual inspection + Parameter verification	焊前	Pre-weld	设备运行正常, 参数设定正确	Equipment operating normally, parameters set correctly	设备点检记录	Equipment Inspection Record
5	5	预热检查	Preheating Check	检查预热温度、预热范围、保温措施	Check preheating temperature, preheating range and insulation measures	测温仪测量	Temperature measurement	焊前	Pre-weld	预热温度符合工艺要求 (一般 $\geq 150^{\circ}\text{C}$)	Preheating temperature meets process requirements (generally $\geq 150^{\circ}\text{C}$)	预热记录表	Preheating Record

4.1.2 焊中检验 In-process Inspection

序号	No.	检验	Inspection Item	检验	Inspection	检验	Inspection Method	检验	Inspection	合格	Acceptance	记录	Record Document
----	-----	----	-----------------	----	------------	----	-------------------	----	------------	----	------------	----	-----------------



号		项目		内容	Content	方法		时机	Timing	标准	Criteria	文件	nt
1	1	焊接参数监控	Welding Parameter Monitoring	监控电流、电压、焊接速度、气体流量	Monitor current, voltage, welding speed, gas flow rate	设备参数读取+记录	Equipment parameter reading + recording	每层每道	Each layer each pass	参数符合工艺规程要求	Parameters meet process specification requirements	焊接参数记录表	Welding Parameter Record
2	2	层间温度控制	Interpass Temperature Control	测量层间温度，确保不超过规定值	Measure interpass temperature, ensure it does not exceed specified value	测温仪测量	Temperature measurement	每层焊接前	Before each layer welding	层间温度≤工艺规定值（一般≤250℃）	Interpass temperature ≤ process specified value (generally ≤250℃)	层间温度记录表	Interpass Temperature Record
3	3	层间	Interpass	检查	Check interpass	目视	Visual inspection	每层	Before each	层间表面	Interpass surface	层间	Interpass



		清理检查	Cleaning Check	层间焊渣、飞溅清除情况	slag and spatter removal	检查		焊接前	layer welding	清洁，无焊渣、飞溅、氧化皮	clean, free from slag, spatter, scale	检验记录表	Inspection Record
4	4	稀释率检测	Dilution Rate Detection	检测每层堆焊的稀释率，确保符合设计要求	Detect dilution rate of each cladding layer, ensure it meets design requirements	金相分析 / 光谱分析	Metallographic analysis / Spectral analysis	每层完成后	After each layer	稀释率≤设计要求值（TIG堆焊一般≤15%，MIG堆焊一般≤25%）	Dilution rate ≤ design required value (TIG cladding generally ≤15%, MIG cladding generally ≤25%)	稀释率检测报告	Dilution Rate Test Report
5	5	焊缝外观检查	Weld Appearance Inspection	检查焊缝成型、	Check weld formation, reinforcement height,	目视检查 + 焊缝	Visual inspection + Weld gauge	每层完成后	After each layer	焊缝成型良好，无超标缺	Weld formation good, no excessive defects	焊缝外观检验记	Weld Appearance Inspection Record



				余高、宽度、咬边、气孔等	width, undercut, porosity	量规				陷		录	
6	6	多层多道顺序检查	Multi-layer Multi-pass Sequence Check	检查焊接顺序、道数、层数是否符合工艺要求	Check welding sequence, number of passes and layers meet process requirements	目视检查 + 计数	Visual inspection + Counting	每层每道	Each layer each pass	焊接顺序正确，层数道数符合工艺规程	Welding sequence correct, number of layers and passes meet process specification	焊接过程记录表	Welding Process Record

4.1.3 焊后检验 Post-weld Inspection

序	N	检	Inspection	检	Inspection	检	Inspection	检	Inspection	合	Acceptance	记	Record Document
---	---	---	------------	---	------------	---	------------	---	------------	---	------------	---	-----------------



号	o.	验项目	n Item	验内容	Content	验方法	Method	验时机	Timing	格标准	Criteria	录文件	t
1	1	焊后热处理	Post-weld Heat Treatment	检查热处理温度、保温时间、升降温速率	Check heat treatment temperature, holding time, heating and cooling rate	测温仪 + 记录仪	Temperature measurement + Recorder	堆焊完成后	After cladding	热处理参数符合工艺要求	Heat treatment parameters meet process requirements	热处理记录表	Heat Treatment Record
2	2	最终外观检查	Final Appearance Inspection	检查堆焊层表面质量、尺寸精度	Check cladding layer surface quality, dimensional accuracy	目视检查 + 量具测量	Visual inspection + Measuring tool	热处理后	After heat treatment	表面平整，尺寸符合图纸要求	Surface smooth, dimensions meet drawing requirements	成品检验记录表	Final Inspection Record
3	3	射	Radiogra	检	Detect	R	RT	热	After	按	Evaluate	R	RT Test



