

Cracking the code: FCC turnaround lifecycle best practices – Part 2

The common FCC equipment and recommended engineering practices are reviewed, followed by unit start-up and turnaround report generation

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Part 1 of this article, published in PTQ Q2 2026, discussed the expanded role of the process engineer in developing the scope for the FCC turnaround. This has put more onus on the process engineer to define and justify the turnaround scope. Process engineers also provide critical support for shutdown and start-up planning and execution. This adds further complexity to scope development and introduces potential technical and operational challenges as units approach end-of-run (EOR) conditions.

Part 2 will focus on the FCC turnaround itself. With an extended timeframe between turnarounds, the turnaround may be the first opportunity for the process engineer to inspect these vessels. The cycle then continues.

FCC general inspection guidelines

With vessels now open, this is the opportunity to finally see first-hand what these vessel internals look like. The prior turnaround report and photo file directory, as well as internal drawings, should offer some insight prior to making an entry for inspection.

Initial visual inspection via open manways can be helpful in early assessment of the equipment condition, particularly the 'as-found' condition. Use of drones and remote cameras can also help in assessing the as-found condition. Process engineering should note the amount of catalyst in the regenerator, reactor stripper, and standpipes, with comparison to prior unit shutdowns. Engineers should note the as-found condition of the trays and packing from the manway, particularly fouling and damage.

General vessel inspection guidelines

It is good practice to plan vessel entry. Review the equipment's internal drawings and note any key dimensions of interest (such as nozzle locations, tray clearances, and weir heights).

Prior to the turnaround, it is helpful to have equipment drawings easily available in a directory or with a file link. This is particularly helpful for other process engineers supporting the turnaround. In addition, create a file structure for storing pictures prior to the turnaround, including sub-folders for 'As-found condition', 'After cleaning condition', and 'Pre and Post Repairs'. It is good practice to download

and sort these photos after inspection or at least at the end of the shift. Naming the best or most important pictures is also helpful.

Additionally, have a system for documenting findings and initial recommendations from the inspection or at least at the end of the shift. Online systems such as Microsoft OneNote can be useful for all the supporting engineers to add their comments.

Regenerator inspection

Due to harsh operating conditions, the FCC regenerator should be inspected at every turnaround. Specialised inspectors will normally review the refractory condition both on the regenerator walls and refractory in cyclones

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and on other internals. In most cases, the issues are from an anchor system failure or erosion in cyclones. However, hot spots may also be caused by erosion from the air grid, spent catalyst distributor, cyclone dipleg outlets, or other purge nozzles.

The inspection will also look for mechanical damage, such as cracks in welds, cyclone supports, cyclone body, and air grid nozzles. Process engineering should inspect the pressure tap nozzles for cleanliness, along with the air grid nozzles, thermowells, spent catalyst distributors, catalyst cooler distributors, torch oil nozzles, and the regenerator standpipe inlet (including debris guard) and aeration inlet distributor.

Pressure taps, fluidisation nozzles, and thermowells

All regenerator pressure taps, including those in the



Figure 1 Air distributor nozzle erosion

standpipes, should be inspected for cleanliness and elevations verified, including the elevation of any internal piping. Any restriction orifices (RO) should be verified. A list of RO locations, types (orifice plate/RO in union coupling/drilled valve), and sizes should be created. All RO installations should be verified prior to unit start-up.

All thermocouples that were not reading or appeared to be inaccurate should be removed, checked for condition, and verified as working. Thermowells that are damaged should be replaced. Any damaged thermowells that could not be repaired should be noted in the turnaround report.

Spent catalyst distributor/regen outlet – standpipe

The regenerator outlet debris guard should be inspected for damage and plugging. Note if excessive debris (usually refractory) was found after catalyst removal. Any damage should be repaired.

The regenerator air distributor nozzles should be inspected for erosion and plugging. A good practice is to have an air grid pattern drawing and note damaged or plugged nozzles

Any damage to the aeration ring for the standpipe inlet should be noted and repaired. If inlet aeration was impaired, it may be worthwhile noting changes in aeration rate and regenerator standpipe operation to determine when the failure occurred.

An alternate design may be needed if loss of aeration has occurred in prior runs and affected the regenerator standpipe performance. Damage to other internal piping for aeration or other purposes should similarly be reviewed for impact on performance and possible upgrade.

Regenerator air distributors

The regenerator air distributor nozzles should be inspected for erosion and plugging (see **Figure 1**). A good practice is to have an air grid pattern drawing and note damaged or plugged nozzles. The turnaround group may want engineering to note nozzles requiring repair with spray paint as well as a drawing.

