THE CARMAGEN Engineering, Inc. REPORT

Partnering in Engineering Excellence

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The Ten (Actually Twelve) Commandments for Achieving Successful Turnarounds

By Robert J. Motylenski, P.E.

Since the cost of a turnaround is the single biggest annual maintenance expenditure that a process plant can experience, it is key that it is executed in an efficient and effective manner. This starts months, if not years, before the first blind is installed for the shutdown. The following is a list of the key activities that are needed to achieve a "World Class" turnaround. There is much more to it than just these items, but without these activities, it will not turn out as well as it could have been.

1. Management

Management must provide the underlying guidance and support needed by the organization to ensure a successful turnaround.

Actions:

- Activate a Turnaround Steering Committee
- Establish guiding principles and turnaround objectives
- Appoint a Turnaround Manager and Turnaround Team
- Provide necessary resources, both budget and personnel
- Steward planning progress and execution.

2. Milestone Plan

The Milestone Plan provides an overview of strategic activities in the turnaround and is a key document in communicating planning progress. It includes all activities that must be carried out before execution, and includes both execution and post-turnaround activities.

Actions:

- Turnaround Manager is responsible for preparing and maintaining the Milestone Plan
- Turnaround Steering Committee endorses initial Milestone Plan and uses it to periodically monitor and steward progress.

3. Work Scope

Work Scope is the process of identifying mechanical, process, engineering, and project work that must be performed during the turnaround in order to achieve the business objectives.

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Actions:

- All work requests must be screened using a risk matrix, and approved by the Turnaround Steering Committee.
- The Turnaround Steering Committee should establish a date when the Work List will be closed and the Extra Work Procedure put in place.
- A "Cold Eyes" review of the finalized work list should be conducted.
- The Turnaround Steering Committee should freeze the Work List about three months before the turnaround, and no additional work is to be added.

4. Planning and Scheduling

Effective planning is one of the critical factors that is needed to achieve a successful turnaround, while scheduling is the activity of optimizing the time and resources required to execute the planned work activities.

Actions:

- A dedicated team will do the planning.
- During planning, alternative methods should be evaluated with the objective of achieving the work scope at the lowest possible cost while maintaining safety, schedule, and quality.
- As early as possible, identify the potential critical and sub-critical works and start preparing detailed work plans.
- Prepare an overall schedule that integrates all work activities, including contractor schedules, into a single document from oil-out to oil-in.
- The Turnaround Steering Committee should approve the final schedule.

5. Contracting

Selecting the right contractors for the turnaround is crucial to ensure success, as they have a major impact on safety, cost, schedule, and the ability of the units to achieve the business objectives.

Actions:

- The Turnaround Steering Committee, in conjunction with the Purchasing Department, should prepare a contracting strategy for the turnaround as soon as the turnaround dates are fixed.
- Contracts should be awarded at least three months before shutdown.
- Contractors' work plans and schedules should be reviewed and approved by the Turnaround Steering Committee.
- Contractors' schedules should be included in the overall turnaround schedule.

6. Materials

Material procurement refers to the complete process of purchasing, delivery, and storage of supplies needed for the turnaround.

Actions:

Materials that have long delivery times must be identified and ordered as early as possible so that they are available onsite in time for the turnaround. This may be 12 to 18 months before the turnaround, or earlier in some cases.

7. Inspection

Inspection is a key turnaround activity, as it is a major factor in determining the turnaround work scope, cost, schedule, and execution plan.

Actions:

- Review the latest changes and interpretations to the legal inspection requirements of the local jurisdiction to ensure that no unnecessary regulatory inspections should be conducted during the turnaround.
- Complete all pre-turnaround inspections as early as possible so that any identified work can be included in the work scope.
- Develop a list of all inspection work that must be performed during the turnaround so that it can be included in the turnaround work scope.
- Ensure that equipment that has a high probability of needing repair is inspected early in the shutdown.

8. Process Operations

Process Operations refers to all activities undertaken by plant operations staff as part of the turnaround.

Actions:

- Each process area should prepare optimized shutdown and startup plans.
- The plans should be made available early and integrated into the overall schedule and turnaround plan.
- Equipment that is on the critical path, or has a high probability of requiring additional work, should be made available early in the shutdown.

