



Cladding-Technology-Shanxi-Co.,-Ltd- CLADDING-ITP-025-Cladding-In- Process-Patrol-Inspection-ITP

科雷丁技术（山西）有限公司

Cladding-Technology-Shanxi-Co.,-Ltd

文件编号 / Document No. : CLADDING-ITP-025

文件名称 / Document Title : 堆焊生产工序巡检程序 / In-Process
Inspection Procedure for Cladding Production

页眉 / Header

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右侧上部分 / Right Upper: 科雷丁技术（山西）有限公司

右侧下部分 / Right Lower: Cladding-Technology-Shanxi-Co.,-Ltd



1. 目的 / Purpose

本程序旨在规范科雷丁技术（山西）有限公司增材制造与精密堆焊生产过程中各工序的巡检管理，确保法兰堆焊、管件堆焊、钢管堆焊、轴套管堆焊、模具堆焊修复及电弧增材制造等产品质量符合技术标准和客户要求，实现过程质量的受控管理。

This procedure is designed to standardize the in-process inspection management of each operation in the additive manufacturing and precision cladding production of Cladding-Technology-Shanxi-Co.,-Ltd, ensuring that the quality of flange cladding, pipe fitting cladding, steel pipe cladding, shaft sleeve cladding, mold cladding repair, and arc additive manufacturing products meets technical standards and customer requirements, achieving controlled management of process quality.

2. 适用范围 / Scope

本程序适用于公司所有堆焊及增材制造产品的生产工序巡检，包括但不限于以下业务范围：

This procedure applies to the in-process inspection of all cladding and additive manufacturing product production operations, including but not limited to the following business scopes:

- 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
- TIG 精密堆焊 / TIG precision cladding
- MIG 高效堆焊 / MIG high-efficiency cladding
- 电弧增材制造 / Arc additive manufacturing
- 梯度材料制备 / Gradient material preparation

3. 职责 / Responsibilities

3.1 生产部 / Production Department

- 负责生产工序的规范操作，配合巡检工作 / Responsible for standardized operation of production processes and cooperation with inspection work
- 对巡检发现的问题及时整改 / Timely rectification of issues identified during inspection



- 填写工序流转卡，记录生产参数 / Fill in process transfer cards and record production parameters

3.2 质量部 / Quality Department

- 负责制定巡检计划，执行工序巡检 / Responsible for developing inspection plans and executing process inspection
- 负责巡检记录的填写与归档 / Responsible for filling in and archiving inspection records
- 负责对不合格品进行标识、隔离和处置 / Responsible for identification, isolation, and disposal of non-conforming products
- 负责巡检结果的统计分析与反馈 / Responsible for statistical analysis and feedback of inspection results

3.3 技术部 / Technical Department

- 负责制定各工序工艺参数标准 / Responsible for developing process parameter standards for each operation
- 负责巡检判定标准的制定与修订 / Responsible for developing and revising inspection criteria
- 负责技术问题的分析与解决 / Responsible for analysis and resolution of technical issues

3.4 设备部 / Equipment Department

- 负责堆焊设备、增材制造设备的日常维护与校准 / Responsible for daily maintenance and calibration of cladding equipment and additive manufacturing equipment
- 配合巡检中对设备状态的检查 / Cooperate with equipment status inspection during inspection

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

4.1 工序巡检总体流程 / Overall Process Inspection Flow

序号 / No.	工序 / Operation	巡检项目 / Inspection Items	巡检频次 / Inspection Frequency	判定标准 / Acceptance Criteria
1	原材料检验 / Raw Material Inspection	焊丝牌号、规格、外观；母材材质证明	每批次 / Each batch	符合采购技术要求，材质证明齐全 / Meets procurement



