Oleflex™ Process

CCR™ Regenerator Section

General Operating Manual

JPC, Iran

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March 2013 Manual #137370 Rev 0

TABLE OF CONTENTS

I. INTRODUCTION

The Oleflex™ Process selectively dehydrogenates propane or butanes to the corresponding olefin using platinum on alumina catalyst. The Continuous Catalyst Regeneration (CCR) section of the Oleflex Unit allows the operator to maintain a high level of reactor section performance by continuously regenerating a circulating stream of catalyst from the Oleflex Reactor Section. Without regeneration capabilities, the Oleflex catalyst would quickly deactivate due to excessive coke formation on its surface. The CCR™ Regenerator Section continuously burns coke and restores catalyst activity, selectivity, and stability to essentially fresh catalyst levels.

Over 125 Continuous Catalyst Regeneration Units are in operation all over the world.

II. PROCESS PRINCIPLES

The Continuous Catalyst Regeneration (CCR) section of the UOP Oleflex unit allows the operator to maintain a high level of reactor section performance by continuously regenerating a circulating stream of catalyst from the Oleflex reactor section. The regeneration section continuously burns coke and restores catalyst activity, selectivity, and stability to essentially fresh catalyst levels.

This section of the manual describes the process principles involved with the two functions of the CCR section, catalyst regeneration and catalyst circulation.

A. CATALYST REGENERATION

Oleflex catalyst regeneration requires six basic steps:

1) Stripping sulfur off the catalyst
2) Removing fines from the catalyst
3) Burning coke
4) Oxidizing and redispersing metal promoters
5) Removing excess chlorine
6) Reducing active metal promoters

The first step occurs in the Catalyst Collector below the last Reactor, the second takes place in the Disengaging Hopper, the next three steps are done in the Regeneration Tower. The sixth occurs in the Reduction Zone on top of the first Reactor.

1. Stripping sulfur off the catalyst

Catalyst drops by gravity from the last Reactor into the Catalyst Collector below the last Oleflex Reactor. The Catalyst Collector below the last Reactor is different from Catalyst Collectors below the other Reactors in that it is divided into two distinct zones – an upper Sulfur Stripping Zone and a lower Cooling Zone. In the upper Sulfur

Stripping Zone, a counter current flow of hot PSA hydrogen purges the catalyst that enters the zone. The hot PSA H_2 gas is used to strip the catalyst of Sulfur and is designed to enter the Catalyst Collector below the last Reactor at about 480°C (896°F). At this temperature, it is expected that more than 95% of the sulfur on the catalyst will be transferred to the gas and will exit the Catalyst collector with the purge.

To ensure integrity of the valves in the catalyst line below the Catalyst Collector, the catalyst needs to be cooled before it exits the Catalyst Collector. This is achieved in the lower Cooling Zone, where the net gas flows counter current to the catalyst at about 115°C (239°F). To prevent mixing of the Net Gas leaving with Cooling Zone with the Hot PSA H_2 entering the Sulfur Stripping Zone, the Net Gas is collected by a baffle and routed to the top of Catalyst Collector via a central pipe.

Catalyst is transferred from the Catalyst Collector below the last Reactor to Lock Hopper 1, in a batch manner. From Lock Hopper 1, the catalyst is dropped into the Lift Engager below to be lifted to the CCR Regeneration Area. A description of catalyst transport through Lock Hopper 1 and the associated Lift Engager is available in the section describing the Catalyst Circulation.

2. Removing fines from the catalyst

Circulating catalyst from the CCR Reactor Area enters the CCR Regeneration Area via the Disengaging Hopper, which is located above the Regeneration Tower. As catalyst is circulated through the reactors and Regeneration Tower, some breakage of the catalyst into small chips and dust, commonly referred to as “fines”, will occur. If not removed, the fines can gradually plug the screens inside the reactors and the Regeneration Tower, and may require a shutdown of the unit for screen cleaning. To avoid this, the fines are removed from the catalyst in the Disengaging Hopper.

Within the Disengaging Hopper, the fines are removed or elutriated from the catalyst using a circulating nitrogen system. The circulating catalyst enters the Disengaging Hopper from the top and flows down by gravity through a pipe call the “elutriation tube”. The circulating nitrogen enters the side of the Disengaging Hopper and flows counter current to the entering catalyst and carries the fines out through the elutriation tube and over to the Dust Collector, where the fines are filtered from the circulating nitrogen. Periodically, the Dust Collector filters are blown down with nitrogen to remove the filtered fines. These fines are then collected in a drum underneath the Dust Collector. Once the fines and chips have been removed, the catalyst flows by gravity into the Regeneration Tower.

The Disengaging Hopper also serves as a buffer zone between the hydrocarbon atmosphere in the Reactor Area and oxygen containing atmosphere in the Regeneration Tower.

3. Burning coke

The coke on the catalyst is composed of three elements: carbon, hydrogen and sulfur. Shown below is the oxidizing reaction for each element:

$$C + O_2 \rightarrow CO_2$$
$$2H_2 + O_2 \rightarrow 2H_2O$$
$$S + O_2 \rightarrow SO_2$$

Each reaction is exothermic, i.e. heat is produced. The heat and products of combustion (CO_2, H_2O and SO_2) must be removed from the Regeneration Tower.

Figure II-1 shows a sketch of the Regeneration Tower. Spent catalyst enters the top section of the Regeneration Tower, from the Disengaging Hopper via catalyst transfer pipes. Inside the Regeneration Tower, the bottoms of the catalyst transfer pipes are each connected to catalyst scoops, which contain and direct the discharge of catalyst from the pipes.

The burning of coke takes place by contacting the catalyst with a cross flow of gas with a controlled oxygen content. To permit this contact, the Regeneration Tower has two concentric screens – the Outer Screen is attached to the Regeneration Tower shell, while the Inner Screen is hung off the head. Each screen has a blanked off portion (with no open area) at the very top, and the catalyst scoops direct the discharge of the spent catalyst into this blanked off area. The catalyst flows in the annular space between the two screens by gravity. The gas with controlled oxygen for the coke burn enters through nozzles in the Regeneration Tower shell into the annular space between the Outer Screen and vessel wall, flows through the Outer Screen, past the catalyst, out through the Inner Screen and finally discharged through nozzles in the Regeneration Tower head.

In commercial experience with Oleflex, the coke deposited on catalyst can be of different types depending on the ease with which it burns. In most cases, the type of coke deposited on the catalyst is easily burnt when contacted with a gas containing 1% O_2 at about 477°C (891°F). However, in some exceptional circumstances, a type of coke that is more difficult to burn can be formed, which may require a combination of significantly higher O_2 concentration and temperature to achieve an effective coke burn. If this type of coke is not completely burnt within about two passes of the regenerator, it can negatively impact the activity of the catalyst. UOP has designed the CCR Regenerator Section to allow the Oleflex Process to recover from any event that creates harder to burn coke than normal operations.

The Regeneration Tower is divided into an Upper Burn Zone and Lower Burn Zone by a horizontal baffle in the annular space between the Outer Screen and vessel wall. The catalyst first travels through the Upper Burn Zone where the majority of normal coke is burnt. Once the catalyst moves through the Upper Burn Zone and passes the baffle, it will enter the Lower Burn Zone. The Lower Burn Zone gas O_2 concentration and temperature can be increased higher than the Upper Burn Zone in order to burn harder to burn coke.

Hot circulating gas enters the Upper Burn Zone with a controlled oxygen content of 0.6 to 1.0 % mol and a temperature of 477°C (891°F). The vast majority of easy to burn coke on the catalyst is consumed in this zone.

Gas leaving the Upper Burn Zone gas outlet nozzle on the Regeneration Tower is first routed to the Upper Regeneration Cooler before it enters the Upper Regeneration Blower. Gas leaving the blower flows to the Upper Regeneration Heater and is then routed to the Upper Burn Zone gas inlet nozzle on the Regenerator. The gas in the Upper Burn Zone is maintained circulating in a closed loop by the Upper

Regeneration Blower. The Upper Burn Zone is at a slightly higher pressure than the Lower Burn Zone resulting in gas exiting the Upper Burn Zone into Lower Burn Zone during Regeneration Tower operations.

The Upper Regeneration Heater is in service during the initial heat up of the Regenerator and in normal operation when operating with low to normal levels of coke on catalyst. In such situations, the Upper Regeneration Cooler will be operating at its minimum load. However, when the Upper Burn Zone is used to burn a higher level of coke, operation of the Upper Regeneration Cooler will keep temperatures in a normal operating range.

Injection of air into this loop at the suction of the Upper Regeneration Blower is used to maintain oxygen concentration in the Upper Burn zone at its target concentration. Apart from the air injected into the loop to maintain the oxygen concentration, a small flow of nitrogen is allowed to leak from the Disengaging Hopper into the Upper Burn Zone. The Upper Burn Zone is not provided a dedicated path to vent excess gas, but instead is allowed to leak gas into the Lower Burn Zone.

After travelling down through the Upper Burn Zone, catalyst moves by gravity into the Lower Burn Zone. The Lower Burn Zone is set up in similar fashion to the Upper Burn Zone, with a dedicated Lower Regeneration Blower for driving gas circulation in this zone. Gas leaving the Lower Burn Zone gas outlet nozzle on the Regeneration Tower is first routed to the Lower Regeneration Cooler before it enters the Lower Regeneration Blower. The main stream of gas leaving the blower flows to the Lower Regeneration Heater and is then routed to the main Lower Burn Zone gas inlet nozzle on the Regenerator. A slip stream from the Lower Regeneration Blower travels through the Cooling Zone Cooler and then into the Cooling Zone just below the Lower Burn Zone.

The Lower Burn Zone and Cooling Zone oxygen concentration is controlled with a vent valve. In normal operation, known as White Burn, the opening of the control valve in the Lower Burn Zone vent is manipulated to control the oxygen level in the Lower Burn Zone. Opening the vent valve increases the flow of gas from the Transition / Chlorination Zones into the Lower Burn Zone. In White Burn, the majority of the Transition / Chlorination gas composition is dry instrument air. For situations when the gas supply to the Transition / Chlorination Zone is switched to nitrogen, known as Black Burn, or if the oxygen demand exceeds the make-up capability by manipulation of the vent valve, air can be injected into the Lower Burn Zone system at the inlet of the Lower Regeneration Blower.

In the Lower Burn Zone, the oxygen concentration of the circulating gas is normally maintained at a level similar to that in the Upper Burn Zone, but the inlet gas temperature is about 25 to 35°C higher. Should the spent catalyst entering the Regeneration Tower contain any of the more difficult to burn coke, it would begin burning in the Lower Burn Zone. Operators are expected to monitor Lower Burn Zone temperatures to detect secondary burn, and increase the severity of the Lower Burn zone conditions to achieve near complete coke combustion. Should coke slip into the Lower Burn Zone (indicated by a peak temperature in the Lower Burn Zone significantly higher than the inlet gas temperature to the zone), the Lower Burn Zone severity can be increased up to a maximum gas inlet temperature of 525°C and a maximum oxygen concentration of 5.0 mol %.

The gas to the Cooling Zone is supplied to this nozzle at 477 °C (891°F), and this is provided to cool the catalyst down, and at a steady temperature before entering the transition.

4. Oxidizing and redispersing the metal promoters

The catalyst flows down from the Cooling Zone into the non-annular portion of the tower. The top section of the non-annular portion is called the transition zone. Here the catalyst is dried by gas coming up from the chlorination zone flowing countercurrent. The residual moisture on the catalyst is a byproduct of the water produced during the coke burning in the Upper Burn Zone and Lower Burn Zone and is removed to a level required for optimum performance of the Chlorination Zone. The lower moisture level improves the re-dispersion of the platinum on the catalyst in the chlorination zone. Water can react with the chlorine to form an equilibrium amount of HCl. The reactions are:

Metal + O_2 + Cl_2	→	Oxidized/Dispersed Metals
$2Cl_2 + 2H_2O$	↔	$4HCl + O_2$

HCl formed does not help in re-dispersion of the platinum on the catalyst, and should be minimized, by limiting the amount of water present on the catalyst and in the air used. The drying that occurs in the Transition Zone is controlled by the temperature difference between the catalyst leaving the Cooling Zone and the temperature of gas from the Air Heater that is input to the Chlorination Zone. The gas from the Air Heater is heated to a temperature about 50 to 70 °C above the expected temperature of catalyst entering the Transition / Drying Zone.

Once the catalyst reaches the Chlorination Zone, the platinum on the oxidized catalyst is re-dispersed by contact with chlorine gas and dry air. The oxygen concentration in the Chlorination Zone can be adjusted from 0 to 21 mol % with the balance of the gas being nitrogen, but is normally maintained at 21 mol % (White Burn). If there is residual coke on the catalyst, oxygen concentrations lower than 21 mol% may be used to avoid high temperatures in the Chlorination Zone.

In order to avoid tramp metal migration, which can deactivate the catalyst, avoid operating at oxygen concentrations in the Chlorination Zone below 0.5 mol%. Iron, nickel and chromium can accumulate on the catalyst during the normal circulation of catalyst through the unit as well as during operation in the Regeneration Tower at abnormally high temperatures. When the catalyst is contacted with chlorine, with very low levels of oxygen, these tramp metals become mobile within the catalyst pill and can associate with platinum, potentially decreasing the quantity of active platinum available for dehydrogenation.

5. Removing excess chlorine

Excess chlorine is removed from the catalyst in the bottom-most section of the Regeneration Tower, in the Chlorine Stripping Section, by counter-current contact with a small flow of dry instrument air. This is done to minimize the amount of chlorine on catalyst which would otherwise be removed from the catalyst once the catalyst is back in the reactors. Chloride removed in the reactors is ultimately trapped by the

Chloride Treater, and so effective stripping of chloride in this section of the CCR Regenerator Section helps extend the service life of the adsorbent loaded in the Chloride Treater.

The regenerated catalyst is then circulated back to the CCR Reactor Area via the remainder of the equipment in the CCR Regeneration Area.

6. Reducing active metal promoters

Once the catalyst has been regenerated, it is circulated to the Reduction Zone situated above Reactor No 1. In the Reduction Zone, PSA hydrogen is heated and passes counter-currently upwards through the catalyst. The hydrogen reacts with the oxidized platinum on the catalyst to reduce the platinum back to its active metal state. Water is produced from the reduction step, and is stripped from the catalyst with the hydrogen used for reduction. Some residual chloride and sulfur present on the catalyst will be stripped off as well.

B. CATALYST CIRCULATION

Oleflex is a process that utilizes UOP's Continuous Catalyst Regeneration (CCR) technology to ensure that the catalyst condition is maintained at near optimal conditions without the need for cyclic operations. This is achieved by removing spent catalyst at a regular pace from the reactors and sending it to a dedicated CCR Regenerator Section for reconditioning. As a small amount of catalyst attrition occurs, make-up with freshly regenerated catalyst is needed to maintain catalyst inventory in the reactors. The movement of catalyst around this circuit is achieved by special catalyst circulation equipment consisting of Lock Hoppers, Lift Engagers and a Flow Control Hopper.

To keep non-selective thermal cracking to a minimum, the Oleflex Reactors are built close-coupled to the Fired Heaters, and so the catalyst circulation system also needs to provide for inter-reactor catalyst transport.

The transfer of catalyst within and from the CCR Reactor Area to the CCR Regeneration Area and back again is the main feature of the CCR Regenerator Section of the Oleflex Process. A network of interconnected vessels transfers catalyst from the hydrogen/hydrocarbon atmosphere of the reactor section to the air/oxygen environment of the regenerator section in a safe and completely controlled manner. A simplified diagram of the catalyst transfer circuit is shown in Figure 1.

1. Inter-Reactor Lift Engagers

Spent, coked catalyst flows by gravity from the bottom of each reactor into their respective Catalyst Collectors. Here the catalyst is cooled and purged of hydrocarbons using net gas from the Oleflex cold separation section. Each Catalyst Collector is connected to a Lift Engager by means of a valved catalyst transfer line. Two different types of valves are used, one to stop catalyst flow without breaking the catalyst pills or damaging the valve (not gas tight) and a second valve to provide a gas tight seal.

From the inter-reactor Lift Engagers, catalyst is transported to the next reactor. This is done when the catalyst level on the downstream Reactor indicates that more catalyst is needed and the catalyst level on the upstream Reactor shows it has a sufficient level to transfer.

2. Lock Hoppers

Lock Hoppers are provided at boundaries which the catalyst needs to be transported and has a significant change in the gas environment. The first such instance occurs at the Catalyst Collector below the bottom of the last Reactor. At this location, catalyst needs to be transported from the hydrogen/hydrocarbon environment in the CCR Reactor Area to the nitrogen environment of the Disengaging Hopper.

As with the Lift Engagers below the upstream Reactor, the Catalyst Collector below the last Reactor is connected to Lock Hopper 1 by a line provided with two types of valves; one to stop catalyst flow and the other gas flow. Because of the change in gas environment, the gas isolation around the Lock Hoppers requires a double block and bleed arrangement. The Lock Hoppers operate by cycling valves in a controlled sequence, which ensures that the gas environment in the Lock Hopper is at all times compatible with the upstream or downstream vessel to which it needs to communicate with to accomplish the catalyst transfer. To minimize the possibility of cross contamination, change of gas environment in the Lock Hopper occurs over multiple purge cycles. Catalyst moves from Lock Hopper 1 into a Lift Engager and is then lifted by lift gas from the Lift Gas blower. The catalyst moves from the Lift Engager to the Intermediate Disengaging Hopper, and is lifted once again through an L-valve assembly, which is also propelled by lift gas from the Lift Gas Blower.

The lift gas blower circulates nitrogen through the Lift Engager below Lock Hopper 1 and the Intermediate Disengaging Hopper L-valve, through the Disengaging Hopper and finally the Dust Collector where the fines are removed before returning to the blower suction.

Lock Hopper 2 is placed below the Surge Hopper and transports catalyst across the boundary of the oxygen containing environment of the CCR Regenerator to the hydrogen environment of the Reduction Zone. It receives catalyst by gravity from the Surge Hopper and drops it to a Lift Engager supplied with PSA Hydrogen as Lift gas. It is controlled in an analogous manner to Lock Hopper 1, with purge cycles designed appropriate to its operation.

3. Flow Control Hopper

The Flow Control Hopper (FCH) controls the overall catalyst circulation rate through the CCR Regenerator Section. The FCH receives catalyst from the Regeneration Tower and it discharges into the Surge Hopper. The FCH is provided with two catalyst valves that are opened and closed in a regular pattern. The catalyst circulation rate, set by the operator, is established by timers which control the opening and closing of the valves above and below the FCH.

