CH402 Capstone Design Problem
Atmospheric Distillation of Crude Oil

Overall Project Objectives

1) Enhanced understanding of unit and process operations.
2) Understanding IT infrastructure in a process plant.
3) Understanding basic controller configuration and operations in a process plant.
4) Understanding and appreciation of piping and instrumentation diagrams (P&IDs).
5) Enhanced understanding of process economics.
6) Enhanced understanding of ChemCAD.
7) Development of communication ability.
8) Enhanced understanding of safety issues confronting process engineers.

Problem Background

Simulation Solutions, Inc. is a company located in Shrewsbury, NJ, that makes process simulators. A process simulator is a virtual chemical plant designed to assist companies in training plant operators, engineers, and supervisors. The software interface is a representation of the actual control room that allows changes in control variables and shows a readout of the responses. The result is a "live" simulation of the plant. The latest beta test version of the software is a virtual petroleum refinery. The program contains control room and outside operator views of the plant. Some additional information about Simulation Solutions, Inc. can be found at: http://www.simulation-solutions.com.

The particular refinery that was modeled by Simulation Solutions is located in Bakersfield, CA. Bakersfield is located at the southern end of the San Joaquin Valley in South Central California. Kern County is home to 18 giant oil fields that have produced more than 100 million barrels of oil each, including four "super giants" that have produced over one billion barrels of oil. According to the San Joaquin Geological Survey, approximately 31,000 oil wells have been drilled in the county and 10% of U.S. oil production comes from this region. The refinery is one of 14 in California that can make the gasoline and diesel that meet the state's environmental regulations, particularly for low sulfur diesel. The refinery previously experienced a series of accidents that led to an overhaul of the safety procedures and to an intensive revamping of the safety protocols in the plant, including training protocols using the Simulation Solutions plant simulators. The Bakersfield refinery was formerly owned by Kern Oil & Refining, and was sold in 2008 to Flying J. The refinery is currently scheduled for a series of upgrades and expansions that will essentially double its production. You can visit the refinery website and view live webcam images at: http://www.bigwestca.com/bigwest/appmanager/bwoc/home?_nfpb=true&_pageLabel=flyingjPortal_portal_page_18

The simulated plant you will be operating is very new, and you will be conducting a "full" start up and shakedown of the plant. *This includes possible revisions of the start-up procedures.* The experiences you will go through are very similar to the issues that engineers and operators face when they start up a real plant. You will be faced with unknown technical questions, as well as possible incomplete procedures and diagrams. Your mission in this assignment is to develop a safe working start up procedure that will be used by operator and engineer trainees in the field. You will be provided with old help menus as well as a preliminary start up procedure, but may need to make modifications as you work your way through the plant.

The time requirements for this project are extensive, but you will have 13 lessons as well as the intervening time to complete it. For example, a minimum of 4-5 hours of simulator time is required for one complete pass through the simulator by a trained operator, which translates to 10-15 hours of actual time for your first run. You will also need to run the simulation multiple times to develop and improve your procedure, but the actual time should decrease substantially as you figure out what you are doing.

You will also have access to a demo FCC unit in Bartlett Hall Room 415 to assist you in visualizing the process. *This is important.* You will need to look at this and study it in order to understand the FCCU simulator. You are also encouraged to make liberal use of the internet in researching the process. There are many good websites with detailed descriptions.

General Tasks in the Design Project (To be completed by the end of the project):

1) Research hydrocarbon cracking chemistry and be able to provide an informed discussion.
2) Research the cracking process and know the basic functions of the major units in the process.
3) Familiarize yourself with the simulation software operating under design conditions. Explore the controllers and understand how each controller responds to disturbances. You will be asked to provide an I/O and a functions diagram of the process.
4) Modify the cold start procedure (provided) so that it is updated and current with the new simulation software.
5) Provide inspection protocols, including a mapping and log sheets, for all sensor, valve, and switch locations for the outside operator.
6) Provide a detailed design of the fractionator column using ChemCAD, and be prepared to offer the Flying J Oil Company a price quote for a new fractionator column for the expansion, including all support equipment, piping, pumps, and heat exchangers.
7) In lessons 38 and 39, you will give a PowerPoint presentation to the class.
8) In lesson 40, you will also be required to submit a written, updated procedure that works. This will comprise the formal report portion of your grade. As part of this grade, you will also be required to submit an electronic copy of your working start-up log file.