				technical requirements, complete material certificates
2	焊前准备 / Pre-weld Preparation	坡口加工、表面清理、装配间隙	每件 / Each piece	坡口尺寸符合图纸要求，表面无油污、氧化皮 / Groove dimensions meet drawing requirements, surface free from oil, oxide scale
3	TIG 堆焊 / TIG Cladding	焊接电流、电压、焊接速度、稀释率	首件全检，后续每 2 小时巡检 / Full inspection of first piece, inspection every 2 hours thereafter	稀释率 $\leq 25\%$ ，焊缝成型良好，无缺陷 / Dilution rate $\leq 25\%$, good weld formation, no defects
4	MIG 堆焊 / MIG Cladding	焊接电流、电压、送丝速度、熔敷效率	首件全检，后续每 1 小时巡检 / Full inspection of first piece, inspection every 1 hour thereafter	熔敷效率达标，焊缝均匀，无未熔合 / Melting efficiency meets standard, uniform weld, no lack of fusion
5	层间温度控制 / Interpass Temperature Control	层间温度测量	每层堆焊前 / Before each cladding layer	符合工艺卡要求，一般 $\leq 150^{\circ}\text{C}$ / Meets process card requirements, generally $\leq 150^{\circ}\text{C}$
6	焊后外观检查 / Post-weld Visual Inspection	焊缝外观、尺寸、表面缺陷	每件 / Each piece	焊缝平整，无裂纹、气孔、夹渣，尺寸符合图纸 / Weld seam flat, no cracks, porosity, slag inclusion, dimensions meet



				drawing
7	无损检测 / Non-Destructive Testing	磁粉检测、渗透检测、超声波检测	按工艺要求 / As per process requirements	符合 NB/T 47013 标准要求 / Meets NB/T 47013 standard requirements
8	硬度检测 / Hardness Testing	堆焊层硬度、过渡区硬度	每件 / Each piece	符合技术协议要求 / Meets technical agreement requirements
9	尺寸检验 / Dimensional Inspection	堆焊层厚度、外径、长度	每件 / Each piece	符合图纸公差要求 / Meets drawing tolerance requirements
10	后处理 / Post-treatment	热处理参数、机加工精度	每批次 / Each batch	热处理曲线符合工艺要求，加工精度达标 / Heat treatment curve meets process requirements, machining accuracy meets standard

4.2 焊前准备工序巡检 / Pre-weld Preparation Inspection

4.2.1 坡口加工检查 / Groove Machining Inspection

巡检项目 / Inspection Items:

- 坡口角度 / Groove angle
- 坡口深度 / Groove depth
- 钝边尺寸 / Root face dimension
- 坡口表面粗糙度 / Groove surface roughness

巡检频次 / Inspection Frequency: 每件产品 / Each product

判定标准 / Acceptance Criteria:



产品类型 / Product Type	坡口角度 / Groove Angle	钝边 / Root Face	表面粗糙度 / Surface Roughness
法兰堆焊 / Flange Cladding	$30^{\circ}\pm 2^{\circ}$	1-2mm	$Ra\leq 6.3\mu m$
管件堆焊 / Pipe Fitting Cladding	$30^{\circ}\pm 2^{\circ}$	1-2mm	$Ra\leq 6.3\mu m$
钢管堆焊 / Steel Pipe Cladding	$30^{\circ}\pm 2^{\circ}$	1-2mm	$Ra\leq 6.3\mu m$
轴套管堆焊 / Shaft Sleeve Cladding	$30^{\circ}\pm 2^{\circ}$	1-2mm	$Ra\leq 6.3\mu m$
模具堆焊修复 / Mold Cladding Repair	根据修复方案 / As per repair plan	根据修复方案 / As per repair plan	$Ra\leq 6.3\mu m$

4.2.2 表面清理检查 / Surface Cleaning Inspection

巡检项目 / Inspection Items:

- 油污去除情况 / Oil removal status
- 氧化皮去除情况 / Oxide scale removal status
- 锈蚀情况 / Rust condition
- 清洁度验证 / Cleanliness verification

巡检频次 / Inspection Frequency: 每件产品 / Each product

判定标准 / Acceptance Criteria: 坡口及两侧各 20mm 范围内无油污、氧化皮、锈蚀，表面清洁度达到 Sa2.5 级 / No oil, oxide scale, or rust within 20mm on both sides of the groove, surface cleanliness reaches Sa2.5 level

4.2.3 装配检查 / Assembly Inspection

巡检项目 / Inspection Items:

