

REINHOLD ENVIRONMENTAL Ltd.



**2013 APC Round Table
& Expo Presentation**

July 8-9, 2013, in St. Louis, MO / Hosted by Ameren

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PJFF Bag and Cage Replacement Project Planning and Execution

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Training Class 6
Reinhold – 2013 APC Round Table & Expo
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- Introductions
- Typical Activities of Bags & Cages Replacement Project
- Documentation that Old Bags Need Replacement
- Procurement of Replacement Bags and Cages
- Technical Specification for New Bags and Cages
- Evaluation of Vendor Proposals for New Bags and Cages
- Planning Installation Phase
- Project Coordination
- Safety and Training

- Project Execution
- Pre-Outage Activities
- Bags and Cages Replacement Project Outage
- Staging and Installation (examples)
- Design and Field Modifications (examples)
- Emission and Field Testing
- Summary
- Acknowledgements

- Project Description
 - Pulse Jet Fabric Filter (PJFF) Bag and Cage Replacement Project at Power Station
- Bag and Cage Replacement Justification
 - Old bags and cages reached end of useful service life
- Goals
 - Replace the PJFF bags and cages and make design changes to improve PJFF system performance
- Team Organization (example)
 - Owner
 - Bags & Cages Suppliers
 - Installation Contractors
 - Consulting Firm

- Documentation That Bags Need Replacement
- Specification of New Bags & Cages
- Procurement
- Engineering & Design
- Fabrication of New Bags and Cages
- New Bags and Cages Shipment and Delivery
- Installation
- Commissioning
- Start-up
- Testing
- Operation & Maintenance



- New Bags
 - QA/QC fit demo



- New Cages





Documentation that Old Bags Need Replacement (examples)

- Monitor and record PJFF system operation & maintenance parameters with regard to potential bag failures (e.g., prepare spreadsheets and graphs from testing, PI or other data to display historical information).
 - Broken bag detector alarms
 - Increase in stack flue gas opacity and/or particulate emissions
 - Increase in PJFF compartment and/or system flue gas pressure drop
 - Changes in bag cleaning sequence (e.g. cleaning frequency vs. pressure drop)
 - Flue gas temperature
 - Flue gas composition (e.g., PI data, “Breen” probe data, flue gas testing, etc.)
 - O&M personnel observations and notes
 - Apply the Weibull distribution to estimate bag failure emissions as a function of time (see AWMA presentation, paper 12112, dated June 26, 2013)
 - Graphs of sample bag lab test results (e.g. Permeability, Mullen Burst, Tensile Strength, MIT Flex test results trends vs. time, from independent laboratories.)
- Safely inspect internals of PJFF system and visually view failed bags and other PJFF components (take photographs and notes)
- Involve PJFF system OEM, bag/cage suppliers, independent engineer or consultants, as required.

- Map and record location, chronology, frequency of bag failures, type of bag/cage, and other parameters within PJFF compartments concerning the failed bags/cages (e.g., repeated failure in certain locations “patterns,” such as “cold wall” effects or “high fly ash erosion” or “high flue gas velocity” areas, etc.)
- Remove and replace individual failed bags/cages as required
- Take samples of failed bags for observation and laboratory testing & diagnostic analysis
- Perform independent laboratory testing and prepare reports describing root-cause failure mode of bags and/or cages.





Documentation that Old Bags Need Replacement (examples)

- Prepare economic and technical analysis & report recommending course of action regarding PJFF bag/cage failures (examples)
 - “live” for a while with periodic bag/cage replacement until it becomes impractical
 - replace bags and try to refurbish & re-use old cages
 - replace all bags/cages of individual compartment
 - replace entire PJFF system bags/cages
 - other examples of course of action
- Decide if any existing cages can be refurbished & re-used or will all new bags have new cages.
- If applicable, review and determine if failed bags/cages met the original provided guarantee/warranty requirements (examples)
 - did bags/cages meet the guaranteed bag life value
 - did or did not warranty text exclude “X%” bag/cage failures
 - did or did not the bags/cages experience flue gas excursions not covered by the original warranty



Independent Laboratory Testing of Failed Bags and New Bags (examples)

- Visual Inspection of Bags
- Pinholes
- Dust Abrasion
- Clean Side Contamination
- Seam Construction
- Permeability Testing (ASTM 737)
- MIT Flex Endurance Test (ASTM D2176 or equivalent)
- Tensile Test (ASTM D5035)
- Mullen Burst Test (ASTM D3786)
- Microscopic Analysis
- Test at Specific Temperatures
- SEM Photographs (e.g., 500X)
- Chemical Analysis

* Bag testing examples are based on ETSI presentation “Bag Life Optimization Through Testing,” Worldwide Pollution Control Association Seminar – October 13, 2011.