Requirements and Guidance on Design Problems for IPR-1:

IPRs are meant to ensure that you are making satisfactory progress toward the completion of the main tasks outlined above. IPRs are during class time, either AM or PM, or by appointment with me. Class time is otherwise reserved for informal group meetings and for project work. You are <u>required</u> to do 4 IPRs at approximately one-week intervals. IPRs are informal desk-side briefings, but there are submission requirements. You will receive written guidance for each. Failure to execute an IPR will result in a grade of zero for that portion of the grade. There are no re-dos allowed on IPRs.

VERY IMPORTANT: You will use the results of each IPR to perform the next IPR. They are cumulative in nature. Save your requirements on files on your share drive so that I can inspect your progress independently. <u>Bottom line</u>: If you meet the requirements of the IPRs, your report performance and preparation will be dramatically improved, and your grade will be considerably higher at the end of the semester.

Submission for IPR 1:

1) Develop chemistry background, including 1 <u>finished</u> PowerPoint slide of the cracking reaction and mechanism. Use reputable literature references. Wikipedia is considered a minimal level of performance (think rubric). SRI, Kirk-Othmer, McKetta’s, and Ullman’s are considered authoritative sources. Read and discuss the process economics as a group. Use this information to define your problem.
2) Develop process engineering background. You will be required to submit 1 <u>finished</u> slide of the I/O diagram for the process and 1 <u>finished</u> slide of the functions diagram. Use Example 4-2 in the text as a guide. Meet as a group and discuss this. Recall that I/O diagrams must include feed, product, and utility costs!
3) Required definitions: light-cycle oil, heavy cycle oil, crude oil, naphtha, fluid catalytic cracking, atmospheric distillation, vacuum distillation. Provide these definitions in <u>finished</u> PowerPoint slides, one definition per slide.
4) Develop general economic background for the problem. Again use reputable literature references. Read and discuss the process economics as a group. Use this information to define your problem. Again, SRI, Kirk-Othmer, McKetta’s, and Ullman’s are considered authoritative.
5) Present evidence to your instructor that you have made some progress on the start-up procedure. Remember that I am looking for multiple iterations.

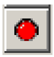
Grading:

The design project is worth 400 points out of 1700 in the course, or approximately 23.5% of your grade. The written report is due on lesson 40 and is worth 200 points. The oral reports will be during lessons 39 and 40, and will be worth 100 points. You are also responsible for four (4) weekly IPRs, each worth 25 points.

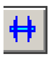
Simulator Instructions

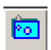
Important Buttons in the Simulator:

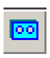
Run Process - starts the simulator; do this at the beginning of your work and after any time you press stop and then want to continue.

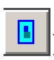
Freeze Process - stops the simulator; this is useful for taking notes in your written log without affecting your score.

 Load Store Initial Condition – allows user to load exercises, snapshots, backtrack, and initial conditions

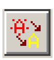
 Exercises – allows user to load previously stored exercises.

 Snapshot

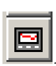
 Backtrack

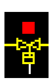
Pumps, valves, and switches - disabled

Audible alarm – disables the audio alarm so that you cannot hear it, but red process variable indicators will still flash.

 Acknowledge Alarm – turns off the alarm. The process variable will remain “red” until it moves within the alarm range.

 Alarm Silence – Silences alarm without deactivating it.

Advanced Trending – shows the time response of each process variable.

  Switches – little red or green boxes that allow you to switch a device on or off. The color of the switch indicates its current state. Red is off and green is on.

Process control variables – moving your mouse over the blue number and clicking it allows you to manipulate the variable.

Note: Process variables that can be manipulated are under control. That is, they have a “C” in their names, such as FIC201, LIC201, etc. Access the controls by moving the mouse over the numeric readout and clicking it. For example, FIC201 appears as above. This variable can be set either manually or automatically.

Cold-start Procedure:

(Provided by Simulation Solutions and to be modified by your group):

Start Cooling Services

The first item after checking completion of all precommissioning activities is to start cooling water to all cooling water exchangers and start all of the air coolers in the unit.

