



Cladding-Technology-Shanxi-Co.,-Ltd- CLADDING-ITP-024-Cladding-First- Article-Inspection-ITP

新产品/新工艺首件鉴定检验与试验计划

Inspection and Test Plan for First Article Verification of New Products/Processes

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| 批准 Approved by | 总经理 General Manager |

1. 目的 Purpose

本文件规定了科雷丁技术（山西）有限公司在新产品试制或新工艺应用阶段，对首件产品进行系统性检验与试验的程序和要求。通过建立标准化的首件鉴定流程，确保增材制造、



TIG/MIG 精密堆焊等工艺在正式批量生产前达到设计要求和质量标准，降低量产风险，验证工艺参数的稳定性和产品性能的一致性。

This document specifies the procedures and requirements for systematic inspection and testing of first article products during new product trial production or new process application at Cladding-Technology-Shanxi-Co.,-Ltd. By establishing a standardized first article verification process, this plan ensures that additive manufacturing, TIG/MIG precision cladding and other processes meet design requirements and quality standards before formal mass production, reduces production risks, and verifies the stability of process parameters and consistency of product performance.

2. 适用范围 Scope

本计划适用于以下情形：

- 全新产品首次试制，包括法兰堆焊、管件堆焊、钢管堆焊、轴套管堆焊、模具堆焊修复等新产品
- 现有产品采用新工艺或新材料进行制造，如 TIG 堆焊工艺替代传统焊接、MIG 堆焊工艺参数重大调整、新型合金材料应用等
- 增材制造技术应用于新产品开发，包括电弧增材制造近净成形、梯度材料制备等
- 关键工艺参数变更后的验证，如堆焊稀释率调整、熔敷速率变化、层间温度控制优化等
- 设备升级或更换后的首件验证

This plan applies to the following situations:

- First trial production of entirely new products, including flange cladding, pipe fitting cladding, steel pipe cladding, shaft sleeve cladding, mold cladding repair and other new products
- Existing products manufactured using new processes or new materials, such as TIG cladding process replacing traditional welding, major adjustments to MIG cladding process parameters, application of new alloy materials, etc.
- Application of additive manufacturing technology in new product development, including arc additive manufacturing near-net-shape forming, gradient material preparation, etc.
- Verification after changes to critical process parameters, such as cladding dilution rate adjustment, deposition rate changes, interlayer temperature control optimization, etc.
- First article verification after equipment upgrade or replacement

3. 职责 Responsibilities

3.1 技术部 Technical Department

- 编制首件鉴定技术方案，确定检验项目、检验方法和验收标准
- 制定工艺参数卡片，明确 TIG/MIG 堆焊、增材制造的关键工艺参数



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- 组织首件试制，记录工艺参数和产品状态
 - 编制首件鉴定报告，分析检验结果
 - Prepare first article verification technical plan, determine inspection items, inspection methods and acceptance criteria
 - Develop process parameter cards, specifying key process parameters for TIG/MIG cladding and additive manufacturing
 - Organize first article trial production, record process parameters and product status
 - Prepare first article verification report, analyze inspection results

3.2 质量部 Quality Department

- 审核首件鉴定方案，确保检验项目完整、标准明确
- 执行或监督检验与试验工作
- 记录检验数据，出具检验报告
- 判定首件鉴定结论，提出改进建议
- Review first article verification plan, ensure completeness of inspection items and clarity of standards
- Execute or supervise inspection and testing work
- Record inspection data, issue inspection reports
- Determine first article verification conclusion, propose improvement suggestions

3.3 生产部 Production Department

- 按工艺文件要求执行首件试制
- 配合技术部进行工艺参数调整
- 提供生产过程中的异常信息
- Execute first article trial production according to process document requirements
- Cooperate with Technical Department for process parameter adjustments
- Provide abnormal information during production process

3.4 总经理 General Manager

- 批准首件鉴定方案
- 批准首件鉴定结论
- 决策是否进入批量生产
- Approve first article verification plan
- Approve first article verification conclusion
- Decide whether to proceed to mass production



