REFRACTORY MANAGEMENT

Outage Planning

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ELITE
REFRACTORY SERVICES
Powered by AIS

Refractory Management - Part 1 - Outage Planning

- Refractory Related Contractors
- Bidding
- Schedule Development and Analysis
- Bid Development
- Outage Planning
- Outage Execution (Part 2)

Economic Demands Changing Outage Styles

2000 - 2008

- Optimize Performance
- Optimize Process
- Outage Speed – Around the Clock
- Refractory Upgrades
- Capital Expenditures

2009 - Present

- Optimize Process Efficiency
- Implement Outage Cost Savings
- Continuous Improvement Strategies

Reliability, Quality, and Safety Standards Remain Consistent

Refractory Related Contractors

- Kiln Demolition
- Refractory Contractors
- Scaffold Contractors
- Mechanical Contractors
- Refractory Dryout Contractors

Kiln Demolition - Concerns

- Coating Removal
- Brick Inspection
- Brick Removal
- Brick Sampling
- Minimize Shell Damage

Kiln Demolition Methods – Kubota vs. Brokk

Brokk

Kubota

Kiln Demolition Methods – Kubota vs. Brokk

Brokk

Powered Electrically

Removes approx 30’ of
brick at a time and then kiln is
turned to remove other half

Highly specialized expensive equipment and usually two on-site

Replacement parts need to be on-site
and specialty parts not readily available

Operator controls machine from distance

Slower / More economical

Kubota

Diesel Powered

Entire kiln replacement area
demoed from same location –
no kiln turning required

More common machine with less
expensive equipment and usually two on-site

Replacement parts and specialty
parts more readily available

Operator physically on machine

Faster / Higher cost

Refractory Contractor - Concerns

- Safety
- Honesty
- Quality
- Execution Plan
- Resources / Equipment
- Capabilities to adjust to unknowns

Refractory Contractors – Value Added Services

- Indirect Safety Incident Costs
    - Crash decks / isolation of work areas
    - Attention to how work areas conflict
- Experience and Inspection
    - Refractory Expansion methods and considerations
    - Reduced emergency failures
    - Less Hot Box installations
    - Lower repair/replacement costs
- Engineering Solutions to Refractory Problem areas
    - Repairs and recommendations based on process conditions, failure analysis, thermomechanical analysis, postmortem analysis, etc.
    - Engineer solutions rather than replace yearly
- Outage Planning and Budget Preparation

Scaffolding Contractor - Concerns

- Safety
- Honesty
- Building Plan and Preparation
- Building Time
- Resources / Equipment
- Crew adjustability
- Who manages priorities?
- Stand-by Time
- Scaffold Damage Costs

Mechanical Contractor - Concerns

- Safety
- Honesty
- Meeting schedule with minimal input
- Work area conflicts:
  - Coolers
  - Risers
  - Tipping Valves
  - External Kiln Work
  - Steel Repairs
- Knowledge / Expertise

Refractory Dryout Contractor - Concerns

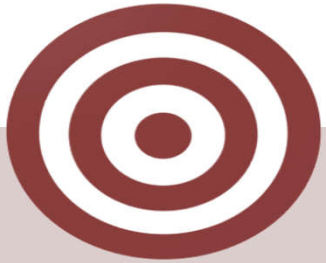
- Do I need it?
- Safety
- Safety
- Fuel method and requirements
  - Hookups
  - Fuel Storage Tank levels and needs
- Temperature monitoring and control

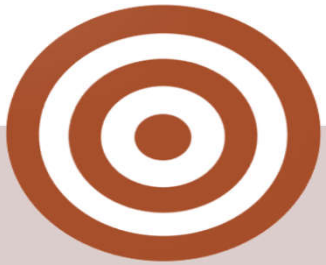
Multi-Disciplined Contractor - Advantages

- Knowledge / Resources for all projects
- Priorities and scheduling worked out internally
- No stand-by crafts
- No work area conflicts
- One contact
- Self sufficient
- Efficient

BIDDING

Types of Bids





Bid Type	Advantages	Disadvantages
Firm Bid	Set Price	No accountability Change Orders Jobs never execute as bid
T&M	Honest	Job overmanned
T&M Not to Exceed	Job price capped	Doesn't work Change Orders Jobs never execute as bid
Unit Pricing	Priced by foot in kiln Other repairs by square footage	Typically overpriced

Change Orders

Goal Comparison

Customer Goals

- **No injuries**
- **On-time**
- **Quality Work**
- **On budget**
- **Cost tracking**

Contractor Goals

- No injuries
- On-time
- Quality Work
- Paid for all work
- Profitable

How to Save the MOST Money on Bid Package

- Clearly define scope
- Define outage schedule including conflicting work areas
- Commitments to meet schedule – including plant activities
- Choose Honest Contractor
- Budget above bids for unknowns and schedule changes

Bid Package Evaluations

- Don’t just look at PRICE
- Evaluate:
  - Bid package particulars
  - Schedule
  - Estimated manhours – RED FLAGS
  - Rental Equipment, Staging, Clean up – Included?
- Check References
- Contractor Equipment charges:
  - Flat rate or by equipment
  - If by equipment, is it equipment used or equipment on site?