1) Open the block valve in the cooling water line upstream of the tube side of the atmospheric overhead trim cooler (E-10).
2) Start the fan motor on the atmospheric overhead air cooler (E-9) using the motor control (HS-100). It is assumed that cooling water to the diesel trim cooler (E-12) and power to the diesel air cooler (E-11) are already started.

Establish Natural Gas Blanket in Vessels

Natural gas is used to establish a slight positive pressure in the crude surge drum and the atmospheric tower, side strippers, and reflux drum prior to introduction of crude oil. Cold feed charged to equipment previously purged with steam can cause the steam to condense, creating a slight vacuum and allowing atmospheric air to enter the system. The natural gas blanket prevents this from occurring. Natural gas will enter the atmospheric tower and side strippers by flowing back through the system from the atmospheric overhead reflux drum (V-4).

1) Set the reflux drum pressure controller (PIC-102) to between 2 psig and 3 psig and the switch controller to the automatic mode. This will establish natural gas flow to the atmospheric tower reflux drum (V-4) and allow the gas to vent to flare. It is assumed that the natural gas blanket to the crude surge drum (V-5) has previously been commissioned and the pressure on this drum is set on automatic control at 30 psig.

Establish Liquid Level in Bottom of Atmospheric Tower (V-1)

In the actual plant, both light and heavy crude oil can be charged to the atmospheric crude unit. The unit should always be started from a cold start with light crude oil. Heavy crude is introduced only after the unit is lined out at design rate.

1) Open the bypass around the desalters (V-3 and S-1) and the crude booster pumps (P-2A & B). This is the line containing a block valve downstream of the shell side of the AGO versus crude exchanger (E-14) to the discharge of the crude booster pumps (P-2A & B).
2) Check that the block valve in the line leading from downstream of the AGO versus crude exchanger (E-14) to the desalters (V-3 and S-1) is closed.
3) Check that the flow control valve (FIC-130) in the bypass line around the crude oil versus atmospheric tower overhead exchanger (E-1) is closed.
4) Open the flow controller (FIC-129) in the line leading to the tube side of the crude oil versus atmospheric tower overhead exchanger (E-1) so the output is about 10%. Use the

flow control valve (FIC-129) to control the forward flow of crude after the crude charge pump (P-1A) is started.

5) Set the flow controllers (FIC-105A & B) in the lines feeding the two passes of the fired heater (H-1) at 8.250 MBPD. This is 50% of the design rate for the unit.
6) Set the master flow controller (FC-114) at 16.500 MBPD.
7) Start the crude charge pump (P-1A) using flow controller FIC-129 to control the flow at a slow forward pumping rate. In the actual plant there are four passes in the fired heater (H-1), but for simplification the simulator includes only two passes. The procedure for setting the flow is nevertheless the same for both the simulator and the plant.
8) After a normal level of about 50% is established in the bottom of the atmospheric crude tower as shown by the level controller (LIC-107), shut off the crude charge pump (P-1A0.

After the charge pump is shut down, the level in the bottom of the atmospheric tower will continue to rise and will eventually settle out at 65%. This is due to the liquid holdup in the heat train and fired heater. This high level is acceptable, since it will be reduced once recirculation is started and the fired heater is started up.

Establish Circulation through the Fired Heater

1) Bypass the vacuum unit by opening the block valve in the line from the discharge of the atmospheric residue pump (P-3A & 3B) to the vacuum heater. Opening the vacuum unit bypass valve accomplishes the following:

    a) Closes the block valve upstream of the tube side of the vacuum residue versus crude oil exchanger (E-8).

    b) Opens the block valve in the jumpover line from upstream of the tubeside of the vacuum residue versus crude oil exchanger (E-8) to downstream of the shell side of this exchanger.

    c) Opens the block valve in the atmospheric residue recirculation line leading from the downstream of the atmospheric residue pumps (P-3A & B) to the inlet of the tubeside of the vacuum residue versus crude oil exchanger (E-8).