Figure II-1

Regeneration Tower

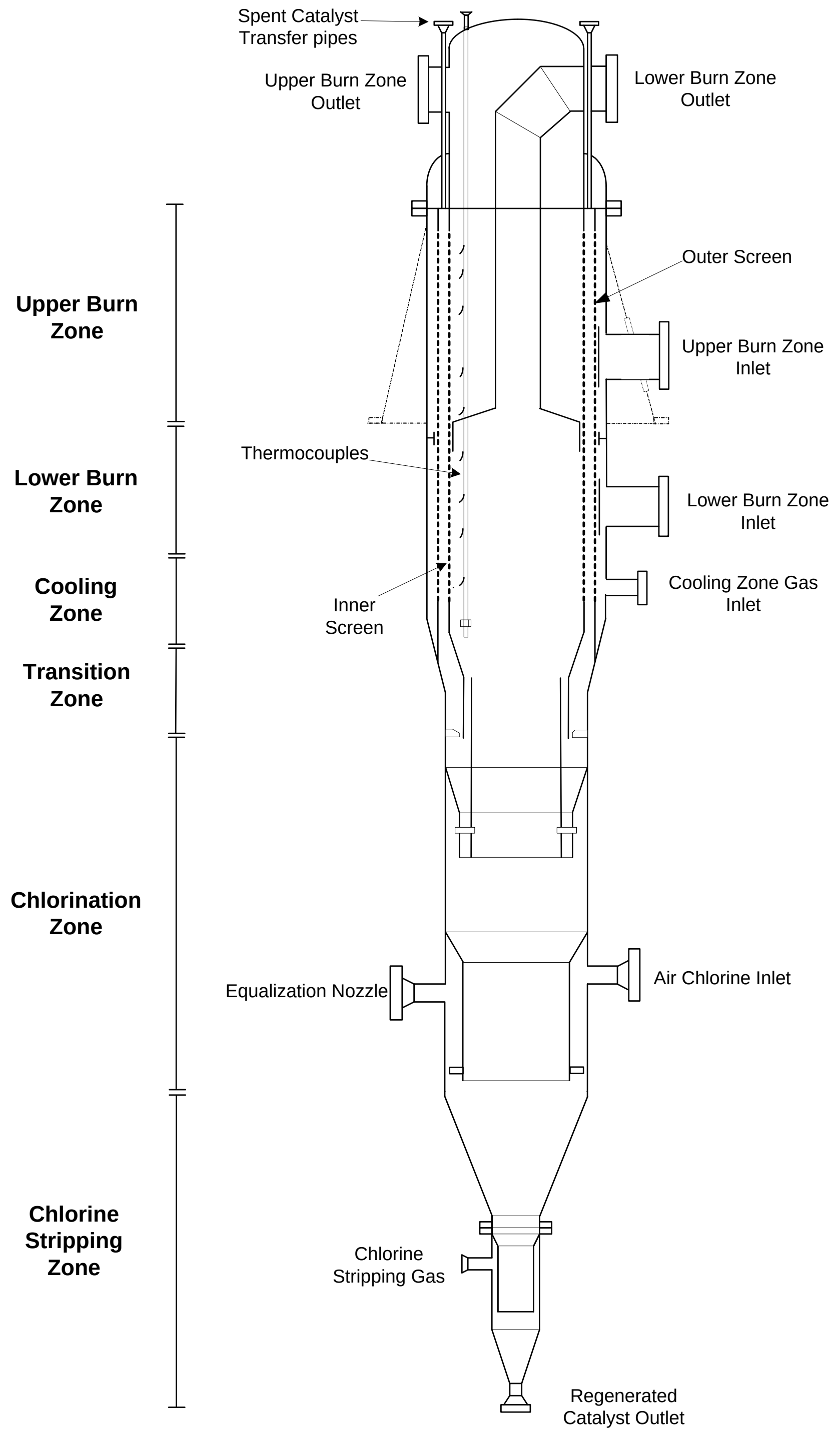
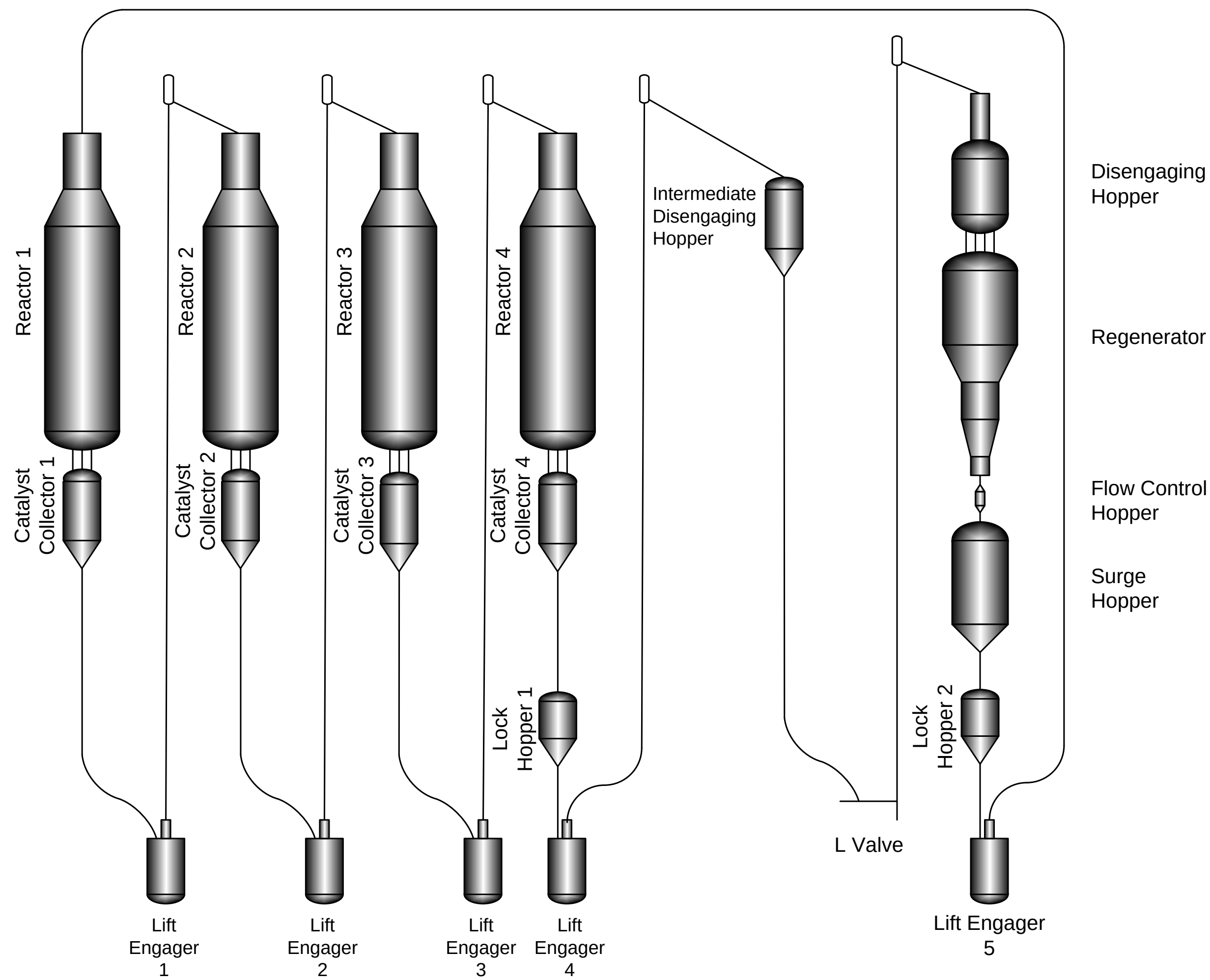


Figure II-2
Catalyst Circulation System



III. PROCESS VARIABLES

A. REGENERATION TOWER

The Regeneration Tower must be controlled so that the Oleflex catalyst is regenerated properly. Catalyst leaving the Regeneration Tower must be in an oxidized state, contain essentially no carbon, be dry, and contain 1.0-1.2 wt% chloride (volatile-free basis). The best indicator of a good regeneration is the catalyst color, which should be a creamy white.

The important variables that must be controlled for proper catalyst regeneration are:

- Catalyst Circulation Rate
- Oxygen Concentration in Upper Burn Zone
- Temperature of the Circulating Gas to the Upper Burn Zone
- Oxygen Concentration in Lower Burn Zone
- Temperature of the Circulating Gas to the Lower Burn Zone
- Chlorine injection to the Chlorination zone
- Air / N2 flow to the Chlorination zone
- Temperature of the Air / N2 to Chlorination Zone
- Air injection rate to the chlorine stripping zone

1. Catalyst Circulation Rate

The catalyst circulation rate is used to control the coke level on the spent catalyst. The presence of excessively high levels of coke on spent catalyst tends to suppress catalyst activity, and where possible catalyst circulation rate should be increased to keep the coke level on spent catalyst in check. A level of about 3.0 wt% coke on spent catalyst is expected to result in minimal reduction in catalyst activity; increasing catalyst circulation rate to target lower coke on spent catalyst is expected to result in little or no gain in Reactor performance, while incurring significant operating costs related to generation of catalyst fines. Increasing the circulation rate beyond design to target coke on spent catalyst below 2.5 wt% is not recommended for normal operation.

Maximum permissible catalyst circulation rate is a function of spent catalyst coke content, regeneration zone inlet oxygen concentration and regeneration gas rate to the zone. The catalyst circulation rate must always be in balance with respect to these independent variables to ensure that essentially all coke combustion is limited to the Upper Burn Zone and Lower Burn Zone, and that there is no residual burn in the Transition or the Chlorination zone/ Drying zone.

Should the combination of Reactor severity and Catalyst circulation rate create a demand for coke burn that exceeds the capability of the Regeneration Tower, it will result in increased temperature in the Transition / Drying Zone and/or the Chlorination zone. If the coke burn capability of the Regeneration Tower cannot be increased by manipulation of other process variables, there will be a need to reduce demand on the Regeneration Tower, which will need a reduction in the catalyst circulation rate and Reactor severity. Note that a reduction in catalyst circulation rate alone will not reduce the amount of coke burn needed in the Regeneration Tower, as the level of coke on spent catalyst will increase as a consequence of the reduction in circulation rate, if there is not a corresponding reduction in Reactor severity.

2. Oxygen Concentration in Upper Burn Zone

The maximum allowable oxygen content of the gas to the Upper Burn Zone is 1.0 % mole. The recommended minimum operating oxygen level is 0.6 % mole. The oxygen content has a direct effect on the potential peak temperature of the catalyst. At a regeneration gas inlet temperature of 477°C (890°F), and 1.0 % mole oxygen, the maximum potential catalyst temperature is about 635°C (1175°F).

Operation at oxygen level of 1.0 mol% maximizes the coke burning potential of the Upper Burn Zone of the Regeneration Tower. However, since the rate of tramp metal pick-up increases at higher temperature, the life of the catalyst is prolonged by choosing the lowest inlet oxygen concentration consistent with the Oleflex Reactor severity.

A guide to the coke burn in the Regeneration Tower is the temperature profile measured by the Upper Burn Zone bed thermocouples. The O2 content should be manipulated to achieve a visible peak in the profile, with the peak temperature ideally located between the third and tenth thermocouples from the top. A change in the temperature profile as observed by higher temperatures towards the bottom thermocouples and/or a shift in the position of the peak temperature towards the bottom indicates that the rate of carbon entering the tower has increased either due to higher coke content on catalyst or a faster catalyst circulation rate. If the rate of coke entering the tower has increased, then the total air consumption will also increase.

Even when operating within the limits of regeneration gas oxygen content, the Regeneration section operation should be monitored for abnormal conditions, such as excessively high temperatures as measured by the Upper Burn Zone bed thermocouples. A change in the value of the peak temperature not accompanied by a change in air demand could indicate a change in the inlet oxygen concentration. Immediately investigate to determine if the oxygen analyzer has malfunctioned.

3. Temperature of the Circulating Gas to the Upper Burn Zone

The temperature of gas to the Upper Burn Zone is normally set to 477°C (890°F). This temperature is appropriate to burn the coke normally produced in the Oleflex Reactor section.

Under certain circumstances, such as following a Reactor Effluent Compressor trip or frequent disruptions to catalyst circulation, the Oleflex Reactors may make coke that is more difficult to burn in the Regeneration Tower. The severty of the zone can be increased by increasing the temperature. The resulting effect on the Upper Burn Zone would be a potential increase in the peak temperature of the zone as more coke is burnt. The oxygen content should be adjusted to ensure that the peak temperatures remain in control.
To assess the reduction in oxygen content needed for a target increase in temperature, consider that a 0.1% mol decrease in oxygen content is needed to offset

a 15°C increase in temperature. To prevent transients with large reductions in Upper Burn Zone severity while making the changes, the changes in oxygen content and temperature should be done alternately, in small steps not exceeding 0.02% mol O_2/3 °C.

4. Oxygen Content and Temperature to the Lower Burn Zone

The oxygen content in the Lower Burn Zone is normally set at the same level as the Upper Burn Zone. When the Oleflex Reactor section is not generating any hard-to-burn coke, and the Upper Burn Zone is operating with a good temperature profile, the temperature profile in the Lower Burn Zone is expected to be a short transition where the catalyst is heated to the inlet temperature of the circulating gas into the Lower Burn Zone, and then flat thereafter.

If coke starts to slip into the Lower Burn Zone, this will be indicated by the development of a temperature profile in this zone. Both the oxygen content and inlet temperature of the circulating gas to the Lower Burn Zone can be increased to burn off the hard-to-burn coke. The oxygen content can be raised to a maximum of 5.0% mol O_2, and the gas inlet temperature can be increased to a maximum of 528 °C, subject to limiting peak temperature in the Lower Regeneration to 605 °C. The oxygen content and gas inlet temperature should be adjusted to ensure that the peak temperatures remain in control.

As with the Upper Burn Zone, unnecessary high temperature could result in increased tramp metal pick-up on the catalyst, and potentially an accelerated rate of catalyst activity decline. Incomplete coke burn in the Lower Burn Zone is indicated by an increase in Transition temperature.

5. Circulating Gas Flow Rate in the Upper and Lower Burn Zones

The circulating gas flow rates through the Upper Regeneration and Lower Burn Zones are not normally controlled, except to set up the pressure balance around the Regeneration Tower, as described in Section VI - Commissioning.

It is, however, vital to monitor the gas circulation flows as they are an indicator of the condition of the Regeneration Tower. Fouling of the Regeneration Tower screens will increase the resistance to gas circulation, and consequently the circulating gas flows are expected to trend slowly down over time. A sharp increase in the rate of flow decline could signal a potential problem in the Regeneration Tower and should be promptly investigated.

6. Chlorine Injection to the Chlorination Zone

Chlorine injection is adjusted as necessary to obtain the desired chloride level (usually 1.0 to 1.2 wt% on a volatile-free basis) on the oxidized catalyst leaving the Regeneration Tower.

The required injection rate is generally 0.6 wt% of the catalyst circulation rate for fresh catalyst. An injection rate of up to about 0.8 wt% of the catalyst circulation rate can be used to keep the catalyst appearance a creamy white color.

The chlorine helps to disperse the Platinum uniformly inside the catalyst pill. If the chlorine injection is too low, it will adversely affect the quality of the Platinum dispersion. If bad enough, catalyst performance will be negatively affected. Poor dispersion is indicated by a gray or dark gray regenerated catalyst color.

7. Air/N_2 Flow Rates to the Chlorination Zone

The gas flow rate to the Chlorination Zone is set by design to be sufficient to avoid flow mal-distribution and to be capable of heating the catalyst to get adequate drying, even at the maximum catalyst circulation rates. To ensure proper drying of the catalyst in the Transition / Drying Zone, the gas flow rate to the Chlorination Zone must at all times be maintained at a rate which sets a Chlorination Zone gas flow rate of 0.295 Nm3/kg (5 SCF/lb) of catalyst based on design catalyst circulation rate. The gas rate to the Chlorination Zone is held constant at or above this rate regardless of the catalyst rate employed.

In normal operation, it should be possible to have only air injected into the Chlorination Zone – this is called the White Burn mode of operation. This mode minimizes the N2 consumption in the Regeneration Tower, and this factor makes this the most economical mode of operation.

When the coke on spent catalyst is higher than can be burnt in a single pass of through the Regeneration Tower, the un-burnt coke could potentially burn in the Transition / Chlorination Zone, with the consequent high temperature having the potential to damage the Regeneration Tower and/or the catalyst. To limit the temperature exotherm and prevent such damage, part of the Air should be substituted by N2. The Regeneration Tower is protected against high temperature in the Transition / Chlorination by a safeguarding system, in the event that the O2 content of the gas to the Chlorination is not reduced sufficiently. The N2 flow can be safely increased up to about 90% of the total flow, and provided this is sufficient to limit the temperatures, there is not a significant risk to catalyst. There is a downside to such operation, as it does increase the N2 consumption in the CCR.

If increasing the N2 fraction in the gas to the Chlorination Zone to 90% is not sufficient to limit temperature increase in the Transition / Chlorination zone, all air to the Chlorination Zone should be shut – the tower should be switched to Black Burn mode of operation. This deals with the immediate concern of the risk to Regeneration Tower integrity, but chlorination in the absence of O2, allows tramp metals to become more mobile within the catalyst and this increases the likelihood of the tramp metal binding the Platinum, with the consequent potential for accelerated activity decline. If the Regeneration Tower has been switched to Black burn mode, Reactor severity should be reduced and/or burn severity in the Upper Burn Zone and Lower Burn Zone should be increased to minimize time that the Regeneration Tower operates in Black Burn mode.

8. Temperature of Gas to the Chlorination Zone

The temperature of Gas to the Chlorination Zone is normally set at 538 °C. This temperature needs to be between 50 and 70 °C higher than the temperature of the catalyst leaving the Lower Burn Zone, to ensure adequate drying of the catalyst. Inadequate drying results in the chlorine injected being used less effectively, as part of the chlorine reacts with the moisture to form HCl.

When operating in Black burn mode, there is some empirical evidence that suggests that operating with gas inlet temperature to the Chlorination Zone towards the lower end of the range (50 °C above temperature of catalyst leaving Lower Burn Zone) could mitigate the loss of catalyst activity due to increased tramp ion mobility.
A low temperature could also potentially negatively impact on Platinum dispersion, which will be indicated by the appearance of grey color on the catalyst pills, If increasing the Chlorine injection rate to 0.8% of the catalyst circulation is not effective in restoring the color of the oxidized catalyst to a creamy white or pale orange, the temperature of gas to the chlorination could be increased in a bid to increase the effectiveness of chlorine utilization.

9. Air flow to the Chlorine Stripping Zone

The air flow to the Chlorine Stripping Zone is designed to remove chlorine from the catalyst. Chlorine not removed in the Chlorine Stripping Zone will be removed in the Reduction Zone, and will ultimately be routed to the Chloride Treater, which will lower the life of the adsorbent.

B. DISENGAGING HOPPER

The key process variables around the Disengaging Hopper are the elutriation gas flow and the differential pressure between the Disengaging Hopper and the Regeneration Tower.

1. Elutriation Gas Flow Rate

The separation of fines from the catalyst in the Disengaging Hopper needs the gas velocity in the elutriation tube to be such that it is intermediate between the terminal velocity of the fines and whole catalyst pills. The elutriation gas flow is established by the Fines Removal Blower, and this flow is set to achieve the required separation. A guide to a good separation is to monitor the fines collected in the Dust Collector for the weight fraction of whole pills in the sample. A dust collector sample containing between 20 and 30% wt whole pills generally indicates a good separation. However, this needs to be confirmed periodically by a fines survey.

2. Differential Pressure between Disengaging Hopper and Regeneration Tower

Maintaining a positive differential pressure between the Disengaging Hopper and the Regeneration Tower is key to inherent safety of Lock Hopper 1, as it ensures that the oxygen does not leak from the Regeneration Tower to the Disengaging Hopper.

The differential pressure is normally set at 2.5 mbar. A low differential pressure could indicate a loss catalyst in the catalyst transfer pipes between the Disengaging Hopper and the Regeneration Tower. If this is detection, catalyst flow through the Flow Control Hopper should be stopped and the cause of the low differential pressure should be investigated.

C. CATALYST CIRCULATION SYSTEM

1. Monitoring Catalyst Transfers

The daily and cumulative transfer of catalyst through the two Lock Hoppers should be monitored in order to detect problems with the transfer systems. The transfer counters associated with the Lift Engagers below Lock Hoppers 1 and 2 should be recorded at the same time each day. Also, the time-averaged Flow Control Hopper catalyst flow rate should be recorded. Based on the calibrated size (weight) of the Lock Hopper 1 and 2 loads, and the number of loads transferred over the 24-hour period, there should be good agreement between the Lock Hoppers and the Flow Control Hopper.

The inter-Reactor Lift Engager counts should be used as an additional source of verification. If one of the three measurements is not in agreement with the other two, then the calibration of that vessel is out of adjustment. If it is a Lock Hopper, then the "Abnormal Load" alarm probably sounds also. If the Flow Control Hopper is out of calibration, then the amount of catalyst transfer will differ appreciably from the Lift Engager counts.

2. Last Reactor Lift Engager Gas Flow Rate

The nitrogen lift gas, which pneumatically transports spent catalyst to the Disengaging Hopper, should have its velocity calculated and adjusted to about 25 ft/sec (7.6 m/sec) based on actual conditions. Higher gas velocities will significantly increase catalyst attrition and erosion of the lift pipe. The measured gas flow rate while the catalyst is being lifted must be corrected to the actual temperature and pressure of the last reactor Lift Engager. The corrected volumetric flow rate is divided by the inside cross-sectional area of the lift pipe to determine the gas velocity.

Once the proper gas velocity is set by sizing the flow/restriction orifice on the line from the Lift Gas Blower, the velocity should be relatively constant. The discharge pressure of the Lift Gas Blower and the temperature of the catalyst as it enters the Lift Engager will affect the lift gas velocity. For this reason, the gas velocity should be calculated and monitored daily.

