

HOT OIL SYSTEM

GENERAL OPERATING MANUAL

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I. INTRODUCTION

To minimize fired heaters in the complex, a hot oil belt is provided as a major heat input source.

All heat required by the belt is supplied by a fired heater.

The hot oil used can be a commercially available heat transfer fluid.

UOP standardized on "modified terphenyl" hot oils in 1990 and the three vendors with their respective trade names for this material are:

- Therminol 66 (Monsanto)
- Dowtherm HT (Dow)
- Therm S 900 (Nippon Steel Chemical)

The "modified terphenyl" was selected as a standard because of good overall properties and availability from many vendors. Prior to 1990, UOP suggested Therminol 66, Dowtherm G, or Therm S 600.

Refinery cut hot oils are used in some cases but these are generally less stable than the commercially available oils. The lack of stability requires the refinery hot oil to be regularly changed out. In most cases the refinery cut hot oil cannot be used in a system designed for more stable specialty hot oils without some changes in equipment.

II. PROCESS FLOW

A. NORMAL FLOW

- 1.0 The hot oil surge drum is N₂ blanketed and pressure controlled to maintain sufficient pump suction pressure and to prevent vapor formation. Typically it is a push-pull pressure system. Hot oil from the surge drum goes to a set of hot oil circulating pumps. Typically there are two pumps and a common spare due to the high circulation flow required.

The pump sends hot oil on flow control to the hot oil charge heater which uses oil-fired and or gas-fired burners. The hot oil heater outlet temperature controls the heater firing.

Hot oil is typically on flow control to the column reboilers, and on temperature control to process stream heaters.

After exiting the hot oil exchangers, the various oil flows recombine and flow back to the hot oil surge drum.

The hot oil surge drum also acts as a disengaging drum to remove any light cracked products formed by thermal degradation. Refinery cut hot oils show a greater tendency to crack to light products.

2.0 Inventorying and Removal of Hot Oil

The hot oil surge drum is inventoried with heat transfer fluid through a makeup line from hot oil drums. If removal of the heat transfer fluid is ever required, the hot oil is removed through a pumpout line after cooldown of the system to a temporary storage tank, or to drums. For periodic withdrawal of small amounts of system hot oil a small cooler is supplied.

B. INSTRUMENTS

The instrumentation for the hot oil system is a PDC control valve at the end of the hot oil header to insure there is sufficient pressure differential for good flow distribution to each hot oil exchanger. If there is more than one large hot oil header with isolation of headers possible, then there may be an additional PDC control valve.

Shutdown systems provided on the hot oil heater are typical of those to process heaters.

III. STARTUP

A. PRESTARTUP REQUIREMENTS

As the construction of the unit nears completion, the startup crew must begin to prepare it for operation. These precommissioning activities have three main purposes: (1) to ensure by thorough inspection and testing that the unit is safe, operable, and constructed as specified; (2) to prepare equipment for operation by washing, running in, etc., and (3) to acquaint the operators with the unit. The importance of these activities cannot be over-emphasized. No matter how well designed a unit is, if the equipment provided is not what was called for, is not properly tested, or is not understood by the operators, it will not perform as expected.

The material in this section gives general guidelines for preparing a unit for startup. Some sections need to be expanded to give specific directions (water washing procedure, for example); this can best be done by personnel on site.

1.0 Vessel Inspection

Vessel inspections can be made at an early stage of construction. The actual installation should be compared to the vessel drawings. Particular attention should be given to the following detailed:

- Vessel temperature and pressure rating
- Vessel metallurgy
- Vessel elevation
- Vessel lining
- Distributors: location, alignment, size and number of openings
- Nozzles
- Vortex breakers
- Demisters; size, materials, support
- Thermowells: location and strength

- Instrumentation
- Linings
- Fireproofing
- Inspection plates in place
- Cleanliness

CAUTION: Before entering a vessel, the refinery's safety precautions should be observed. These usually include the following - sampling the vessel for toxic vapors and oxygen concentration, wearing a safety harness, and having an attendant outside the vessel. AN UNATTENDED VESSEL SHOULD NEVER BE ENTERED.