2) Check that the block valve is closed in the line that admits vacuum residue from the vacuum unit to the tube side of the vacuum residue versus crude oil exchangers (E-8 and E-18).
3) Open the flow control valve (FIC-1102) in the line downstream of the atmospheric residue pumps to about 10% output, and leave on manual.
4) Start the reduced crude pump (p-3A) and begin pumping from the bottom of the atmospheric crude tower back through the discharge line from the atmospheric residue pumps to control the flow rate. As the recirculation system fills with oil, the level in the

bottom of the atmospheric tower will drop to between 35 and 40%, as shown by level controller (LIC-107).

5) Set the level controller (LIC-107) set point to 50% and switch the instrument to automatic.

6) Switch the flow controller (FIC-1102) to cascade. The level controller (LIC-107) will adjust the flow controller to maintain a stable level in the bottom of the atmospheric tower.

7) Allow the unit to stabilize before proceeding.

8) Restart the crude pump (P-1A) temporarily to bring in fresh crude to the atmospheric tower. Open the flow controllers (FIC-105A and 105B slightly to allow for the flow of fresh crude into the system. Shut this pump down and adjust the flow controllers (FIC-105A and 105B) to allow a flow of 8.200 MBPD to each pass of the heater as soon as the recirculation flow rate reaches about 16.000 MBPD.

<u>Start the Fired Heater</u>

Flush each pass of the fired heater (H-1) by closing one pass and forcing the maximum flow through the pass being flushed.

1) Open the flow controller (FIC-105A) to 100% and then close flow controller (FIC-105B to force all of the flow through one pass.

2) After a short period, open flow controller (FIC-105B) to 50%, and then close flow controller (FIC-105A) to 50%.

3) Follow the same procedure in flushing the other pass.

4) Reset both flow controllers at the heater inlet (FIC-105A & B) to 8.250 MBPD or about 50% of the design rate.

5) Check to see that the atmospheric tower overhead air cooler (E-9) has been started, and ensure that cooling water is flowing through the atmospheric tower overhead trim cooler (E-10). Set the output of the atmospheric tower overhead air cooler (E-9) fan pitch control to about 50%.

6) Purge the fireboxes of the fired heater (H-1), light the pilots and reset the low flow shutoffs (FSL-105A & B) to the off position using the bypass low flow heater shutdown (HS-105A).

7) Use the fuel selector switch (HS-101) to utilize gas as the startup fuel. Start the fired heater (H-1) on fuel gas only. Fuel oil can be used as a base load fuel if so desired after the unit is lined out at design rate.

8) Start the fired heater (H-1) on fuel gas using the fuel gas flow controller (FIC-106) to start the flow of gas to the burners. Open the flow control valve (FIC-106) to about 10%

initially and use the flow controller on manual to increase the fuel gas to the heater in order to raise the outlet temperature.

9) Raise the outlet temperature of the heater in 50oF increments until the outlet temperature reaches 250oF. In actual plant operation the increase in heater outlet temperature should be carried out at approximately 50oF per hour.

10) Maintain the heater outlet temperature at 250oF until it is certain that all water remaining in the tower has been vaporized. Since the removal of residual water is a field operation, it is not included in this simulation. However, in actual plant operation, the removal of residual water can be ascertained from the rate at which it is necessary to drain condensed water from the overhead reflux drum. When water is no longer accumulating in this drum, resume raising the heater outlet temperature in 50oF increments.

11) Continue raising the heater outlet temperature slowly until the temperature is at the normal operating temperature of 730oF.

12) As the heater outlet temperature is raised, the lighter fractions of the crude oil will start to vaporize and move up the tower. As a result, the level in the bottom of the atmospheric tower will begin to drop. The crude oil charge pump (P-1A) should be started periodically to maintain this level. When levels are established in the overhead reflux drum and side strippers, it will be necessary to restart the crude oil pump (P-1A) to replenish the supply of recirculating atmospheric residue. In addition, it is necessary to periodically blow down the material recirculated through the fired heater and atmospheric tower to minimize coking.

13) Close the vacuum unit bypass valve and allow the atmospheric residue pump (P-3A) to pump material out of the unit until the level in the atmospheric tower drops to about 10%.

14) Open the vacuum unit bypass valve and resume recirculation.

15) Open the flow control valves at the inlet to the fired heater (FIC-105A and 105B) to permit additional flow into the system.