- 装配间隙 / Assembly gap
- 错边量 / Misalignment
- 定位焊质量 / Tack weld quality

巡检频次 / Inspection Frequency: 每件产品 / Each product



判定标准 / Acceptance Criteria: 装配间隙符合工艺要求, 错边量 $\leq$ 壁厚的 10%且不大于 2mm, 定位焊无裂纹、气孔 / Assembly gap meets process requirements, misalignment $\leq 10\%$ of wall thickness and not greater than 2mm, tack weld free from cracks and porosity

4.3 TIG 精密堆焊工序巡检 / TIG Precision Cladding Inspection

4.3.1 焊接参数检查 / Welding Parameter Inspection

巡检项目 / Inspection Items:

参数 / Parameter	法兰堆焊 / Flange	管件堆焊 / Pipe Fitting	钢管堆焊 / Steel Pipe	轴套管堆焊 / Shaft Sleeve	模具修复 / Mold Repair
焊接电流 / Current (A)	80-120	100-140	120-160	80-110	60-100
焊接电压 / Voltage (V)	10-14	11-15	12-16	10-13	9-12
焊接速度 / Speed (mm/min)	80-150	100-180	120-200	60-120	50-100
氩气流量 / Ar Flow (L/min)	8-12	10-15	12-18	8-12	8-10

巡检频次 / Inspection Frequency: 首件全检, 后续每 2 小时巡检一次 / Full inspection of first piece, inspection every 2 hours thereafter

判定标准 / Acceptance Criteria: 焊接参数在工艺卡规定范围内, 偏差 $\leq\pm 5\%$ / Welding parameters within process card specified range, deviation $\leq\pm 5\%$

4.3.2 稀释率控制检查 / Dilution Rate Control Inspection

巡检项目 / Inspection Items:

- 稀释率测量 / Dilution rate measurement
- 熔深控制 / Penetration depth control

巡检频次 / Inspection Frequency: 每层堆焊完成后 / After of each cladding layer

判定标准 / Acceptance Criteria:

产品类型 / Product Type	稀释率要求 / Dilution Rate Requirement
耐腐蚀堆焊 / Corrosion-resistant Cladding	$\leq 20\%$



耐磨堆焊 / Wear-resistant Cladding	≤25%
模具修复堆焊 / Mold Repair Cladding	≤30%

4.3.3 焊缝成型检查 / Weld Formation Inspection

巡检项目 / Inspection Items:

- 焊缝宽度 / Weld width
- 焊缝高度 / Weld height
- 焊缝表面平整度 / Weld surface flatness
- 焊缝过渡圆滑度 / Weld transition smoothness

巡检频次 / Inspection Frequency: 每层堆焊完成后 / After of each cladding layer

判定标准 / Acceptance Criteria: 焊缝宽度均匀，高度符合工艺要求，表面平整，过渡圆滑，无咬边、未熔合、焊瘤 / Uniform weld width, height meets process requirements, flat surface, smooth transition, no undercut, lack of fusion, or weld overlap

4.4 MIG 高效堆焊工序巡检 / MIG High-Efficiency Cladding Inspection

4.4.1 焊接参数检查 / Welding Parameter Inspection

巡检项目 / Inspection Items:

参数 / Parameter	法兰堆焊 / Flange	管件堆焊 / Pipe Fitting	钢管堆焊 / Steel Pipe	轴套管堆焊 / Shaft Sleeve
焊接电流 / Current (A)	200-300	220-320	250-350	180-280
焊接电压 / Voltage (V)	22-28	24-30	26-32	20-26
送丝速度 / Wire Feed (m/min)	4-6	5-7	6-8	3-5
气体流量 / Gas Flow (L/min)	15-20	18-22	20-25	12-18

巡检频次 / Inspection Frequency: 首件全检，后续每 1 小时巡检一次 / Full inspection of first piece, inspection every 1 hour thereafter



判定标准 / Acceptance Criteria: 焊接参数在工艺卡规定范围内，偏差 $\leq\pm 5\%$ / Welding parameters within process card specified range, deviation $\leq\pm 5\%$

4.4.2 熔敷效率检查 / Deposition Efficiency Inspection

巡检项目 / Inspection Items:

- 熔敷速度 / Deposition rate
- 熔敷效率 / Deposition efficiency
- 材料利用率 / Material utilization