3. Regeneration Section and Inter-Reactor Lift Engager Flow Rates

The superficial velocity of the hydrogen-rich lift gas (PSA quality) which lifts regenerated catalyst to the reduction zone should be calculated and adjusted to about 50 ft/sec (15 m/sec) based on actual conditions. Higher velocities will significantly increase catalyst attrition and erosion of the lift pipe. The measured flow rate during catalyst lifting must be corrected to the actual temperature and pressure at the Regeneration Section Lift Engager and corrected for the molecular weight of the gas.

The corrected volumetric flow rate is divided by the inside cross-sectional area of the lift pipe to determine the gas velocity.

The proper gas velocity is established by the restriction orifice size (or flow control valve) in the hydrogen gas source piping. A significant change in the operating pressure of the reactors or of the source gas will change the lift velocity. Though the molecular weight of the PSA hydrogen should not fluctuate, a significant change in its molecular weight will also change the lift gas velocity. Normally, the catalyst temperature will not change, as it is being cooled in the Surge Hopper, and will not affect the lift gas velocity. The gas velocity should be calculated and monitored daily.

Each inter-reactor Lift Engager uses a lift system of hydrogen rich gas (net gas). Each supply line has an independent flow indicator on it. The gas velocity should be adjusted to about 30 ft/sec (9.1 m/sec) and monitored daily. A hand operated valve is provided in each lift gas supply line for flow adjustment.

4. Catalyst Collector Continuous Purge

To insure that the catalyst from the reactors is sufficiently cooled and purged of hydrocarbons, the flow rate of the purge gas to the Catalyst Collectors should be held near design and the inlet temperature should be maintained at about 149°C (300°F).

There are two reasons that the catalyst must be cooled prior to exiting the Catalyst Collectors. The V-valves and B-valves below the catalyst collector are not designed to withstand high temperatures, and hot catalyst will disrupt the lift gas velocity in the Lift Engager below. It is therefore critical that the catalyst be cooled down prior to exiting the Catalyst Collectors.

5. Catalyst Fines Collection

Catalyst fines, elutriated from the circulating catalyst in the disengaging hopper, are collected in the dust collector. The fines are blown down from the dust collector to a 55-gallon drum at least once a day and should be inspected to ensure that sufficient amount of whole pills are being elutriated along with the catalyst fines. Usually, 20-30% whole pills should be present in the blow down. The elutriation gas rate should be adjusted accordingly.

The amount of catalyst fines collected should be expressed as a weight percent of the catalyst circulation rate and are an excellent indicator of several possible problems. During normal operations, if the amount of fines collected increases as a weight percent of the catalyst circulation rate, this indicates that something caused more catalyst attrition, such as a high lift gas velocity. If the amount of fines decreases as a weight percent of the catalyst circulation, this could indicate poor removal efficiency due to high catalyst flux or low elutriation gas velocity in the elutriation tube.

6. Catalyst Addition

The catalyst level in the Surge Hopper should be determined with the use of a plumb bob every day and should be maintained at least 8-12" above the cooling coils. Over time, catalyst attrition will cause the catalyst level to drop below this. It is then necessary to add fresh catalyst to the Surge Hopper via the Catalyst Addition Funnel.

When adding catalyst it is important not to open the valves above and below the Catalyst Addition Hopper simultaneously. If this were to happen, the positive pressure differential between the Regeneration Tower and the Surge Hopper would be lost and result in a tower upset. The pneumatically operated J-valves system installed above and below the Catalyst Addition Hopper ensures that only one valve at a time is opened.

IV. PROCESS FLOW AND CONTROL

This section of the manual provides a general description of the process flow and controls for operating the Regeneration Tower and associated equipment. Operating procedures and a general review of the Lock Hopper and Lift Engager logic steps are included in Section VIII, Normal Operations, of this manual. A more detailed and unit-specific description of the Lock Hopper Control System (LHCS) is contained in a separate manual that is provided by UOP's Process Information and Control (PIC) group.

I. PROCESS FLOW

A flow diagram of the Regeneration Tower Flow Scheme is shown in Figure IV-1.

A. Upper Burn Zone and Lower Burn Zone

In the Upper Burn Zone, hot circulating nitrogen gas with a controlled amount of oxygen burns the coke on the catalyst. The gas enters the annulus formed by the regenerator vessel wall and outer screen, passes across the catalyst bed and through the inner screen, then out through the top of the Regeneration Tower. Figure IV-2 depicts the gas flow through this portion of the Regeneration Tower. The catalyst residence time in the Regeneration Tower is approximately six hours at design catalyst circulation rate, of which three hours are in the Upper Burn Zone and the remaining three hours in the Lower Burn Zone.

From the upper regenerator outlet, the hot gas flows to the Upper Regeneration Cooler where it flows cross-current to and exchanges the heat of combustion with air from the Cooler Blower. The gas is then recycled through the Regeneration Heater and returned to the Upper Burn Zone. A similar gas circulation loop is provided for the Lower Burn Zone; Gas leaving the Lower Burn Zone is cooled in the Lower

Regeneration Cooler, and then flows through the Lower Regeneration Blower, where it splits into two streams:

1.) A major stream flows through the Lower Regeneration Heater and returns to Lower Burn Zone via the main gas inlet nozzle for this zone, while …

2.) The other smaller stream flows through the Cooling Zone Cooler and then to Cooling Zone inlet.

While there is considerable mixing between gases in the two zones, the interzonal baffles maintain a degree of separation between the two circuits. The flow rates to the Upper Burn Zone and the Lower Burn Zone and the pressure balance between the two zones is set by the adjusting the speed on the respective Regeneration Blower – the pressure in the Upper Burn Zone is maintained marginally higher than that of the Lower Burn Zone. The flow rate of circulating gas through both the Upper Burn Zone and the Lower Burn Zones is set by the size and speed of the respective Regeneration Blower and should not be varied during operation.

The temperature controller on the outlet of the Upper Regeneration Heater regulates the Upper Burn Zone inlet temperature by a split-range temperature control that either adjusts a valve in the Cooler Blower discharge to vary the amount of air going to the Regeneration Cooler, or adjusts the power to the electric Regeneration Heater. An oxygen analyzer measure oxygen concentration in the Upper Burn Zone, and manipulates the flow rate of upper air addition to the Upper Burn Zone. Net flue gases from the Upper Burn Zone are vented to the Lower Burn Zone.

A separate temperature controller on the outlet of the Lower Regeneration Heater controls the temperature of the gas to the Lower Burn Zone, and works in a similar manner to the controller in the Upper Burn Zone. An oxygen analyzer measures the oxygen content at the inlet to the Lower Burn Zone.

The output from the oxygen analyzer will either control the valve on the vent gas from the Regeneration Tower which is sent to the Vent Gas Treatment System net flue gas line if the Regeneration Tower is in 'White Burn Mode' of operation, or it will adjust the flow controller for the lower combustion air addition, if the Regeneration Tower is in either 'Dual-Zone Burn Mode' or 'Black Burn Mode' of operation.

White Burn is the normal mode of operation for the Regeneration Tower. In White Burn, all of the coke is being burned off the catalyst before it reaches Transition Zone and Chlorination/Drying Zone. In White Burn operation the Chlorination/Drying Zone is operated with air (21 mol% oxygen) being injected into it. In White Burn Mode, the oxygen concentration in the Upper Burn Zone is controlled by addition of Upper Burn Zone air, upstream of the Upper Regeneration Blower. As more coke enters the Upper Burn Zone and is burned, the oxygen concentration will be maintained by the addition of more Upper Burn Zone air. Conversely, if less coke enters the Upper Burn Zone, the Upper Burn Zone air will close maintaining the oxygen concentration set by the operator. If the amount of coke combustion in the Lower Burn Zone increases, the Vent Valve will open in order to maintain the oxygen concentration set by the operator. As the Vent Valve opens, more air will be drawn up from the Chlorination Zone into the Lower Burn Zone. Figure IV-3 depicts the operating conditions in the Regeneration Tower during White Burn mode of operations.

In Black Burn operation, the Chlorination Zone is operated under nitrogen atmosphere. The oxygen concentration in the Lower Burn Zone is directly controlled by adjusting the lower regeneration combustion air flow control valve. If the oxygen analyzer on the outlet of the Lower Regeneration Heater is drifting low, the output from the analyzer will gradually open the Lower Regeneration combustion air flow control valve and vice-versa if the oxygen analyzer starts to drift high. During Black Burn mode of operations, the Lower Regeneration vent gas valve is maintained in manual, open sufficiently to allow the combustion gases generated in the Regeneration Zone to be vented to the Vent Gas Treatment System. Figure IV-4 depicts the operating conditions in the Regeneration Tower during Black Burn mode of operations.

The Lower Burn Zone allows for the catalyst to be exposed to oxygen concentrations of up to 5 mol% as well as higher burn zone temperatures. During normal operations, the Lower Burn Zone operates at the same oxygen concentration as the Upper Burn Zone. However, during periods following an emergency shutdown or when the catalyst has developed hard-to-burn coke, the additional oxygen can be added to the Lower Burn Zone to help burn off the core coke.

Temperatures detected by the Upper Burn Zone and Lower Burn Zone catalyst bed thermocouples will display a distinct temperature profile along the axial length of the entire Burn Zone for a given set of zone operating conditions. These temperatures are a function of overall burning conditions but are most sensitive to Upper Burn Zone and Lower Burn Zone inlet oxygen concentrations as well as the total coke burning rate. An example of the temperature profiles is presented in Figure IV-5. As shown, the highest temperatures are typically observed in the top section of the Upper Burn Zone. The lowest 3 or 4 thermocouples in the Lower Regeneration Zone above the Cooling Zone show approximately the same temperature, which is near the temperature of the gas entering this zone, indicating that all of the coke has been burned from the catalyst.

A thermocouple located at the bottom of the Transition Zone (thermocouple ‘M’ in Figure IV-5) is used to warn the operator if coked catalyst is about to migrate into the Chlorination Zone. This thermocouple is positioned such that it is exposed to the higher oxygen concentrations in the Chlorination Zone. If there was still coke on the catalyst migrating from the Lower Burn Zone, the temperature at this location would increase, possibly placing the Regeneration Tower in cold shutdown if the high temperature shutdown set point is reached. Dual Zone mode of operation, as described in the next section, may be used to allow for some air to enter the Chlorination Zone in this situation.

B. Chlorination Zone and Chlorine Stripping Zone

In the Chlorination Zone, dried and heated instrument air (when in White Burn mode) or nitrogen (when in Black Burn mode) is used to remove moisture accumulated on the catalyst from the Upper Burn Zone and Lower Burn Zone. The residence time in the Chlorination Zone is approximately four hours at design catalyst circulation rate. Figure IV-6 depicts both catalyst and gas flow in the Chlorination Zone.

If there is more than a very low amount of coke still present on the catalyst as it enters the Transition Zone, there is a risk of increased catalyst temperature that could damage the catalyst pill and risk mechanical integrity of the regenerator. To prevent generating such hot spots, there is a provision to substitute a part or all of the air to the Chlorination Zone with nitrogen. The mode of operation when part of the air has been replaced with nitrogen is referred to as Dual Zone Burn mode. This is typically done to avoid long term catalyst deactivation from excessive operation with only nitrogen to the Chlorination Zone known as Black Burn mode. Some air is desirable for long term operation even if there is a very low level of coke. Tramp metals such as iron, chromium, or nickel may be present on the catalyst. These metals, if present, are typically on the surface of the catalyst pill. However, operation without oxygen in the presence of chlorine increases the mobility of the metals, which can then migrate into the catalyst pill and block active platinum sites. Adding a small amount of oxygen, in the range of 1 – 2 mole%, can prevent this deactivation from occurring while avoiding high temperatures if only air is added as is done in White Burn mode.

Instrument air, often referred to as “lower air”, passes through Air Dryers then flows to the electric Air Heater before entering the Chlorination Zone. A slip stream of air bypasses the Air Heater, passes through a venturi, and pulls chlorine gas into the air stream entering the Chlorination Zone. The chlorine gas is used for re-dispersing the platinum on the catalyst pills. There is also a slip stream of air that is sent to the bottom-most section of the Regeneration Tower, the Chlorine Stripping Zone, to strip off residual chlorine from the catalyst prior to it entering the Surge Hopper.

The small differences in catalyst rates through the various sections of the system are normalized in the Surge Hopper which also cools the regenerated catalyst. The catalyst is then transferred batch-wise from the Surge Hopper to Lock Hopper No. 2 and then from Lift Engager No. 5 to the Reactor section.

C. Reduction Zone

Reduction of the catalyst occurs in the Reduction Zone located on top of Reactor No. 1. In this zone, PSA-grade hydrogen gas reduces the regenerated catalyst from its oxidized state. The lift gas, which transports the regenerated catalyst to the top of the reactors, is also PSA-grade hydrogen.

The reduction gas is heated by the electric Reduction Gas Heater. The average residence time in the Reduction Zone at design catalyst circulation rates is approximately two hours to ensure complete reduction before catalyst enters the reactor bed.

In addition to reducing the catalyst, the reduction gas also maintains a positive pressure between the Reduction Zone and the lower portion of the reactor, preventing the reactor gases from migrating through the catalyst transfer pipes and into the Reduction Zone. The purge gas streams to each of the Surge Pots for the other reactors also perform a similar function.

A portion of the Reduction Zone gas exits the side of the Reduction Zone and is used for purge gas in for the Catalyst Collector below the last reactor. The Reduction Zone gas will contain a few hundred ppm of HCl as a byproduct of the catalyst reduction. The majority of the HCl will be adsorbed onto the spent catalyst in this catalyst collector.

D. Vent Gas Treatment System

A by-product of the regeneration process is the release of HCl, Cl_2 and SO_2. A packaged system, called the Vent Gas Treatment System, is used to scrub these components from the regeneration vent gas, using circulating caustic, before the gas is vented to the atmosphere. The Vent Gas Treatment System is typically constructed from fiberglass reinforced plastic (FRP), which is resistant to the corrosive liquid produced from the scrubbing of the regeneration vent gas. The system is provided with internal circulating spray systems to quench the incoming vent gas and protect the FRP from the high temperatures which could otherwise damage the system. In the event of a loss of scrubbing liquid, high temperatures or other shutdowns, the vent gas from the Regeneration Tower is automatically diverted to the atmosphere.

Refer to the vendor manuals for more detailed information on the flow scheme and operation of the system.