16) Start the crude charge pump (P-1A) and allow the level in the atmospheric tower to built up to about 50%.

17) Shut down the crude charge pump (P-1A) and adjust the fired heater flow controllers (FIC-105A and 105B) to about 8.200 MBPD. Intermittent makeup will become more frequent and eventually a continuous makeup flow will be established as the startup progresses.

18) Discontinue manual control and place the heater outlet temperature on automatic control by adjusting the set point of the temperature controller (TIC-101) to 730oF and switching the instrument to automatic. Switch the fuel gas flow controller (FIC-106) to cascade. The temperature controller (TIC-101) will reset the gas flow controller (FIC-106) to maintain the heater outlet temperature.

Establish Liquid Level in Overhead Reflux Drum (V-4)

1) As the heater outlet temperature is raised, liquid will begin to accumulate in the overhead reflux drum (V-4). Check the liquid level (V-4) using the level controller (LIC-101). It will take some time to establish a liquid level in the overhead reflux drum (V-4). Use this time to blow down some of the atmospheric residue and replace it with fresh crude. Follow the procedure described previously in the "Start the Fired Heater" section.
2) When the level in this drum reaches 50%, as shown by the level controller (LIC-101), start the naphtha product pump (P-6A).
3) Use the naphtha flow controller (FIC-100) to control the flow rate and maintain a normal level in the overhead reflux drum (V-4).
4) Commission the overhead reflux drum level controller (LIC-101) by adjusting the set point to 50% and switching the instrument to automatic. Switch the flow controller (FIC-100) to cascade. The level controller will reset the naphtha flow controller (FIC-100) to maintain a normal level in this vessel. It is assumed that the debutanizer is started simultaneously and is capable of accepting unstabilized naphtha from the overhead of the crude tower. In actual plant operation this is an important point since it is not possible to slop unstabilized naphtha. It must be debutanized before being sent to storage.

Establish Liquid Levels on Atmospheric Tower Trays and Draw Pans

1) After a stable level is established in the atmospheric tower overhead reflux drum (V-4) and the level controller (LIC-101) is on automatic, start the atmospheric tower reflux pump (P-5A).

2) Use the reflux flow controller (FIC-101) to control the flow rate to the tower.

3) Continue pumping reflux to the atmospheric crude tower using the reflux flow controller (FIC-101) on manual control until there is a liquid level on all of the draw pans in the tower. In the actual plant there are level indicators on the overflash draw pan (LI-112 and LI-113) and a flow indicator on the overflash flow (FI-121). When these level instruments show a level indication on the draw tray and the flow indicator shows a flow of overflash liquid, the atmospheric tower will have liquid traffic on all of its trays. Remember that initially this liquid contains unstabilized naphtha and thus can't be sent to slop.

1) When liquid levels are established throughout the atmospheric crude tower, set the overhead temperature controller (TIC-102) at its specified temperature of 277oF. Switch the temperature controller (TIC-102) to automatic and switch the reflux flow controller (FIC-101) to cascade. The temperature controller (TIC-102) will reset the reflux flow controller (FIC-101) to maintain the top tower temperature.

2) Allow the temperature profile in the atmospheric crude tower to stabilize before proceeding with the next step in the startup.

Establish Liquid Levels in Product Strippers (V-2A and V-2B)

In the actual plant, it will be necessary to check that all product cooling exchangers are in service, including those which may be within another process unit such as the vacuum unit.