巡检频次 / Inspection Frequency: 每 2 小时巡检一次 / Inspection every 2 hours

判定标准 / Acceptance Criteria: 熔敷效率 $\geq 90\%$ ，材料利用率符合工艺要求 / Deposition efficiency $\geq 90\%$, material utilization meets process requirements

4.4.3 自动化堆焊检查 / Automated Cladding Inspection

巡检项目 / Inspection Items:

- 机器人轨迹精度 / Robot trajectory accuracy
- 焊枪姿态 / Torch orientation
- 跟踪精度 / Tracking accuracy

巡检频次 / Inspection Frequency: 每班巡检一次 / Inspection once per shift

判定标准 / Acceptance Criteria: 轨迹精度 $\leq\pm 0.5\text{mm}$ ，焊枪姿态符合工艺要求，跟踪精度 $\leq\pm 0.3\text{mm}$ / Trajectory accuracy $\leq\pm 0.5\text{mm}$, torch orientation meets process requirements, tracking accuracy $\leq\pm 0.3\text{mm}$

4.5 层间温度控制巡检 / Interpass Temperature Control Inspection

4.5.1 温度测量 / Temperature Measurement

巡检项目 / Inspection Items:

- 层间温度 / Interpass temperature
- 预热温度 / Preheating temperature
- 后热温度 / Post-heating temperature

巡检频次 / Inspection Frequency: 每层堆焊前测量 / Measurement before each cladding layer

判定标准 / Acceptance Criteria:

母材类型 / Base	预热温度 / Preheating	层间温度 / Interpass	后热温度 / Post-
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Material Type			heating
碳钢 / Carbon Steel	100-150°C	≤150°C	200-300°C
低合金钢 / Low Alloy Steel	150-200°C	≤200°C	250-350°C
不锈钢 / Stainless Steel	100-150°C	≤150°C	300-400°C

4.6 焊后外观检查巡检 / Post-weld Visual Inspection

4.6.1 外观缺陷检查 / Visual Defect Inspection

巡检项目 / Inspection Items:

- 裂纹 / Cracks
- 气孔 / Porosity
- 夹渣 / Slag inclusion
- 咬边 / Undercut
- 未熔合 / Lack of fusion
- 焊瘤 / Weld overlap
- 飞溅 / Spatter

巡检频次 / Inspection Frequency: 每件产品 / Each product

判定标准 / Acceptance Criteria:

缺陷类型 / Defect Type	允许程度 / Allowable Level
裂纹 / Cracks	不允许 / Not allowed
气孔 / Porosity	单孔直径≤1mm，间距≥3 倍孔径 / Single pore diameter ≤1mm, spacing ≥3 times pore diameter
夹渣 / Slag Inclusion	长度≤5mm，间距≥10mm / Length ≤5mm, spacing ≥10mm
咬边 / Undercut	深度≤0.5mm，长度≤10mm / Depth ≤0.5mm, length ≤10mm
未熔合 / Lack of Fusion	不允许 / Not allowed
焊瘤 / Weld Overlap	高度≤1mm / Height ≤1mm



4.6.2 尺寸检查 / Dimensional Inspection

巡检项目 / Inspection Items:

产品类型 / Product Type	检查项目 / Inspection Items	公差要求 / Tolerance
法兰堆焊 / Flange Cladding	堆焊层厚度、外径、密封面平面度	$\pm 0.5\text{mm}$ 、 $\pm 0.3\text{mm}$ 、 $\leq 0.1\text{mm}$
管件堆焊 / Pipe Fitting Cladding	堆焊层厚度、内径、长度	$\pm 0.5\text{mm}$ 、 $\pm 0.3\text{mm}$ 、 $\pm 1\text{mm}$
钢管堆焊 / Steel Pipe Cladding	堆焊层厚度、外径、长度	$\pm 0.5\text{mm}$ 、 $\pm 0.5\text{mm}$ 、 $\pm 2\text{mm}$
轴套管堆焊 / Shaft Sleeve Cladding	堆焊层厚度、外径、长度	$\pm 0.3\text{mm}$ 、 $\pm 0.3\text{mm}$ 、 $\pm 1\text{mm}$
模具堆焊修复 / Mold Cladding Repair	修复尺寸、表面粗糙度	按图纸要求 / As per drawing