2.0 Piping and Instrument Check

The unit should be checked to ensure that it conforms to the UOP piping and instrument diagram. This can best be done by coloring every line and notation on the drawing with marking pencils as the check is done. In addition to the process flow, the inspection should include the following:

- Line sizes and materials
- Flanges and gaskets
- Bolting
- Drain and vents
- Pump ratings
- Relief valve settings
- Lines and equipment supports
- Equipment accessibility
- Expansion provisions
- Utility lines
- Tie-ins with other units/storage
- General safety requirements
- Heaters, including burners and internals

3.0 Strength and Leak Testing

Any equipment - whether piping, vessels, or exchangers which has been modified, repaired, or had connections made to it by welding during a downtime or construction period preceding a startup should be STRENGTH TESTED. This strength testing is normally done by hydrostatic pressure test. When hydrostatic pressure testing is performed in the field, operating personnel assigned to witness and record the test should determine that blinds have been properly placed to isolate the equipment to be tested from all other equipment which has a lower design pressure.

All equipment newly constructed or opened during a downtime should be LEAK TESTED by refinery operating personnel before any hydrocarbon is admitted. Normally flanges and connections found to be tight under the hydrostatic test do not need to be leak tested again provided these lines are not subsequently opened.

Distillation towers and certain associated piping can be leak tested with air or nitrogen.

NOTE: Although leak testing as above gives reasonable assurance of startup without serious leaks, it must be borne in mind that leaks often develop after equipment has reached full operating temperature, when lines and vessels have expanded. Operators must be alert as startup progresses for development of leaks.

- 3.1 Blind (or block and bleed) all safety valves, instruments, and pressure gauges that would over overranged by the hydrostatic test pressure.
- 3.2 Test Gauges must be placed at the low point of a large line or vessel so that the liquid head will be taken into account.
- 3.3 High Point Vents must be provided on all lines and vessels to allow purging out of all air when pressuring the system with H₂O.

NOTE: Before draining any liquid from a vessel, a vent must be opened on top to avoid pulling a vacuum and collapsing the shell.

- 3.4 Hydrostatic Test Pressure is normally set at 1.5 times the cold design pressure. In some cases, however, vessels that have been shop tested cannot be hydrostatically tested in the field and must be blinded from the process piping under test. These are vessels that have been designed and/or supported such that they cannot safely be filled with water.

The refinery piping code ANSI B 31.3 must always be followed when testing process piping.

- 3.5 Fine Mesh Screens should be placed in the suction lines of all pumps before any liquid or gas is allowed to pass through them from newly constructed or dirty lines. If this is not done, scale, weld metal, slag, stones, etc., may freeze and/or damage the impellers of the pumps. The screens also act to trap such dirt in a place where it can be conveniently removed. Suction screens are normally placed in a flange or T-type strainer between the suction valve and the pump. The screens should be made of fine screen retained by a heavy gauge, punched hole, cone-type strainer. These should be placed in the lines before the unit is pressure tested so that the test liquid can be pumped through the lines for the purpose of washing them (see: 4. Flushing.)
- 3.6 An Air Pressure Test using plant air can be placed on the sections of the unit prior to the hydrostatic test so that any open lines or flanges may be discovered and taken care of before water is admitted.
- 3.7 Water Temperature. In pressure testing equipment, particularly in cold weather, care should be taken that the testing of the vessels is not carried out at temperature levels so low that the metal becomes brittle. As metal temperature decreases, the tendency for brittleness increases. Temperatures above 60°F (16°C) are considered minimum for testing to

eliminate the possibility of cold fracturing of equipment. Such temperatures can be attained by warming of the testing medium with steam.

- 3.8 Isolate Sections. It will not be practical to test all of the equipment together. Thus, the unit will be divided into sections as governed by the location of the various items of equipment and the test pressures to which each item will be subjected. Suitable blinds must be made up for insertion in nozzles and between flanges to isolate the various sections of equipment as required by different pressure ratings. Normally the exchangers, receivers, etc., for the various towers will be tested together with the piping.
- 3.9 Exchangers. Special attention should be given to testing of heat exchangers and coolers using sheet and tube type construction. If there is a possibility that materials such as heating fluid or water can enter the process side of such exchangers, the tube rolls should be given a very careful hydrostatic test. Any leaks detected, however small, must be repaired before the unit is considered ready for startup. This leak testing is critical as it can prevent the leakage of hot oil to the process side of the exchanger. Hot oil can cause damage to solvents, catalyst, sorbents and desorbents.