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

4.1 首件鉴定启动条件 Initiation Conditions

满足以下条件之一时，应启动首件鉴定程序：

- 新产品设计图纸和技术要求已冻结，进入试制阶段
- 新工艺方案已通过技术评审，具备试制条件
- 关键工艺参数发生变更，需验证变更效果
- 设备或工装发生重大变更，需验证设备能力

The first article verification procedure shall be initiated when any of the following conditions are met:

- New product design drawings and technical requirements have been frozen and entered the trial production stage
- New process plan has passed technical review and is ready for trial production
- Critical process parameters have been changed and need to verify the effect of changes
- Equipment or tooling has undergone major changes and needs to verify equipment capability

4.2 首件鉴定流程 First Article Verification Process

4.2.1 方案编制 Plan Preparation

技术部根据产品图纸、技术要求和工艺方案，编制首件鉴定方案，内容包括：

- 产品基本信息：产品名称、规格型号、材料牌号、数量
- 工艺路线：增材制造、TIG 堆焊、MIG 堆焊等工艺顺序
- 检验项目清单：尺寸检验、外观检验、无损检测、力学性能试验、化学成分分析等
- 检验方法和标准：引用国标、行标或企业标准
- 检验时机：首件检验、过程检验、最终检验
- 检验设备：测量工具、检测设备、试验仪器

The Technical Department shall prepare the first article verification plan based on product drawings, technical requirements and process plan, including:

- Product basic information: product name, specification model, material grade, quantity
- Process route: additive manufacturing, TIG cladding, MIG cladding and other process sequence
- Inspection item list: dimensional inspection, visual inspection, non-destructive testing, mechanical property test, chemical composition analysis, etc.
- Inspection methods and standards: reference national standards, industry standards or enterprise standards
- Inspection timing: first article inspection, process inspection, final inspection
- Inspection equipment: measuring tools, testing equipment, test instruments



4.2.2 工艺参数确认 Process Parameter Confirmation

首件试制前，技术部应确认以下关键工艺参数：

TIG 堆焊工艺参数 TIG Cladding Process Parameters

参数项目 Parameter Item	参数范围 Parameter Range	备注 Remarks
焊接电流 Welding Current	根据基材和堆焊材料确定	影响稀释率和熔深
焊接电压 Welding Voltage	根据电流匹配设定	影响焊缝成形
焊接速度 Welding Speed	根据熔敷效率确定	影响生产效率和稀释率
保护气体流量 Gas Flow Rate	8-15 L/min	氩气纯度≥99.99%
钨极直径 Tungsten Electrode Diameter	2.4-4.0 mm	根据电流选择
层间温度 Interpass Temperature	≤150℃	防止过热影响性能
Parameter Item	Parameter Range	Remarks
Welding Current	Determined by base material and cladding material	Affects dilution rate and penetration depth
Welding Voltage	Set according to current matching	Affects weld formation
Welding Speed	Determined by deposition efficiency	Affects production efficiency and dilution rate
Gas Flow Rate	8-15 L/min	Argon purity ≥99.99%
Tungsten Electrode Diameter	2.4-4.0 mm	Selected according to current
Interpass Temperature	≤150℃	Prevent overheating affecting performance

MIG 堆焊工艺参数 MIG Cladding Process Parameters

参数项目 Parameter Item	参数范围 Parameter Range	备注 Remarks
焊接电流 Welding Current	根据熔敷效率确定	影响生产效率和稀释率
焊接电压 Welding Voltage	根据电流匹配设定	影响电弧稳定性
送丝速度 Wire Feed Speed	根据电流匹配设定	影响熔敷量
保护气体流量 Gas Flow Rate	15-25 L/min	根据工艺要求选择
干伸长 Dry Extension	10-15 mm	影响电弧稳定性
摆动参数 Oscillation Parameters	根据焊缝宽度确定	影响焊缝成形
Parameter Item	Parameter Range	Remarks
Welding Current	Determined by deposition efficiency	Affects production efficiency and dilution rate
Welding Voltage	Set according to current matching	Affects arc stability



Wire Feed Speed	Set according to current matching	Affects deposition amount
Gas Flow Rate	15-25 L/min	Selected according to process requirements
Dry Extension	10-15 mm	Affects arc stability
Oscillation Parameters	Determined by weld width	Affects weld formation