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- Update all blinding lists and ensure that all blinds are onsite prior to shutdown.
- Review the work permit procedure that will be used during the turnaround and ensure that it does not require an undue amount of administration that could lead to unproductive time.
- Revise and update purging procedures.

9. Engineering/Project Activities

Projects are the one area that, if not integrated into the overall plan and schedule, can cause major downtime extensions.

Actions:

- The Engineering Group should define what project work will be executed during the turnaround and what project work can be performed outside the turnaround.
- All engineering activities and materials procurement should be in accordance with the turnaround timeline for detailed planning and material ordering.
- Once the work list is closed, no project work should be added to the turnaround work list.
- Material takeoffs and ordering must occur in parallel with design to ensure that all materials are onsite for the turnaround.

10. Safety

Turnarounds add significant risks to personnel safety and health. Both the Owner and contractors must pay special attention to these areas.

Actions:

- The number one goal for the turnaround should be that there would be no disabling injuries.
- Overall comprehensive safety, health, and environmental plans must be prepared for the turnaround. The plans should be reviewed and approved by the Turnaround Steering Committee.
- Safety requirements and goals must be stressed to contractors during bid reviews, and each contractor should review and discuss its safety program.
- All contractors should conform to the plant's safety requirements.

11. Organization

Since turnarounds involve a large number of people from different organizations, they must be organized so that there is effective interaction and efficient transfer of information among the groups.

Actions:

- The Refinery Manager should appoint a Turnaround Manager as soon as the timing for the turnaround is decided.
- The Turnaround Manager should be a member of the Turnaround Steering Committee and has the responsibility and authority to resolve problems that arise during planning and execution.
- Start forming a Turnaround Team once the Turnaround Manager is designated and the turnaround dates established.
- Roles and responsibilities should be defined for all turnaround personnel.

12. Execution

Execution is the process of performing turnaround work as described in the detailed work plans and schedule. The turnaround could be a failure if the execution is not performed effectively.

Actions:

- All pre-turnaround work must be completed before the turnaround starts.
- A Turnaround Execution Manual should be prepared and issued to all supervisors (Owner and contractors).
- All Owner supervisors should have a clear understanding of the work the contractors are to perform and their role in monitoring the contractors' activities.
- Equipment turnover checklists should be used to receive completed equipment from the contractors.

Successful process plant turnarounds don't just happen by themselves. Ensuring that these twelve activities are included in your turnaround plan will help your plant become a "World Class" performer. To ensure consistent performance, each plant should have a Turnaround Manual that documents procedures and practices. The Turnaround Manual should be updated after each turnaround as part of a continued improvement process.

CEI can help your organization prepare a Turnaround Manual and implement the Twelve Commandments for a Successful Turnaround.

Bob Motylenski has over 40 years experience in the reliability and maintenance area, mostly with the Reliability and Maintenance Services Group of Exxon Research and Engineering Company. Please contact Vince Carucci if you'd like more information on Carmagen's expertise in this area.

Fluid Catalytic Cracking Unit Flue Gas and Transfer Line Refractory Lining System Development

By Paul E. Schlett

Industry has come a long way over the years with respect to refractory lining systems in FCCU Flue Gas and Transfer Lines. This article summarizes where we started, where we are now, and how we got here.

The ***first generation*** refractory linings in FCCU flue gas and transfer lines were dual layer type. The hot face layer was a “T” stud-supported, hexmesh-anchored, erosion resistant, hot face lining. The backup layer was an insulating castable. Problems that often occurred with this lining system were weld failures between the hexmesh and the “T” stud anchor supports on the hot face. This caused a breach in the hot face lining which permitted catalyst bypassing, metal casing hot spots and, in some cases, holes in the lines. As weld failure progressed, sheets of hexmesh would be detached from the “T” studs and plug the lines.