NOTE: Check exchanger vendor name plate test pressure regulations in cases where differential design is used on the tube bundles.

4.0 Flush Lines

All piping should be thoroughly cleaned before startup. Generally, lines designed to handle liquids are flushed with water and drained. Lines designed to handle gas can be cleaned by blowing with air or nitrogen or, if their supports are designed for liquid, flushed with water. Frequently a convenient source of water is that which has been used for hydrostatic testing. Notes applicable to water flushing are:

- 4.1 Orifice plates should not be installed prior to flushing.
- 4.2 Control valves should be rolled out. Flush to both sides of the valves.
- 4.3 Instrument air lines should be thoroughly blown with clean, dry air then closed off or disconnected.
- 4.4 Relief valves should be blinded.
- 4.5 Dirty lines should not be flushed through exchangers. Disconnect lines at exchanger inlets and outlets and flush through the open end of the lines to the exchanger.
- 4.6 Pump suction spool pieces should be rolled out and basket screens installed after flushing the pump. Pump suction and discharge piping should be flushed while the pump is disconnected.
- 4.7 When filling vessels, open a vent.
- 4.8 When draining vessels, care must be taken not to pull a vacuum. Adequate venting must be provided and water should not be drained too rapidly.
- 4.9 Lines should be flushed away from vessels. Do not flush debris into equipment.
- 4.10 Where possible, flush down or horizontally.
- 4.11 Flush headers from source to end, then flush lines away from header to end.
- 4.12 Flush through open end lines. When possible, do not restrict flow.
- 4.13 Flush through all drains and vents.

- 4.14 In all cleaning, use maximum safe volume and velocity.
- 4.15 Regulate flushing water from source.
- 4.16 Water-flushed lines which do not drain freely should be blown clean with air.
- 4.17 Upon completion of line flushing for any system, carefully check that all temporary breaks are reconnected, control valve replaced, blinds removed, and pumps aligned.

5.0 Run In Pumps and Drivers

Proper installation and operation of pumps and drivers is essential for trouble-free performance. All drivers should be run in for a minimum of four hours at no load conditions. Following this, pumps and drivers should be coupled, properly aligned, and serviced for operation. This initial run in is usually done with water and frequently can be included with the water flushing. However, whenever the fluid used for run-in is heavier than what the pump was designed for, precautions must be taken to avoid overloading the motor.

Operations notes are as follows:

- 5.1 Check rotation of electric motor drivers uncoupled from the pump. Run in for a minimum of four hours uncoupled, verifying operability.
- 5.2 Run in, uncoupled from pump, drivers other than electric. Check overspeed trip, bearings, control, etc.
- 5.3 Prior to running in the pump, do the following:
 - 5.3.1 Review the manufacturer's operating instructions.

- 5.3.2 Check that the overall installation is complete.
- 5.3.3 Verify that the pump and driver are properly aligned.
- 5.3.4 Verify that cooling water piping is connected and in service where required: pedestals, bearing jackets, stuffing boxes, etc.
- 5.3.5 Verify that steam piping is connected where required.
- 5.3.6 Check gland or seal oil piping. Conventionally packed pumps in hot service are generally furnished with gland oil. When a pump is furnished with mechanical seals, verify that all components of the flushing system, such as strainers, separators, restriction orifices, and coolers have been correctly installed and are clean. It is very important that the flush system be clean as the loss of flush or dirty flush can cause the loss of seals.
- 5.3.7 Verify that packing on seals is installed.
- 5.3.8 Verify that temporary strainers have been installed in the suction piping.
- 5.3.9 Verify that bearings and shafts are clean and properly lubricated.
- 5.4 When ready to start the pump, do the following:
 - 5.4.1 Rotate pump and driver by hand, verifying that they will roll freely.
 - 5.4.2 Check that the run-in water supply and delivery circuits are lined up.
 - 5.4.3 Establish cooling water, where required.

