DCU Commissioning and Start-Up Key Considerations

REFCOMM ROTTERDAM
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Discussion Points:

Purpose: Review important considerations when moving from mechanical completion to commissioning to start-up to full unit rate. Provide pluses and minuses of various options and strategies, with examples

The following topics will be addressed:

- EPC (Engineering-Procurement-Construction) Contract Structure
  - "Lump Sum" or "Time & Material"
- Properly defining Mechanical Completion
  - One size does not fit all – Specialty equipment and new technologies have unique requirements
- Commissioning Strategies for Various System Types
- Air-Free, Pressure Test (AFPT); Hydrocarbon Introduction, Heat-Up, Resid Introduction and Coking
- Learnings with Examples

DCU EPC Contract Structure – Lump Sum:

- All EPC activities are regulated with a total fixed price agreement
  - Such a contract is favored on grassroots projects that typically have a clear scope, few unknowns and a defined schedule
  - Pre-Contract - A lot of work & understanding required for the Owner & EPC Contractor
    - Engineering Standards & Site-specific facilities requirements must be clearly established
    - Qualified vendors/subs for all equipment manufacturer / purchase must be negotiated
    - Labor contracts, with all wage rates / working schedules, established with various trade companies
  - Post-Contract – Much less work for the Owner; much more difficult for the EPC Contractor
- Advantages:
  - Great control of capital and EAWC (Expense Associated with Cap) costs
  - The owner gets exactly what he/she requested
- Disadvantages:
  - Contractor ultimately has control of schedule
  - Labor Productivity and effects on Schedule become bigger risk factors
  - All items with no quality standard will be “low-quality” since the contractor is always minimizing cost within the confines of the contract
  - Conflicts between standards will almost always be resolved by selecting lowest cost option
  - Any change (addition or upgrade) comes at a high price

DCU EPC Contract Structure – Time & Material with Cost Cap:

- Engineering & Labor rates are established. Scope is not completely known, but a schedule is created based on knowns with place holders for potential unknowns
  - Used for retrofit (aka Debottleneck) jobs involving a lot of unknowns (old equipment replacement, underground excavation) that can increase project cost significantly
  - Pre-Contract - Less work & understanding required for the Owner & Contractor
    - Engineering Standards & Site-specific facilities, as with Lump Sum
    - Qualified contractors, as with Lump Sum
    - Labor sources are identified, but skill level & final labor rates can be negotiated
  - Post-Contract – Both Owner and Contractor are working hard together
- Advantages:
  - Engenders Team Approach between Owner and Contractor
  - Owner more involved in project strategy, allowing trade-offs on timing and project cost
  - Productivity versus labor rate can be negotiable, if markets change
- Disadvantages:
  - Negotiated rate for discovery items can be significant
  - Final cost & schedule can be significantly higher than forecast

DCU EPC Strategies to Consider:

Modular Construction

- Can be used as part of all contract structures
  - Fixed price quote, since scope is completely set by the blue prints up front
  - Delivery time (i.e., project schedule) is accurate, since the “mod yard” has a known track record regarding productivity.
    - Weather is much less of a factor given that the “mod yard” has in-door shop facilities, and the facilities are typically located in nice climate areas, such as the Mediterranean Sea
    - Safety Risk to workers is reduced
    - Labor productivity is well understood
    - Construction equipment and materials staging is understood (no competition with other areas)
  - Ultimately a cost and schedule analysis is needed comparing onsite and mod yard.