** Please note, if required independent laboratories must modify or interpret ASTM or STM test procedures so that the testing is applicable to PJFF bags.

- Chemical Attack Testing ($\text{SO}_3/\text{H}_2\text{SO}_4$, HF, HCl, NH_4HSO_4 , NaHSO_4 , etc)
- Fiber Identification by FTIR
- Filtration Performance Test (ASTM D6830)
- Weight (ASTM D3776)
- Construction (Yarn Count – ASTM D3775 and Type of Weave ASTM D579)
- Thickness (ASTM D1777)
- Organic Content (LOI, ASTM D578)
- Width (ASTM D3774)
- Water Repellency (ASTM D2721)
- Surface Resistance (STM 11.11)
- Volume Resistance (STM 11.12)
- Two-Point Resistance (STM 11.13)

* Bag testing examples are based on ETSI presentation “Bag Life Optimization Through Testing,” Worldwide Pollution Control Association Seminar – October 13, 2011.



** Please note if required, independent laboratories must modify or interpret ASTM or STM test procedures so that the testing is applicable to PJFF bags.



Laboratory Analysis Test Report for Failed Bags

- Introduction
 - Background
 - Objective
 - Test program
- Summary of Results
 - Visual Inspection
 - Permeability
 - Mullen Burst
 - Tensile Strength
 - MIT Flex Endurance
- Conclusions
- List of Appendices
 - Summary of Results
 - Test Data and Results
 - Visual Observations
 - Photographs



Test Report - Visual and Microscopic Evaluation of Failed Bags

- Summary
- Discussion
- Background
- Visual Observations
- Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM/EDS)
- Comparative Analysis of the Unused Sample
- Figures
- Photographs
- SEM Images
- EDS Elemental Spectra
- Backscatter Electron (BE) Images



Procurement of Replacement Bags and Cages

- Development of Bidders List
- Prepare Specification for New Bags and Cages
- Comparison of Bids
- Award of Contract
- New Bags and Cages Procured



- Specification prepared to solicit competitive bids for replacement bags and cages (priced bids for various options comparing different materials and configurations for bags and cages options)
- Guarantees requested
 - Emissions (filterable particulate matter)
 - Pressure drop (inch w.c.)
 - Bag and cage life (years)

Typical Subjects Discussed During Meeting Concerning Specification

- A specification for replacement filter bags and cages with several material options will be developed.
- Bag and cage performance to be addressed in the specifications are:
 - Particulate emission guarantee
 - Bag and cage life guarantee
 - Bag and cage materials (options to be quoted)
 - Bag and cage flue gas pressure drop
 - Pulse air pressure and consumption
 - Installation Q/A & Q/C and labor requirements
 - Leak detection and pre-coat conditioning requirements and methods
- Other considerations
 - Schedule for boiler outage (if applicable)
 - Schedule for PJFF bag/cage replacement work (boiler online or offline)
 - Replacement strategy
 - Tube sheet coating (if required)
 - Future emission regulations



Technical Specification – Supply and Installation of Replacement Bags and Cages for Pulse Jet Fabric Filter (PJFF)

- Project Title Page
- Table of Contents
- Work & General Requirements
- Site Design Data
- Project Schedule
- Submittal Procedures
- Reference Documents
- Quality Control For Bags and Cages
- Shipment, Delivery, Unloading, Handling, and Storage of Bags & Cages and Leak Detection & Pre-Coat Materials

Technical Specification – Supply and Installation of Replacement Bags and Cages for Pulse Jet Fabric Filter (PJFF)