These dual layer lining systems were replaced with a ***second generation*** lining system: a single layer, erosion resistant, heat-insulating lining. With this more dense single layer lining, the assumption was made that there would be no direct flow paths back to the metal shell. In addition, the refractory linings would be erosion resistant enough to resist catalyst flow, and would have adequate thermal insulating capability to keep the metal shell cool enough from a differential thermal expansion standpoint.

In the early days of the single layer lining system, erosion resistance was adequate, but the coefficient of thermal conductivity (K-factor) of the refractory products selected for this service was too high. The high thermal conductivity resulted in higher than expected metal casing temperatures leading to greater than expected line thermal growth. Thermal conductivity values published by the manufacturers of these products were typically much lower than the actual, as-installed values.

Except for when the lines were dried improperly (i.e., in a reheat furnace from the outside) or when too much water was added during installation, permanent linear change (i.e., shrinkage) of this ***second generation*** of refractories was adequate to minimize gas and catalyst bypassing, but metal shell casing temperatures were higher than desirable.

Because of the higher than expected or desired K-factors, a ***third generation*** of refractories was developed that would have lower densities (leading to better thermal insulating properties), less erosion resistance, and the same permanent linear change. The ***second generation*** of refractories would continue to be used in transfer lines because of the need for erosion resistance, but the ***third generation*** could be used in vapor and flue gas lines where erosion is not as severe. Some ***third generation*** refractories were Resco Products RS 17 E MW and Harbison-Walker (now ANH Refractories) Thermax.

Although several suppliers were successful in providing ***third generation*** refractories in the 1980’s, the desire to have a ***fourth generation*** that would satisfy both the erosion resistance and heat insulating requirements brought about continued refractory product development. Four suppliers, and now a fifth, have been working on ***fourth generation***-type products. North American Refractories (now ANH Refractories) made “HPV Castable”; RHI Refractories made “LEGRIT 135-1,9 COR 0-3 (D171)”; Resco Products made “Rescocast 110C”; and Thermal Ceramics made “Kaotuff 110C”. “Kaotuff 110C” was the first of the *fourth generation* products and was developed in 1989. Vesuvius is now offering “ACTCHEM MWVC”. There may be others available or under development that are not noted here.

Although these products have about the same erosion resistances (ACTCHEM MW-VC appears to be the most erosion resistant), and K-values are within the range originally required for ***second generation*** products, they **do not** represent a generic refractory group. The suppliers appear to be approaching the physical properties requirements by using differing raw materials combinations depending on the proprietary technology they have available. Note that ***second generation*** refractories were nearly all the same, but with different brand names.

One physical property that separates them is permanent linear change from room temperature cured-to-dried at 230°F (110°C). HPV Castable and ACTCHEM MW-VC shrink more than the others at lower temperatures, while the other two have only minor shrinkage in the cured-to-dried range. Those products with significant shrinkage at such low temperatures allow cracks to form during the initial dryout which may not close up back to the metal shell during operation. This means that a potential catalyst bypass situation and subsequent hot spot could develop during operation.

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When a product has minimal shrinkage at the low temperatures, the cracks seen on the refractory hot face are not through-thickness cracks and will grow together in service. This minimizes the possibility of catalyst and hot gases getting back to the metal shell.

Of the four products presented above, Resco Products Rescocast 110C and Thermal Ceramics Kaotuff 110C have fairly low shrinkages at low temperatures. These two products should perform acceptably in transfer lines. Kaotuff 110C has lower shrinkage, lower K-value, and better erosion resistance than Rescocast 110C. RHI Refractories advertises physical properties for LEGRIT 135-1,9 COR 0-3 (D171) that, if correct, are better than both of these. This product would need to be evaluated carefully before it could be recommended.

Paul Schlett has over 30 years experience as a refractory engineering specialist with extensive experience in the hydrocarbon processing industry, especially in FCCUs. He has prepared refractory material specifications, design and installation details, and repair specifications, and monitored refractory installation and repair during new unit construction and turnarounds. Please contact Pradeep Shah if you'd like more information on Carmagen's expertise in this area.

Those Stinkin' Mercaptans … They're Back

By Winston Robbins, Ph.D.