		射线检测 RT	射线检测 RT	检测堆焊层内部缺陷（气孔、夹渣、未熔合等）	检测堆焊层内部缺陷（气孔、夹渣、未熔合等）	UT检测	UT检测	UT检测	UT检测	UT检测	UT检测	UT检测	UT检测
4	4	超声波检测 UT	超声波检测 UT	检测堆焊层与母材结合面及堆焊层内部	Detect defects at cladding layer-base material interface and within cladding layer	UT检测	UT检测	UT检测	UT检测	UT检测	UT检测	UT检测	UT检测



				缺陷									
5	5	磁粉检测 MT	Magnetic Particle Testing	检测堆焊层表面及近表面缺陷	Detect surface and near-surface defects in cladding layer	MT 检测	MT Testing	热处理后	After heat treatment	按 NB/T 47013 标准评定，无超标缺陷	Evaluated per NB/T 47013 standard, no excessive defects	MT 检测报告	MT Test Report
6	6	渗透检测 PT	Penetrant Testing	检测堆焊层表面开口缺陷	Detect surface opening defects in cladding layer	PT 检测	PT Testing	热处理后	After heat treatment	按 NB/T 47013 标准评定，无超标缺陷	Evaluated per NB/T 47013 standard, no excessive defects	PT 检测报告	PT Test Report
7	7	硬度检测	Hardness Testing	检测堆焊层	Detect hardness distribution in cladding	硬度计测量	Hardness tester measurement	热处理后	After heat treatment	硬度值符合	Hardness value meets design requirements	硬度检测报告	Hardness Test Report



				及过渡区硬度分布	g layer and transition zone					设计要求		告	
8	8	化学成分分析	Chemical Composition Analysis	检测堆焊层化学成分	Detect chemical composition of cladding layer	光谱分析	Spectral analysis	热处理后	After heat treatment	化学成分符合焊材标准要求	Chemical composition meets welding material standard requirements	化学成分分析报告	Chemical Composition Analysis Report
9	9	金相组织检查	Metallographic Structure Inspection	检查堆焊层组织、稀释率、结合面质	Check cladding layer structure, dilution rate, interface quality	金相显微镜	Metallographic microscope	热处理后	After heat treatment	组织均匀，稀释率符合要求，结合面良	Structure uniform, dilution rate meets requirements, interface good	金相检验报告	Metallographic Inspection Report



				量					好			
--	--	--	--	---	--	--	--	--	---	--	--	--

4.2 多层多道堆焊控制要求 Multi-layer Multi-pass Cladding Control Requirements

4.2.1 TIG 堆焊多层多道控制 TIG Cladding Multi-layer Multi-pass Control

控制项目	Control Item	技术要求	Technical Requirements
焊接电流	Welding Current	根据管径和壁厚确定， 一般 80-160A	Determined by pipe diameter and wall thickness, generally 80-160A
焊接电压	Welding Voltage	一般 18-24V	Generally 18-24V
焊接速度	Welding Speed	根据稀释率要求控制， 一般 100-200mm/min	Controlled according to dilution rate requirements, generally 100-200mm/min
保护气体流量	Shielding Gas Flow Rate	氩气流量 10-15L/min	Argon flow rate 10-15L/min
道间清理	Interpass Cleaning	每道焊接后清除焊渣和飞溅	Clean slag and spatter after each pass
层间温度	Interpass Temperature	控制在 150-250℃范围内	Controlled within 150-250℃ range
稀释率控制	Dilution Rate Control	每层稀释率≤15%	Dilution rate per layer ≤15%

4.2.2 MIG 堆焊多层多道控制 MIG Cladding Multi-layer Multi-pass Control

控制项目	Control Item	技术要求	Technical Requirements
焊接电流	Welding Current	根据管径和壁厚确定， 一般 180-300A	Determined by pipe diameter and wall thickness, generally 180-300A



焊接电压	Welding Voltage	一般 24-32V	Generally 24-32V
焊接速度	Welding Speed	根据熔敷效率控制，一般 200-400mm/min	Controlled according to deposition efficiency, generally 200-400mm/min
保护气体流量	Shielding Gas Flow Rate	氩气或混合气体流量 15-20L/min	Argon or mixed gas flow rate 15-20L/min
道间清理	Interpass Cleaning	每道焊接后清除焊渣和飞溅	Clean slag and spatter after each pass
层间温度	Interpass Temperature	控制在 150-250℃范围内	Controlled within 150-250℃ range
稀释率控制	Dilution Rate Control	每层稀释率≤25%	Dilution rate per layer ≤25%