- Testing and Commissioning of Bag and Cage System
- Spare Parts and Special Tools of Bag and Cage System
- Design of Bags and Cages for Installation, Operation, and Maintenance
- Bag and Cage System Description
- Guarantees and Testing of Bag and Cage System
- Appendices
 - Division of Responsibility (DOR)
 - PJFF Inlet Flue Gas and Boiler Coal Data
 - Description of Owner's Pulse Jet Fabric Filter System
 - Description of Current Replacement Bag
 - Sketch or Drawing of Original Bag
 - Description of Original CS Cage
 - Drawing and Photographs of Original CS Cage
 - Owner's Correspondence Items for the Technical Specification
 - Bag & Cage Supplier Correspondence Items for the Technical Specification



Technical Comparison of Contractor Bids for Replacement Bags and Cages


- Conformance to Technical Specification Requirements
- Review of Exceptions and Clarifications
- Scope of Supply (including quantity & spares)
- Quality of Proposed Bags & Cages
- Installation Safety Records
- Review of Guarantees, Warranties, and Testing
- Proposed Project Team Organization
- Proposed Schedule for Delivery and Installation

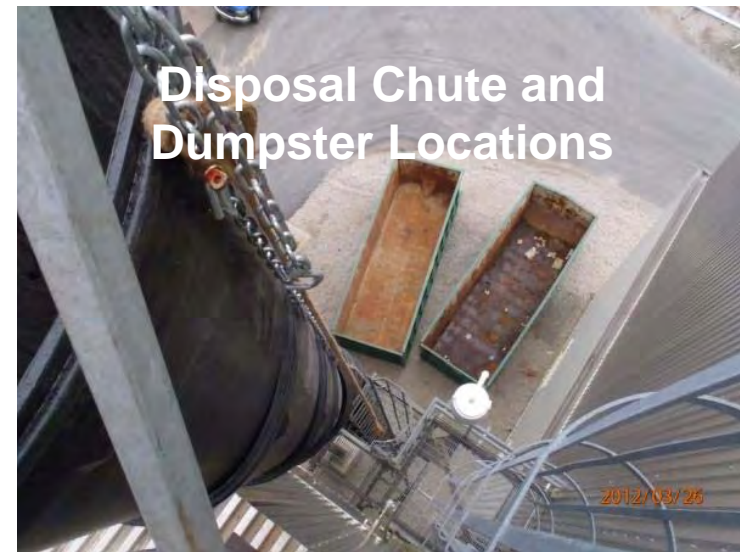


Comparison of Contractor Bids (cont) – Replacement Bags and Cages – Format (example)

Commercial Comparison of Contractor Bids for Replacement Bags and Cages

- Conformance to Commercial (T&Cs) Requirements
- Review of Commercial Exceptions and Clarifications
- Comparison of Capital Costs
 - Material and Delivery Cost
 - Installation Cost
 - Spare Bags & Cages
 - Owner's Costs (BOP)
 - Total Installed Cost Comparison (sum of above)
- Comparison of Annual Operation and Maintenance Costs
 - Bag Life and Costs (material, labor, and services)
 - Cage Life and Costs (material, labor, and services)
 - Bag/Cage Flue Gas Pressure Drop
 - Pulse Jet Air Requirements (pressure, flow rate, etc.)
 - Total Annual O&M Cost Comparison (sum of above)
- Comparison of Net Present Value (NPV)

- Plan first  execute to plan
- Firm up outage windows with contingencies if work is not completed during outage
- Inlet and outlet ductwork to be cleaned
- Crane location identified for each unit
- Material storage and disposal bin locations and movement routes identified
- Filter bag and cage removal and new materials movement logistics



- Implement Lessons Learned from previous work
- Recycled materials, cages, cardboard and wood
- Filter bag disposal, in clear bags
- Vacuum truck available to clean hoppers
- Cleaning out hoppers of dropped filter bags and cages (confined space)
- QA/QC of filter bag to cage fit and their installation



- Coordinate the running of fans for leak detection powder injection
- Shut down and tag-out the boiler for leak inspection
- Coordinate the running of fans for pre-coat (conditioning agent) injection
- Coordinate the start-up of the boiler immediately after the pre-coat to set and get ash on the newly coated filter bags