1) Open the manual controller (HC-101) in the line from the atmospheric tower to diesel stripper (V-2A) by setting the output to about 10%, and allow flow of liquid from the atmospheric tower to the diesel stripper and establish a liquid level in the stripper.
2) When there is a normal liquid level in the diesel stripper (V-2A), start the diesel product pump (P-8A) and control the level using the diesel flow controller (FIC-102).
3) Adjust the set point of the diesel level controller (LIC-108) to 50% and switch the instrument to automatic. Switch the flow controller (FIC-102) to cascade. The level controller (LIC-108) will reset the diesel flow controller (FIC-102) to maintain a normal level in the bottom of the stripper.
4) Continue to pump the diesel product to storage.
5) Open the manual control valve (HC-102) on the inlet line to the AGO stripper (V-2B) by setting the output to about 15% and allow a level of liquid to build up in the bottom of this tower.
6) When a normal level is established in the AGO stripper (V-2B), start the AGO product pump (P-7A) and pump AGO product to storage using the AGO flow controller (FIC-113) to control the level in the stripper.
7) Set the AGO level controller (LIC-109) at 50% and switch the instrument to automatic. Switch the flow controller (FIC-113) to cascade. The level controller will reset the AGO product flow controller (FIC-113) and maintain a normal level in the vessel.
8) Continue to pump the AGO product to storage.
9) Since material is now being removed from the atmospheric crude unit by the naphtha product pump, diesel product pump and AGO product pump, the level in the bottom of the atmospheric tower will begin to fall. Start the crude pump (P-1A) as necessary to make up for the material being pumped from the unit and maintain a normal level in the bottom of the atmospheric tower. Follow the procedure described in the "Start the Fired Heater" section to control the unit while bringing in fresh crude. In the actual plant, alternate rundown lines to the slop tank are provided for the diesel and AGO products. Initially both products are pumped to slop until the unit is brought on-line and products are on specification. Once the products are on specification, they are diverted to product storage.

Start the Pumparound Reflux Circuits

1) Open the block valve upstream of the shell side of the HVGO versus crude exchanger (E-15).

1) Set the mid-pumparound flow controller (FIC-104) at 6.625 MBPD. This is about 50% of design rate.

2) Start the mid-pumparound pump (P-9A) and establish flow through the mid-pumparound circuit.

3) Allow temperatures in the mid-pumparound circuit, crude oil, and atmospheric tower to stabilize before proceeding with the next step of the startup.

4) Set the bottom pumparoumd flow controller (FIC-108) at 7.530 MBPD. This is about 50% of design rate.

5) Start the bottom pumparound pump (P-10) and establish flow through the bottom pumparound circuit.

6) Allow temperatures in the bottom pumparound circuit, crude oil and atmospheric tower to stabilize.

7) Switch the pumparound flow controllers (FIC-104 and FIC-108) to automatic and allow the temperature profile in the atmospheric tower to stabilize.

8) Open the block valve upstream of the shell side of the HVGO product exchanger (E-3).

9) Slowly open the flow controller (FIC-130) in the bypass around the atmospheric tower overhead exchanger (E-1) until there is a flow rate of .750 MBPD through the bypass.

10) Switch the exchanger bypass flow controller m(FIC-130) to automatic.

11) Continue using the crude flow controller (FIC-129) on manual to control the flow of crude oil to the atmospheric tower.

Steam Stripping

Steam used for stripping in all three towers is superheated in the steam superheating coil in the convection section of the atmospheric unit fired heater. This coil is not included in the simulator, however, in actual practice, only this source of steam is to be used for steam stripping. Under no circumstances should saturated steam be used for stripping.

Several precautionary measures should be taken before introducing stripping steam into the atmospheric towers or strippers. Check to make certain that the sour water system is available to accept condensate from the overhead of the atmospheric unit. Introduction of the steam will cause sour condensate to accumulate in the overhead reflux drum.

Vent the stripping steam to the atmosphere from each of the lines leading to the towers, until all traces of water are blown out and it is certain that the steam and the lines are dry. Introduction of wet steam into these towers can produce catastrophic results.

Be careful to control the levels in each of the towers as steam is added because introduction of steam into liquid can cause tray damage.

1) Begin stripping by slowly adding a small amount of steam to the bottom of the atmospheric tower using the stripping steam flow controller (FIC-109).
2) Slowly bring the stripping steam up to 4.000 MPPH (approximately 50% of design rate) and allow the flash zone temperature to stabilize. The flash zone temperature is shown by temperature indicator TI-1003.
3) Admit stripping steam to the AGO stripper using stripping steam flow controller (FIC-112) following the same procedure as described for the atmospheric tower. Slowly bring the flow rate of steam up to .250 MPPH.
4) Follow the same procedure for the diesel stripper using stripping steam flow controller (FIC-111). Slowly bring the steam flow rate up to 1.400 MPPH.
5) Watch the level in the boot of the atmospheric tower overhead reflux drum (V-4). When an interface level develops, line up the flow to the sour water system and start the sour water pump (P-4).
6) Set the interface level controller (LIC-102), allow the flow and level to stabilize, and then switch to the automatic mode.