Figure IV-1
Regeneration Tower Flow Scheme

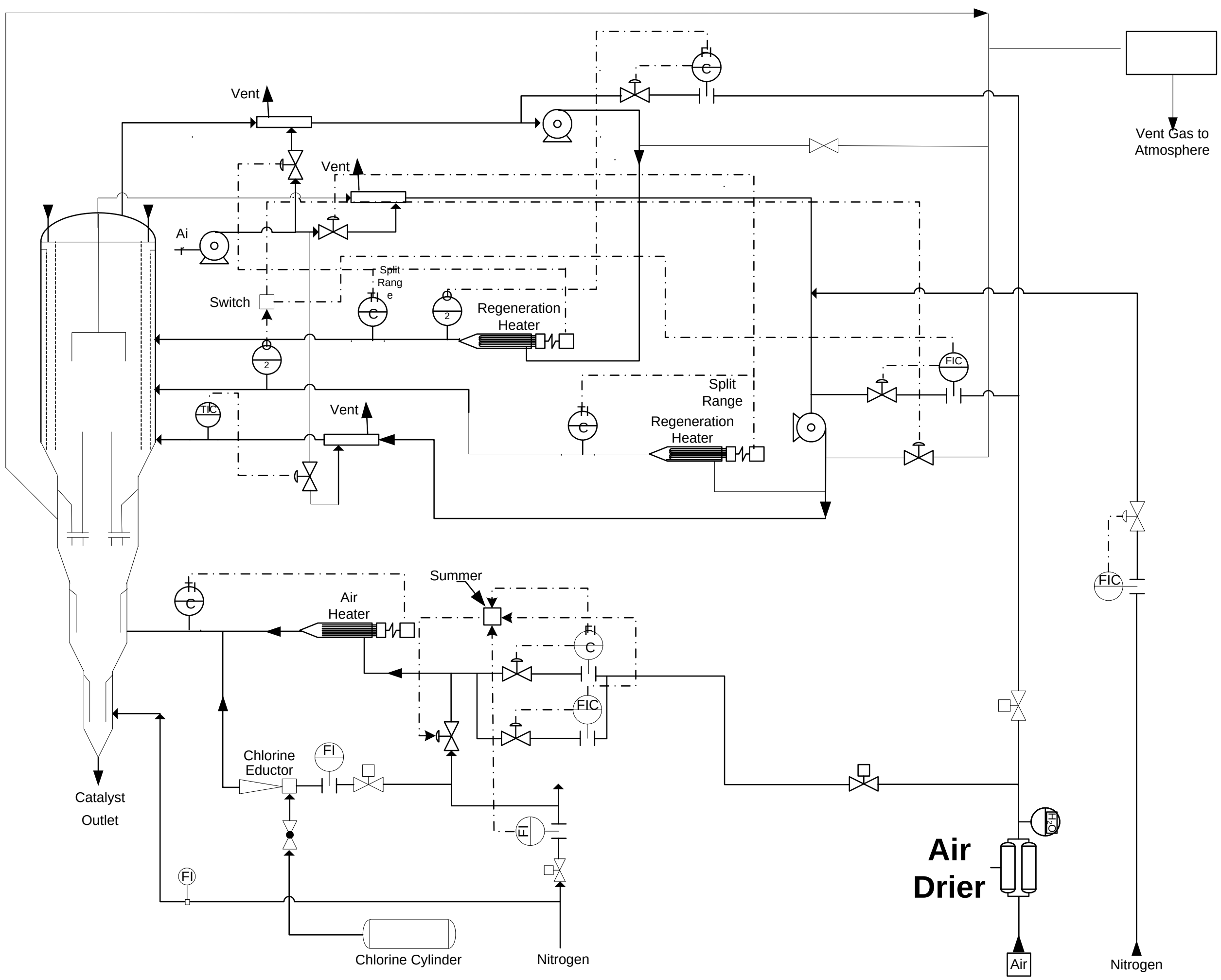


Figure IV-2
Gas Flow in the Regeneration Tower

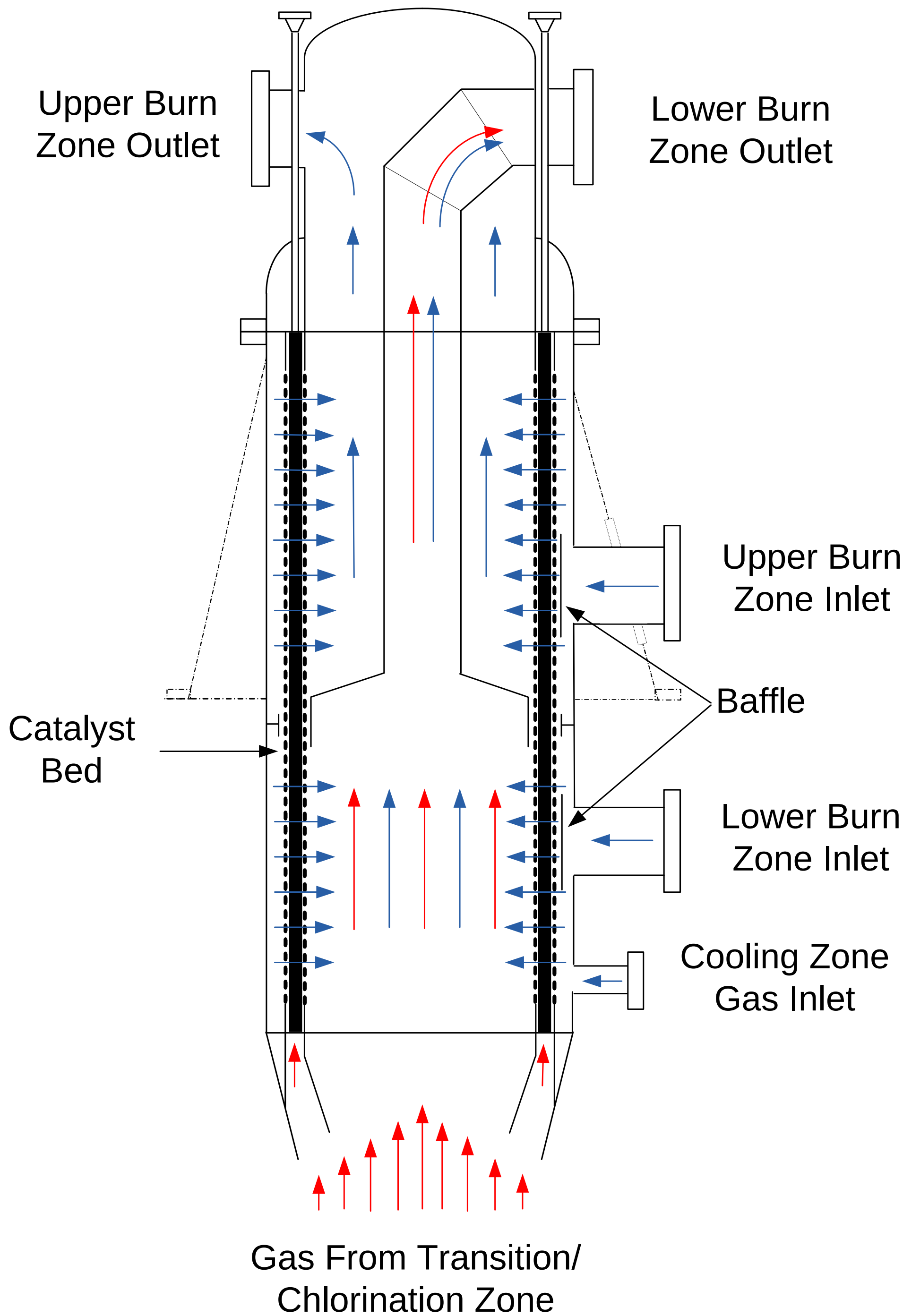


Figure IV-3
White Burn Mode of Operations

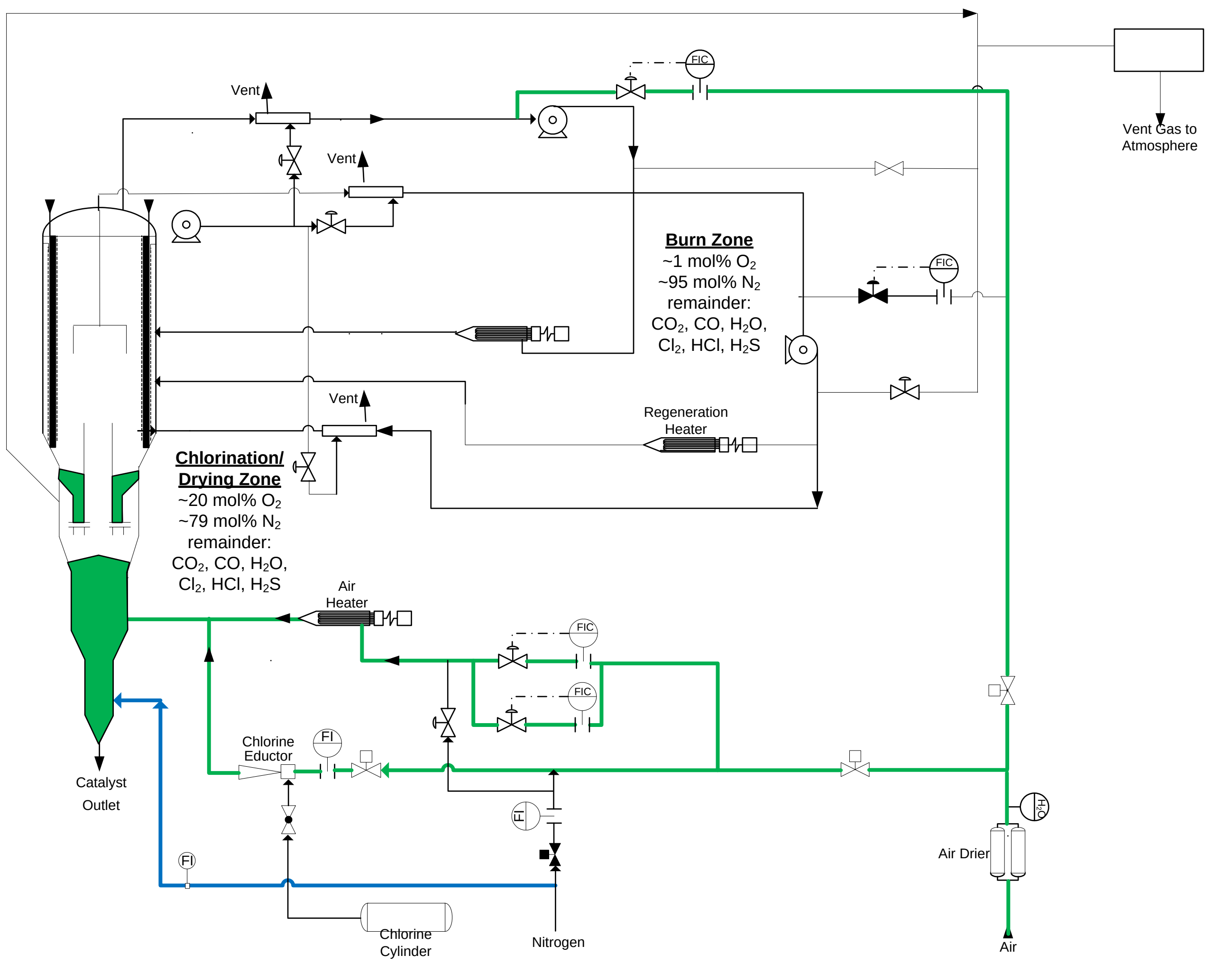


Figure IV-4

Black Burn Mode of Operations

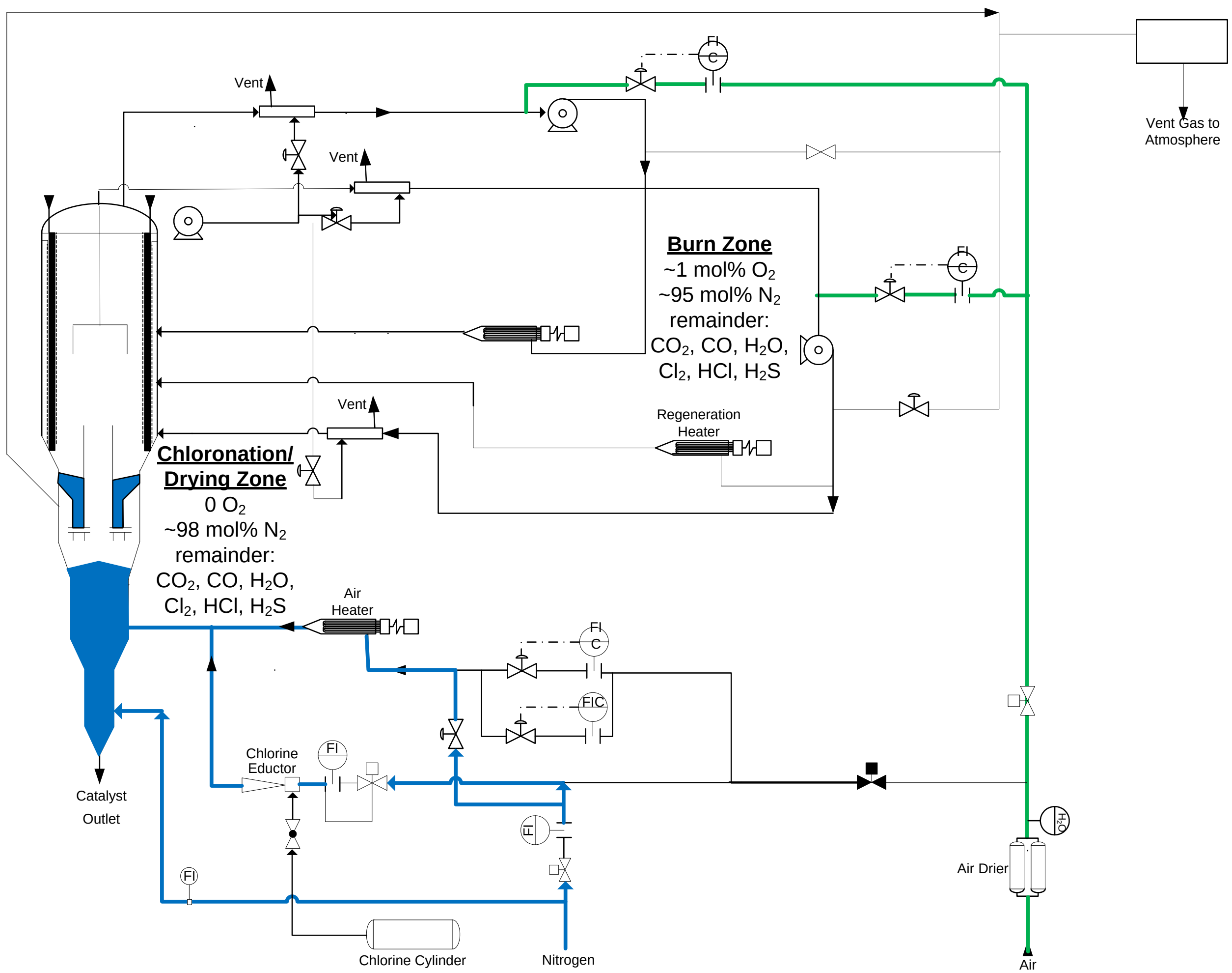


Figure IV-5
Regeneration Zone Temperature Profile

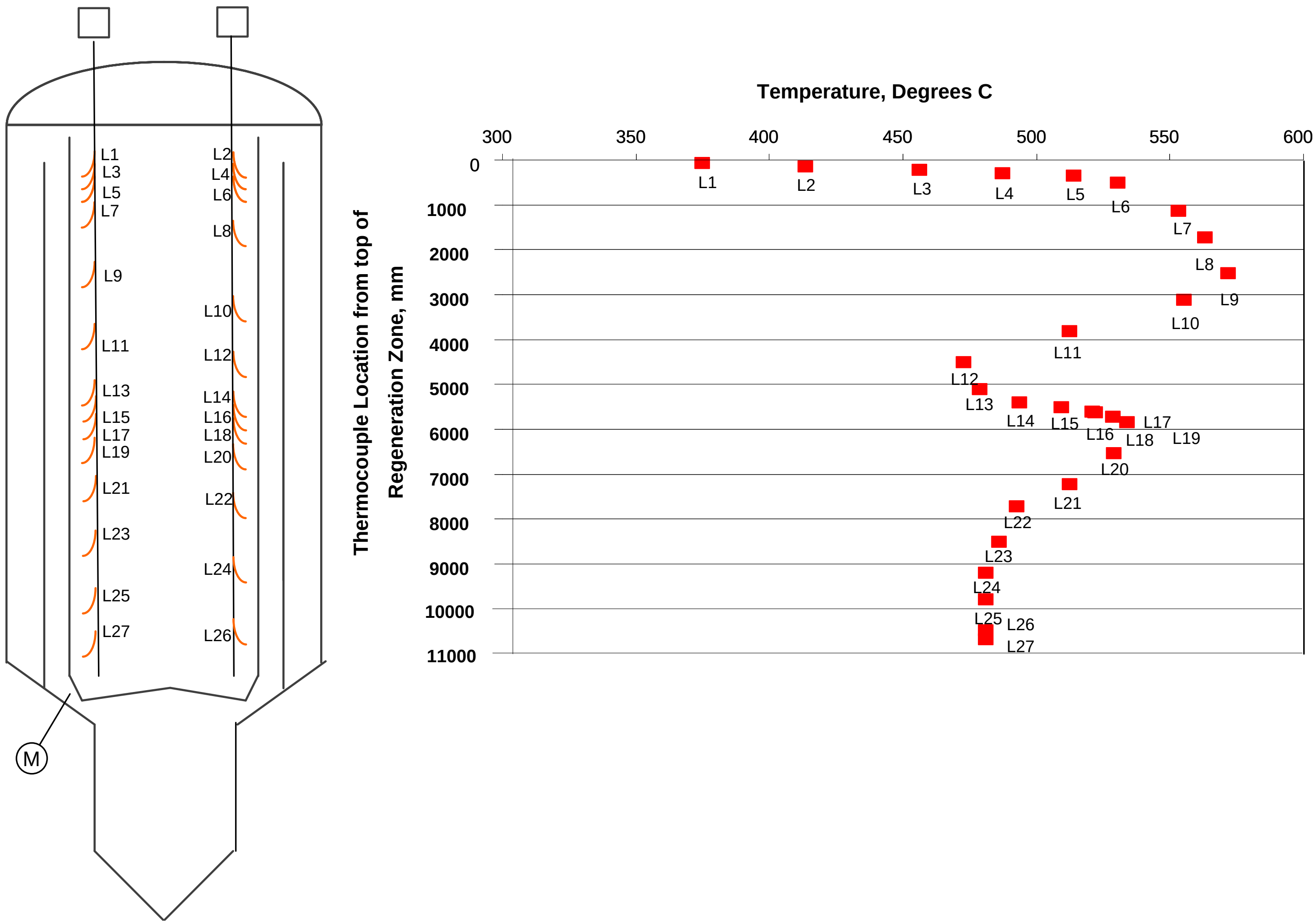
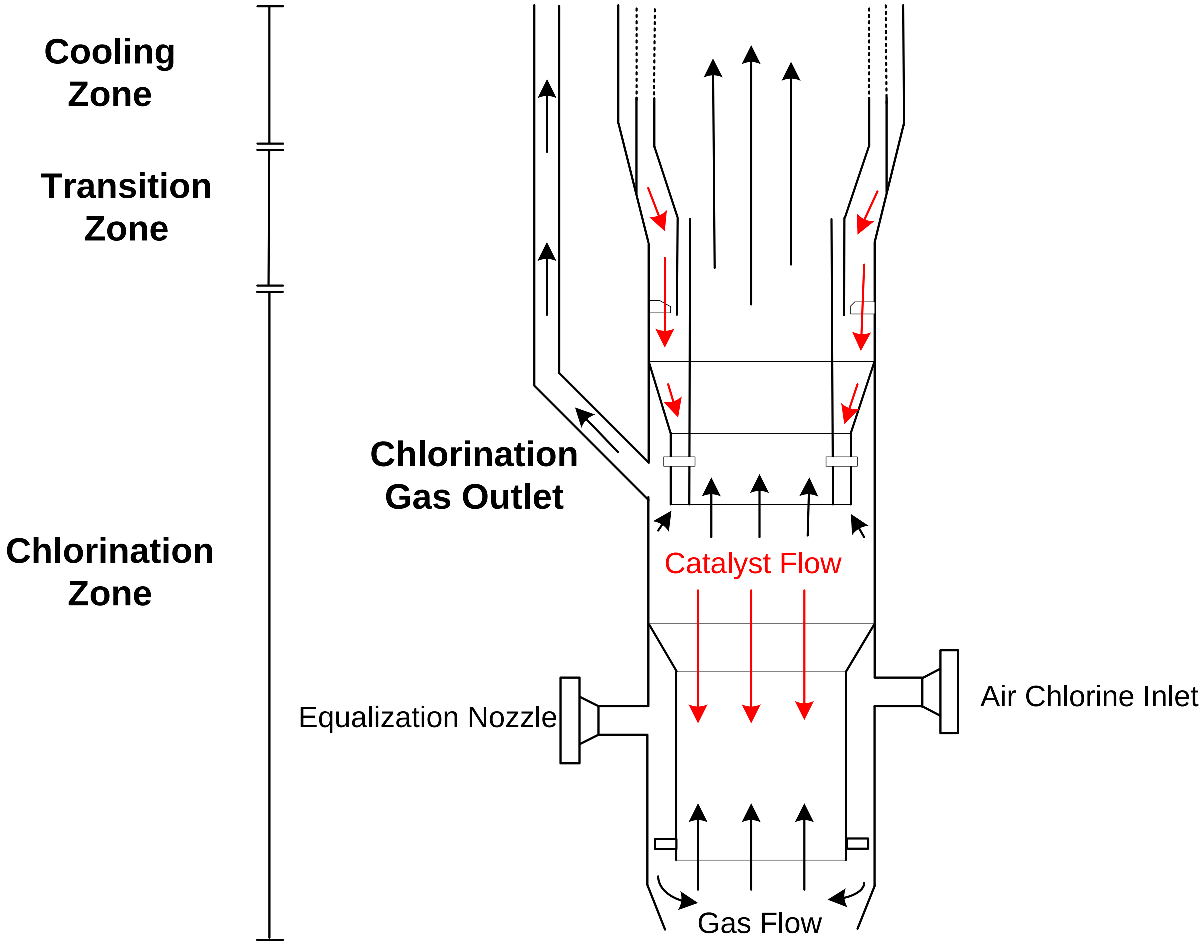


Figure IV-6
Gas and Catalyst Flow in Transition/ Chlorination Zone



II. Process Control

The following describes the functions of the primary control loops for operation of the Regeneration Tower. Refer also to the instrumentation specification in the UOP Engineering Project Specifications for detailed information regarding all control loops.

1. Disengaging Hopper/ Regeneration Tower Differential Pressure Control

A differential pressure controller is provided to maintain the differential pressure between the Disengaging Hopper and the Regeneration Tower at approximately 18.7 mm Hg (10 inches H_2O) with the Disengaging Hopper having the higher pressure. The purpose for maintaining the Disengaging Hopper at a higher pressure is to prevent any oxygen from the Upper Burn Zone from migrating into the circulating nitrogen stream and possibly leaking into Lock Hopper No 1, located directly above the spent catalyst Lift Engager. By maintaining the Disengaging Hopper at a higher pressure, a portion of the circulating nitrogen migrates down the catalyst transfer pipes and into the Regeneration Tower. The cool nitrogen and catalyst entering the Regeneration Tower results in the top two or three temperature indicators in the Upper Burn Zone to typically show temperatures which are substantially cooler than other temperature indicators (see Figure IV-5). The output from the differential pressure controller is sent to a control valve that supplies make-up nitrogen to the circulating nitrogen stream, located around the Dust Collector.

2. Oxygen Concentration Control in the Upper Burn Zone

The concentration of oxygen in the Upper Burn Zone is controlled by the oxygen analyzer on the circulating regeneration gas at the inlet to the Upper Burn Zone. The oxygen analyzer controller will control the oxygen concentration by adjusting the rate of upper air injection. Figure IV-7 depicts the oxygen control scheme in the Upper Burn Zone.

3. Lower Burn Zone Oxygen Control and Air Flow Control

The concentration of oxygen in the Lower Burn Zone is controlled by a similar oxygen analyzer. The controller output is switched, depending on the mode of operation of the regenerator. In White Burn mode, the controller manipulates the valve that controls the vent gas flow from the Lower Regeneration gas circuit to the Vent Gas Treatment system. If the oxygen concentration decreases, the controller will gradually open the Lower Burn Zone vent valve allowing more oxygen to migrate into the Lower Burn Zone from the Chlorination Zone. The Lower Burn Zone vent valve will gradually close if the oxygen concentration in the Lower Burn Zone begins to increase.

In general, it is recommended to operate the regenerator in White Burn mode with the oxygen analyzer controlling the Lower Burn Zone vent valve, rather than in Black Burn or Dual Zone burn mode, where the oxygen analyzer directly controls the flow of upper air addition to the Lower Burn Zone. Operating in White Burn with only air being injected into the Chlorination Zone allows for 21 mole% oxygen concentration in the Chlorination Zone, which promotes better re-dispersion of the platinum on the catalyst. Also, less nitrogen is required for normal operation during White Burn mode, as only air is injected into the Chlorination Zone

A more detailed discussion on hard-to-burn coke and the use of Lower Burn Zone is covered in Chapter VIII, Normal Operations, of this manual.

4. Lower Burn Zone air flow control

There may be periods when the spent catalyst contains hard-to-burn coke level so high that not enough oxygen can be supplied to the Lower Burn Zone from the Chlorination Zone. During these periods, the valve on the lower regeneration gas vent line will be substantially opened, but the oxygen concentration in the Lower Burn Zone will be below the desired concentration. During these periods, it is recommended to supplement the oxygen concentration in the Lower Burn Zone with air, using the Lower Burn Zone air flow control valve.

An alternative to adding Lower Burn Zone air to the Lower Burn Zone during periods of high coke level would be to slow the catalyst circulation rate down. However, this would result in the spent catalyst coke level to increase due to the longer residence time in the reactor circuit. If it is decided to reduce catalyst circulation rate, some corresponding changes should be made in the reactor circuit so as to prevent the coke level on the spent catalyst from increasing even further.