Make Safety Number 1 in the Correct Way

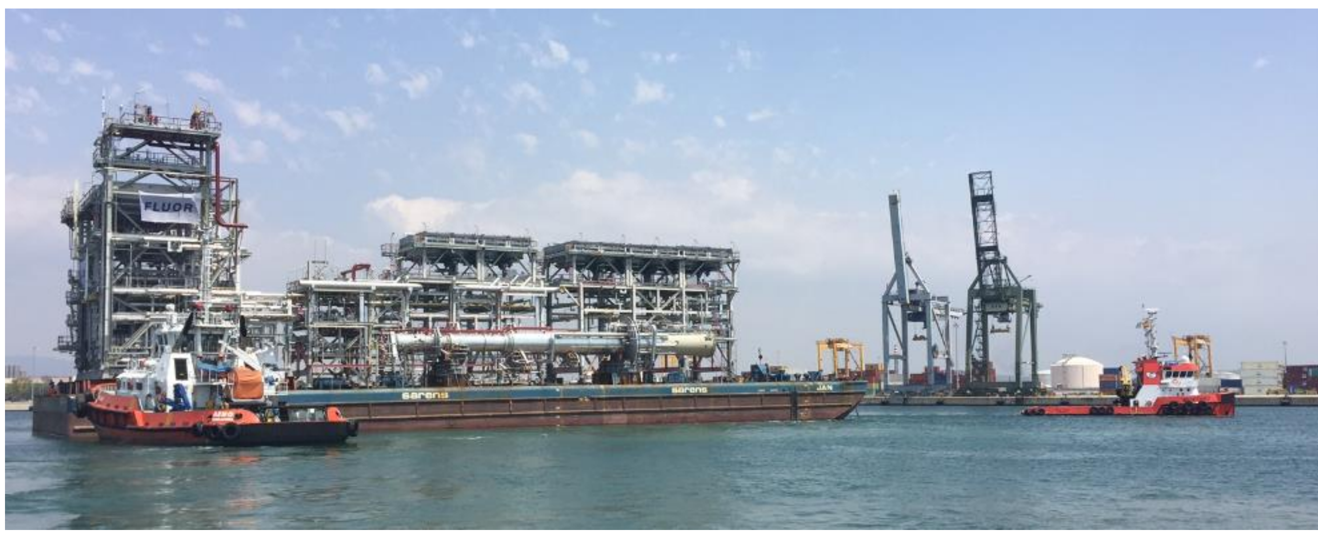
- On-Board and Train day-1 to Set the Culture & Expectations for All
  - Set the standards, make them reasonable, and kindly enforce them
  - Know your worker’s experience level and manage it

Bring the Plan and Schedule to Each Work Team Each Work Day

- Communication at the start of the day is key – Reinforce Basic Principles, Set Objective for the team (all planned at the end of the previous day) => Ideally in their Work Area

DCU EPC Strategies to Consider:

Modular Construction



DCU EPC Strategies Suggestions:

How should the Progression of MC -> Commissioning -> SU Proceed?

- The EPC job is NOT to just complete the construction, handover and get out of the way.
- The owner, contractor and workers must be committed to the same end goal –

  Successful, Safe, On-Time Start-up of the Delayed Coker !

  - Creating an incentive for all workers, even those that leave in the middle of the project, to meet this goal should be implemented.
  - You have to overcome the worker's incentive to stay on the job site, especially in poor economic times.
- Hand-over and commissioning activities need to be well planned and choreographed. The method and particulars for each system need to be well delineated in the contract.
  - I have never been on a DCU EPC project that did not overlap mechanical completion activities, system commissioning and start-up. This must be expected and planned.
  - Handover of generic DCU systems typically goes well. *However, specialty equipment handover can sometimes fall through the cracks. A plan, checklist, & proper ownership sign-off on both sides are essential.*
  - I have never been on a DCU EPC project that did not have last minute equipment issues during commissioning and start-up. This is unpredictable, but must be expected, with a place holder in the plan.

Progression of MC -> Commissioning -> SU:

- Enlist the most experienced Operations/Technical talent that you can for the SU Team
  - This will pay dividends with cleaner systems to SU and better troubleshooting during SU
- Commissioning systems during construction means just that – DCU equipment operations are occurring simultaneously with ongoing construction
- Start-Up Team can perform commissioning of "low risk" systems during "B" shift from 16.00 to midnight
  - Manage (aka avoid) risk to construction workers
  - If construction activities are occurring, water system work can be coordinated such that construction work occurs in unrelated areas
  - These low-risk systems can be shutdown to allow construction activities, if needed
- Key enablers of Commissioning/Construction Overlap:
  - Proper shift-by-shift communication between SU Team and Construction Team
  - Proper signage and zone demarcation barriers (tape or more) & protocols in the field