<u>Line out the Unit at 50% of Design Rate</u>

Crude oil has been intermittently brought into the tower through the heater as needed to maintain levels in the vessels and maintain a material balance. In addition, a periodic "blowdown" of residue to slop is required to prevent coking in the fired heater and atmospheric tower flash zone.

However, now that the distillate products are being pumped to storage, the crude charge pump should be running on a continuous basis.

1) Set the desalter pressure controller (PIC-108) set point at 150 psig.
2) Open the block valve in the line leading from downstream of the AGO product versus crude exchanger (E-14) to the desalters (V-3 and S-1). Leave the block valve open in the bypass from downstream of the AGO product versus crude exchanger (E-14) to the discharge of the crude booster pumps (P-2A and P-2B) until the desalters are filled.
3) Use the flow controllers in the inlet to the fired heater (FIC-105A and 105B) to throttle the flow of crude oil to the heater and thus increase the filling rate of the desalters.
4) Allow the desalters outlet pressure to increase to 150 psig.

5) Start the crude booster pump (P-2A).

6) Close the block valve in the bypass from downstream of the AGO product versus crude exchanger (E-14) to the discharge of the crude booster pumps (P-2A and P-2B).

7) The desalter outlet pressure will drop initially and then slowly increase back to 150 psig. Open the crude flow controller (FIC-129) slightly to increase the pressure recovery in the desalters at a faster rate.

8) When the desalter outlet pressure reaches 150 psig, switch the desalter pressure controller (PIC-108) to automatic.

9) Switch the crude flow controller (FIC-129) to cascade. The desalter pressure controller (PIC-108) will adjust the crude flow controller (FIC-129) to maintain a constant pressure of 150 psig at the desalter outlet.

10) Set the flow controller (FIC-132) to 50% upstream of the desalters (V-3 and S-1) and switch to automatic.

11) Allow temperatures, pressure and flows to stabilize before proceeding.

12) Start flow from the vacuum unit through the vacuum residue cooler (E-8) by opening the vacuum residue to crude exchanger valve.

13) Slowly open the flow controller (FIC-138) to 50% output to increase the flow rate of vacuum residue to about 2.350 MBPD (about 50% of design rate). After the fired heater fuel gas firing controls stabilize, switch to automatic control.

14) Allow temperatures to stabilize before processing.

15) Set the master crude flow controller (FIC-114) at 16.500 MBPD and switch to automatic control. Switch the fired heater flow controllers (FIC-105A and 105B) to cascade. The master controller (FIC-114) resets the flow controllers (FIC-105A and FIC-105B) at the inlet to the fired heater (H-1) so that equal flows will be maintained through each pass of the heater.

Meet Product Specifications and Route Products to Storage

There are three specification products produced in the atmospheric crude unit. They are unstabilized naphtha, diesel oil, and atmospheric gas oil (AGO). Atmospheric residue is further processed in the vacuum unit and off-gas from the overhead of the tower is further processed for use as fuel gas in the refinery.

On-line analyzers are provided to check the most important specifications for naphtha, diesel, and AGO. Naphtha is checked for initial boiling point temperature and 90% point, diesel is checked for 5% point and 90% point, and AGO is checked for 10% point.

Adjustments are made in product draw rates and stripping steam to achieve these specifications. In general, draw rate affects endpoint and stripping steam and affects initial point. However, it is important to recognize that the specifications and adjustments are interrelated and that a change in one will produce changes in other specifications of the same product, as well as changes in other products. Therefore, small adjustments are made to move towards on one product, similar adjustments are made on the adjacent product, specifications are checked using the on-line analyzers and the process is repeated until all products are within specification. Naphtha product draw rate can be changed in several ways.

1) Changing the top tower temperature by varying reflux,
2) Changing the temperature in the overhead drum by varying the amount of overhead cooling.
3) Changing the pressure in the overhead drum. Normally small adjustments to meet product specifications are achieved by varying the amount of reflux and thus top tower temperature.