Nozzles may need to be plugged if they are severely damaged or causing impingement. A repair plan should be developed between the turnaround group, process

engineering/subject matter expert (SME), and operations. The final repair should be documented on the air grid nozzle and included in the turnaround report. If nozzles are plugged, estimates on the air loss should be calculated.

Regenerator cyclones

As part of the regenerator inspection, the regenerator cyclones should be inspected at every turnaround. Even with cyclones just completing their first cycle, they should still be reviewed for unexpected wear. Common areas of damage are:

- Primary cyclone inlet.
- Target area of primary and secondary cyclone (back side of cyclone).
- First-stage outlet tubes.
- Entrance to the crossover ducts (often in the corner) and in the crossover.
- Second-stage hopper cones and lined dipleg stubs.

Damage should be compared to the notes from the prior turnaround. If the damage has increased, review the process velocities for changes in cyclone velocities, increases in regenerator temperatures, and/or afterburn in the cyclones. Also note any changes in regenerator catalyst losses, catalyst fines content, and regenerator electrostatic precipitator (ESP) or scrubber fines particle size distribution.

As cyclones age, there can be concerns with cyclone metal weldability (i.e., difficulty in attaching anchors). There can also be issues with general refractory roughness, which can increase fines losses and may require replacing the cyclones in the next turnaround.

Units that still have condensate and/or steam dilute-phase injection distributors/nozzles should consider whether they can be eliminated. These injection systems have a higher risk of damage to internals from impingement, along with loss of energy and increased velocities. Otherwise, these should be repaired if there are signs of damage.

Catalyst transfer lines

Transfer lines, such as the spent catalyst standpipe, U-bend and lift system (if so designed), and regenerator standpipe and riser, are subject to severe erosion and thermal conditions. Refractory is used to protect metal from erosion and excessive temperature, so its integrity is crucial.

Aeration taps/distributors and instrument taps should all be inspected for cleanliness. These taps should again be checked when the unit is first pressurised with the air blower to ensure they are clear.

Slide valves

Slide valves are also subject to erosion and thermal issues. Modern designs are refractory-lined, and the refractory will need to be inspected. Erosion to the guides and gate should be noted in the turnaround report. Process conditions (valve differential pressure ΔP and opening) should be investigated if excessive damage is noted. Replacement is often recommended when repair time approaches the critical path or repair costs approach 50% of a new valve.

Unit monitoring of slide valves during operations between turnarounds can be used to help indicate slide gate wear

(see **Figure 2**), especially severe wear on the slide valve gate. Excessive wear around the stem and/or guides may indicate issues with the packing purge or excessive use of the guide purge. Erosion issues should be reviewed with the slide valve vendor to determine whether the valve can be refurbished or should be replaced. Sticking issues during the run may also indicate issues with packing purge, guide clearance, or wear.



Figure 2 Severely eroded slide valve gate

After the slide valve has been installed, it is recommended to mark where the plate edge meets the overhang (mark of actuator) and note the position in the control room. Also, record when the valve is fully open. Verify the time required to fully close the valve and compare it with the design criteria.

The valve hydraulic system should also be serviced, preferably by the hydraulic skid vendor. Any issues with hydraulic oil condition or servo should be noted for possible increased monitoring (usually by the hydraulic skid vendor).

Prior to unit start-up, the slide valve packing purge should be checked for proper operation, including ensuring that the restriction orifice is installed and open, and verifying the purge flow (usually from the bleeder). The purge meter flow should also be verified. Any guide purge piping should be disconnected but ready if needed.

Inspect all taps and ensure aeration and pressure taps are all clear. All ROs should be inspected (pulled, verify opening, replace as needed). Carefully inspect the wye/l bend area for unusual wear (see **Figure 3**). Identify areas of excessive wear for repair and upgrades in future turnarounds. Note areas with significant refractory repair and assess if replacement is justified.

Feed nozzles

Riser feed nozzles are critical to achieving optimal and reliable unit performance. These nozzles are subject to wear, particularly at the tips, and should be repaired at every turnaround. Feed nozzle components are long lead items – spare tips and other critical components should be stocked in advance, as recommended by the nozzle technology provider and informed by experience from the previous turnaround. Note if there were issues removing the nozzles from the prior turnaround and any changes to the nozzle preparation.

If there are issues, recommend reviewing the feed nozzle preparation prior to nozzle insertion (see **Figure 4**). Damage to the insert may also need to be addressed. Feed nozzles should be inspected in the riser prior to removal for plugging, coke around or near the nozzles and refractory

wear possibly due to misdirection. The nozzle preparation along with the preparation procedure should be noted in the turnaround report.