Mercaptans (i.e., sulfur compounds with the generic formula of R-SH) have a long history of generating problems for refiners. Control of mercaptans is necessary because these compounds have an objectionable odor, high toxicity, and high corrosivity. Although mercaptans are easily reduced by hydrotreating, control has historically been accomplished by application of wet chemical techniques.

In the 1920's, the "Doctor process" (i.e., lead catalyzed air-oxidation to disulfides) was used to reduce the objectionable mercaptan odor in gasoline. In the late 1950's, UOP developed the Merox process for eliminating mercaptans from light ends, and this process is still widely used today. In that process, patented catalysts are used to oxidize mercaptans in caustic, which is used to extract the low molecular weight (MW) mercaptans. After separation of a disulfide phase, the regenerated caustic is recycled. Numerous variations of the Merox approach were developed by the late 1970's. For example, Merichem applied its thin-film contactor technology for mercaptan control, and UOP developed a catalytic carbon bed that extended the oxidation to the higher MW mercaptans in jet fuel.

Until 2000, these technologies were adequate for mercaptan control. Since then, however, mercaptans have reappeared to create process and product quality problems. These problems arise from both world-wide changes in crude slates and stringent fuel sulfur specifications.

Mercaptans in new crudes are creating problems in crude unit corrosion and jet fuel quality. In traditional crudes, mercaptan levels in crudes generally drop rapidly with MW (and boiling point). For these crudes, mercaptans distill into naphtha cuts with only trace ppm levels of mercaptans in higher boiling fractions. However, some crudes, especially some condensates, contain higher MW mercaptans that distill into higher boiling fractions. Published crude assay data for some crudes show high ppm concentrations of mercaptans in higher boiling fractions (Figure 1). For some of these crudes, the total mercaptan concentration is greater than the concentration in any of the fractions shown, i.e., for these crudes, there may be even higher mercaptan concentrations in the vacuum cuts (i.e., mercaptans are not routinely assayed in 650+ cuts).

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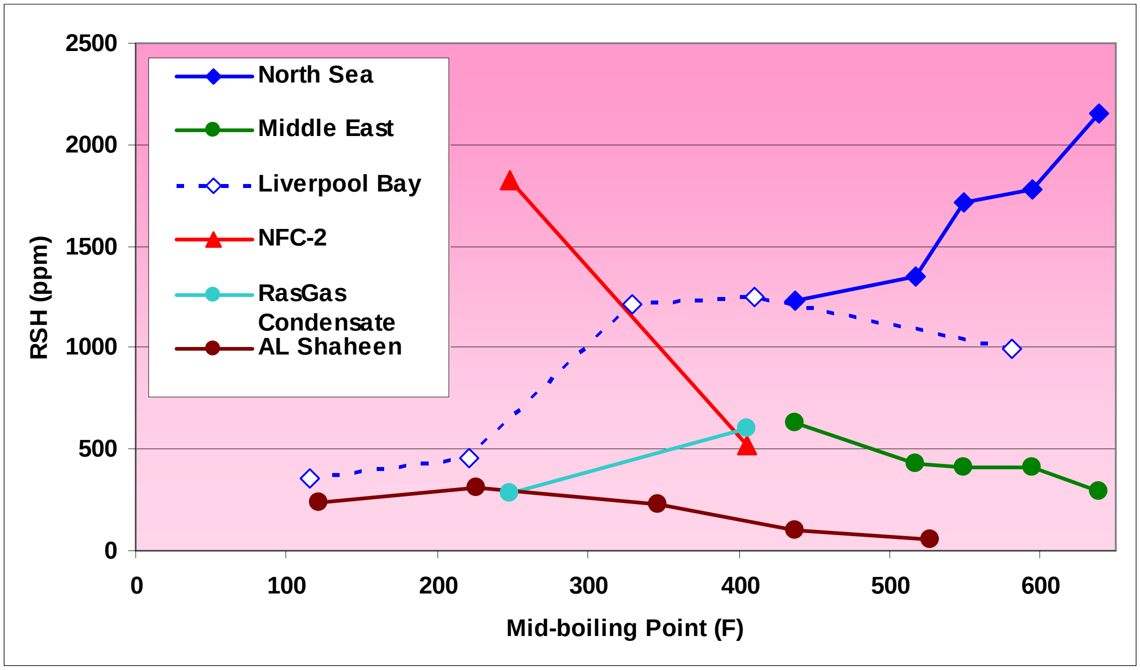
Figure 1. Boiling Point Distribution For High Mercaptan Crude Oils