Draw rates of the diesel and AGO products are varied by changing the quantity of liquid drawn off the atmospheric tower to the strippers. This is accomplished using the manual control valves (HC-101) and (HC-102).

Increasing the quantity of steam to the strippers increases the initial 5% and 10% points. Decreasing the quantity of stripping steam will lower these temperatures. Increasing draw rate will increase the endpoint and 90% point. Decreasing the draw rate will lower these temperatures.

1) Start the atmospheric tower overhead compressor and allow the compressor to accept the off-gas from the overhead reflux drum (V-4).
2) Check the analysis of naphtha to the debutanizer using the on-line analyzer (AI-101) to check the endpoint.
3) Make the necessary adjustments to bring the endpoint to 400oF.
4) Check the analysis of the diesel oil product using the on-line analyzer (AI-102) to check the 90% point and analyzer (AI-103) to check the 5% point.
5) Make the necessary adjustments to move the 5% point to 410oF and the endpoint to 580oF.
6) Check the 10% point of the AGO product with the on-line analyzer (AI-104).
7) Make adjustments to move the 10% point of the AGO product toward 620oF.
8) Check the specifications of the naphtha and diesel products. Repeat the procedure until all three products are within specifications. In the actual plant, the diesel AGO, and atmospheric residue are routed to slop tankage until all specifications are met. Once the adjustments are complete and all products are on specification, they are switched from slop to product tankage.

Once all distillate products are on specification and routed to product tankage, the atmospheric residue can be diverted from slop to the vacuum unit. Initial boiling point can be adjusted by changing stripping steam. Endpoint is adjusted by changing the product draw rates.

Start Desalters

1) Watch for the temperature of the crude oil into the desalters to stabilize at 311oF. Temperature indicator(TI-180) at the outlet of exchanger E-14 can be used to check this operating temperature.

2) When the operating temperature reaches 311oF, start the desalter water injection pumps (P-11A and P-11B) and begin injecting water using the flow controllers (FIC-103 and FIC-133) at about 5% of the crude oil flow rate of .400 MBPD for each desalter.

3) When the interface level is at 15% in each desalter, as shown by the level controllers (LIC-103 and LIC-161), switch the instruments to automatic. In the actual plant, the startup and initial operation of the desalters is a rather involved and time consuming process. It generally takes from 6 to 12 hours to bring the units on-line, establishing a water-oil interface, sampling the treated crude oil and making the necessary adjustments to achieve stable operation. Optimum desalting usually requires 2 to 3 days of adjustment, analysis, and readjustment. It is for this reason that startup of the desalters is reserved for last.

Bring the Unit up to Design Rate

1) Increase the feed rate in increments so that complete control of the unit is maintained. Start by increasing the flow controller at the inlet to the desalters by a specific amount.

2) Increase the set point of the flow controllers upstream of the fired heater (FIC-105A and FIC-105B) by the same amount.

3) Adjust the set point of the flow controllers on the water injection to the desalters (FIC-103 and FIC-133) to maintain a ratio of 5% of crude oil flow.

4) Adjust the flow rate of vacuum residue to the residue coolers upsteam of the fired heater to account for the increase in crude oil flow rate and allow the heater to stabilize.

5) Increase the diesel and AGO pumparound flow rates as well as the set points of all product rundown flow controllers to accommodate the increase in crude oil charge rate. Note that stripping steam rates do not have to be increased for each increment in crude oil charge, but may have to be adjusted upward as design rate is approached.

6) After each increase in charge rate, allow the unit to stabilize and check all product specifications using the on-line analyzers to ensure specification products are being sent to storage.

7) If any of the product specifications deviate too far from specification during increases in charge rate, divert the product to slop tankage and correct the problem before continuing.

8) After the unit has been brought up to 100% of design charge rate, the operating conditions should be allows to stabilize.

9) Once all conditions are stable, switch all controllers that are still on manual to automatic.

10) The following items are not included in the simulation; however, in actual plant operation, they must be carried out to complete the startup:

    a) Close all bypasses around control valves.

    b) Open the pump warmup lines where applicable.

    c) Prepare the auto start pumps by opening the process block valves at the suction and discharge.

CONGRATULATIONS - THE UNIT IS NOW ON-LINE!!!