    => Difficult to manage since barriers and signage must be properly installed & removed

    => Proper tagging of live equipment, typically valves, is an absolute key

      - Best idea is to use a special **unique color** to designate 'in service' piping and valves
      - "LIVE EQUIPMENT – IN SERVICE - Do Not operate"
      - If necessary, in several languages

Progression of MC -> Commissioning -> SU:

- Get all the easy, safe (for construction workers) systems done early
  - All water systems can be tested & commissioned:
    - Firewater System
    - Tempered Water System
    - Cooling Water System
    - Quench Water System
    - Watery Sludge System
    - Coker Blowdown Water System
    - Cutting Water System
    - Coker Water System
    - Sour Water System (using plant water)
  - Air Systems – Plant and Instrument
  - Flare System
    - Typically is an isolated system outside of DCU battery limits
  - Nitrogen System
    - Carries more risk due to asphyxiation possibilities in confined spaces, so must be properly timed and managed

Water System Specifics

- Firewater System
  - This is usually priority one for obvious reasons; earlier, the better
  - It consists of underground piping in the first stages of the project & is great to have as project proceeds
- Tempered Water System
  - Typically used for heavy oil cooling
    - ✓ Seal Oil Coolers, Lube Oil Coolers, High Pour Pt Liquid Sample Coolers
  - Upgraders that produce "Synthetic Crude Oil" often have to cool the product prior to storage for vapor pressure and safe transport reasons
  - The System recirculates through coolers and a drum (which is designed to remove oil from the recirculating system that may arise due to leaks
- Cooling Water System
  - Can range from cooling tower based, to once-through sea/river water, to not being used (just air fin fan cooling)
- Quench Water System
  - This system typically consists of tank, pumps, spillback controls & flow control to each coke drum pair
  - The spillback operation can be established
  - However, flow to the coke drums can be constrained by the availability of the coke drums and coker water return system (coke pad, coke pit, coke sluiceway or coke slurry system)

Water System Specifics (cont'd)

- Watery Sludge System
  - Most Delayed Cokers have this as part of their design.
    - ✓ API Separator Sludge, DAF Sludge and BIOX Sludge (aerobic with low residence time) are recycled to the DCU
  - This system is typically NOT commissioned until after DCU start-up, since it is not possible to flow through the coke drum. Of course, plant water can be used to validate flow paths, pumps and cv's
- Coker Blowdown Water System
  - This system handles the steam evolution during coke bed cooling, condensing the steam in air fins, separating the oil and gas and generating sour water
  - Dispositions for this water:
    1) The refinery sour water system (tank and/or Sour Water Stripper feed drum) – most typical
    2) Recycle to the DCU quench/cutting water system – much less typical
    3) Recycle as desuperheater coolant for the hot coke drum vapors entering blowdown contactor
  - Normally a pump spillback flow control is used - water rates covers a wide range.
  - In the least, the spillback system can be commissioned; and the desuperheater flow can be checked.
  - At most, the entire system can be placed in service early… depending on circumstances.

Water System Specifics (cont'd)

- Cutting Water System
  - Typically consists of one jet cutting water pump (but can have two), a cutting water control valve, piping to the coke drum and back to the water tank, which is usually used for quench and cutting water.
    - Early commissioning of this system is extremely desirable to ensure this important equipment is ready to go, it consists of a very large motor, PLC, EHMS and lube oil skid
    - PLUS the sooner the coke cutters can be trained, the better

      => given today's advanced technology, if possible, perform a simulated coke cut…. but there is nothing like the real thing
    - Most coke cutters get most of their training on-the-job ☺ … Why?