5. Lower Burn Zone Nitrogen Flow Control

There may be periods when the spent coke level will be so low that the oxygen concentration cannot be controlled at the desired level. During these periods, the Lower Burn Zone vent valve will be closed or nearly closed, but there will still be some oxygen migrating up from the Chlorination Zone into the Lower Burn Zone, resulting in the oxygen concentration in the Lower Burn Zone to gradually increase above the desired set point. During these periods, it is recommended to dilute the oxygen concentration in the Lower Burn Zone by injecting some nitrogen into the zone, using the Lower Burn Zone nitrogen flow control. This will result in the Lower Burn Zone vent valve to open and allow the oxygen analyzer to re-establish control of the oxygen concentration.

6. Total gas to Air Heater flow

The total flow to the Air Heater and Chlorination Zone is controlled by a flow controller. This flow measures the amount of air being added to the Air Heater and Chlorination Zone by each of the two air flow controllers, and controls the flow of nitrogen to the Air Heater and Chlorination Zone to maintain the total flow at a constant value. As the amount of air to the Chlorination Zone is increased, the total gas flow controller will decrease the flow of nitrogen to the Chlorination Zone, maintaining a constant total gas flow.

7. Lower Air flow control – Dual Zone

Operating the Chlorination Zone with 21 mole% oxygen concentration as is done during normal White Burn and with regenerated catalyst coke levels greater than approximately 0.2 wt% can result in the generation of excessive heat as the residual coke is burned. This can cause damage to the catalyst and/or the internals of the Regeneration Tower. During periods when the catalyst coke level exiting the Lower Burn Zone is above 0.2 wt% and the Chlorination Zone cannot be operated in White Burn mode, it should be operated in Dual Zone Burn mode operations. Dual Zone Burn mode allows the oxygen concentration in the Chlorination Zone to be controlled between 0.1 and 21 mol%.

The flow of air to the Chlorination Zone uses two separate flow control loops, with two different sized flow control valves. One controller is used to control the flow of air so as to control the oxygen concentration entering the Chlorination Zone between 0 and 2 mol%, while the other controller us used to control the flow of air so as to control the oxygen concentration entering the Chlorination Zone between 2 and 21 mol%.

See Figure IV-9 for illustrations of the nitrogen and air flow controls to the Chlorination Zone.

Dual Zone Burn mode should always be used as a transition between Black Burn and White Burn during start-up and restarts of the Regeneration Tower, and may be used when hard-to-burn coke enters the chlorination zone. See Section VII, Normal Startup, and Section VIII, Normal Operations, for more discussion on these procedures.

8. Circulating Nitrogen Lift Gas and Elutriation gas to Disengaging Hopper Flow Controls

Spent catalyst is lifted from the spent catalyst lift engager below Lock Hopper No 1 into the Intermediate Disengaging Hopper by a circulating nitrogen stream. The catalyst will flow out of the Intermediate Disengaging Hopper to an L-Valve which lifts the catalyst into the Disengaging Hopper with the same circulating nitrogen stream.

Catalyst chips, dust and fines are separated from the spent catalyst in the Disengaging Hopper and collected in a Dust Collector. The nitrogen exits the Dust Collector and either goes to the Elutriation Gas Blower or the Lift Gas Blower. The discharge from the Elutriation Gas Blower is sent back to the Disengaging Hopper. The discharge from the Lift Gas Blower is returned to the spent catalyst lift engager and L-Valve located below the Intermediate Disengaging Hopper. The spent catalyst lift system is shown in Figure IV-12.

The catalyst chips, dust and fines removed in the Disengaging Hopper are sent to the Dust Collector where the catalyst material is collected on filter bags. Over time, the catalyst material builds-up on the filter bags causing a high pressure differential alarm. Once the high pressure differential alarm is generated, the Dust Collector should be blown down to remove the chips and fines. During normal operations, the Dust Collector is typically blown down and emptied about 2-3 times per day. See more detailed instructions for blowing down the Dust Collector in Section VIII Normal Operations of this manual. The bags in the Dust Collector should last approximately 2 years and should be replaced at every turnaround to ensure no problems with leakage.

In general, the material emptied from the Dust Collector should contain between 20-30 wt% whole pills. If there are too many whole pills in the material collected, the elutriation gas flow rate should be reduced slightly. The material that is collected should also be weighed and recorded. In general, the amount of catalyst fines is expected to be approximately 0.1-0.15 wt% of catalyst circulation.

A Hydrogen/Hydrocarbon analyzer monitors the circulating nitrogen stream for the presence of either of hydrogen or hydrocarbons. If the analyzer detects either of these components, an alarm will be generated. Hydrogen or hydrocarbons leaking into the circulating nitrogen stream is normally a sign of leaking valves around Lock Hopper No 1 that are allowing hydrogen or hydrocarbons to leak into the spent catalyst lift engager.

9. Air to Chlorine Stripping Zone flow

The flow of air to the Chlorine Stripping Zone at the bottom of the Regeneration Tower is used to strip excess chlorine and water from the catalyst before it is cooled in the Surge Hopper and transported to the Reduction Zone above Reactor No 1. As the flow rate is relatively low and is kept at its normal flow rate and not varied during normal operation, the flow is measured by a rotometer, and controlled using a globe valve on the air line to the Chlorine Stripping Zone.

10. Upper Burn Zone temperature

A temperature controller located at the outlet of the Upper Regeneration Heater controls the Upper Burn Zone inlet temperature by split-range temperature control, either adjusting the butterfly valve position of the cooling air to the Upper Regeneration Cooler or by regulating the power to the electric Upper Regeneration Heater. During periods of high coke generation, the heat of combustion in the Upper Burn Zone will supply heat in excess of heat lost from the system; thus only the Upper Regeneration Cooler would be operating to remove the excess heat necessary to give the desired Upper Burn Zone inlet temperature.

During periods of low coke generation and Regeneration Tower heat up, the Upper Regeneration Heater will have to fire to maintain the inlet temperature. The valve to the Upper Regenerant Cooler will be closed. See Figure IV-10 showing the split-range temperature controller on the Upper Burn Zone inlet temperature.

11. Lower Burn Zone temperature

The temperature controller on the outlet of the Lower Regeneration Heater function in a manner similar to the Upper Regeneration Heater; on split range it controls the amount of heater firing in the Lower Regeneration Heater and the air flow to the Lower Regeneration Cooler so that the temperature of the circulating regeneration gas going to the Lower Burn Zone can be maintained. Normally, the Lower Regeneration Heater will be in operation, except when there is a significant amount of coke being burnt in Lower Burn Zone.

12. Air heater outlet temperature

The temperature controller on the outlet of the Air Heater controls the amount of heater firing so that the temperature of the nitrogen/instrument air entering the Chlorination Zone is kept constant. Upstream of the Air Heater, a slip stream of the gas is diverted to the Chlorine Eductor then returns to the nitrogen/instrument air stream directly upstream of the temperature controller. The slip stream flow rate is controlled by a globe valve. If the slip stream is too large, it will result in additional Air Heater firing to maintain the target temperature. The operator should carefully adjust the slip stream flow rate such that sufficient chlorine is injected into the Regeneration Tower and the Air Heater firing is not excessive.

13. Reduction Gas Heater and Surge Pot Heater Temperature Control

The temperature controller on the outlet of the Reduction Gas Heater controls the amount of heater firing so that the temperature of the Reduction Zone gas entering the Reduction Zone can be maintained. The temperature of the Reduction Zone gas should be kept above 550 C to ensure complete reduction of the platinum on the catalyst as it enters Reactor No 1. Heating the Reduction Zone gas also serves to heat the catalyst as it flows down into the lower portion of Reactor No 1, so as to minimize thermal cycling and stress on the reactor internals as the catalyst circulates into the reactor

Similar temperature controls are provided on the outlet of each of the other reactors' Surge Pot Heaters. The purge gas to each Surge Pot is heated, so as to heat up the catalyst from the nominal 150 C (300 F) temperature that the catalyst is maintained during inter-reactor lifting, to approximately 600 C (1110 F) so as to minimize thermal cycling and stress on the reactor internals as the catalyst circulates into each reactor.

14. Chlorine injection flow

Chlorine is injected into the Chlorination Zone via eduction by a slip stream of nitrogen/instrument air passing through the Chlorine Eductor. The desired chlorine injection rate is between 0.6-0.8 wt% of catalyst circulation. For example, if the catalyst circulation rate was 1,500 lbs/hr (680 kg/h), the chlorine injection rate would be between 98 kg/day and 131 kg/day. The chlorine injection rate is controlled by a globe valve on the nitrogen/instrument air slip stream to the eductor and by a globe valve on the chlorine gas piping.

The primary method for measuring the chlorine injection rate is by monitoring the weight of the chlorine cylinder every 8-12 hours. The chlorine injection rate should be controlled by adjusting the globe valve on the chlorine injection line. A coriolis type flow transmitter on the chlorine gas that is being injected is also provided, to provide a low flow alarm when the chlorine injection rate has dropped below a predetermined minimum flow rate, indicating that the current chlorine cylinder may be emptied and it is time to switch to a new cylinder.

An XV valve on the slip stream must be opened or closed from the Lock Hopper Control System (LHCS) to start chlorine injection flow. The XV valve will not open unless the Air Heater outlet temperature is above 400°C. In the event of a hot or cold shutdown of the Regenerator (see Chapter XII, Emergency Procedures), the LHCS will close the XV valve and stop the injection of chlorine. If catalyst circulation is manually stopped at any time, the operator will have to stop chlorine injection by depressing the CHLORINE selector button in the LHCS, which will close the XV valve on the slip stream. See Figure IV-11 to see how the chlorine injection rate should be controlled.

15. Vent Gas Treatment System controls

Refer to the vendor's information for information on the Vent Gas Treatment System controls.

16. Catalyst Circulation Rate

The catalyst circulation rate is usually set by the amount of coke on the spent catalyst entering the Regeneration Tower. The spent catalyst coke level is controlled by the operating conditions in the reactor section. Assuming that reactor operating conditions remain unchanged (LHSV, reactor inlet temperatures and H_2/HC), the catalyst circulation rate should be adjusted to maintain a coke level on spent catalyst of between 2 and 3 wt.% to maintain optimum catalyst performance.

The Catalyst Regeneration Section is designed to handle up to 5 wt% coke on spent catalyst at 100% circulation rate. A higher level of coke on spent catalyst can be regenerated, but may required operation at lower than design catalyst circulation rates. Lower catalyst circulation rates may require reduced reactor section operating conditions (i.e., lower reactor inlet temperatures and/or higher H_2/HC).

The method for adjusting catalyst circulation rate is to change the frequency that the valves around the Flow Control Hopper (FCH) cycle.

The Flow Control Hopper (FCH) is located directly below the Regeneration Tower and is sized to hold approximately the amount of catalyst that will be circulated in one minute at the design circulation rate. The FCH for a 1,500 lb/hr CCR Regenerator Section will hold between 25-30 lbs of catalyst. The FCH is used for moving small batches of catalyst from the Regeneration Tower into the Surge Hopper and controls the rate at which catalyst is circulated throughout the CCR Reactor area – CCR Regenerator area. The actual size of the FCH will be measured during commissioning after catalyst has been loaded into the Regeneration Tower. See Section VI Commissioning for further information on FCH calibration.

The Vee port valve at the top of the FCH (the loading valve) is programmed to open long enough to ensure the FCH is completely filled with catalyst from the Regeneration Tower, normally about 30 seconds. Once the top Vee port valve closes, the bottom Vee port valve (the unloading valve) will open to allow the catalyst to flow into the Surge Hopper, located directly below the FCH. Changes in catalyst circulation rate will change the amount of time that the unloading valve remains open. For example, at design catalyst circulation rates, the unloading valve will remain open approximately 30 seconds. At catalyst circulation rates of 50% of design, the unloading valve will remain open approximately 90 seconds. Once the bottom unloading valve closes, the loading valve will open again to allow the next batch of catalyst to migrate from the Regeneration Tower to the Surge Hopper.

More detailed instructions for changing catalyst circulation rate are located in Section VIII Normal Operations of this manual. When the catalyst circulation rate is increased, each of the Lift Engagers and Lock Hoppers will have to circulate more frequently to maintain adequate levels in each reactor and in the Regeneration Tower. Each Lift Engager and Lock Hopper begins to lift catalyst once the vessel immediately downstream registers a low catalyst level. However, the FCH continues to cycle without regard to catalyst level and will only stop moving catalyst if catalyst circulation is manually stopped or the Regeneration Tower goes to a hot or cold shutdown. The catalyst circulation system should be capable of maintaining a catalyst circulation up to 120% of the design rate without any problems. If one of the Lift Engagers or Lock Hoppers is unable to maintain a high catalyst circulation rate, the level in the Surge Hopper will gradually increase over a period of 8-12 hours. If this were to happen, each of the Lift Engagers and Lock Hoppers should be monitored to determine where the bottle neck in the catalyst circulation is located. More detailed information will be discussed in Section X Trouble Shooting of this manual.