Manhour Evaluation:
How many manhours to weld 3,000 anchors?

- 1 Brick Mason (BM) can weld 200 – 500 anchors in a 10-hour shift
- Why big discrepancy?:
    - # of anchors in one location?
    - Is BM doing layout and welding? Or just welding?
    - Anchor Types
- If you average 300 per BM per 10-hour shift, how many manhours? 100?
- How did anchors get there?
- How did welding machine, leads, etc. get set up?
- Are there ceramic anchors?
    - How did they get hung in place?
    - How did they get wrapped in plastic if Lightweight is being shot?
- A good estimate is entirely dependent on the project and area but 150-200 manhours is more reasonable

Effective Use of Plant Personnel

- Avoid mixing into refractory crews if possible
  - Breaks, Lunches
  - Effectiveness at type of work
  - Type of Work
- Where to utilize best:
  - Staging materials and equipment – forklift operators
  - Material Mucking off floors
  - Elevator operators
- When they must mix in:
  - Have them coordinate breaks, lunches, etc. with contractor crew
  - Assign supervisor to monitor punctuality – not contractor supervisor
  - Expect slower production

SCHEDULE DEVELOPMENT AND ANALYSIS

How to determine best outage working hours:

- SCOPE AND SCHEDULE!!!!
- Define outage scope
- Define outage duration
- New to the Plant?
    - Look at Old plans
    - Talk to involved personnel
- Additional Concerns:
    - Plant Personnel Schedule and OT allowances
    - Critical Path conflicts – Error on side of getting ahead!
    - Time lost at the beginning of an outage can’t be gotten back
- Work with contractor to determine best value

Is all OT bad?

- Outage work is highly specialized
- No such thing as local refractory or mechanical crews that are highly competent due to industry size and locations
- Traveling crews is part of the business
- Per diem, rental cars, rental equipment, and productivity of shifts have to be evaluated to determine best overall value

Kiln Brick and Gunite Example

- Assumptions:
    - ~15’ kiln - no tapers/retaining rings, excessive brick changes, etc.
    - 4 week outage
    - 100 feet of kiln brick installation
    - 350 sq ft castable – 3” lightweight, 6” hardcast - ~ 18 total tons
        - 9” anchor spacing = ~533 anchors

Working hour shift breakdown

- Breaks and Lunches:
    - 15 - minute Safety Meeting
    - 1 – 1 hr lunches (1 on 12-hour shift)
    - 15 - minute clean up

	Paid	Working	
Shift	Hours	Hours	% Paid
12-Hours	12	10.5	88%
10-Hours	10	8.5	85%
8-Hours	8	6.5	81%

Production based on 12-hour shifts

- Gunite Schedule:
    - Demo 300 sq ft – 3 shifts
    - Scarf and weld anchors – 1 shift
    - Hang bottle brick & Gun 3 tons Lightweight – ½ shift
    - Prep expansion and gun 15 tons hardcast – 1 shift
    - Cleanup – ½ shift
    - Total = 6 shifts
- Kiln Brick Installation Schedule:
    - 45’ per shift bedout – 2 shifts to 90’
    - Bed 10’, cut in, set rig, key 5 foot – 3rd shift
    - 35’ keying per shift – 2 shifts to 75’
    - Key 15’, closure, reshim, remove rig – 6th shift
    - Finish rig removal, flash doors and load out – 8 hours 7th shift
    - Total 6 12-hour shifts and 1 8-hour shift

Shifts and Costs

Shift	Paid hours	Working hours	Gunite	Kiln Brick	8-hr shifts	Total Working Hours	Total Shifts
12-hours	12	10	6	6	1	128	12+1
10-hours	10	8.5	7	8	0	127.5	15
8-hours	8	6.75	9	9	1	129.5	19

Shift Type	Travel Cost	Weekday Shift	Saturday Shift	Sunday Shift	8-hr shift	Non-working day	Rentals
7 - 12's	$ 9,247	$ 7,270	$ 8,622	$ 9,630	$ 4,666		$ 1,260
6 - 12's	$ 9,247	$ 7,270	$ 8,622		$ 4,666	$ 810	$ 1,260
5 - 12's	$ 9,247	$ 7,270			$ 4,666	$ 810	$ 1,710
6 - 10's	$ 9,247	$ 5,968	$ 7,320			$ 810	$ 1,710
5 - 10's	$ 9,247	$ 5,968				$ 810	$ 2,070
5 - 8's	$ 9,247	$ 4,666				$ 810	$ 2,520