- 5.4.4 Check that lubrication is satisfactory.
- 5.4.5 Check that pump vent and case drains are closed.
- 5.4.6 Open suction valves fully, venting air from piping and pump, completely filling with liquid.
- 5.4.7 Open pressure gauge tappings.
- 5.4.8 Make sure that electric power is available from the switch gear to the starter of the electric motor drivers. For steam turbine drivers, the turbine is warmed by slowly opening the exhaust valve. Back in steam while draining water from the casing. The exhaust valve is always fully opened before starting. Where the exhaust valve is under vacuum, the case must be warmed by gradually introducing the driving steam after opening the exhaust valve. In the vacuum exhaust system, sealing steam to the turbine shaft labyrinths must be admitted to avoid loss of vacuum.
- 5.4.9 Barely open the discharge valve of a centrifugal pump and fully open the discharge valve of a positive displacement pump before starting.
- 5.4.10 Gradually warm up pumps in hot service to near operating temperature before placing in service. Uneven expansion of the internals and casing may cause seizure and damage when starting.
- 5.4.11 Start the pump and bring up to speed immediately, observing the discharge pressure. If the pressure does not build immediately, stop the pump and find the cause. Refill the pump and restart when previous difficulty is corrected.

- 5.4.12 When the discharge pressure of a centrifugal pump has increased satisfactorily after starting, gradually open the discharge valve to obtain the desired flow rate.
- 5.4.13 In the event of unusual noise, vibration, overheating, or other abnormal conditions, shut the pump down immediately. Correct the cause before resuming operation. Continue checking for abnormal conditions as these may occur after prolonged operation.
- 5.4.14 Check shaft sealing. Mechanical seals should show no leakage. Conventionally packed stuffing boxes must always be permitted to leak slightly to provide some lubrication and prevent overheating. Stuffing box gland nuts are generally only finger tight. A mechanical seal may show leakage on startup. After the pump has been started and stopped a few times, the leakage should stop. If the seal leakage persists, then steps are to be taken to correct the problem.
- 5.5 The pumps are normally delivering a material of lighter weight than the water circulated during the initial run-in. The pump driver is sized for the normal pumping fluid; consequently, while pumping water, the electric motors can be easily overloaded. To avoid overloading the motor driving a centrifugal pump, the flow must be limited by throttling the pump discharge valve. If possible, check the amp usage against design. Avoid restricting the discharge to the extent that it will cause internal slippage and excessive heat generation.
- 5.6 The discharge valve of an operating positive displacement pump, rotating or reciprocating, should never be closed as the pump case can be overpressured.
- 5.7 During run-in, the strainers may cause some restriction on flow. As debris is collected, the flow to the pump will fall off. Do not permit the

pump to cavitate, that is, lose suction, which may cause damage to the pump.

- 5.8 Inspect and clean screens as required.
- 5.9 Recheck and realign, if required, after any disturbance of piping such as required for suction screen cleaning.
- 5.10 Operate the pump directing flows through all suction and discharge piping.
- 5.11 In shutting down a centrifugal pump, close the discharge valve first, thereby maintaining discharge pressure while the pump rolls to a stop. This also prevents rolling backward after shutdown if the discharge check valve leaks. Positive displacement pump discharge valves must not be closed until the pump is shut down and rolling stops.
- 5.12 After all lines available to the pump have had suitable flushing, the temporary suction strainer may be removed only after showing no debris on two successive examinations. The permanent strainers may then be installed where required.

6.0 Clean and Service Utility System

For ease of operation, the utility system (water, air, nitrogen, steam, fire main) should be put into service as soon as the construction schedule allows. Fuel gas, fuel oil, and flare lines should be prepared for service but not commissioned until the unit is prepared to receive hydrocarbons. The various lines must be tested for leakage and washed free of debris. Steam lines can be conveniently cleaned by blowing them as long as necessary with steam. They should be warmed up slowly to minimize water hammer. The other utility lines can be cleaned by blowing with steam or air, or by water flushing if possible.

Commissioning of the steam system requires certain precautions. Hazards which should be avoided include thermal and mechanical shock, over-pressuring of steam turbine casings, and introduction of condensate into other systems.

Before bringing steam into any system, all drains, vents, and bypasses on steam traps should be opened. Steam should be very carefully cracked into a system by slowly opening the block valve until steam is heard to just pass through the valve. Withdraw condensate through drains and warm up the system slowly in order to avoid water hammer and thermal shock. Keep drains and vents open until dry steam issues from each point, then throttle valves back slowly until the lines are at the desired pressure. Place all steam traps and condensate lines in service.