增材制造工艺参数 Additive Manufacturing Process Parameters

参数项目 Parameter Item	参数范围 Parameter Range	备注 Remarks
单层厚度 Layer Thickness	1.5-3.0 mm	根据产品精度要求确定
道间距 Track Spacing	根据焊丝直径确定	影响层间结合
扫描策略 Scanning Strategy	根据产品形状确定	影响残余应力
预热温度 Preheating Temperature	根据材料确定	防止裂纹产生
后热处理 Post Heat Treatment	根据材料确定	消除残余应力
Parameter Item	Parameter Range	Remarks
Layer Thickness	1.5-3.0 mm	Determined by product accuracy requirements
Track Spacing	Determined by wire diameter	Affects interlayer bonding
Scanning Strategy	Determined by product shape	Affects residual stress
Preheating Temperature	Determined by material	Prevent crack formation
Post Heat Treatment	Determined by material	Eliminate residual stress

4.2.3 首件试制 First Article Trial Production

生产部按确认的工艺参数执行首件试制，技术部全程跟踪记录：

- 记录实际工艺参数与设定值的偏差
- 记录生产过程中的异常情况
- 记录环境条件（温度、湿度）
- 记录操作人员信息

The Production Department shall execute first article trial production according to confirmed process parameters, and the Technical Department shall track and record throughout the process:

- Record deviations between actual process parameters and set values
- Record abnormal situations during production
- Record environmental conditions (temperature, humidity)
- Record operator information

4.2.4 检验与试验 Inspection and Testing

首件鉴定检验与试验项目如下：

4.2.4.1 尺寸检验 Dimensional Inspection



| 检验项目 Inspection Item | 检验方法 Inspection Method | 检验标准 Inspection Standard | 检验时机 Inspection Timing |

| 堆焊层厚度 Cladding Layer Thickness | 超声波测厚仪 Ultrasonic Thickness Gauge | 图纸要求 $\pm 0.5\text{mm}$ | 过程检验 Process Inspection |

| 堆焊层宽度 Cladding Layer Width | 卡尺/千分尺 Caliper/Micrometer | 图纸要求 $\pm 0.3\text{mm}$ | 过程检验 Process Inspection |

| 产品外径/内径 Outer/Inner Diameter | 卡尺/千分尺 Caliper/Micrometer | 图纸要求 | 最终检验 Final Inspection |

| 产品长度 Product Length | 卡尺/卷尺 Caliper/Tape Measure | 图纸要求 | 最终检验 Final Inspection |

| 圆度/直线度 Roundness/Straightness | 三坐标测量机 CMM | 图纸要求 | 最终检验 Final Inspection |

| 堆焊层表面粗糙度 Surface Roughness | 粗糙度仪 Roughness Tester | $Ra \leq 6.3\mu\text{m}$ | 最终检验 Final Inspection |

| Inspection Item | Inspection Method | Inspection Standard | Inspection Timing |

| Cladding Layer Thickness | Ultrasonic Thickness Gauge | Drawing requirements $\pm 0.5\text{mm}$ | Process Inspection |

| Cladding Layer Width | Caliper/Micrometer | Drawing requirements $\pm 0.3\text{mm}$ | Process Inspection |

| Outer/Inner Diameter | Caliper/Micrometer | Drawing requirements | Final Inspection |

| Product Length | Caliper/Tape Measure | Drawing requirements | Final Inspection |

| Roundness/Straightness | CMM | Drawing requirements | Final Inspection |

| Surface Roughness | Roughness Tester | $Ra \leq 6.3\mu\text{m}$ | Final Inspection |

4.2.4.2 外观检验 Visual Inspection

| 检验项目 Inspection Item | 检验方法 Inspection Method | 验收标准 Acceptance Criteria |

| 焊缝成形 Weld Formation | 目视检查 Visual Inspection | 焊缝均匀，无咬边、未熔合 |

| 表面缺陷 Surface Defects | 目视检查 Visual Inspection | 无裂纹、气孔、夹渣 |

| 飞溅 Spatter | 目视检查 Visual Inspection | 飞溅量 $\leq 5\%$ |

| 颜色 Color | 目视检查 Visual Inspection | 无过热变色 |

| 增材层间结合 Interlayer Bonding | 目视检查 Visual Inspection | 层间结合良好，无分层 |

| Inspection Item | Inspection Method | Acceptance Criteria |

| Weld Formation | Visual Inspection | Uniform weld, no undercut or lack of fusion |