Highest and Lowest within 3% of one another

Additional Considerations

- 2 shifts
  - Shift Changes
    - 12-hour shifts = smooth transitions
    - 10-hour shifts = no night to day turnover
  - Gunning and Shotcrete installations
    - Shotcrete installations take highest amount of most expensive personnel + equipment charges
- More manpower vs. Overtime
- Manpower Types

BID DEVELOPMENT

Scope and Schedule

TASK	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17
Kiln Brick	demo	demo							6	6	6	6					
Cooler	demo		4			4	4	2	2			4	6	4			
TA Duct					4			4		1	1	6	4				
Calciner		8	6	6	6	6	6	3	3	3	3	3	4	4	6	6	8
Stage 4			8	4	4	4		3			4			6	4	4	
Stage 3				6			4	2	4	4			4				
Tool/Ground		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Elevator		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Scaffold Adjustments		0	0	0	2	2	2	2	2	2	2	2	0	0	0	0	0
Total / Shift	0	11	21	15	15	19	19	19	20	19	19	22	21	17	13	13	11

Legend

- Scaffold
- Demo
- Welding
- Brick
- Lightweight
- Shotcrete

Additional Cost Considerations

- Safety Manager
- Tool Room Personnel
- Ground Operators
- Elevator Operators
- Unplanned Scaffold Needs
- Rental Equipment

OUTAGE PLANNING

Planning Additional Considerations

- CONFLICTING WORK AREAS!!!
    - Cooler Maintenance
    - Tower Tipping Valves (address during cool down)
- Desired Contractor's Schedule
- Coordination with Company Plants and/or Local Plants
- Power Outages
    - Early in outage is most cost-effective for most crafts but typically gets scheduled in middle
    - Early in outage, lights can be converted to welding machines, air for demo can be run from compressors, and high percentage of low-cost labor on-site
- Elevator inspection / overhaul

Planning Additional Considerations

- Material Delivery schedule:
  - Get all anchors on-site pre-outage
  - Material deliveries can be co-ordinated but material should be made
  - On-site storage and freezing protection
- Material Return Policy
  - Work out deals with suppliers and other plants who have later outages to take excess after outage

Material Needs

- Brick
    - Calculate pallets of the actual ratio
    - Always have a ring or 2 of Long Brick
    - Is the Kiln critical path?
        - Demo and Muck at same time
        - Bed and Key at the same time

- Castables
    - Have them staged and separated – spray paint
    - A few pallets of gunning material for patches
    - One or two pallets of plastic ram

Considerations for Insulation

- The amount of potential fuel savings that the refractory actually controls is minimal in most industrial plants. It is estimated that only 3-6% of the total “available heat” is accounted for in heat losses through or stored in the refractory. This means that small changes to the overall refractory economics conditions would be almost un-measurable in a real life situation. On the same hand, large changes of refractory economic conditions within a small area of the furnace would also be un-measurable. Also any fuel savings realized with insulation would be quickly vaporized if the insulation was responsible to any un-planned outages and repairs.

- With this in mind, reducing or eliminating the insulation more often has a positive effect on lining reliability and service life than any perceived fuel economy savings. It is always better to error on the side of less (or no) insulation when in doubt. Regardless of any economic calculations, the following areas should never have insulation installed.

No Insulation

- Critical areas not adaptable to “Hot Spot Procedures” that would cause an outage
- Critical areas prone to previous premature failures
- Areas prone to high abrasion
- Bullnoses and high strain (unrestrained) areas
- Areas prone to corrosion and especially sulfur salt condensation
- Areas within moving equipment
- Areas prone to mechanical damage
- All panelize construction “hard returns”
- Any areas or zones subject to air or water blasting
- Areas beyond the active heat transfer / heat recovery regions
- Areas around any opening or penetrations in the shell
- Applications when the total lining thickness is less than 4.5”

Brick vs Monolithic

- If installation time allows, the amount of firebrick should be maximized to achieve the most economical installation.
- Brick should be a minimum of 6” thick to maximize stability and “working thickness”.
- Board Insulation should be used as the backup lining as opposed to IFB for decreased costs and better heat flow.
- Brick should only be used in cylindrical vessels.
- Brick can be upgraded and/or zoned for optimum results without affecting the overall economics.
- Shotcrete should be used on all non-cylindrical areas and transition areas to eliminate excessive brick cuts.
- Shotcrete should be used in any area where if a brick becomes unkeyed whole sections unravel and cause safety issues such as the overhead section of ducts on an angle.