A recent NACE paper (#07565) describes the potential for crude unit corrosion by mercaptans. Under the conditions tested, the maximum mercaptan corrosion rate was observed around 527°F (275°C), i.e., on the high end of the jet range. Mercaptans in this boiling range may also present a challenge for control with catalytic Merox technology. This may be especially true if a high mercaptan crude is blended with an acidic crude. Because the catalytic process involves the reaction of mercaptides with air, the charcoal bed must be kept alkaline. Consequently, the feed to a jet fuel Merox treater must be pre-treated with caustic not only to convert the mercaptans to mercaptides, but also to neutralize and extract low MW acids. Successful operation requires careful control of the pre-treater, avoiding soap carry-over while providing protection of the catalytic bed.

Not all the new mercaptan problems are related to high mercaptan crudes. In fact, one of the bigger challenges arises from trace mercaptans formed in retro reactions that occur in cat cracking. Mercaptans are formed in sufficient concentrations to exceed the 2006 low sulfur fuel specifications. Even with hydro-treated feed, cat cracking generates some H_2S that reacts with olefins in the cracked products before the separator. Although mercaptans in cat naphtha can be readily reduced with hydrogen, such a treatment would also saturate the high-octane olefins. Several schemes have been developed to remove these trace mercaptans. One of the most successful is ExxonMobil's SCANFINING technology that optimizes conditions to avoid retro-reactions, removes mercaptans from the light cat naphtha using a Merichem thin film technology, and hydrotreats intermediate and heavy naphtha with selective catalysts to reduce thiophenes with minimal olefin reduction.

Every refinery is engineered to different requirements. As the low sulfur specifications continue to force process changes and new crudes challenge operations, understanding the role of mercaptans is becoming increasingly important. If you have any questions about mercaptans or mercaptan control processes, please contact us.

Win Robbins has extensive analytical expertise in the areas of reactive sulfur/naphthenic acids characterization, HPLC-2 ring type definition technology, and polynuclear aromatic hydrocarbons (PNA) characterization. Please contact Jerry Lacatena if you'd like more information on Carmagen's expertise in this area.

HIGHLIGHTS

- Reviewed onsite installations of relatively new, plastic piping systems installed at a chemical plant after several failures occurred. Several design and installation flaws were identified that were determined to be the root causes of the failures. Provided onsite assistance to identify and rectify all locations that were questionable.
- Continued to provide significant project management and cost engineering consulting support for multiple clients in the US and overseas.
- Continued to provide welding, materials, and process engineering litigation consulting support for multiple major cases.
- Issued a report that provides recommendations to develop cost-effective repair and maintenance strategies, and select contractors, for major turnarounds being done on aboveground atmospheric storage tanks. This report was part of a two-year program to make significant improvements in the maintenance and reliability of these tanks at a major refinery in Europe.
- Preparing a delayed coker unit maintenance guide for a major international oil company. This guide will include guidelines and recommendations for operations, inspection, maintenance, and repairs, primarily concentrating on the coker drums.
- Evaluated the design and installation of a multiple-pump piping system to determine the cause of significant pump vibration and maintenance issues being experienced. It was concluded that the most likely cause of the problems is very high piping loads applied to the pump nozzles (up to 12 times their allowable values). Recommendations were made to significantly reduce the piping loads by adding pipe restraints to direct the thermal movement, replacing spring supports and adding new ones, and adjusting the loads being carried by several other springs.
- Providing plot layout support for domestic and international refiners.
- Continuing to provide relief system helpdesk support for major refiner.
- Performing strategic reliability initiatives for an international refiner, including a hydrocracker catalyst evaluation and reactor loading plan to maintain conversion, increase run length, and also produce a 10 ppm sulfur diesel plus assessment of unit performance based on feed quality/ preparation and filtering.
- Continuing support on developing LOPA standards for a domestic refiner.
- Providing process design support in a major technology provider's offices.
- Providing ongoing environmental support to domestic refiner.
- Providing technical support in expanding role to a major domestic client for "first-of-kind" Biomass process development for ethanol production, and CO_2 removal technology evaluation.
- Providing technical litigation support in analytical chemistry, process and metallurgical areas to defend major refiner in class action suit.
- Providing technical support to provide a design package for a major refiner to design MHO and slide valve specs in the FCC flue gas system, and improve mechanical reliability.
- Performing PIMS modeling and refinery planning support.
- Provided process design consultation on refinery planning for a Northwest refiner anticipating expansion to handle oil sands.
- Providing ongoing technical Mogas blending consultation to seven domestic refineries regarding optimization, equipment and controls assessment, and certification.
- Providing process support for evaluation of vacuum heater performance/transfer line pressure profile.
- Completed noise consultation and preparation of a front end design for a jet line noise reduction package.
- Performing HAZOP support at multiple locations for a domestic refiner.
- Supporting client's work for a Northeast refiner's expansion program to investigate broad process opportunities, including fuel gas balance improvement, H_2 management and reformer octane optimization, review of tower internal modifications and other miscellaneous support.
- Conducting revamp studies for Northeast refiner's multiple trains of crude and vacuum unit fractionation and profitability improvement.
- Conducted scoping study for FCC unit performance improvement for an overseas refiner.
- Providing extended onsite support to a West Coast refiner's expansion program, including support in contractor's office to assist in program engineering execution work.