After commissioning the steam, block valves at vessels, snuffing steam valves, atomizing steam valves, and turbine steam supply valves should be kept closed.

All feed, chemical, and product storage tanks must be thoroughly washed, leak tested, dried and air free prior to bringing in hydrocarbons. Where possible, flush all lines to and from these storage tanks and run a "pig" through these lines to assure that they are free of debris. Blow out the main volume of water with N₂, then tape the flanges and check for leaks. When storage tanks are air free, leave them under a positive N₂ blanket and purge. Remember that N₂ is normally the first dangerous chemical brought on-site.

7.0 Service and Calibrate Instruments

Preparation of the plant instrumentation for startup and operation should include the following inspections and tests:

- Visual inspection of instruments to verify compliance with specifications

- Visual inspection of instrument installation to verify compliance with specifications and with the installation details in the instrument instruction manual
 - Pressure testing of instrument piping
 - Testing and calibration of instruments
 - Testing of instrument air signal lines
 - Testing of thermocouple wiring
 - Loop checking
 - Final preparation
- 7.1 Inspecting instruments for compliance with specification, attention should be given to instrument range, pressure rating, connections, materials of construction, size, electrical characteristics, and special features. Special attention should be paid to notes in the specification. Orifice plates should be inspected as soon as possible so they will be ready for installation when line flushing is complete; inspection should include size, materials of construction, location of weep hole, if any, counterbore, overall condition, measurement of orifice bore, and verification of information stamped on tab.
- 7.2 Inspection of installations should include attention to location of transmitters with respect to the connection point; to piping for proper drainage, and for proper valves and gaskets; to transmitters and control valves to ensure that they are not installed backwards; and to special treatment such as winterizing for proper coverage and insulation. Orifice installations should be checked as soon as possible to ensure that straight run requirements are met, so that any piping change required can be made.

- 7.3 Instrument piping should be inspected visually for completeness and condition of welds and connections, and tested by pressuring with instrument air and brushing joints with soap solution. During hydrostatic testing of the plant, the first block valve at the process line should be closed and a drain valve opened to relieve any pressure. Control valve assemblies may be included in the hydrostatic test, providing that it is understood by all personnel that any leaks at control valve stem packing will be corrected by a qualified instrument technician only. It is generally safer to exclude the control valve assemblies from hydrostatic tests.
- 7.4 Testing and calibration of instruments should include calibration of transmitters (in place, if possible), control board equipment, and local controllers. Control valves and positioners should be adjusted. Special attention should be given to instrumentation used in critical services (such as heater firing, etc.) and accounting service (such as charge and product meters.) Temperature transmitters should be checked for proper thermocouple burnout protection. Meter factor tags and valve position indication on controller output indicators should be installed at this time, and control actions should be set.
- 7.5 Instrument air signal lines should be checked for leakage, kinked tubing, and for connections to the proper port of shutdown solenoid valves and controllers.
- 7.6 Thermocouple wiring should be inspected for proper polarity at the thermocouple head. Point by point verification of the switch identification at the temperature indicator on the operator's desk can be accomplished by selecting a point to be checked, opening the circuit at the thermocouple head, and checking the temperature indicator to see if it drives upscale or otherwise indicates an open circuit. The same applies for TRC instruments on the control board.

- 7.7 Loop checking involves checking inputs and outputs to ensure that piping and wiring has been properly done. A signal should be simulated at the transmitter, and the control board instrument should be watched for response. The controller output should be adjusted manually, and the control valve watched for response. Special attention should be given to split range loops and complicated systems.
- 7.8 Final preparation includes checking instrument piping to verify that valves are in the proper position, making preliminary control mode adjustments, filling seal pots and seal legs, and making sure that instrument air and electrical power are supplied to all instruments. It may also be necessary to have the steam tracing operable at this time.
- 7.9 Commissioning of instruments will be carried out as the plant comes on stream. Most attention in commissioning of instruments will be directed toward liquid flow measurements; differential pressure instrument piping must be drained to eliminate accumulated dirt and water, and the instruments must be adjusted to obtain a correct zero reading on the scale on the control board instrument. Controllers must be tuned, interface level transmitters must be zero checked; scale, weld slag, and trash must be removed from sticking control valves, and other malfunctions must be corrected. Inspection and commissioning of analyzers should include attention to sample line lengths, analyzer enclosures, auxiliary equipment, such as carrier gas for chromatographs, and other items as indicated in the instruction manual for the particular analyzer.
- 7.10 In general, analyzers should be inspected, calibrated, and commissioned in accordance with procedures and instruments in the instruction manual for the analyzer. The specifications for the chromatographs include the services of a competent service engineer to review installation and supervise calibration and initial startup. Chromatographs should be inspected to see that all external piping and wiring is complete, and that no parts have been lost or damaged in

shipment. No other action should be taken until the arrival of the service engineer.