Surface Defects	Visual Inspection	No cracks, porosity, inclusions
Spatter	Visual Inspection	Spatter $\leq 5\%$
Color	Visual Inspection	No overheating discoloration
Interlayer Bonding	Visual Inspection	Good interlayer bonding, no delamination

4.2.4.3 无损检测 Non-Destructive Testing

| 检验项目 Inspection Item | 检测方法 Testing Method | 验收标准 Acceptance Criteria | 适用产品 Applicable Products |

| 表面裂纹检测 Surface Crack Detection | 渗透检测 PT | 无裂纹 | 所有堆焊产品 All Cladding Products |

| 近表面缺陷检测 Near-Surface Defect Detection | 磁粉检测 MT | 无裂纹、未熔合 | 铁磁性材料 Ferromagnetic Materials |

| 内部缺陷检测 Internal Defect Detection | 超声波检测 UT | 无超标缺陷 | 厚壁产品 Thick-walled Products |

| 内部缺陷检测 Internal Defect Detection | 射线检测 RT | 无超标缺陷 | 关键产品 Critical Products |

| Inspection Item | Testing Method | Acceptance Criteria | Applicable Products |

| Surface Crack Detection | PT | No cracks | All Cladding Products |

| Near-Surface Defect Detection | MT | No cracks, lack of fusion | Ferromagnetic Materials |

| Internal Defect Detection | UT | No excessive defects | Thick-walled Products |

| Internal Defect Detection | RT | No excessive defects | Critical Products |

4.2.4.4 力学性能试验 Mechanical Property Testing

| 试验项目 Test Item | 试验方法 Testing Method | 验收标准 Acceptance Criteria | 取样位置 Sampling Location |

| 拉伸试验 Tensile Test | GB/T 228.1 | 抗拉强度 $\geq$ 母材标准值 | 堆焊层与母材结合区 |

| 弯曲试验 Bend Test | GB/T 2653 | 弯曲 180°无裂纹 | 堆焊层 |

| 冲击试验 Impact Test | GB/T 229 | 冲击功 $\geq$ 规定值 | 堆焊层与母材结合区 |

| 硬度试验 Hardness Test | GB/T 230.1 | 硬度值符合技术要求 | 堆焊层、热影响区、母材 |

| Test Item | Testing Method | Acceptance Criteria | Sampling Location |

| Tensile Test | GB/T 228.1 | Tensile strength $\geq$ base material standard value | Cladding layer and base material bonding zone |

| Bend Test | GB/T 2653 | Bend 180° without cracks | Cladding layer |

| Impact Test | GB/T 229 | Impact energy $\geq$ specified value | Cladding layer and base material bonding zone |



| Hardness Test | GB/T 230.1 | Hardness value meets technical requirements | Cladding layer, HAZ, base material |

4.2.4.5 化学成分分析 Chemical Composition Analysis

| 分析项目 Analysis Item | 分析方法 Analysis Method | 验收标准 Acceptance Criteria |
| 堆焊层化学成分 Cladding Layer Composition | 光谱分析 Spectral Analysis | 符合材料标准要求 |

| 稀释率 Dilution Rate | 金相分析 Metallographic Analysis | ≤设计要求 |

| 元素分布 Element Distribution | EPMA | 梯度材料符合设计要求 |

| Analysis Item | Analysis Method | Acceptance Criteria |

| Cladding Layer Composition | Spectral Analysis | Meets material standard requirements |

| Dilution Rate | Metallographic Analysis | ≤ design requirements |

| Element Distribution | EPMA | Gradient material meets design requirements |

4.2.4.6 金相检验 Metallographic Inspection

| 检验项目 Inspection Item | 检验方法 Inspection Method | 验收标准 Acceptance Criteria |

| 堆焊层组织 Microstructure | 光学显微镜 Optical Microscope | 组织均匀，无异常组织 |

| 稀释率 Dilution Rate | 光学显微镜 Optical Microscope | ≤设计要求 |

| 层间结合 Interlayer Bonding | 光学显微镜 Optical Microscope | 结合良好，无缺陷 |

| 晶粒度 Grain Size | 光学显微镜 Optical Microscope | 符合标准要求 |

| Inspection Item | Inspection Method | Acceptance Criteria |

| Microstructure | Optical Microscope | Uniform structure, no abnormal structure |