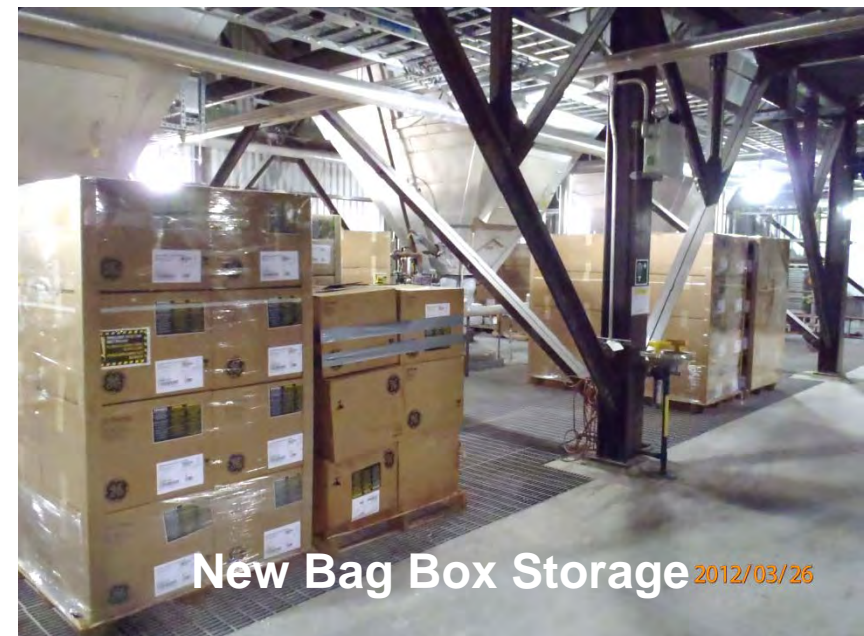
- Schedule of Project, Coordination
- Division of Responsibilities (DOR)
- Safety
- Project Management
- Outage Schedule of Units



- Execution of the Project
- Safety (LOTO)
- Pre-outage Inspections
- Team Meetings
- Outage Activities

- Installation of the New Bags and Cages
- Quality Assurance and Control
- Disposal of Spent Bags and Cages
- Field Performance Testing
- Other Activities of the Project

- Type of filter bags and cages
- Fabrication, delivery, handling, storage
- Installation, leak testing, pre-coating of the bags
- Bag monitoring program



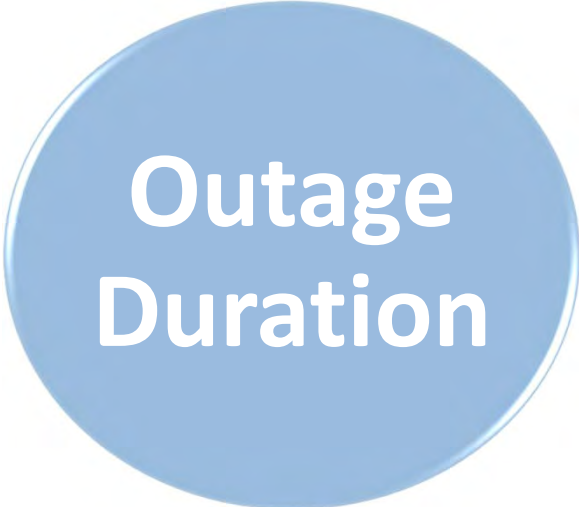
- Pre-outage activities - safety
- Cleaning out deposits in the PJFF “J” tubes (example)
- Cleaning the compartments and vacuum inlet and outlet ductwork
- Replacement of compartment cover gaskets during the project
- Team Meetings



Typical Notes of Meeting (format)

- Attendees
- Overview
 - To discuss pre-construction & work schedule on bag and cage replacement.
- Safety Items
- Work Schedule
- Work Coordination
- Bag/Cage Specifications
- Action Items

- Safety During Project (examples)
 - Plant safety procedures
 - Lock-out and Tag-out (LOTO) procedures
 - Personal protection equipment (PPE), eye-wash, shower, dust control, etc.
 - Safe lighting and ventilation
 - Fire prevention and protection (e.g. boxes, wood, etc.)
 - Safe access and inspection procedures
 - Safe crane & lift procedures
 - Safe removal, handling, transport, and disposal of spent bags & cages
 - Safe handling, storage, and use of leak detection and pre-coat materials
- Bag and cage maintenance and operation training with plant personnel prior to project execution
- Review operational changes required with new bags to maximize performance
- Review strategy of laboratory testing bags periodically (yearly) to monitor permeability, burst, tensile strength, and flex trends