      => It is very difficult to complete the cutting water pump, water flow control valve and coke cutting equipment early enough; plus the flow rate is 1200 gpm into the coker water system, which must be ready; plus this is a very high pressure system (up to 4500 psig or 300 barg), meaning workers must be cleared from the risk areas

      => DCU's with pits and pads use that area as a staging area, laydown area and construction elevator location, which is not demobilized until near the end.
    - The tank may have an agitation and drain system (manual or automatic) to handle coke fines

      => Again, pit and pad availability is a constraint

Water System Specifics (cont'd)

- Coker Water System
  - There are four fundamental system types:
    1) Pit and Fines settling (which can have 1 set of pumps or 2 sets of pumps)
    2) Pad with fines settling lane
    3) Sluiceway (crusher to sluice [sluice pump] to Hydrobins to tank, with clarifier purge)
    4) Slurry System (e.g., Triplan) with water-coke separation and peripheral water pumps
  - System should be commissioned early, given that it is integral to the coke cutting system.
  - Cutting water system availability is not needed to commission the equipment. The systems can be run on recirculation with proper control/oversight.
- DCU Sour Water (SW) System (using plant water)
  - Sour water is generated in the Main Fractionator (MF), Wet Gas Compressor (WGC) Train & Gas Plant.
    - MF SW is typically recycled back to the inlet of the Condensers.
    - WGC train SW is typically pressurized back to the inlet of the overhead drum.
  - The MF SW pump can be commissioned with plant water early on.
  - Establishing WGC SW flows has to wait until start-up, though hydrotests and flushing of the piping and valves are done as part of system handover.

Progression of MC -> Commissioning -> SU:

What other systems can be commissioned early?

- Plant Air and Instrument Air
- Nitrogen
  - Pressurization of this system must be done with proper communication, and must be done in close concert with the construction team.
  - Tagging, signage and even locking of valves (on a risk mitigation basis) should be done and controlled by the Start-Up Team
  - Use of nitrogen from the process system for construction activities is typically prohibited, and would only be done on a special "permit basis."
- Flare Relief System
  - Obviously needed once pressure relief is required as part of commissioning
  - In my experience, three coker start-ups had their own dedicated flare system, and two others were connected to the plant flare system.
  - In all cases, the flare system was ready in advance of DCU and was not a bottleneck to SU.
  - Ultimately this system can process two fundamental streams -
    - ✓ Water-laden oil stream drains
    - ✓ Gas purges and pressure relief flows
- MEA Piping should be degreased, but not commissioned
  - More than just water washing should be done to remove oils that could cause foaming

Steam Systems Commissioning?

- This is a big step in the SU timeline since it is the first introduction of a high temperature fluid to the construction injury risk matrix
  - Almost always done concurrently with construction activities, since piping insulation and tracing work often lags until the end
  - Pressurization of these systems must be done with proper communication, and should only be done in close concert with the construction team.
  - Tagging, signage and even locking of valves (on a risk mitigation basis) should be done and controlled by the Start-Up Team

  Re-Stated: Use special **unique color** to designate 'in service' piping and valves
  Valve Tags => "LIVE EQUIPMENT – IN SERVICE - Do Not operate"
  If necessary, in several languages
- Typically several systems – High Pressure, Medium Pressure, Low Pressure and Condensate
  - Strategy on order of commissioning is a function of equipment commissioning seriatum
  - Have steam blowdown, steam exhaust drums and condensate collection systems in service early to avoid creating steam clouds during construction and SU
  - Often steam tracing on heavy oil lines is not commissioned until introduction of heavy oils since insulation work lags until the end, meaning leaks are likely and the SU team should be prepared for that

Air Freeing & Pressure Testing (AFPT) of DCU Systems

- Prior to introducing hydrocarbons, oxygen concentration must be lowered so that the system is below LEL (Lower Explosive Limit) on introduction of hydrocarbon.
- The standard for decades was to steam the equipment with vents and drains open in the various systems, raising and lowering pressure to reduce the air concentration below the plant's minimum criteria. Several key disadvantages:
  - ✓ Steam condenses & must subsequently be removed by oil flushing, creating wet slop oil
  - ✓ Water removal not always complete, requiring slow heat up to avoid explosive water-to-steam surges that damage equipment internals and cause a flare release
  - ✓ There is a risk of vacuum when the steam condenses, if system components are blocked in
  - ✓ Several days are required to complete this "dewatering" process
- The best approach is to strategically use nitrogen gas in appropriate systems:
  - ✓ Furnace (inlet and outlet piping up to switch valve), Main Fractionator & associated HC equipment, WGC and Gas Plant HC equipment
  - ✓ Many refiners shied away from using nitrogen given the perception that such operations created an asphyxiation risk, but that is only in confined spaces, which are not created by this procedure (air is 79% nitrogen and is not greatly altered should 100% N2 mix with it in the open air)
  - ✓ N2 pressure in a given system is raised/lowered three times
  - ✓ Significant dewatering can be accomplished at the same time.