8.0 Fired Heater Dry Out

Before startup circulation is established, it is necessary to slowly expel the excess moisture from the insulating concrete of the fired heaters by gradually raising the temperature. During this initial period, it is preferable that no material be flowing through the tubes.

8.1 For UOP-type heaters, the following dryout procedure and precautions apply. (Other types of heaters may require changes in the procedure which are to be made according to the manufacturer's recommendations.)

- 8.1.1 Make a temporary installation of thermocouples for temperature measurement in the hip sections of the heater. The tips of these thermocouples should extend 15-20 cm beyond the inside face of the insulating concrete.
- 8.1.2 Before starting to light any burners, all individual burner block valves are to be closed and the fire box steamed out to remove any gas accumulation. Open all dampers.
- 8.1.3 Light pilots and one or more burners, as required, in each section of the heater and fire slowly so that the temperatures in the fire box, as indicated by the thermocouples in the hips, are increased at a rate of about 15°C per hour until a level of 110-120°C is reached.
- 8.1.4 Maintain this temperature for at least 48 hours, during which period the burner operation is to be rotated frequently in order to distribute the heat as evenly as possible throughout the length of the drying.

- 8.1.5 Light additional burners as required after the 48 hour period to increase the temperature at a rate of about 40°C per hour to a level of 500°C. Hold this temperature for ten hours.
 - 8.1.6 All of the burners should now be shut off and the heater allowed to cool slowly by keeping the air inlet doors and stack dampers closed.
 - 8.1.7 After the heater has been dried out, the refractory should be inspected and repairs made if necessary. On subsequent heater operations, temperature increase/decrease rates are set by the heater vendor and/or process limitations.
- 8.2 The following is a general procedure for firing a heater on fuel gas:
- 8.2.1 When the unit is shut down, always blind off the fuel gas supply line because gas may leak through the block valves at the heaters and fill a furnace.
 - 8.2.2 Before lighting any burners, see that all individual burner block valves are closed and steam out the firebox to remove gas accumulation. Make sure that the dampers are opened.
 - 8.2.3 Light each burner individually with a torch, opening the gas valve to each burner after the torch is inserted in front of the burners.
 - 8.2.4 Burners should be fired to produce a blue flame with a yellow tip, obtained by regulating the primary and secondary air supply. The furnaces should be checked frequently for dirty burners which might give either too long, too short, or misdirected flame. There must be some excess air to the burners so that an increase in fuel gas flow will have sufficient air to produce complete combustion. Proper spud size is important so that the burners

will have the correct fuel gas pressure for operation. A hydrogen rich fuel gas usually requires burner pressures in the range of 1 to 1.5 kg/cm² for best performance on most types of burners.

8.2.5 If, for any reason, the fires in a furnace go out, then:

8.2.5.1 Shut off gas supply immediately. This can be done by closing the main block valve in the fuel gas supply to the furnace. This will take care of any bypass and pilot lines which might be open around the control valves.

8.2.5.2 Put snuffing steam in the fire box.

8.2.5.3 Close individual burner valves and pilots.

8.2.6 As in all heaters, care must be taken that no flame impingement on the tubes is permitted.

9.0 Air Freeing

After completion of the water flushing and prior to admitting hydrocarbon, the plant must be purged to remove the air and all free water. It is assumed that all hydrotesting and tie-ins have been completed.

The easiest way to assure that all piping is air-free is to divide the unit into sections and purge each part separately. Normally, piping and instrument diagrams will be posted in the control room so that all piping can be inked out as the lines are purged and sampled for O₂. A final unit leak test can now be performed as all hydrotesting blinds should have been removed.

Steaming or evacuation is the most common method to air free a system. When a vacuum cannot be pulled on a vessel, the following procedure should be used.