Outage Duration



Bags & Cages Replacement Project Outage

Man hours

Crew Size @ Peak

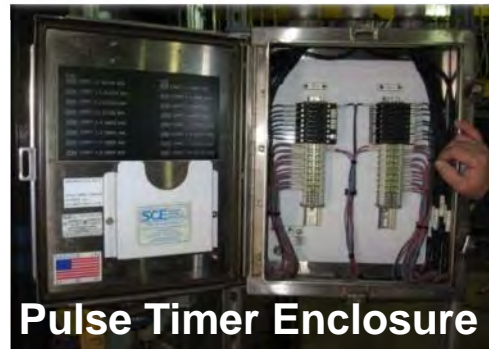


Work Personnel – Examples

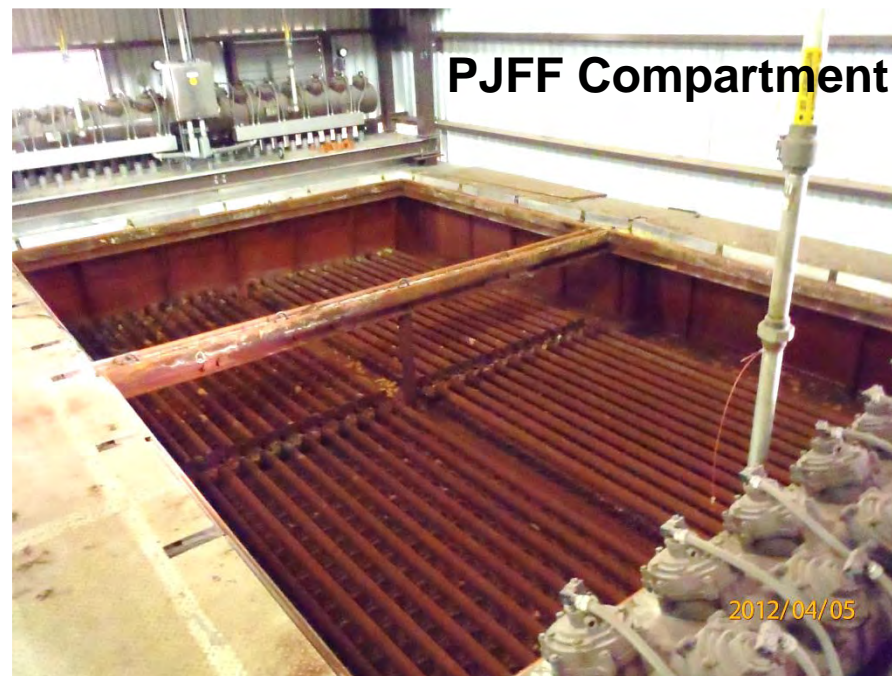
- Plant Personnel
 - Labors
- Specialty Contractors
- Safety Personnel
 - Other



- Pulse air pressure lowered
- Pulsing sequence changed per supplier's recommendations (e.g. stagger pulsing)
- Start-up procedure revised to start pulsing sequence at recommended pressure drop across PJFF compartment



- Pulse air “J” tubes and pulse headers cleaned of deposits
- Compartment cover gaskets replaced
- Compartment sides and covers were sandblasted and coated with epoxy





Technical Specification – Guarantee Testing Protocol - Replacement Bags and Cages - Format (example)

PERFORMANCE TESTING (Summary Section)

- The Owner will procure the services of a third party testing contractor to perform the Replacement Bag/Cage Guarantee Testing.
- The Owner and third party testing contractor will prepare a draft detailed Guarantee Testing Protocol. The protocol will be provided to the Bag/Cage Contractor for review and comment. Owner and Bag/Cage Contractor will mutually agree to the final Guarantee Testing Protocol.
- The third party testing contractor will prepare a draft Guarantee Test Results report of the results and submit the report to Owner.

* Above are key items for a summary section. Obviously, a replacement bag/cage technical specification will also include detailed text describing the specifics of testing program.