AFPT of DCU Systems (cont'd)

Nitrogen for air freeing & pressure testing - Considerations

- ✓ Availability and Cost at the plant
  - In some plants, nitrogen distribution grids supplied by an outside contract supplier facility (Aire Liquide, Praxair, Air Products , etc.) are part of the infrastructure
  - Older plants may not have that capability, meaning trucks are required, which can be cost prohibitive.
- ✓ Typically cannot achieve a system pressure above 90 psig (6 barg), so further leak checks are needed in systems that increase to pressures above that when on oil
- ✓ Some systems require pressure relief protection in place to prevent accidental overpressure
- ✓ Water removal is not always complete, requiring a slow heat up of the system to avoid explosive water-to-steam surges that damage equipment internals and cause a flare release

Coke Drums, piping downstream of the switch valve, Coker Blowdown System Equipment can employ steam, but vacuum risk must always be managed.

An excellent approach to introducing nitrogen or steam to systems is to do so in series ,flow-wise from one equipment item to the next.

⇒ The advantage is that you can verify flow continuity

⇒ Why would flow continuity not exist? Because a construction blind was missed.

⇒ I have had this happen on two start-ups. In one case, the cost was millions of dollars, in another it was just thousands of dollars. In Argentina they called the blind "Oreja de Van Gogh" because the indicating tab had broken off. In Venezuela they called it "Mala Suerte" because it had been hidden by the thick insulation.

Hydrocarbon Introduction

- Next big step is introduction of fuel gas / natural gas to DCU Main Frac & Gas Plant
  - At this point, the DCU is nearing mechanical completion
    - Remaining work is typically insulation, clean-up and final work in the downstream coke handling area (coke conveyors, coke load out facilities), but hopefully not much !!
    - In my experience, I have often seen coke cutting equipment still being worked on….
  - Remaining non-essential construction work is deferred during this black-out period, where everything transitions from 'construction work permitting' to SU team 'process unit permitting'
  - All further construction work will be permitted using the normal live unit permit process
- If WGC testing has not been done, it will be done now (see next page)
- In the same timeframe, start-up naphtha is introduced and flushing oil is introduced into the various liquid flow circuits
  - This allows final dewatering checks and instrument calibrations for the many liquid flow circuits. Heaven forbid that you encounter a construction blind in a flow path !!
  - During this time period you will likely encounter equipment problems. The better the job done by the SU team regarding system handover, the less problems there will be.
    - Steam turbines can be very finicky
    - New instrumentation technology will be a slowdown item, since vendor support will be needed for final calibration & troubleshooting (site techs are on learning curve)

Gas Compressor Commissioning

- I have been involved with the commissioning and start-up of six major projects, four of which had large compressors or groups of compressors
  - A modular ("packaged") set of 3 large helical screw instrument air compressors
  - A group of reciprocating hydrogen gas compressors for a naphtha isomerization unit
  - A WGC (Wet Gas Compressor) for a DCU in Venezuela
  - A WGC (Wet Gas Compressor) for a DCU in Europe
- The first three all performed SAT run-in checks using air well in advance of the actual start-up and had no compressor related delays during the start-up sequence
  - There was a $2M/day incentive to start up the Ven DCU, so spending money to install temporary piping with suction screen and discharge silencer was well justified
  - The test was performed, piping checked , certified clean and system readied for SU
- The latter opted to wait, largely at the strong urging of the manufacturer, who only wanted to do the SAT on natural gas.
  - This added several days to planned SU timeline, during which problems were addressed
  - The system was then purged and shutdown to replace the temporary suction strainers with permanent strainers and then the system was restarted.
  - In reality, this added time did not translate into as many days of delay, since other issues were occurring in parallel with other systems of the DCU, which impeded progress…