- 9.1 Nitrogen is brought into the vessels and lines and the system pressure brought to 100 psig (7 kg/cm²) (or to the available nitrogen pressure). While the system is under full nitrogen pressure, soap test all flanges and screwed connections for leaks. Perform a pressure test on the equipment. There should be no loss in pressure over a two hour period. NOTE: Always follow design pressure limitations when air freeing vessels, as most storage tanks are designed for a maximum of 3 inch (76 mm) of H₂O pressure and most fractionation columns are designed for 50 psig (3.5 kg/cm²).
- 9.2 Depressure the vessels and lines to a low positive pressure (10 psig, 0.7 kg/cm²). It is important that the system be depressured on the opposite end from which it is filled in order to be sure that a maximum amount of oxygen is removed in the depressuring process. Vent at each available low and high point vent in a downstream pattern.
- 9.3 Perform steps 9.1 and 9.2 two times. On repressuring with N₂, the pressure need only be raised to 20 psig (1.4 kg/cm²).
- 9.4 Obtain an analysis of the gas at the most downstream bleed points of each line and vessel being purged to determine the percentage of oxygen remaining in the system. Theoretically, after the second displacement, the oxygen content should be down to near 0.5%. If the analysis shows the oxygen content to be 0.5% or below, the nitrogen displacement step is complete. If the oxygen content is greater than 0.5%, then repeat the nitrogen displacement procedure.
- 9.5 Upon completion of the air freeing operation, leave all vessels and lines under a positive pressure of 5 psig (0.3 kg/cm²). Storage tanks are left at 1 inch (25 mm) of H₂O pressure.

All lines to and from offsite storage tanks and the unit battery limits must be air-freed. This includes the feed lines, chemical make-up lines,

product rundown lines, and off-test lines. By using nitrogen or steam, the lines can also be blown air free prior to admitting hydrocarbon.

B. INITIAL STARTUP PROCEDURE

- 1.0 Prior to introducing hot oil to the hot oil system, the entire system should be thoroughly clean of any construction debris and be freed from any oxygen by purging with nitrogen.

NOTE: Any previous water washing or steam may cause residual water to be present in the hot oil system, which might cause foaming during initial heatup and startup. For this reason, an adequate N₂ purge to dry out the system is required.

- 1.1 Commission the hot oil surge drum pressure controller at the appropriate operating pressure. Also commission level glasses and level indicator.
- 1.2 Hot oil is transferred into the hot oil surge drum. After all the oil has been added, stop addition and start cold circulation. Make up hot oil as required to hold the level in the surge drum.
- 1.3 Commission the hot oil circulating pump and hot oil heater flow controller and adjust the setpoint such that the control valve is approximately 50% open. After circulating through the main header for a period of time, slowly commission every reboiler in the complex.
- 1.4 Continue circulating in this manner until all trapped water has been removed and no more liquid water is detected at the low point drains of the system.

- 1.5 Steam out the hot oil heater box for one-half hour after steam is visible coming from the stack. Block in the hot oil flow to every individual reboiler in the complex. Start lighting pilots in the heater; the pilots should provide enough heat to increase the temperature to 90°C.
- 1.6 Continue checking for water at the low point drains.
- 1.7 When no water has been found in the system for a few hours, start increasing the hot oil heater outlet temperature to 150°C at a rate of 5°C/hr. Watch for signs of foaming such as loss of pump suction or erratic pressure control in hot oil surge drum. Hot bolt all flanges. Check lines and vessels for any abnormal expansion.
- 1.8 If no signs of water are detected, increase reboiler oil heater outlet temperature to the design condition at a rate of 10°C/hr. The level in the surge drum will rise due to thermal expansion. Export hot oil as required to hold the surge drum level.
- 1.9 When the hot oil outlet temperature is close to design, commission the heater TRC. Hot bolt again to prevent leaks.
- 1.10 Blankoff any steam connection to the reboiler oil system to prevent accidental introduction of water into the system.

C. NORMAL OPERATION

- 1.0 The hot oil system during normal operation is quite easy to operate. Adequate heater firing is required to maintain a specified heater outlet temperature. Good heater operation is most important to prevent shutdowns, such as rotating burner firing on a regular basis, regular burner tip cleaning, adequate atomizing steam for good fuel oil burning, sufficient heater draft, etc.