Figure 3 Riser wye – steam chest

Riser

The feed riser often has refractory requiring repair. If the damage is significant from the prior turnaround, replacement of the riser may be recommended for the next turnaround. In addition to the feed nozzles, the riser may also include lift steam and emergency steam nozzles, recycle nozzles, pressure nozzles, and guarded thermowells. Lift steam and emergency steam at the riser base are often subject to erosion and damage.

Any specialised nozzle distributors should be procured prior to the turnaround. Any issues with pressure or temperature indication should be included in the turnaround scope. Nozzles should be inspected for plugging due to coking or other contaminants. Damage to thermowell guards should be noted. If the damage has been significant, consider a review of an alternate design.

Reactor

Today's reactors function as housing for riser termination



Figure 4 Feed nozzle measurement prior to installation



Figure 5 Primary cyclone inlet refractory damage

separation and cyclones with only small amounts of hydrocarbon and steam in the dilute phase. As a result, they are subject to internal coke formation, particularly around the riser crossover ducts, top of cyclones, support members, and in the dome area. The degree of coking should be compared with prior turnaround results.

A significant increase in coking versus typical should be investigated. Excessive coke build-up in the dome may show some steam ring damage or inadequate dome steam rates. Designs include a baffle to prevent hydrocarbon in the dome area. For these designs, excessive coking may be the result of damage to the dome area or insufficient steam. The steam meter should be checked for accuracy.

Large pieces of coke should be removed to reduce the likelihood of coke combustion during the heat-up phase of the start-up. Inspection will often require coke removal to inspect welded areas.

As with the other equipment, any issues with temperature and pressure instruments should be included in the turnaround scope. All pressure tap nozzles should be checked to ensure they are clear. The location of pressure and temperature instruments should be verified. Prior to start-up, all purge ROs should be verified for size and proper installation.

The condition of steam distributors, such as dome steam rings, cyclone steam, primary cyclone pre stripping steam (see **Figure 5**), cyclone bathtub grid and other internal piping, should be inspected and damage noted. Damage should be investigated for possible upgrades, particularly if similar damage was noted in the prior turnaround.

External wear to the riser termination/reactor cyclones



Figure 6 Secondary cyclone dipleg erosion

should be noted for possible impingement issues. Reactor wall refractory wear is common and should be addressed by refractory inspection.

As with the regenerator cyclones, the riser termination area and reactor cyclones are subject to wear, particularly around the inlet area, the internal cyclone back wall (target area), cross-over duct areas, and around the bottom of the dust bowl outlet into the dipleg.

Reactor rise termination and cyclones should be inspected for unusual wear patterns, wear to hex mesh, coke build-up in cyclones, and damage. Ensure inspection of unlined portions of the dipleg for wear (inspection should also check dipleg thickness). Inspect for dipleg hole-through, particularly in transition areas from the lined to unlined sections of the dipleg. Today, diplegs are often inspected with cameras. Coke around the back side of the secondary cyclone is common and should be removed if excessive to prevent spalling of the coke, potentially plugging the secondary dipleg (see **Figure 6**).

Reactor cyclone trickle valves are subject to wear and thermal deformation. The trickle valve hinges should be free of coke and move freely. Note the location of any wear (wear at the top would show vapour egress into the cyclones). Gas leakage up the dipleg is a common issue causing internal dipleg and dustbowl erosion.

Replacement of the entire trickle valve is a widespread practice to lessen turnaround repair scope and issues matching trickle valve clearances.

Units may use counter-weighted flapper to seal diplegs. Like the trickle valves, inspect for proper flapper seal and free movement. Any deformation or sticking should be



Figure 7 Steam distributor nozzle erosion



Figure 8 Reactor overhead isolation valve coke build-up



Figure 9 Fractionator inlet coke build-up

noted for repair. Proper clearance is needed to ensure that any coke formation on the hinges is cleared during operation. As with trickle valves, it may be prudent to replace these valves if wear and damage have been noted:

- For existing valves, recommend replacing/altering when clearances exceed 1/8in.
- New trickle valves should be able to meet less than 1/16in clearance.

Reactor stripper and distributors

The reactor stripper should uniformly distribute catalyst and steam over the stripper diameter. Damage and plugging to the shed trays, disc/donuts or stripper packing should be noted and addressed in the turnaround. Plugging distribution holes in the tray decks should be noted and cleared. Damage to the stripping steam distributor nozzles or steam distribution should be noted and repaired (see **Figure 7**).