Heat Up, Resid Introduction & Coking

- Once water levels are validated to be low, programmed heat-up occurs
  - The biggest concern is water-to-steam explosion and internals damage. Using nitrogen for AFPT and proper dry-out of steam are the key mitigations
  - The coker furnace is on total circulation and goes through staged heating to dry out castable refractory.
- Changeover from gas oil to vacuum resid is the next big step
  - Biggest concern is tripping the heater charge pump during this step and plugging equipment.
  - Trick is to reduce the MF inventory to minimum and quickly introduce resid, while purging gas oil through the coker blowdown system or to the refinery heavy slop system.
    - Criteria to determine when the changeover is complete – comparison of resid volume introduced to the system volume, and/or visual examination of the recirculating oil . The former is safer than the latter. Plus you should be able to see a calculated increase in the discharge pressure of the heater charge pump.
  - REPEAT - Often steam tracing on heavy oil lines is not commissioned until introduction of heavy oils since insulation work lags until the end, meaning leaks are likely and the SU team should be prepared for that

Learnings

- Close involvement of an experienced SU team with the Construction team during system handovers is absolutely essential to a successful SU
  - ✓ Ensuring that all pipes are properly water flushed during final hydrotesting
  - ✓ Flushing and handover will greatly reduce headaches and safety risks during commissioning.
- If interconnected and integrated process units (typically via heat exchangers) are being started up, it is important to have blinding points installed should one unit be in service before another.
- All large projects in my experience, started up later than planned
  - ✓ In 1982 the delay was a couple of months (on a clean naphtha unit with lots of new technology); but now can easily be one year
  - ✓ Positive Reason - Increased Safety Standards
  - ✓ Negative Reasons – less than planned labor productivity, labor strikes, construction errors, equipment fabrication errors, failure of high risk installations, engineering design errors, lack of qualified labor, errors in various stages of the project, equipment delivery delays (due to customs delays or manufacturer productivity), poor handover from project to SU team, design errors

Examples of things that went wrong

Design Errors that resulted in delays or problems:

- ✓ Restriction orifice sizing program was in error requiring replacement late in the schedule
- ✓ At reduced feed rates, the heater charge pump discharge pressure was higher the 450 psig velocity steam supply pressure. Fortunately, that steam came from a 600 psig letdown station. The control valve was bypassed, safely allowing the DCU HP steam grid pressure to be raised.
- ✓ Resid entering the system was 190 psig (13 barg) vs 150 psig (10 barg) expected. Natural gas purges on feed line instruments were 170 psig (11.6 barg), which allowed resid to back flow into instrument tubing and solidify.
  - Tubing was replaced on 4 instruments, and gas was replaced with HP steam and tracing installed.
- ✓ Proper access to high point vent and low point drain were not provided, requiring use of man-lifts and fall protection PPE during certain commissioning steps.

Examples of things that went wrong

Design Errors that resulted in delays or problems (cont'd):

- ✓ A crack occurred where an anchored 317LSS piping support was welded to the 90° elbow of one Diluent Recovery Unit furnace outlet (8 passes). The piping was thinner than normal due to low design pressure and low corrosion allowance, making the weldment high risk as the piping expanded from ambient to 740^{o}F (393^{o}C). Remedy – Eliminate the anchor from the support, monitor the piping (which now can oscillate) and redesign the piping support for installation at the next opportunity.

- ✓ Fuel gas MEA Contactor had high foaming at design rates. Following review, it was determined that the installed sieve holes were 0.5" diameter instead of 0.75". The number was not transcribed correctly from the basic engineering data sheet to the final detailed engineering sheet.

- ✓ 690^{o}F (366^{o}C) resid feed control valve station bypass not properly sized causing severe vibration

Examples of things that went wrong

Construction errors that resulted in delays:

- ✓ All DCU cooling water exchangers were found to be fouled with rust and scale while being stored outside ; the problem was discovered during commissioning when water rates and DP's were checked.
  - Proper storage indoors and/or proper isolation with plastic plugs would have prevented the problem
  - Also, it was discovered that the bleeder valves on the inlet and outlet of the water piping to the coolers were not installed and had been lost.
- ✓ Installation of incorrect metallurgies in the fractionating towers.
- ✓ Ultrasonic furnace flow meter was wired backwards, but plant I&E technicians were not trained.