- 1.1 Conradson carbon, bromine index, and distillation are the regularly checked analysis. Conradson carbon is used to look for the formation of coke due to bad heater firing or insufficient hot oil flow to the heater. An increase in bromine index and/or a lowering of the distillation IBP and 5% point, indicates the breaking down of the hot oil. The stability of the hot oil will determine how often batches of hot oil must be pumped out, or small amounts of hot oil taken out as drag, and fresh hot oil made up. If the IBP is allowed to get too low pump cavitation can occur.
- 1.2 If the complex heat demand is lower than design, the heater firing should be reduced to maintain the required hot oil temperature. The flow rate to the heater should not be reduced, because low flow rates may cause hot oil cracking and/or heater tube coking.

IV. SHUTDOWN

A. NORMAL SHUTDOWN

1.0 General Instructions

- 1.1 Stop firing in heater. Continue circulating oil for about one hour to cool down the heater tubes.
- 1.2 If the shutdown is of sufficiently long duration, the pour point of the oil should not drop below the ambient temperature, otherwise it will set up in the lines. If the ambient temperature drops below the pour point, the oil should be returned from the reboilers, piping and vessels to the hot oil storage drum, or the heater should be run to keep hot oil temperature above the pour point.
- 1.3 In case the oil has to be replaced, it can be pumped through the pumpout cooler to drums or to a temporary storage tank.

B. EMERGENCY SHUTDOWN PROCEDURE

1.0 Guidelines

The following guidelines describe means of handling emergency situations which might arise. These guidelines do not cover every possible situation, and any action taken in a non-listed emergency should be in the best interest of personnel safety and equipment protection.

1.1 Electrical Power Failure

An electrical power failure will cause all the pumps in the hot oil system to fail.

Snuffing steam could be introduced into the heater firebox to cool down the tubes. The pilot gas has to be shut off first before introducing snuffing steam. As soon as the power is back, restart the circulating oil pump and start lighting burners.

1.2 Loss of Circulating Pump

The most probable cause for loss of circulating pump would be foaming in the reboiler oil system or a plugged suction strainer. Cut the fires in the hot oil heater and try to start the spare pump. If the problem is foaming, try to locate the source of water contamination.

1.3 Exchanger Leak

The hot oil system may operate at a higher pressure than some of the users. Hot oil may leak and contaminate the other unit's products. In cases in which the user stream is higher in pressure than the hot oil, user product may leak into the hot oil. In either case the exchanger will have to be isolated and the leak fixed.

1.4 Leakage, Line Rupture or Fire

Try to isolate the leakage or fire by using block valves. Try to maintain circulation of hot oil if at all possible. If circulation is not possible, pump as much of the reboiler oil to storage as possible. Shut down the heater.

1.5 Instrument Air Failure

Instrument air failure will result in loss of fuel flow to the heater and manual operation of the heater is not recommended. Circulation should be continued manually, and every attempt should be made to repair the air system to prevent excessive cooling of the oil.

V. LAB ANALYSIS SCHEDULE

		<u>Test Number</u>	<u>Frequency</u>	
<u>Analysis</u>			<u>Normal</u>	<u>S/V</u>
Note (1)	Conradson Carbon	D-189	Occas.	Occas.
	Pour Point	D-97	Occas.	Occas.
(2)	Distillation	D-1160	Occas.	Occas.
(2)	Gravity	D-1298	Occas.	Occas.
(3)	Viscosity	D-88	Occas.	Occas.
(4)	Bromine Index	D-1492	Occas.	Occas.
(4)	Flash Point	D-92	Occas.	Occas.
	Water	Karl Fisher	Occas.	Occas.
	Sulfur	D-1552	Occas.	Occas.

NOTES: (In comparison to fresh oil)

- (1) Increasing value indicates cracking.
- (2) Watch for decreasing IBP and increasing FBP, low IBP can cause flashing and cavitation problems in pumps, heavies can cause fouling.
- (3) Lower values indicate cracking taking place.
- (4) Increasing value indicates cracking taking place.

There are many more analyses that can be run to evaluate the hot oil quality and the vendor recommendations should be followed. It is recommended that the hot oil vendor be consulted regarding any evaluation testing that he can provide as a service.