| Dilution Rate | Optical Microscope | ≤ design requirements |

| Interlayer Bonding | Optical Microscope | Good bonding, no defects |

| Grain Size | Optical Microscope | Meets standard requirements |

4.2.5 检验结果评定 Inspection Result Evaluation

质量部根据检验结果进行综合评定：

- 所有检验项目合格，判定首件鉴定通过
- 部分检验项目不合格，分析原因，采取纠正措施后重新检验
- 关键项目不合格，判定首件鉴定不通过，需重新试制

The Quality Department shall comprehensively evaluate based on inspection results:

- All inspection items qualified, first article verification passed
- Some inspection items unqualified, analyze causes, take corrective actions and re-inspect
- Critical items unqualified, first article verification failed, need to re-trial



4.2.6 首件鉴定报告 First Article Verification Report

首件鉴定完成后，技术部编制首件鉴定报告，内容包括：

- 产品基本信息
- 工艺参数记录
- 检验与试验结果汇总
- 不合格项及处理情况
- 鉴定结论
- 改进建议

After first article verification is completed, the Technical Department shall prepare the first article verification report, including:

- Product basic information
- Process parameter records
- Summary of inspection and testing results
- Non-conformities and handling status
- Verification conclusion
- Improvement suggestions

4.3 首件鉴定记录 First Article Verification Records

首件鉴定过程中应保存以下记录：

- 首件鉴定方案
- 工艺参数记录表
- 检验与试验记录
- 不合格项处理记录
- 首件鉴定报告
- 首件产品照片

The following records shall be maintained during first article verification:

- First article verification plan
- Process parameter record sheet
- Inspection and testing records
- Non-conformity handling records
- First article verification report
- First article product photos

4.4 首件产品处置 Disposal of First Article Products

首件产品经鉴定后，按以下方式处置：



- 鉴定通过且客户要求的，交付客户
- 鉴定通过但客户未要求的，作为留样保存
- 鉴定不通过的，报废处理或返工后重新鉴定

After first article verification, the first article products shall be disposed as follows:

- Passed verification and required by customer, deliver to customer
- Passed verification but not required by customer, keep as sample
- Failed verification, scrap or rework and re-verify

5. 监督考核 Supervision and Assessment

5.1 监督检查 Supervision and Inspection

质量部每月对首件鉴定执行情况进行监督检查，检查内容包括：

- 首件鉴定方案是否完整
- 检验项目是否齐全
- 检验记录是否规范
- 不合格项处理是否及时

The Quality Department shall conduct monthly supervision and inspection of first article verification implementation, including:

- Whether first article verification plan is complete
- Whether inspection items are complete
- Whether inspection records are standardized
- Whether non-conformity handling is timely

5.2 考核评价 Assessment and Evaluation

- 首件鉴定及时率纳入部门绩效考核
- 首件鉴定一次通过率纳入技术部绩效考核
- 检验记录完整性纳入质量部绩效考核
- First article verification timeliness rate included in department performance assessment
- First article verification first-pass rate included in Technical Department performance assessment
- Inspection record completeness included in Quality Department performance assessment

6. 附则 Supplementary Provisions

6.1 相关文件 Related Documents

- 工艺文件管理制度



- 检验与试验控制程序
- 不合格品控制程序
- 记录控制程序
- Process Document Management
- Inspection and Testing Control Procedure
- Non-conforming Product Control Procedure
- Record Control Procedure

6.2 相关记录 Related Records

- 首件鉴定方案
- 工艺参数记录表
- 检验与试验记录表
- 首件鉴定报告
- First Article Verification Plan
- Process Parameter Record Sheet
- Inspection and Testing Record Sheet
- First Article Verification Report

6.3 修订记录 Revision History

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文件结束 End of Document