Examples of things that went wrong

Fabrication errors that resulted in delays:

- ✓ 2-inch ball valves purchased for the structure valve spool steam and drains where determined to be inoperable, requiring the installation of high-pressure nitrogen actuators.
  - Even with those actuators the valves did not operate reliably
  - Cause was identified to be the use of inconsistent materials for the valve body, internals and shaft, which created thermal expansion issues and valve seizing.

- ✓ Large 30” MO gate valves in coke drum vapor service did not operate properly during final stroke checks; fabrication errors were found in all valve, which required last-minute shop repair.

- ✓ An inadequate weld on a 30” coke drum vapor line created a small leak at the cutting deck, requiring train circulation and repair.

Examples of things that went wrong

Construction-to-SU Team Handover errors that resulted in delays:

- ✓ Check Valves backwards
  - 20 years ago, the check valve position indicators and the protocols to verify position were not as good as today. Still it can happen if insulation covers them early in the construction phase.
  - Most experienced SU teams have this integrated into their system turnover list.
  - 20 years ago, a lot of the installation errors were not discovered until AFPT.
- ✓ High amounts of sediments, scale and trash in piping required frequent strainer cleanings, extending SU at least two days.
- ✓ Construction blind was left in a key preheat exchanger in an upstream unit, which was not placed into service until later in the DCU gas oil heat-up sequence. When placed in service, the DCU furnace tripped on low flow, signaling the problem. => 4 day delay (it happened Friday PM)

Examples of things that went wrong

Construction-to-SU Team Handover errors that resulted in delays:

- ✓ Construction blind was left in the blowdown settler gas outlet (Oreja de Van Gogh)
  => 2 day delay , since discovered during natural gas pressurization

- ✓ On the vapor valve deck, heavy plastic shields had been installed in the 30” vapor line piping to prevent objects from falling down into downstream equipment. These thick plastic shields were not removed and became wedged in the seats of two valves, preventing them from closing completely.

  The valves showed closed, but were not. 30” valves can pass significant flow at 99% closed, and position indicators are accurate to only +/-0.5 % at best. The plastic shield gave way in one valve, creating a very loud noise and was carried by the spool steam into the sister drum and out the bottom head. This resulted in a near miss incident.

- ✓ BUD spring hangers were not released as part of handover to the SU Team

Examples of things that went wrong

SU Team Error:

- ✓ During AFPT with steam in the winter, the rate of pressurization can be low. Remedy was to add supplemental nitrogen flow.

- ✓ Heat exchanger head channel gasket leaks (those seeing the highest gas oil temperature) occurred on two separate DCU SU's, delaying schedule.
  - At one DCU, there were too issues – 1) the hot oil was introduced to the steam generator before a BFW level was established, and 2) the gasket surface was damaged
  - Of note – Yes, the HX passed the 1.5xMAWP hydrotest, but the force on the bolts is much higher at normal operating pressure and normal operating temperature.

Progression of MC -> Commissioning -> SU:

Examples of things that went wrong

SU Team Error:

- ✓ During circulation of oil from the bottom of the MF to furnace to the coke drum vapor line to the MF flash zone, a field operator used the SP-5 steam-purged gate valve to throttle flow. When resid was introduced to the system, which went very smoothly on nights with no pump issues, the high pressure between the furnace and SPV-5 allowed the resid to push into the steam purge lines through the check valves and into the steam grid supplying the valve purge steam.
  - This caused a 3-day delay while the steam piping was cleaned.

- ✓ In a start-up I was not part of, velocity steam was introduced to the furnace purges during the early stage of oil circulation. The steam condensed in low pressure sections of the DCU (Main Frac overhead trays and Gas Plant) extending system dry out until it was removed from the furnaces.

- ✓ WGC filling started ahead of schedule, and a piping bleeder was open, allowing natural gas to leak to the atmosphere.