Note if any nozzles were plugged and update the drawing (verify the change in nozzle velocities because of the nozzle plugging). Frequent nozzle damage should be investigated for high or low velocities and possible replacement for the next turnaround. Distributors should be checked for poor operating range as part of the pre-turnaround preparation. Monitoring distributor nozzle velocities during the run is also good practice.

The reactor overhead line can be subject to erosion and coke build-up (see **Figure 8**). As part of the inspection, note any coke build-up in the reactor overhead line. Note any damage to refractory lining, particularly around elbows. Significant coke build-up should be removed. Sites can consider using high-pressure water to dislodge coke. Coke in the fractionator inlet should also be noted and removed (see **Figure 9**).

Start-up process activities

Start-up is usually an extensive effort between operations, process engineering, and mechanical support. With round-the-clock coverage, effective communication is needed between shifts. Process engineering is active during key parts of the start-up, in particular:

- Tracking the refractory dry-out (if needed) and general unit heat-up.
- Tracking catalyst addition rates and levels.
- Torch oil addition.
- Initial catalyst circulation and reactor heat-up.

- Tracking instrumentation issues.
- Feed into the unit and lining-out units.

Process engineering will aid the operations unit in monitoring and troubleshooting process issues. Engineering can help with trend analysis to provide early warning of potential issues. Engineering support often helps track turnaround progress and should document key issues that may require procedural changes or mechanical upgrades. Note times and any issues for key activities for the turnaround report, including:

- Start of the air blower.
- Start/shutdown of the air heater.
- Start/completion of refractory cure.
- Start/completion pulling main fractionator blind.
- Start/completion of catalyst addition.
- Start of torch oil.
- When a product is on spec and routed to product storage/downstream processing (sometimes from slop to cutter to finished product or downstream processing).
- Start of catalyst circulation.
- Feed into the unit.
- Note significant issues during the start-up.

Post-turnaround process activities

After some time to recuperate, it is time to complete the turnaround report. The most important part is the findings from the turnaround. This should include recommendations on:

- Changes in unit monitoring (process, testing).
- Changes in shutdown and start-up practices and procedures.
- Recommended equipment replacement or repair, particularly for possible upgrades that will require engineering.
- Issues that were found but not resolved and will require additional follow-up.

The report should include a summary noting the as-found condition compared with the prior turnaround, a summary of repairs, and any operational or mechanical upgrades recommended for each piece of equipment reviewed during the turnaround. A summary photo is also helpful, with other photos kept in a turnaround directory.

It is helpful to have an outline developed prior to the turnaround, with summary notes added during the turnaround. The final report is normally distributed for review/comment to the process engineering team and then issued for future reference.

Post-turnaround benchmarking test run

A post-turnaround test run to bench mark the unit operation shortly after the unit has been restarted and the operation is stable is also recommended. The post-turnaround test run should include comprehensive data collection on the unit process data, including:

- Collect a full pressure and temperature survey of the unit.
- Survey or standpipes for pressure build-up.
- Include cooling water flows to exchangers (enlist the help of a chemical vendor).
- Full set of samples for analysis (recommend collecting two sets spread apart).

- Sampling of equilibrium catalyst, catalyst fines, and catalyst in slurry.
- May also include tower scans.

This comprehensive test run can be used to update current unit simulation models. It can also track equipment performance for degradation during the run or equipment issues. The test run is also used as the basis for engineering studies and basic stream data. The cycle then continues.

Conclusions

Given the importance of FCC units in modern refineries and the complexity of operations under demanding economic and environmental parameters, the role of the process engineer has significantly expanded. Today's engineers must integrate operating data, inspection findings, and operational experience to develop a turnaround scope that appropriately protects the safety, reliability, and profitability needs of the refinery.

The practices outlined in this article provide a structured framework and the technical 'armour' needed to support necessary scope using data, economics, and historical evidence rather than opinion. Equally critical is maintaining continuity across multi-year turnaround cycles. Thorough post-turnaround reporting, clear documentation of as-found conditions, and well-defined recommendations preserve institutional knowledge and prevent each turnaround from becoming a rediscovery exercise.

When the issues described in this article are identified,

quantified, and documented, even small or hard-to-inspect problems can be translated into operational recommendations and defensible turnaround scope with significant reliability and economic benefit. Ultimately, successful FCC turnarounds are built on disciplined preparation, continuity, and execution – turnaround after turnaround. This article provides guidance only. Each turnaround is different, and plans should be tailored to meet the unique circumstances of each facility.

This article is based on the 2025 AFPM Summit Presentation *Cracking the Code: FCC Turnaround Best Practices for Process Engineers*.

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