Figure IV-7
Upper Burn Zone Oxygen Control

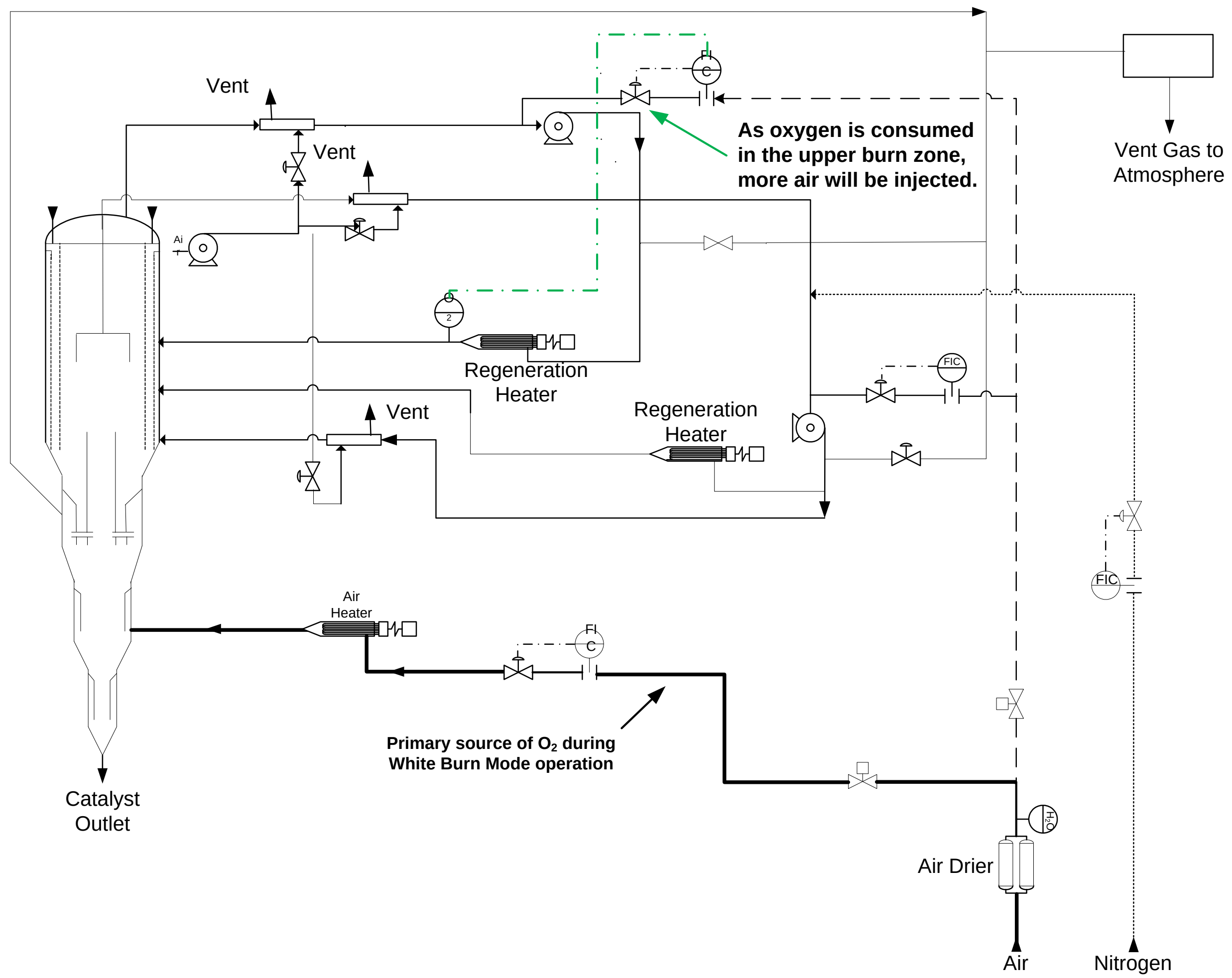


Figure IV-8
Lower Burn Zone Oxygen Control

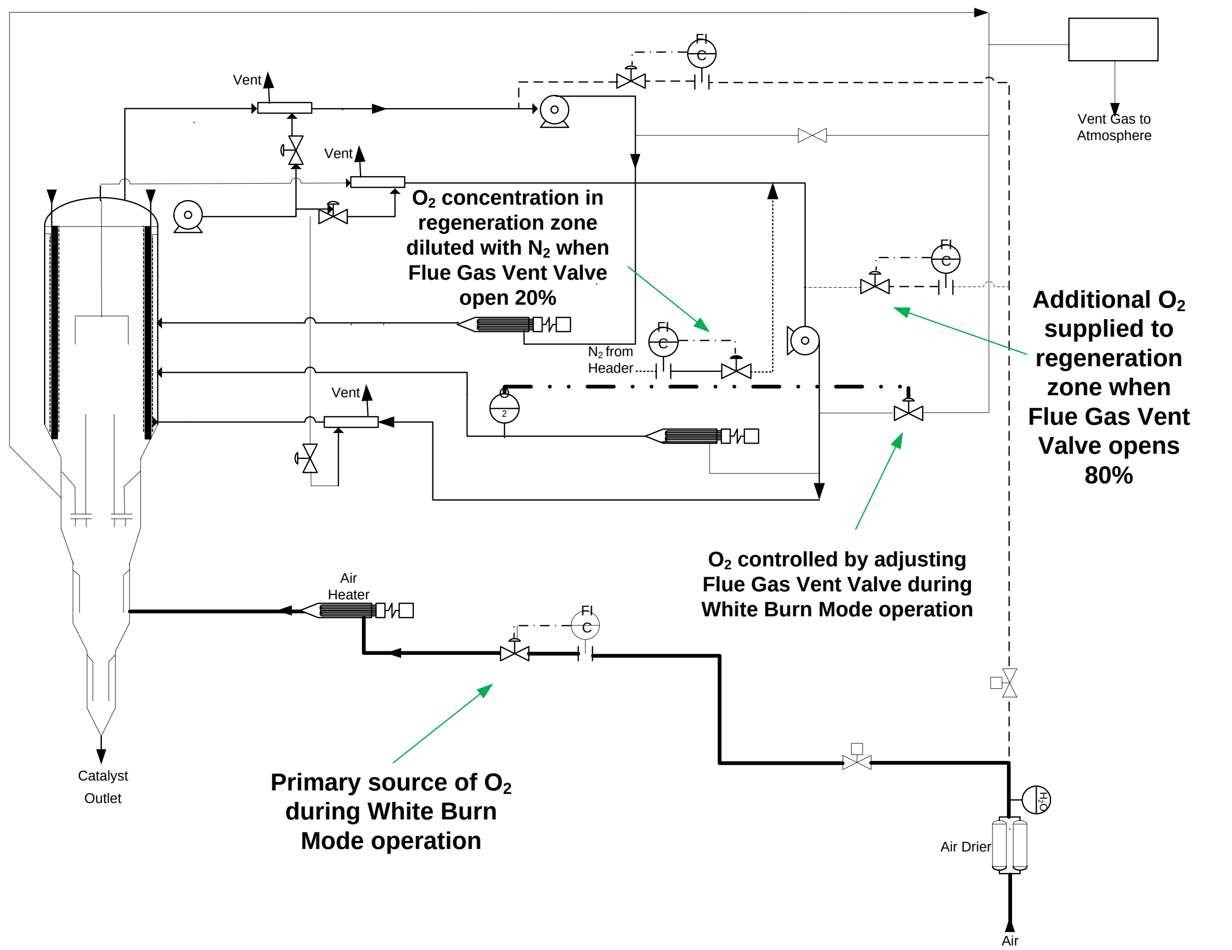


Figure IV-9
Dual Zone Burn

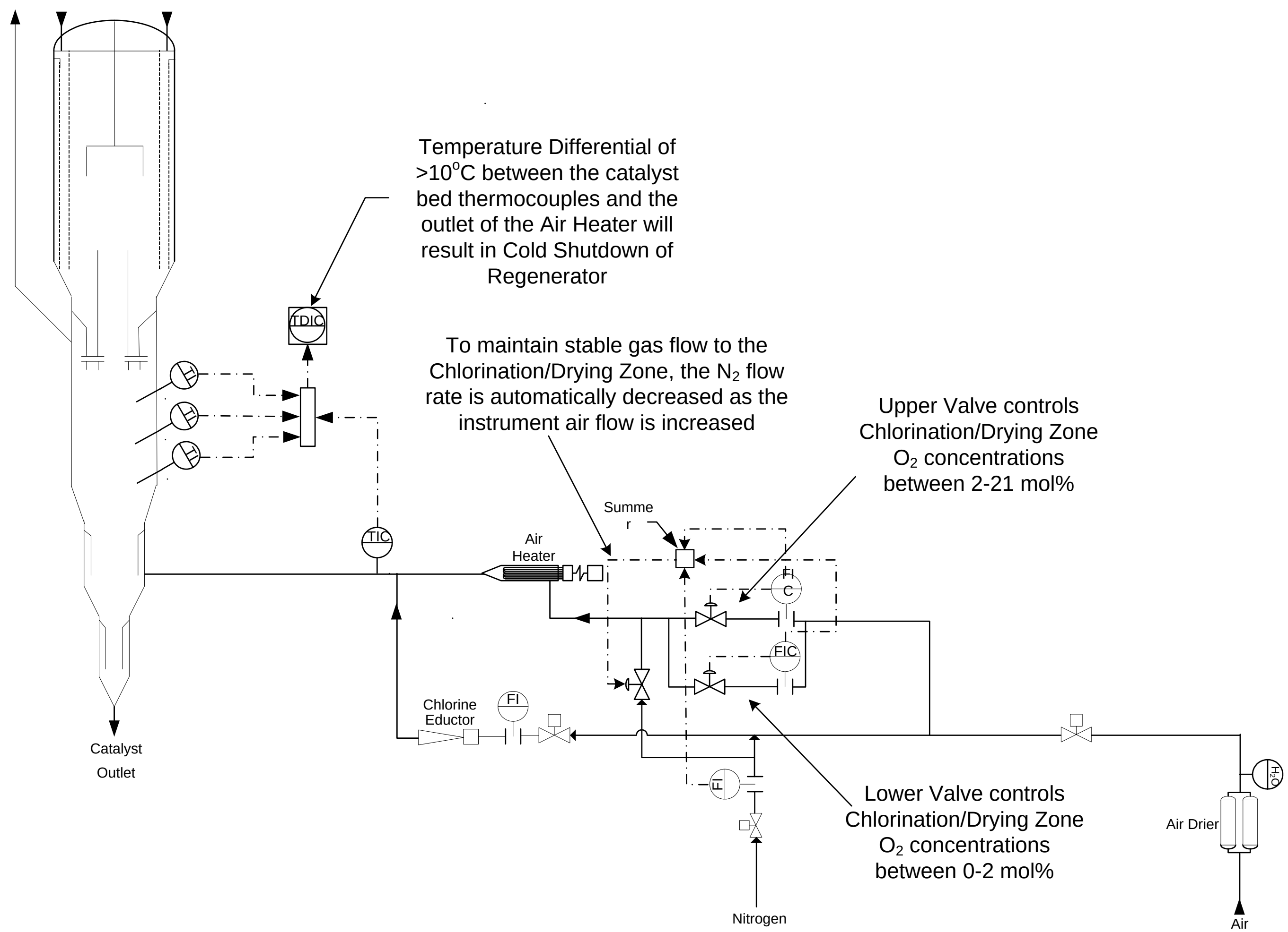
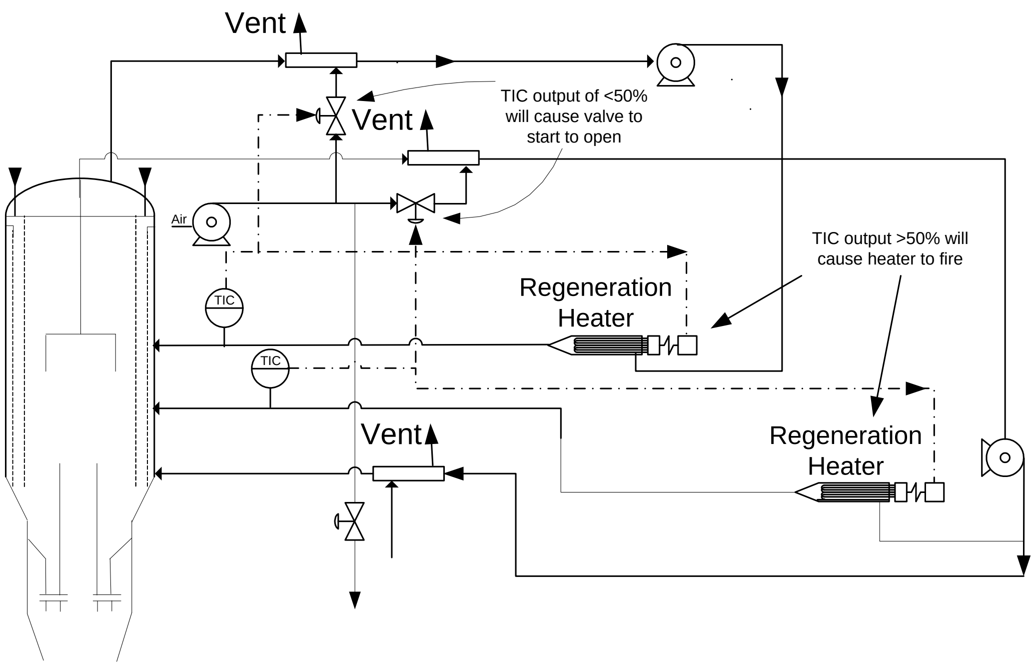
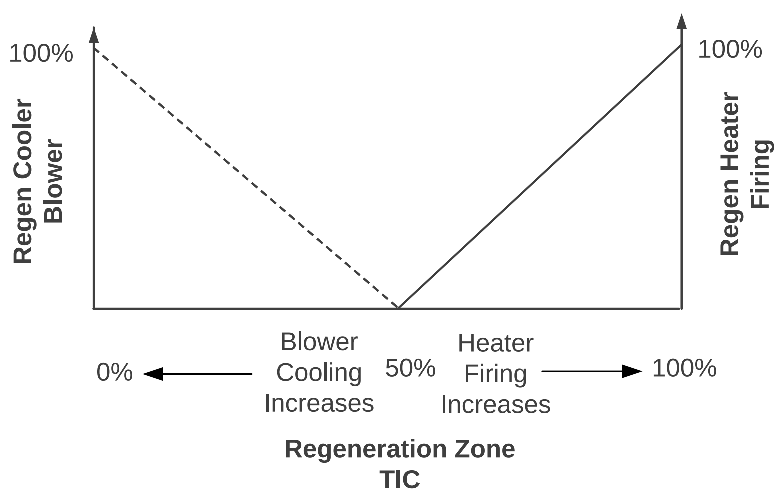


Figure IV-10
Upper Burn Zone Inlet Temperature Control





The same control function is applicable to both Upper and Lower Burn Zones

Figure IV-11
Chlorine Injection Control

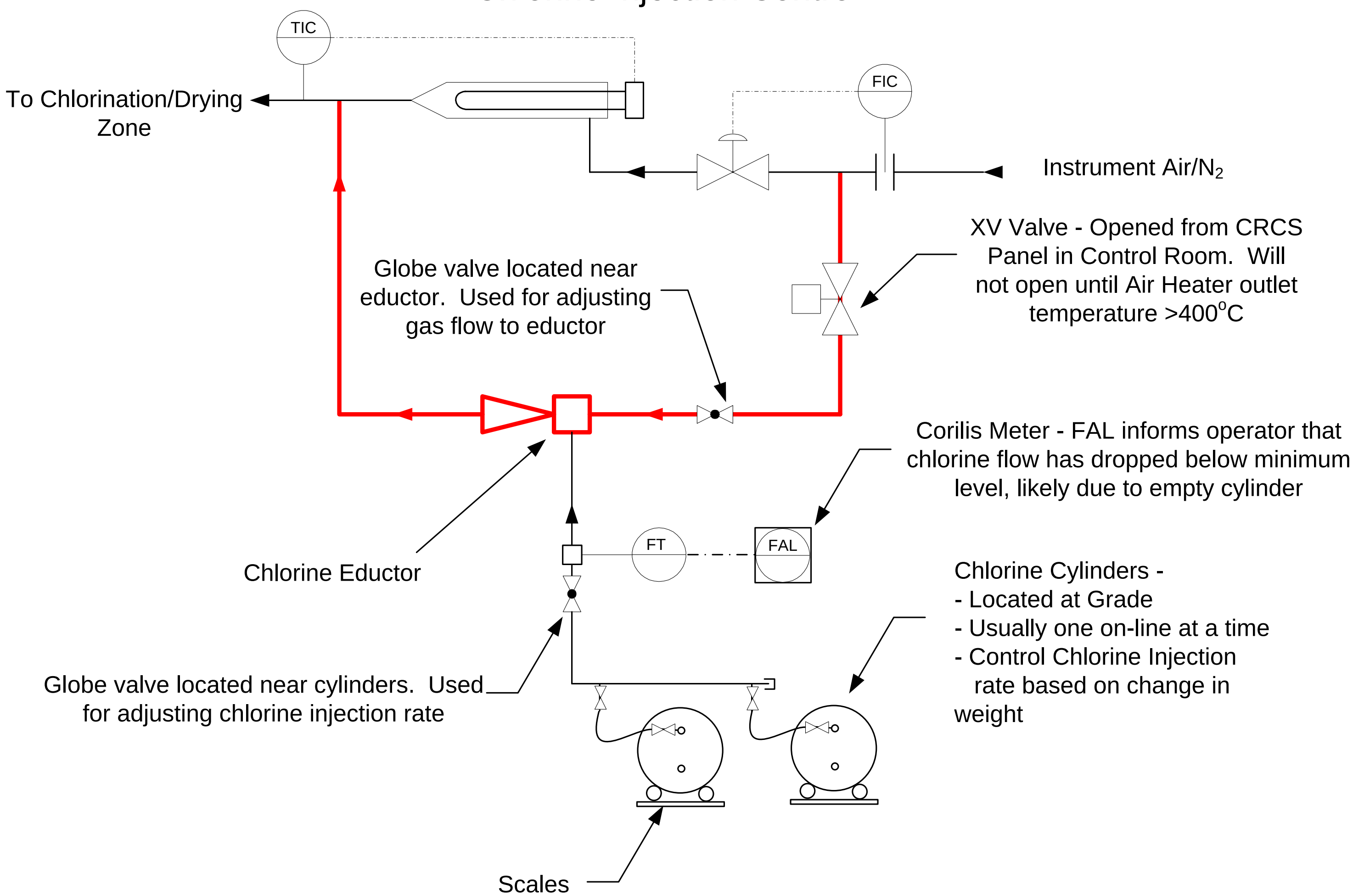
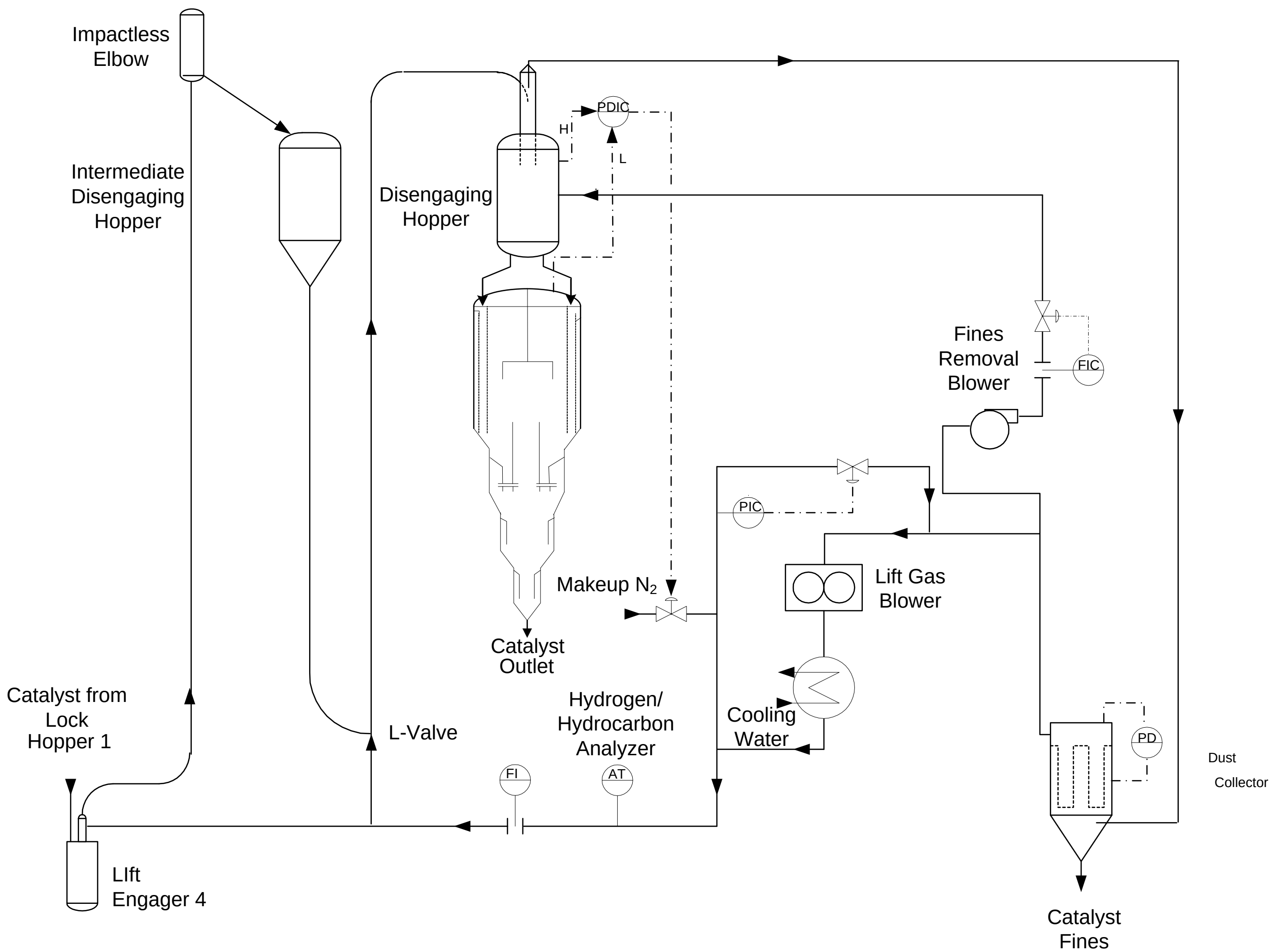


Figure IV-12
Spent Catalyst Lift System and Fines Removal



Appendix I
CHLORINATION SYSTEM

Anhydrous chlorine, added to the drying zone of the Regeneration Tower, is supplied under vacuum to an eductor using dry air from the Air Dryers as the motive fluid. The system includes all equipment and facilities required for the safe storage and handling of chlorine in locally available one-ton containers. See Figures 1 and 2 for general arrangement of equipment, piping, and instrumentation.

All of the detailed specifications and requirements are indicated in Project Specification 729 in the UOP Engineering Project Specifications for the CCR Section – Reactor Area. For reference, a summary of the equipment specified by UOP to be supplied in the chlorination system is listed below.

- Two remote vacuum regulators with automatic switchover capability
- Chlorine rate valve and gas rate indicator
- Chlorine Eductor
- Two manifold assemblies, each with hookups for two one-ton chlorine containers, chlorine filter, and drip leg heater
- Chlorine flow transmitter
- Trunions for all chlorine containers
- Load cell type scales for all chlorine containers connected to the manifolds
- Monorail mounted hoist and related lifting equipment
- Chlorine monitor(s)
- Heated building to house all equipment other than the eductor
- Building ventilation facilities
- Safety equipment for normal and emergency operations
- Operating manuals
- Piping, valves, fittings, structural steel, and accessories as required ensuring a functional and safe system

As shown above, a chlorine flow transmitter is included in the scope of supply, and allows for continuous monitoring of the chlorine flow to the Regeneration Tower drying zone. This flow rate is typically 0.6 to 0.8 wt% of the catalyst circulation rate.

When commissioning the chlorine injection system, special attention must be given to the air heater operation. This is due to the fact that the motive air to the Chlorine Eductor is a slipstream of the lower air stream, and bypasses the air heater. With a sudden change in air flow to the air heater when commissioning the Chlorine Eductor, the air heater sheath temperatures may rise quickly until a high temperature signal shuts down the heater. There are two ways to avoid this occurrence. First, put the air heater temperature controller in manual before commissioning the motive air to the Chlorine Eductor. After commissioning the motive air, manually change the air heater output as necessary to avoid the automatic sheath temperature shutdown. Return to automatic control after the temperature has been stabilized at the desired level (typically 538°C). Second, attempt to minimize the required motive air during commissioning without sacrificing the performance or safety of the chorine injection system. This is accomplished by increasing the PSL switch setting within the chlorination system, but should only be done as approved by the chlorination system vendor. With a higher PSL switch setting, somewhat less vacuum is needed, which translates into less required motive air. Once this motive air rate is established, the globe valve on the motive air line is left at that position.

Figure App. I-1
Chlorination Sysem Flow Scheme

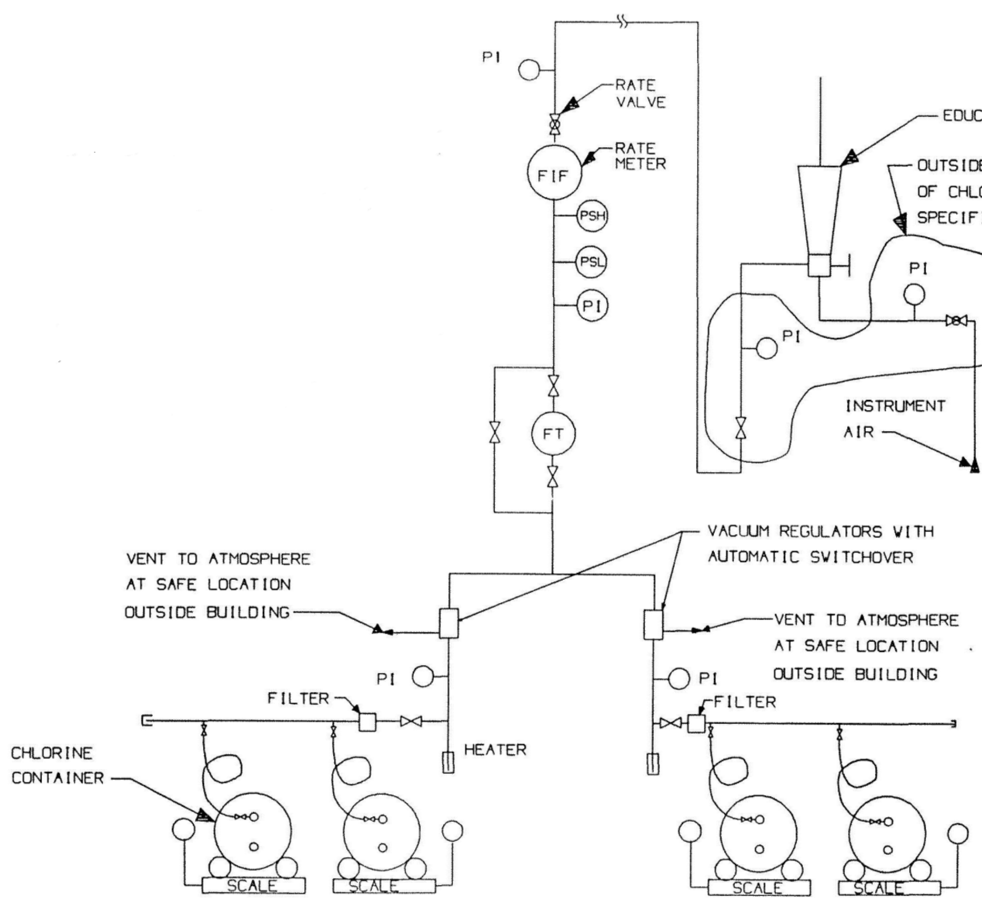
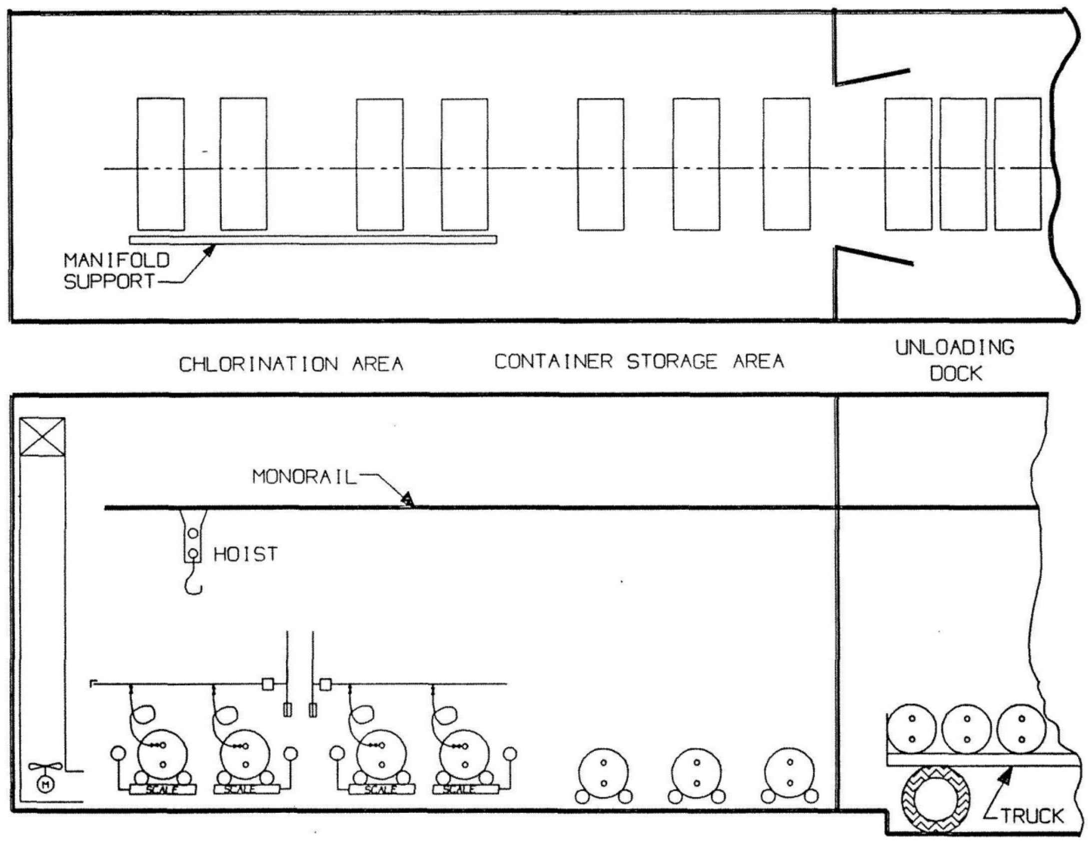