Summary Checklist of Activities – example Owner’s Independent Field Testing – Replacement Bags/Cages

Test Documentation Table – Checklist of Activities Before & During Test

Test Activity	Owner	Flue Gas Testing Company	Bag/Cage Supplier	Independent Testing Contractor
Activity Before Test				
Develop Draft Test Protocol				X
Send to Parties the Draft Test Protocol for Team Review	X			
Review Draft Protocol	X	X	X	X
Provide Calibrated Test Equipment		X		X
Plant Calibrated Magnehelic gauges on each PJFF compartment of Unit	X			
Provide Template Forms for Recording Magnehelic gauges values of each PJFF compartment of Unit	X			
Provide PI Data Excel Spreadsheet Template and other Forms for Other Data Collected During Test	X			
Activity During Test				
Unit Boiler Operation and Dispatch	X			
Operation and Maintenance of Unit PJFF System	X			
Collect and Record PI Data and Other Data	X			X
Collect and Record Pressure Drop Readings from Magnehelic gauges on each PJFF Compartment				X
Measure Particulate Emissions at Unit PJFF Outlet		X		
Witness Test	X	X	X	X
Coordinate Flue Gas Testing Company During Test	X			X
Collect Samples of Coal, PFA Ash, DSI, ACI, SDA During Test	X			X



Summary Checklist of Activities – example Owner’s Independent Field Testing – Replacement Bags/Cages

Test Documentation Table – Checklist of Activities After Test

Test Activity	Owner	Flue Gas Testing Company	Bag/Cage Supplier	Independent Testing Contractor
Activity After Test				
Prepare Test Draft Report for PJFF PM Emissions		X		
Prepare Test Draft Report for PJFF Compartment Pressure Drop Readings from Magnehelic gauges on each PJFF Compartment				X
Prepare Final Draft Guarantee Test Results Report for Review				X
Send Final Draft Guarantee Test Report to Parties for Review	X			
Review Final Draft Guarantee Test Results Report	X	X	X	X
Issue Final Guarantee Test Results Report	X			



Guarantee Performance Test Results Report – format (example)

- Cover Page
- Table of Contents
- Summary of Results
- Introduction and Purpose of Guarantee Performance Testing
- Description of Test Methods, Locations, and Test Equipment
- Detailed Results of Guaranteed Performance Testing



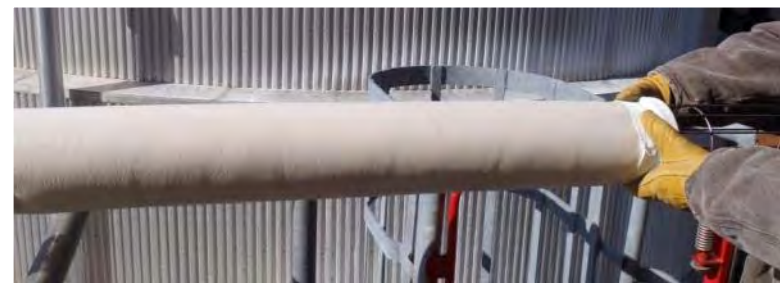
Guarantee Performance Test Results Report – Format (example) (cont)

■ Appendices

- Division of Responsibility (DOR) and Organization of Testing Program
- Safety Policy During Testing Program
- Test Schedule
- Details of Test Methods, Matrix, Locations, and Durations
- Sketches of Testing Locations
- Calibration of Instruments and Test Devices
- Description of PJFF System
- Description of Replacement Bags and Cages
- Detailed Logs for Compartment Flue Gas Pressure Drop Measurements
- Detailed Logs for PJFF System Outlet Particulate Matter Emission Testing
- PI Data (spreadsheets)
- Field Notes of Observations made During Test Period
- Coal Analysis Results
- Flue Gas Flow Rate, Properties, and Composition Results
- PJFF Solids Sample Analysis Results (flyash, DSI sorbent, ACI PAC, CDS/SDA solids, etc.)
- Photographs Taken Testing Period

Summary

- Bags and cages replacement project includes numerous activities that require pre-planning.
- Upfront pre-planning results in on-time and successful projects.
- PJFF design modifications are sometimes performed to maintain optimum performance.
- Proper bags/cages, safe installation, commissioning, and start-up are key to a successful project.







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