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- Providing Independent Project Review of Gulf Coast refiner's proposed FCC flue gas and wet gas scrubbing modifications developed by third party/licensor.
- Providing materials engineering analytical chemistry support to chemical/corrosion inhibitor vendor for a client intending to process high acid crudes.
- Provided HAZOP training and support to a client in China.
- Completed limited FCC feed train safety study and provided recommendations.
- Provided process support and participation with licensor at meetings with Middle Eastern refiner regarding impacts of IGCC implementation.
- Provided consultation and study of overseas refiner's sour water storage facilities and provided recommendations.
- Providing technical consultation regarding client's review of third party intellectual property and proprietary catalyst benefits.
- Providing technical support to prepare a video tour of a client's proprietary pilot plant facilities.
- Carried out Coker CO Boiler study for installation of a new Economizer for a US refiner. The available options were examined and evaluated in detail to recommend a new design.
- At the conclusion of review of eleven (11) critical heater designs and operations for a West-European client, general consulting continued in the area of materials and study of potential hot spots in radiant section tubes of selected heaters.
- Numerous FCC unit refractory problems were attended to for a major domestic refiner with multiple refineries throughout summer and fall seasons. These activities had to do with attending to emergency shutdowns caused by refractory problems as well as turnaround planning for FCC units after a busy summer.
- Corrosion Mitigation Guidelines were developed for a domestic oil company for the FCC plants at multiple locations. The work involved complete investigation of the plant inspection reports and plant geometry to determine and highlight the state of corrosion in various process areas of the plant in detail.
- Continued to provide long term resident engineering support in the areas of cost estimation, procurement and construction management to a major grassroots petrochemical undertaking in the Far East.
- Concluded Phase 3 of a major RBI (Risk Based Inspection) assessment activity for a major, domestic chemical plant that resulted in significant manpower and cost savings for the client.
- Reviewed the Materials Requisition documents prepared by multiple EPC contractors for machinery and air cooler equipment for potential omission of significant requirements for a European refiner's major upgrading project. Related to the same project, a separate FFS (Fitness for Service) evaluation project for towers and a fired heater is progressing.
- Assisted a major European refiner with a study of seven (7) major heaters from the point of view of efficiency improvement via better control of combustion parameters, as well as potential investment in equipment such as air preheaters, etc. The heaters were also examined from the points of view of combustion box steel casing corrosion and cracking that might be responsible for significant air leakage.
- Assisted a Canadian refiner in reviewing crane usage manual for a major multi-step move (in parts) of a large crude distillation tower during a revamp project. A number of issues related to crane usage safety were summarized in the final report.