Examples of things that went wrong

SU Team Error: (cont'd)

- ✓ During initial stages of oil circulation and dewatering, the furnace pass flow control was very unsteady, which was attributed to plug-type control valve design. The position of the plug was change 180^{o} to see if that helped. As it turned out, water was likely flashing across the control valve and causing the problem.
- ✓ During initial stages of oil circulation and dewatering, the furnace pass flow control was very unsteady, which was attributed to plug-type control valve design. The position of the plug was change 180^{o} to see if that helped. As it turned out, water was likely flashing across the control valve and causing the problem.
- ✓ Poor level readings in the DeButanizer reflux drum, the MEA FG Absorber KO drum and the Fuel Gas KO drum, allowed foaming in the MEA tower to carry through into the fuel gas grid and trip the heavy oil furnaces.
- ✓ Following SU of both coking trains at 60% of rate, high MEA entrainment into the downstream KO Drum was noted. Coker wet gas was diverted to the flare, allowing changing of MEA rates, which allowed determination that the level was much higher than indicated due to plugged level taps (no blowbacks). Steam blowing the taps allowed the level to be brought into range.

Errors that did not delay SU:

- ✓ Late scope addition to the onsite project – coke crushing was added to the pad operation 6 months before SU. Crushing was to be done at the shipping terminal, but they eliminated it from their scope without telling the project.
- ✓ The sieve tray holes of the MEA absorber were 0.5" instead of 0.75". There was a hack in the final design spec sheets. The basic engineering package was correct.
- ✓ DCU furnace burner fuel gas tubes modified to allow passing of FAT light off test, but subsequently resulted in exposure to excess radiant heat
- ✓ Sundyne pumps used for LPG on the Debutanizer overhead (best pumps for low flow and high head) could not be put in service because they would trip on high amps
  - Night shift crew tried to use the discharge gate valve to control the high-speed pumps
  - The day crew worked with the console supervisor to use the control valve instead of the discharge gate valve to bring the pump on line.
  - No delay was incurred, just longer downgrade of the LPG to slop
- ✓ Hahn&Clay bottom deheader leaked 12 hrs after coking initiated
  - Remedies - thicker gasket, increased nitrogen pressure to the force-actuator bladder, re-torquing of bolts, and reinstallation of the force actuator bolts

Errors that did not delay SU (cont'd):

- ✓ Piping guides and stops for the transfer line from the furnace to the coke drums were all improperly designed and broke after SU. Remedy -
  - On-line replacement, taking advantage of coke drum cycles and furnace spalls
- ✓ Piping guides and stops for the cutting water piping up on the top deck improperly designed and broke after SU. Remedy -
  - On-line replacement, taking advantage of coke drum cycles
- ✓ Clean fin fans work too well in the winter
  - In one instance, gas hydrates formed in the fin fan tubes upstream of the Fractionating Absorber, causing a major tower upset. Remedy - Operating envelope adjusted to include minimum allowed temperature.
  - On another DCU where they used steam for AFPT, a significant amount was condensing in the air fin fan tubes. Remedy – Installed tarps on the fan bays during AFPT

Questions and Comments are Very Welcome

RefComm Rotterdam

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DCU Commissioning and Start-Up Key Considerations

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EPC Contract Structure – Cost Plus with Cap:

- Contractor is paid for all EPC related expenses plus an agreed-upon profit
  - Contractor cannot lose, unless penalties are negotiated relative to schedule
  - All costs are typically audited as part of the contract
  - Costs related to negligence or error are not typically paid
  - Scope & schedule are part of the contract, with cost cap and incentives/penalties often included
  - This type contract is used when a job is simply defined, but must happen quickly and no design or cost estimate is in place.
  - Preferred by government agencies , since contractor can be selected based on their qualification , and not based on low-bid
  - Also used for R&D work where a budget is set and controlled by the contracting officer.
- Advantages:
  - Can be used for smaller well-defined jobs with a known contractor (for example, tank demolition at the start of a project)
  - Requires regular supervision of the job site
  - Contractor can be replaced if under performing
- Disadvantages:
  - Relying on integrity of the contractor