巡检频次 / Inspection Frequency: 每件产品 / Each product

4.7 无损检测巡检 / Non-Destructive Testing Inspection

4.7.1 磁粉检测 / Magnetic Particle Testing

巡检项目 / Inspection Items:

- 表面裂纹 / Surface cracks
- 近表面缺陷 / Near-surface defects

巡检频次 / Inspection Frequency: 按工艺要求，一般每件 / As per process requirements, generally each piece

判定标准 / Acceptance Criteria: 符合 NB/T 47013.4 标准要求，不允许线性缺陷，圆形缺陷按标准评定 / Meets NB/T 47013.4 standard requirements, no linear defects allowed, circular defects evaluated per standard

4.7.2 渗透检测 / Penetrant Testing

巡检项目 / Inspection Items:

- 表面开口缺陷 / Surface opening defects

巡检频次 / Inspection Frequency: 按工艺要求 / As per process requirements

判定标准 / Acceptance Criteria: 符合 NB/T 47013.5 标准要求 / Meets NB/T 47013.5 standard requirements



4.7.3 超声波检测 / Ultrasonic Testing

巡检项目 / Inspection Items:

- 内部缺陷 / Internal defects
- 结合强度 / Bonding strength

巡检频次 / Inspection Frequency: 按工艺要求 / As per process requirements

判定标准 / Acceptance Criteria: 符合 NB/T 47013.3 标准要求, 缺陷等级不超过II级 /
Meets NB/T 47013.3 standard requirements, defect level not exceeding Grade II

4.8 硬度检测巡检 / Hardness Testing Inspection

4.8.1 硬度测量 / Hardness Measurement

巡检项目 / Inspection Items:

- 堆焊层硬度 / Cladding layer hardness
- 过渡区硬度 / Transition zone hardness
- 母材硬度 / Base material hardness

巡检频次 / Inspection Frequency: 每件产品 / Each product

判定标准 / Acceptance Criteria:

产品类型 / Product Type	堆焊层硬度 / Cladding Hardness	过渡区硬度 / Transition Zone
耐磨堆焊 / Wear-resistant	500-650HB	350-500HB
耐腐蚀堆焊 / Corrosion-resistant	200-300HB	180-250HB
模具修复 / Mold Repair	按技术要求 / As per technical requirements	按技术要求 / As per technical requirements

4.9 后处理工序巡检 / Post-treatment Inspection

4.9.1 热处理检查 / Heat Treatment Inspection

巡检项目 / Inspection Items:

- 加热温度 / Heating temperature
- 保温时间 / Holding time
- 冷却速度 / Cooling rate



- 热处理曲线 / Heat treatment curve

巡检频次 / Inspection Frequency: 每批次 / Each batch

判定标准 / Acceptance Criteria: 热处理参数符合工艺卡要求，温度偏差 $\leq \pm 10^{\circ}\text{C}$ ，保温时间偏差 $\leq \pm 5\%$ / Heat treatment parameters meet process card requirements, temperature deviation $\leq \pm 10^{\circ}\text{C}$, holding time deviation $\leq \pm 5\%$

4.9.2 机加工检查 / Machining Inspection

巡检项目 / Inspection Items:

- 加工精度 / Machining accuracy
- 表面粗糙度 / Surface roughness
- 几何公差 / Geometric tolerance

巡检频次 / Inspection Frequency: 每件产品 / Each product

判定标准 / Acceptance Criteria: 符合图纸技术要求，表面粗糙度达到 $Ra1.6\mu\text{m}$ 或更高要求 / Meets drawing technical requirements, surface roughness reaches $Ra1.6\mu\text{m}$ or higher requirements

5. 巡检记录与标识 / Inspection Records and Identification

5.1 巡检记录要求 / Inspection Record Requirements

- 巡检人员应如实填写《工序巡检记录表》 / Inspectors shall truthfully fill in the "Process Inspection Record Form"
- 记录内容包括：产品名称、规格型号、工序名称、巡检项目、实测数据、判定结果、巡检人员、巡检时间 / Records include: product name, specification model, operation name, inspection items, measured data, judgment results, inspector, inspection time
- 记录应字迹清晰、数据准确、不得涂改 / Records shall be clear, data accurate, and no alterations allowed
- 巡检记录保存期限不少于产品使用寿命 / Inspection records shall be retained for no less than the product service life