Figure App. I-2
Typical Building Layout



V. PROCESS EQUIPMENT

Catalyst regeneration is performed in the CCR Regenerator Section which includes the Intermediate Disengaging Hopper, Disengaging Hopper, Regeneration Tower, Flow Control Hopper, Surge Hopper, Reduction Zone, Surge Pots, Catalyst Collectors, Lock Hoppers, Lift Engagers and all associated piping and equipment. This section is intended to detail the important features of each vessel and piece of equipment.

A. Intermediate Disengaging Hopper

Due to the long horizontal distance between the last lift engager in the reactor system below Lock Hopper 1 and the Disengaging Hopper, an Intermediate Disengaging Hopper is placed in between these vessels. Long horizontal catalyst transfer lines lead to a higher amount of fines creation. The Intermediate Disengaging Hopper eliminates these long horizontal runs and subsequently lowers fines make.

Catalyst is lifted from the last lift engager below Lock Hopper 1 by the lift gas blower to the Intermediate Disengaging Hopper. The catalyst flows by gravity out of the bottom of the vessel on an L-Valve assembly. The catalyst is lifted from the L-Valve by the lift gas blower to the Disengaging Hopper.

B. Disengaging Hopper

There will be some catalyst attrition while circulating throughout the reactor-regenerator system. The resulting fines must be removed to minimize plugging of the regenerator screens and to a lesser extent, the inner screens and outer screens in the reactors. The Disengaging Hopper is designed to remove these catalyst fines and chips which might otherwise tend to generate pressure drop across the various screens.

The Disengaging Hopper is a cylindrical vessel constructed of killed carbon steel with elliptical top and bottom heads (see Figure V-1). The bottom head has several equally spaced catalyst transfer nozzles attached around it (see Figure V-2). The pipes attached to each nozzle feed catalyst to the annular space between the inner and outer screens of the Regeneration Tower. A nuclear level indicator is installed on the side of the Disengaging Hopper, which sends a signal to the Lock Hopper Control System (LHCS) to maintain a catalyst level in the Disengaging Hopper. The top head contains a line for a relief valve and another for a pressure tap.

The main feature of the Disengaging Hopper is the elutriation tube located in the top head. The tube is flanged to the top head and extends well into the vessel. The catalyst lift line is inserted into the side of the elutriation tube and extends down toward the center of the vessel (See Figure V-3).

Catalyst and the nitrogen lift gas from the L-Valve assembly below the Intermediate Disengaging Hopper are transported to the Disengaging Hopper. The catalyst and gas enter the tube and are immediately directed down the tube. Nitrogen gas, used for elutriation, is brought into the side of the vessel and immediately contacts a deflection baffle. The elutriation gas flows counter current to the catalyst and carries the fines and chips up and out of the elutriation tube and over to the Dust Collector, where the fines are filtered from the circulating nitrogen. The nitrogen used for lift gas is then recycled back to the last reactor Lift Engager and L-Valve assembly via the Lift Gas Blower. The nitrogen used for elutriation is also recycled by Fines Removal Blower. The catalyst exiting the bottom of the Disengaging Hopper is essentially free of fines. The removal of catalyst fines allows the Regeneration Tower to operate much longer between screen cleanings.

The second major function of the Disengaging Hopper is to act as an inert gas buffer between the reactor and regeneration sections as it has a constant high flow of nitrogen passing through it. A portion of the circulating nitrogen migrates down the catalyst transfer pipes to prevent migration of oxygen from the Upper Burn Zone. The recirculating nitrogen is sampled by an H2/HC analyzer to monitor possible contamination.

C. Regeneration Tower

The Regeneration Tower is constructed of Inconel and is comprised of two primary sections as shown in Figure V-4. The top section, comprising the Upper Burn Zone and the Lower Burn Zone, contains two concentric screens, referred to as the ‘inner screen’ and the ‘outer screen.’ Their function is to contain catalyst and allow the regeneration gas to flow radially across the catalyst bed. The outer screen is welded to the vessel wall at the top and bottom and fabricated with vertical screen wire to minimize catalyst attrition. The inner screen is also fabricated with vertical screen wire and is permanently attached to the head of the Regeneration Tower. In newer units, the inner screen is fabricated from 304 stainless steel rather than Inconel; this is done to provide more protection from corrosion due to possible combination of high regeneration gas temperatures and high SO2 content.

The catalyst is transferred to the Regeneration Tower from the Disengaging Hopper via a set of catalyst transfer pipes located around the circumference of the two vessels. The pipes enter the top head of the Regeneration Tower and extend into the inner and outer baskets of the Upper Burn Zone. The distance between the end of catalyst transfer pipes in the tower and where the screen openings begin maintains a catalyst seal which prevents regeneration gas to bypass the catalyst. In addition, this seal prevents fluidization of the catalyst.

There are baffles provided between the shell and the outer screen and inside the inner screen to separate the Upper Burn Zone from the Lower Burn Zone. The gas exiting the inner screen in the Lower Burn Zone is routed to the outlet nozzle through a pipe routed from the separation baffle to the top head of Regenerator.

The top head of the Regeneration Tower also has nozzles installed to allow temperature indicator assemblies to be lowered into the length of the tower. These indicators are spaced to give a representative temperature profile along the length of both the Upper Burn Zone and Lower Burn Zone. These thermocouples are contained in sheaths which guide the thermocouple tips to the inner surface of the inner screen.

The thermocouples provide representative point temperatures of the gas leaving the Upper Burn Zone and Lower Burn Zone. Figure V-5 illustrates the thermocouple installation details and Figure V-6 shows a picture of actual thermocouples installed in a Regeneration Tower.

The lower section of the Regeneration Tower, called the Chlorination Zone, removes the moisture from the catalyst which was generated in the Upper Burn Zone and Lower Burn Zone and also distributes the platinum on the catalyst by contacting with chlorine. Air and chlorine enter through a side nozzle directly into an annular distributor. This annular baffle forces the air to flow down to the bottom of the distributor where it turns up and flows counter-current to the catalyst. The gas from the Chlorination Zone is vented to the Vent Gas Treatment System through a nozzle at the side of the Regeneration Tower, located behind an annular baffle at the top of the Chlorination section.

An equalization line from the Surge Hopper is attached to another nozzle located on the side of the Chlorination Zone. This line has a steady flow of nitrogen from the Surge Hopper through a check valve to the Regeneration Tower. This maintains a slightly higher pressure in the Surge Hopper to minimize air leakage into the Surge Hopper.

A smaller annular distributor is installed just beneath the Chlorination Zone. A slip-stream of dry air enters through a side nozzle and flows counter-current to the catalyst. This ensures that any entrained chlorine is stripped off the catalyst before it leaves the tower and enters the carbon steel Surge Hopper.

D. Associated Regeneration Equipment

Other equipment involved in catalyst regeneration is the Upper Regeneration Heater which heats the circulating regeneration gas to 477°C. The heater is installed vertically and manufactured out of Inconel 600. A similar heater is provided for heating the circulating gas to the Lower Burn Zone, called the Lower Regeneration Heater. Figure V-7 is a diagram of a typical heater.

The Upper Regeneration Blower is a low head blower that circulates the hot regenerant gas through the Upper Burn Zone. Depending on the design of the Regeneration Tower, the Regeneration Blower will be mounted either at grade or somewhere in the middle of the structure. The blower is manufactured out of Inconel 600. A similar blower is provided for circulation of gas through the Lower Burn Zone. Figure V-8 is a depiction of the Upper Regeneration Blower & Lower Regeneration Blower.

There is also an Upper Regeneration Cooler and Cooler Blower that are used for cooling the gas exiting the Upper Burn Zone. The Lower Regeneration Cooler and same Cooler Blower are used for cooling the gas exiting the Lower Burn Zone. The Regeneration Coolers are vertical jacketed pipe exchangers with the hot regenerant gas flowing downward through the inner pipe. The cool ambient air flows upward through the annulus between the inner pipe and the outer jacket. Figure V-9 is a diagram of the Upper Regeneration Cooler & Lower Regeneration Cooler. The Cooling Zone Cooler is a similar smaller exchanger that is also cooled by the Cooler Blower.

The Cooler Blower blows ambient air through the outer annulus of the Upper Regeneration Cooler, Lower Regeneration Cooler and Cooling Zone Cooler. The suction side of the blower should be equipped with a rain hood and a bird screen. Valves on the discharge of the blower regulates air flow to three coolers and also to atmosphere to allow the blower to stay running when no cooling is needed on any of the coolers. Although cooling may not always be necessary, the Regeneration Cooler Blower will always be in-service when the Regeneration Tower is operating.

The instrument air supplied to the Chlorination Zone passes through the Air Dryers to reduce the moisture level to > 5 ppm before entering the Regeneration Tower. The Air Dryer package customarily consists of two vessels containing desiccant and is automated such that each vessel can be regenerated as required. A picture of a typical Air Dryer package is shown in Figure V-10.

The gas to the Chlorination Zone is heated by the Air Heater. The Air Heater is constructed of stainless steel and consists of four bundles in series. Figure V-11 is a diagram of a typical Air Heater.

The net flue gas from the Regenerator is sent to the Vent Gas Treater System (VGTS) section where the gas is scrubbed prior to being vented to the atmosphere. This is a packaged system designed to cool and scrub the gas using circulating caustic. A picture of a typical VGTS is shown in Figure V-12.

E. Flow Control Hopper

The Flow Control Hopper (FCH) is located directly below the Regeneration Tower and is sized to hold approximately the amount of catalyst that will be circulated in one minute at the design circulation rate. The FCH for a 1,500 lb/hr Regenerator will hold between 25-30 lbs of catalyst. The FCH is used for moving small batches of catalyst from the Regeneration Tower into the Surge Hopper and controls the rate at which catalyst is circulated throughout the Reactor-Regenerator system.

The Flow Control Hopper also contains a sample port for taking samples of regenerated catalyst. Figure V-14 shows a diagram of a typical Flow Control Hopper.

F. Surge Hopper

Both the Lock Hoppers and the Lift Engagers transfer catalyst in relatively large batches, cycling at roughly 3 times per hour. For a 1500 PPH unit, each batch is approximately 600 pounds. The Flow Control Hopper typically has a load size of 25 to 30 pounds. The disparity between these two transfer rates results in the catalyst volume surging somewhere in the catalyst circuit. This inequity is taken up in the Surge Hopper. See Figure V-15 showing a diagram of the Surge Hopper.

The Surge Hopper also performs two other important functions. First, the vessel is purged continuously with a low flow of nitrogen, which allows the hopper to be a buffer between the oxygen atmosphere in the Regeneration Tower above and the hydrogen atmosphere in Lock Hopper No 2, located below. The nitrogen purge flows up through the catalyst bed and is then directed to the Regeneration Tower via the equalization line. There is a special low pressure drop check valve in the equalization line which prevents backflow of gas from the Regeneration Tower into the Surge Hopper. See Figure V-16 for a diagram of the pressure equalization line. As a final assurance of maintaining the inert gas environment in the Surge Hopper, an H2/HC analyzer samples the Surge Hopper atmosphere. If the levels of contaminants rise to the shutdown point, the entire Regeneration Section is shutdown by the LHCS.

The second major function of the Surge Hopper is to cool the catalyst to a temperature of approximately 200°C (400°F). The cooling of the catalyst aids in the proper operation of the Lock Hopper valves and the overall performance of the Lift Engagers. Cooling of the catalyst is achieved by a cooling water panel coil located at the bottom of the Surge Hopper.

A specially designed holding pot known as the Flow Dampener is affixed inside to the top head of the Surge Hopper vessel. This flow dampener (see Figure V-17) has a number of holes aligned vertically on either side, which allows hot catalyst to drain through at an even rate into the Surge Hopper. This minimizes pressure surges created by periodic batches of hot catalyst, falling from the Flow Control Hopper, through the nitrogen atmosphere. Minimizing the pressure surges decreases the cross-contamination of the Chlorination/Drying Zone and Surge Hopper atmospheres.

G. Catalyst Addition Funnel and Catalyst Addition Lock Hopper

Periodically catalyst must be added to the systems due to losses from fines generation. Makeup catalyst is added to the system using the Catalyst Addition Funnel and the Catalyst Addition Lock Hopper. Both vessels are will be located above the Surge Hopper. Figure V-18 shows a diagram of the Catalyst Addition Funnel and Figure V-19 shows a diagram of the Catalyst Addition Lock Hopper.

More detailed instructions for adding makeup catalyst can be found in Section XIII Special Procedures of this manual. In general, only one drum of catalyst is added to the Surge Hopper at a time. After the drum is dumped into the Catalyst Addition Funnel, the XV valve located directly above the Catalyst Addition Lock Hopper is opened and the catalyst is drained into hopper. Once all the catalyst has drained into the Lock Hopper, the top valve is closed and the valve below the hopper is opened, allowing the catalyst to drain into the Surge Hopper. The XV valves located above and below the Lock Hopper are operated by a local control station.

To prevent rain water from entering into the Surge Hopper and damaging the catalyst, it is important to keep the Catalyst Addition Funnel covered when not adding catalyst.

H. Lock Hoppers

Lock Hoppers are located beneath the last reactor and the Surge Hopper. These vessels are designed to allow for the safe transfer of catalyst from one environment to another. Lock Hopper No. 1 receives catalyst from the last reactor’s Catalyst Collector and changes the environment from hydrogen/hydrocarbon to nitrogen so that the catalyst is safely compatible with the oxygen containing atmosphere of the Upper Burn Zone and Lower Burn Zone. Conversely, Lock Hopper No. 2 receives catalyst from the Surge Hopper and changes the environment from nitrogen to hydrogen. This is required before transporting catalyst to the Reduction Zone.

A Lock Hopper (Figure V-20) has no special internals. The catalyst enters and exits via single catalyst transfer pipes. The vessel also has a line for pressuring and depressurizing. A nitrogen purge line is located near the bottom of the vessel on the outlet transfer pipe and into the middle of the vessel to allow for effective nitrogen purging. Finally, a nuclear level indicator is mounted on the side of the vessel for determining when the required amount of catalyst has been loaded into the vessel. Detailed instructions of the Lock Hopper logic will be discussed in Section VIII Normal Operations of this manual.

I. Lift Engagers and Catalyst Transfer Lines

Lift engagers are below each catalyst collector, except Rx 4 for C3 units and Rx 3 for C4 units which have lift engagers below Lock Hopper 1. These vessel used for transporting catalyst from the bottom of each reactor or the regeneration section to the top of the downstream vessel is the Lift Engager. Figure V-21 is a general depiction of a Lift Engager. This is a vertical vessel with a with a standard elliptical bottom head.

The catalyst inlet nozzle is installed in the top head. The catalyst outlet nozzle is the inner pipe of two concentric pipes which pass through the center of the top head. The outer pipe is attached to the head and extends to near the bottom tangent line of the vessel. The upper portion of the outer pipe extends several inches out of the vessel to a capped joint with the inner pipe. The inner pipe, or catalyst lift pipe, extends into the vessel a short distance below the end of the outer pipe. The primary lift gas inlet nozzle is located on the external portion of the outer pipe. Primary lift gas flows through the annulus between the two pipes and fluidizes the catalyst as it changes direction to flow out of the engager through the inner pipe. The distance between the inner and outer pipe is maintained by three Allen screws that are screwed into the outer pipe. These screws can be accessed through the drain flange at the base of the Lift Engager.

The gap between the length of the inner and outer pipe is adjusted during commissioning to fine-tune the time each Lift Engager requires to lift one load of catalyst. If the Lift Engager is taking too long to lift a load of catalyst, the gap is increased slightly and vice-versa if a load of catalyst is being lifted too quickly.

In addition, a portion of the lift gas sent to each Lift Engager's lift pipe can be sent directly into the Lift Engager above the surface of the catalyst, to assist in lifting the catalyst as needed. This “secondary lift gas” is normally not required, but can be used in case of recurring difficulty in lifting catalyst.

The catalyst and the lift gas flow out of the Lift Engager through the catalyst lift pipe to a catalyst transfer line, which extends to the top of the downstream vessel. The catalyst transfer line construction is rigorously specified to minimize catalyst attrition: directional changes are made with long radius bends; line joints are minimized and are of special construction; no upward sloping runs are allowed; and the total number of bends and the total length of the transfer lines are minimized. Impactless elbows, described in section M, are used wherever possible to minimize fines creation. Figure V-22 illustrates the recommended method of joining lengths of pipe using a Dur-o-lok coupling.

J. Reduction Zone and Surge Pots

The vessel at the top of the Reactor No 1 is called the Reduction Zone. In this vessel, the catalyst is reduced by a pure hydrogen stream heated to between 550 and 600 °C. Identical vessels are located at the top of the other reactors, and are called Surge Pots. Each of these vessels connects directly to the top of their respective reactor. The purpose of these vessels is to heat the catalyst up to about 600°C using pure hydrogen prior to dropping the catalyst into the reactor so as to avoid thermal cycles of the reactor screens.

The hydrogen purge gas enters the side of the vessel and migrates down the catalyst volume. Most of the purge gas will exit through the purge gas outlet line. However, some of the purge gas will migrate down the catalyst transfer pipes, enter the reactor annulus and exit the reactor along with the reactor effluent. The purpose of this is to prevent hot hydrocarbon in the reactor feed from migrating into the Reduction Zone or Surge Pot and potentially causing coke formation. See Figure V-23.

The catalyst will enter at the top of the Reduction Zone or Surge Pot through a flange located in the center of the vessel. The typical catalyst volume in the vessel during normal operations is approximately half way between the top of the vessel and the top of the first annular distributor.