REFRACTORY MANAGEMENT

Part 2 – Outage Execution

Refractory Management - Part 2 - Outage Execution

- Safety
- Shutdown Procedures
- Inspection
- Contractor Meetings
- Emergency Outages

SAFETY

Safety – Practice what you Preach!

- Safe Tower Entry
  - Buildup Removal During Cool Down
  - Buildup / Widowmaker Inspection and Identification
  - CARDOX, Shotguns, exterior scaffolds?
- Interior Scaffold to remove buildup
- Headache Deck design and entering to install
- Kiln Feed Dust and Alkali Burns
- Silica – Dust Protection, EPA, MSHA focus
- Roof Anchor Failures
- Lockout Procedures and Verification?
- Scaffold Tagging and Harness Requirements
- Costs and certain expectations factored in bid or all change orders?

Safety – Equipment

- Who is renting equipment? Plant or contractor?
- Forklifts – checked for all MSHA requirements:
    - Lights, Alarms, Brakes are obvious
    - Fire Extinguisher checked within month?
    - Who is task training operator?
    - Supplied with wheel chocks
- Welding machines
    - Fire Extinguishers equipped with proper inspection tag?
    - Any of lead visible?
    - Terminal Covers checked?
- Oxygen / Acetylene Racks
    - Request “No Smoking” signs or stamps on bottles
- Do you require your contractor to do these things?
    - The more MSHA citations your contractor receives, the longer the inspector is on-site
- Costs and certain expectations factored in bid or all change orders?

SHUTDOWN PROCEDURES

Shutdown Procedures

- Is there a Kiln shut down procedure
    - Burnout – Cool down schedule ?
    - Empty Kiln as much as possible
    - Empty all fuel/feed bins
- Kiln Coating Removal
    - Can certain chemistry changes reduce/remove coating to speed up kiln demolition?
    - Will those changes effect feed dust in tower and potentially increase reactive dust?
- Critical Entry Timing
    - Lockout
    - Opening Kiln Doors and Installing and securing Ramp
    - Coordinate tower work plan with kiln demolition
        - Draft Considerations
        - Cooler Work

Shutdown Procedures

- Equipment used for Mucking
    - Haul truck(s) serviced
    - Backup skid steer(s)

- Safety Orientation schedule
    - Contractors coming in both shifts

- Typical Attitude at Beginning of Shutdown:

    “WE GOT PLENTY OF TIME, WE’RE JUST GETTING STARTED”

INSPECTION

Inspection – What to Look For?

- Bullnoses
    - Cracking along thrust plates
    - Separation / Bulging
- Roofs
    - Hanging / Bulging
    - Buildup or Refractory
- Anchors
    - Oxidation / Sulphurization
    - Welding
- Refractory
    - Hotface / Lightweight Interface
    - Salt condensation
- Demo Inspection Areas

SHUTDOWN MEETINGS

Contractor / Shutdown Meetings

- Contractors don't need to be present for review of every job going on during outage
- Plants shouldn't have shutdown meetings without representation from major contractors
- Recommend:
    - Major Contractors and plant personnel gather to update status
    - Review conflicting work area schedules / major project schedules
    - Keep short
    - Timing is very important:
        - Morning meetings should be at least 1 hour after shift change
        - Afternoon meetings should be at least 1 hour prior to end of shift
        - This allows main contractor representatives to get crews going in morning and planning in afternoon prior to night shift change. Day and night shift supervisors can stay on same page as updates happen.

EMERGENCY OUTAGES

Emergency Outages

- "It's not what you do for me during a planned outage that I appreciate the most, it's what you do for me during emergencies."
- Know your Production/Maintenance needs:
    - Fast as possible? Or Cheap as Possible
    - Critical Path identification – is it something other than failure?
- Fast Planning in the middle of the night:
    - Notification – notify immediately
    - Realistic evaluation of cool-down schedule saves costs
        - Is Safety still your first priority?
- Wishing it to be small doesn't make it small – Preparation may cost more on small job, but saves exponentially if it grows

Emergency Outage Materials to Have

- Equipment:
    - Forklift (Extended Boom?)
    - Welding Machines
    - Compressor
- Refractory Materials
    - Gunite – always good to have a couple pallets – they can usually be used during next outage or for hot boxes/special needs
    - Anchors – they don't go bad
    - Brick Shims and Mortar
- What can you do to speed up outage and keep costs down?
    - Order and/or receive equipment/scaffolding
    - Stage materials
    - Assure buildup removal & remove as much kiln feed as possible
    - Prepare for worst

Hitting Your Target

MOST EFFECTIVE, LOWEST COST OUTAGE

DISCUSSION / QUESTIONS?