5.2 产品标识要求 / Product Identification Requirements

- 每件产品应具有唯一性标识 / Each product shall have a unique identification
- 标识内容包括：产品编号、工序状态、检验状态 / Identification includes: product number, process status, inspection status



- 标识应清晰、牢固、不易脱落 / Identification shall be clear, firm, and not easily 脱落

6. 不合格品处理 / Non-conforming Product Disposal

6.1 不合格品判定 / Non-conforming Product Determination

巡检中发现不符合判定标准的产品，判定为不合格品 / Products found not meeting acceptance criteria during inspection shall be determined as non-conforming products

6.2 不合格品处置流程 / Non-conforming Product Disposal Process

步骤 / Step	内容 / Content	责任部门 / Responsible Department
1	标识隔离 / Identification and isolation	质量部 / Quality Department
2	不合格评审 / Non-conformance review	质量部、技术部、生产部 / Quality, Technical, Production Departments
3	处置方案制定 / Disposal plan development	技术部 / Technical Department
4	返工返修 / Rework and repair	生产部 / Production Department
5	重新检验 / Re-inspection	质量部 / Quality Department
6	记录归档 / Record archiving	质量部 / Quality Department

6.3 返工返修要求 / Rework and Repair Requirements

- 返工返修前必须制定返工返修工艺方案 / Rework and repair process plan must be developed before rework and repair
- 返工返修后必须重新进行检验 / Re-inspection must be conducted after rework and repair
- 同一部位返工返修次数不得超过 2 次 / Rework and repair at the same location shall not exceed 2 times



7. 监督考核 / Supervision and Assessment

7.1 巡检质量监督 / Inspection Quality Supervision

- 质量部每月对巡检记录进行抽查，抽查比例不低于 20% / Quality Department shall conduct random checks of inspection records monthly, with a sampling rate not less than 20%
- 对巡检中发现的问题及时纠正，防止类似问题重复发生 / Timely correction of issues found during inspection to prevent recurrence of similar issues
- 对巡检人员进行定期培训，提高巡检技能 / Regular training for inspectors to improve inspection skills

7.2 考核指标 / Assessment Indicators

考核项目 / Assessment Item	目标值 / Target Value	考核周期 / Assessment Period
巡检计划完成率 / Inspection plan rate	$\geq 98\%$	月度 / Monthly
巡检记录完整率 / Inspection record completeness rate	$\geq 99\%$	月度 / Monthly
巡检问题及时整改率 / Timely rectification rate of inspection issues	$\geq 95\%$	月度 / Monthly
工序一次合格率 / First-pass yield rate of processes	$\geq 95\%$	月度 / Monthly

8. 附则 / Supplementary Provisions

8.1 相关文件 / Related Documents

- 《焊接工艺规程》 / Welding Procedure Specification
- 《质量检验规程》 / Quality Inspection Procedure
- 《不合格品控制程序》 / Non-conforming Product Control Procedure
- 《设备维护保养规程》 / Equipment Maintenance Procedure



8.2 相关记录 / Related Records

- 《工序巡检记录表》 / Process Inspection Record Form
- 《不合格品处置单》 / Non-conforming Product Disposal Form
- 《返工返修记录表》 / Rework and Repair Record Form
- 《设备点检记录表》 / Equipment Inspection Record Form

8.3 文件修订 / Document Revision

本程序由质量部负责修订，技术部配合，经管理者代表批准后实施 / This procedure shall be revised by the Quality Department with cooperation from the Technical Department, and implemented after approval by the Management Representative

8.4 生效日期 / Effective Date

本程序自发布之日起生效 / This procedure shall take effect from the date of issuance

文件控制信息 / Document Control Information

项目 / Item	内容 / Content
文件编号 / Document No.	CLADDING-ITP-025
文件名称 / Document Title	堆焊生产工序巡检程序 / In-Process Inspection Procedure for Cladding Production
版本号 / Version	A/0
编制 / Prepared by	质量部 / Quality Department
审核 / Reviewed by	技术部 / Technical Department
批准 / Approved by	管理者代表 / Management Representative
发布日期 / Issue Date	2024 年 / 2024
实施日期 / Effective Date	2024 年 / 2024

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