4.3 稀释率检测方法 Dilution Rate Detection Methods

4.3.1 金相法检测 Metallographic Method

1. 在堆焊完成后，从堆焊层截取金相试样
2. 试样经打磨、抛光、腐蚀后，在金相显微镜下观察
3. 测量堆焊层与母材熔合线处的稀释深度
4. 计算稀释率：稀释率 = 母材熔入量 / (母材熔入量 + 堆焊材料量) × 100%

4.3.2 光谱分析法检测 Spectral Analysis Method

5. 对堆焊层进行逐层光谱分析
6. 通过母材元素含量的变化判断稀释率
7. 建立稀释率与元素含量的对应关系
8. 计算实际稀释率并与设计要求对比

4.4 无损检测要求 Non-destructive Testing Requirements

4.4.1 检测时机 Detection Timing

检测类型	Testing Type	检测时机	Detection Timing	检测比例	Testing Ratio
------	--------------	------	------------------	------	---------------



外观检查	Visual Inspection	每层完成后	After each layer	100%	100%
射线检测 RT	Radiographic Testing	热处理后	After heat treatment	按设计要求	As per design requirements
超声波检测 UT	Ultrasonic Testing	热处理后	After heat treatment	100%	100%
磁粉检测 MT	Magnetic Particle Testing	热处理后	After heat treatment	100%	100%
渗透检测 PT	Penetrant Testing	热处理后	After heat treatment	100%	100%

4.4.2 合格标准 Acceptance Criteria

缺陷类型	Defect Type	合格标准	Acceptance Criteria
气孔	Porosity	单个气孔直径 ≤1.5mm, 密集气孔面 积≤5%	Single pore diameter ≤1.5mm, dense porosity area ≤5%
夹渣	Slag Inclusion	长度≤5mm, 深度 ≤1mm	Length ≤5mm, depth ≤1mm
未熔合	Lack of Fusion	不允许	Not allowed
裂纹	Crack	不允许	Not allowed
咬边	Undercut	深度≤0.5mm	Depth ≤0.5mm

5. 监督考核 Supervision and Assessment

5.1 检验记录管理 Inspection Record Management

- 所有检验与试验记录必须真实、完整、及时填写
- 检验记录由检验人员签字确认, 质量管理人员审核
- 检验记录保存期限不少于产品使用寿命期
- 检验记录应包含: 检验日期、检验人员、检验项目、检验结果、判定结论



5.2 不合格品控制 Non-conforming Product Control

- 发现不合格项时，立即停止相关作业
- 填写不合格品报告，描述不合格情况
- 由技术部门制定返修方案
- 返修后重新进行相关检验
- 不合格品处理过程全程记录

5.3 考核指标 Assessment Indicators

考核项目	Assessment Item	目标值	Target Value	考核周期	Assessment Period
一次检验合格率	First-time Inspection Pass Rate	≥95%	≥95%	月度	Monthly
稀释率控制合格率	Dilution Rate Control Pass Rate	≥98%	≥98%	月度	Monthly
无损检测合格率	NDT Pass Rate	≥95%	≥95%	月度	Monthly
检验记录完整率	Inspection Record Completeness Rate	100%	100%	月度	Monthly

6. 附则 Supplementary Provisions

6.1 相关文件 Related Documents

- CLADDING-ITP-001 质量管理体系文件控制程序
- CLADDING-ITP-002 焊接工艺规程管理程序
- CLADDING-ITP-003 无损检测管理程序
- CLADDING-ITP-004 不合格品控制程序
- CLADDING-ITP-005 检验记录管理程序



6.2 参考标准 Reference Standards

- GB/T 19418 焊接 钢、镍及镍合金的焊接工艺评定试验
- NB/T 47013 承压设备无损检测
- NB/T 47014 承压设备焊接工艺评定
- JB/T 4730 承压设备无损检测
- ASME Section IX 焊接和 brazing 资格评定

6.3 文件修订记录 Revision History

版本号	Version	修订日期	Revision Date	修订内容	Revision Content	修订人	Revised By
A/0	A/0	2025-01-01	2025-01-01	首次发布	Initial Release	质量管理部	Quality Management Department

编制：_____ 日期：_____

Prepared By: _____ Date: _____

审核：_____ 日期：_____

Reviewed By: _____ Date: _____

批准：_____ 日期：_____

Approved By: _____ Date: _____

科雷丁技术（山西）有限公司

Cladding-Technology-Shanxi-Co.,-Ltd

CLADDING-ITP-019