K. Catalyst Collector

The Catalyst Collector is located immediately below each reactor and is attached to its reactor by means of several catalyst transfer pipes. The number of pipes will vary between 8 and 16, depending on the reactor size. These pipes are not valved and are designed to allow catalyst to flow freely. The catalyst flows through these pipes into independent, equally spaced segments of the Catalyst Collector (see Figure V-24). Each segment of the distributor makes up an equal volume, ensuring equal flow of catalyst from each catalyst transfer pipe and therefore, from all parts of the annular space of the reactor. The pipes are provided with fluted holes and extend into the catalyst bed in the Collector. In normal operation, the bottom opening of the pipe is not exposed, and catalyst flows out through the flute holes. The flute holes are sized, such that on transfer of load of catalyst out of the Catalyst Collector to the Lift Engager or Lock Hopper, it takes about 75% of the cycle time of the respective Lift Engager / Lock Hopper to replenish the catalyst inventory of the Catalyst Collector with catalyst from the Reactor. This slows down the rate at which catalyst is withdrawn from the Reactors, and allows near continuous catalyst withdrawal of catalyst out of the Reactors. The Catalyst Collector is also provided with a conical bottom, which further aids in ensuring uniform catalyst flow through all of the catalyst transfer pipes. The evenly distributed movement of catalyst from the reactor maintains the catalyst's free-flowing properties which are desirable for transfer. The total volume of the Catalyst Collector on Reactors other than the last Reactor is equal to approximately twice that of the Lift Engager, located below the Catalyst Collector.

The Catalyst Collector is purged with hydrogen-rich net gas to sweep entrained hydrocarbons off the catalyst. This prevents coke from forming in the collector or in the inlet pipes to it. Additionally, the hydrogen purge cools the catalyst which helps maintain a longer ball valve life. The purge gas enters the Catalyst Collector from the side, down an annular distributor, then up through the catalyst volume. The purge gas exits the Catalyst Collector through the outlet nozzle located on the top head. This purge gas than connects with the reactor effluent stream associated with that particular collector.

During normal operations, some of the feed gas from the reactor will migrate down through the catalyst transfer pipes and exit with the Catalyst Collector purge gas. This is to prevent the possibility for catalyst in the Catalyst Collector from potentially fluidizing and migrating into the Reactor.

The Catalyst Collector below the last Reactor is provided with two sections – an upper section for stripping sulfur from the catalyst, and a bottom section to cool the catalyst (similar to the other Catalyst Collectors). Hot PSA hydrogen gas enters the Catalyst Collector behind an annular distributor and flows up through the catalyst bed in the Sulfur Stripping Zone of this Catalyst Collector. Catalyst drops from the Sulfur Stripping Zone into the Cooling Zone. Net gas heated in the CCR Gas Heater enters behind the annular distributor in the Cooling Zone and flows up the catalyst in this zone. A funnel at the top of the Cooling Zone collects most of the cooling gas, and routes it through a pipe to the top of the Stripping Zone, so that the cool gas does not mix with the Hot PSA hydrogen used for stripping.

L. Valves

Three types of automatic valves are used in the Catalyst Regeneration Section; “Vee port” valves, “B” valves, and “G” valves. Each valve is equipped with an actuator which is controlled by the transfer system’s logic controller. The valve operates in fully open or fully closed positions only. Each valve has two limit switches which act as valve position indicators.

Wherever catalyst flow must be stopped, a special ball valve called a Vee-port valve is used. It is designed to stop catalyst flow without breaking the catalyst pills. This type of valve does <u>not</u> seal against gas flow.

Regular ball valves or “B” valves are used to provide a gas tight seal in the catalyst transfer lines entering and exiting the Lock Hoppers. These valves are <u>not</u> intended to close on catalyst since doing so would result in damage to both catalyst and the valve.

A special Masoneilan or “G” valve is used for all gas double block and bleed services. This is a globe valve with a double seat, designed so the hard seat closes first and is followed by closing of its soft seat.

M. Impactless Elbows

In order to minimize the amount of catalyst fines generated as the catalyst is circulated, impactless elbows are used in the catalyst lift lines. These devices replace two conventional long radium elbows between the vertical lift line from a Lift Engager and the horizontal line connecting with the Surge Hopper or Disengaging Hopper. The impactless elbow allows for the catalyst to change directions without impacting against the inside of an elbow, which otherwise will cause some catalyst to break and create fines. Figure V-25 shows a sketch of the impactless elbow.

Figure V-1
Disengaging Hopper

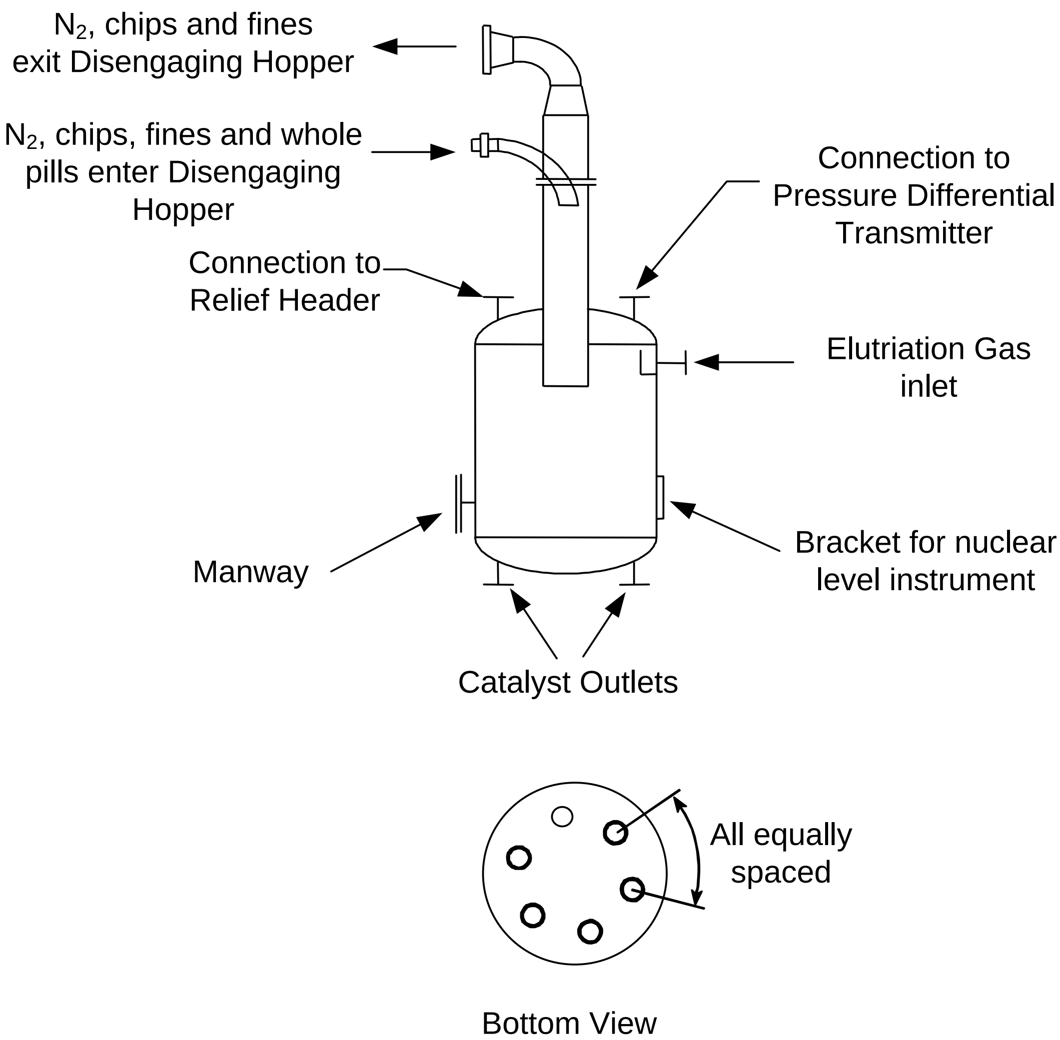


Figure V-2
Catalyst Transfer Pipes

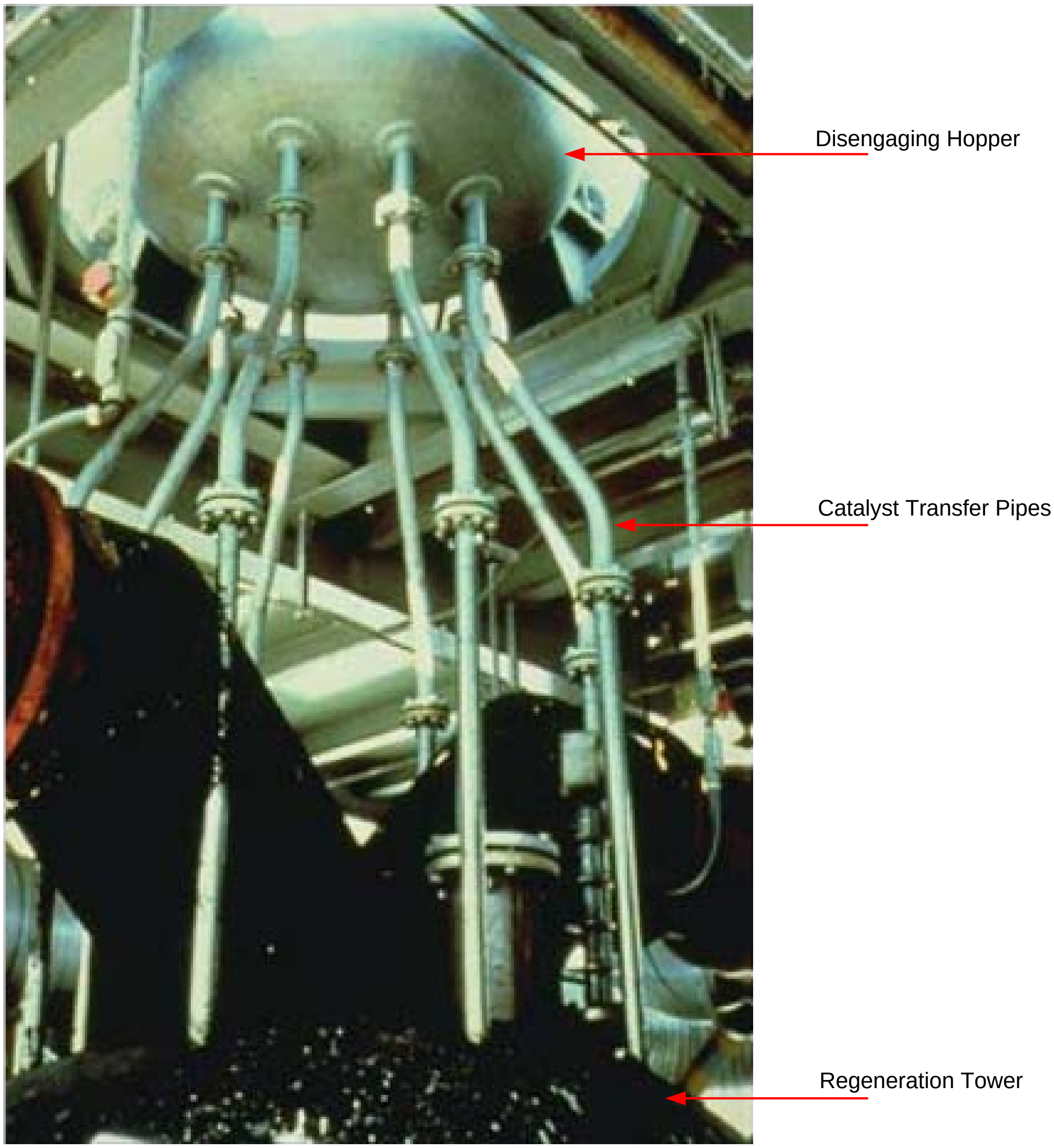


Figure V-3
Down Flow Elutriator

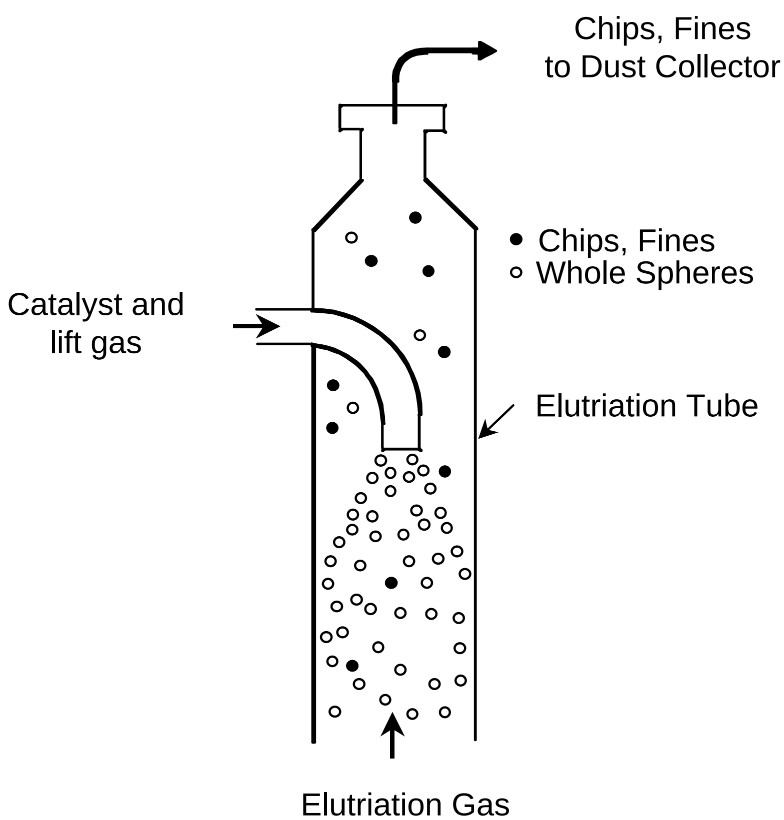


Figure V-4
Regeneration Tower

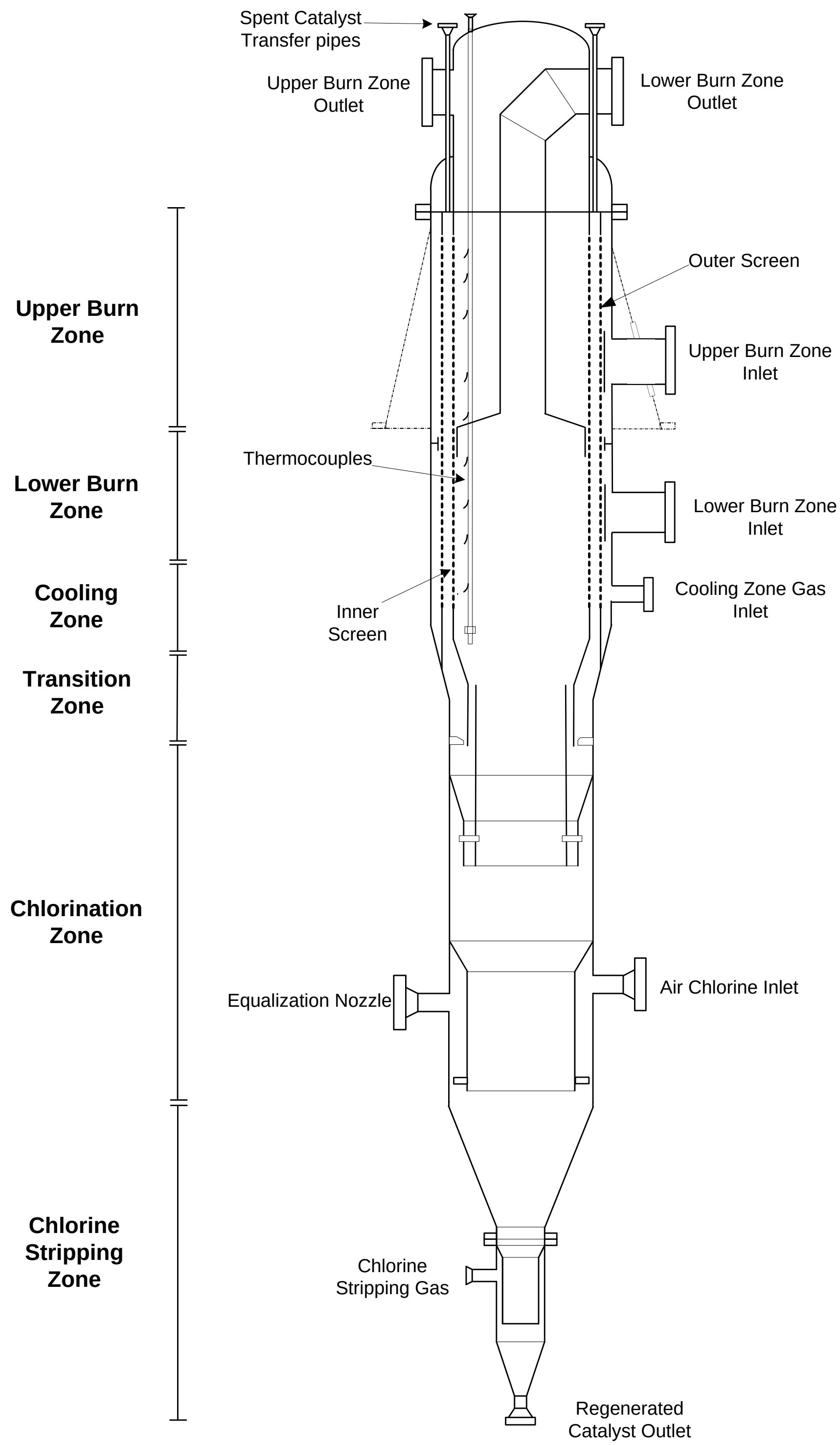


Figure V-5
Regeneration Zone Bed Temperature

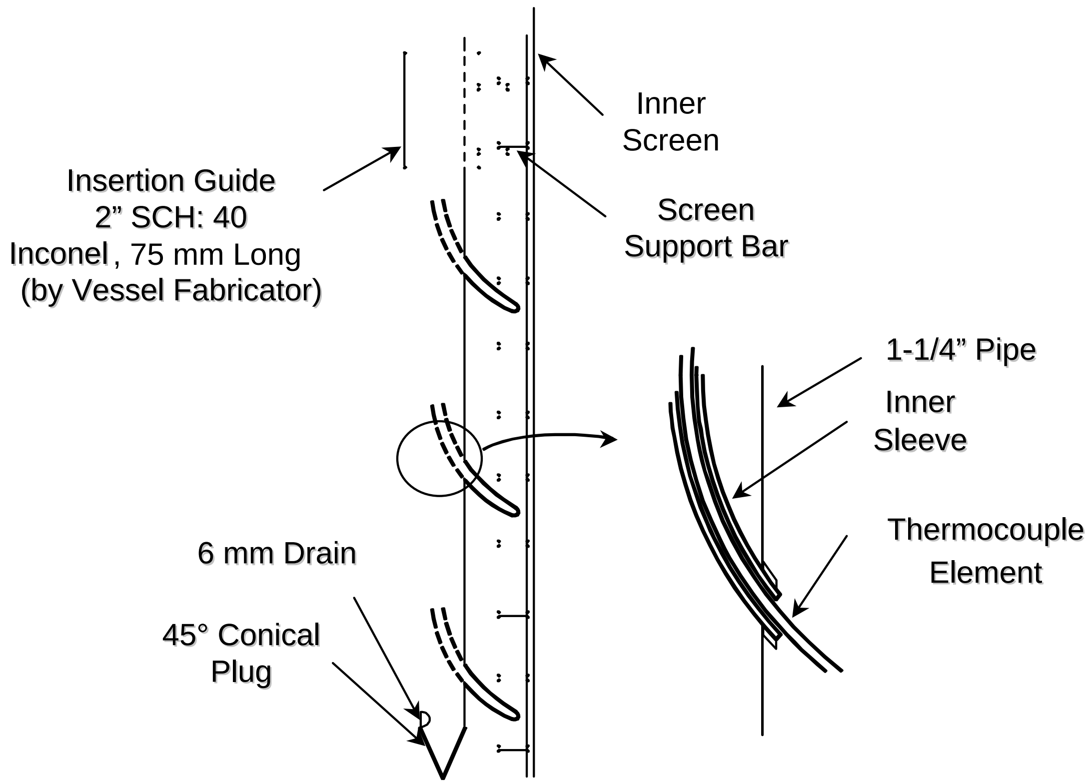


Figure V-6
Regeneration Zone Bed Thermocouple

Figure V-7

Upper Regeneration Heater & Lower Regeneration Heater

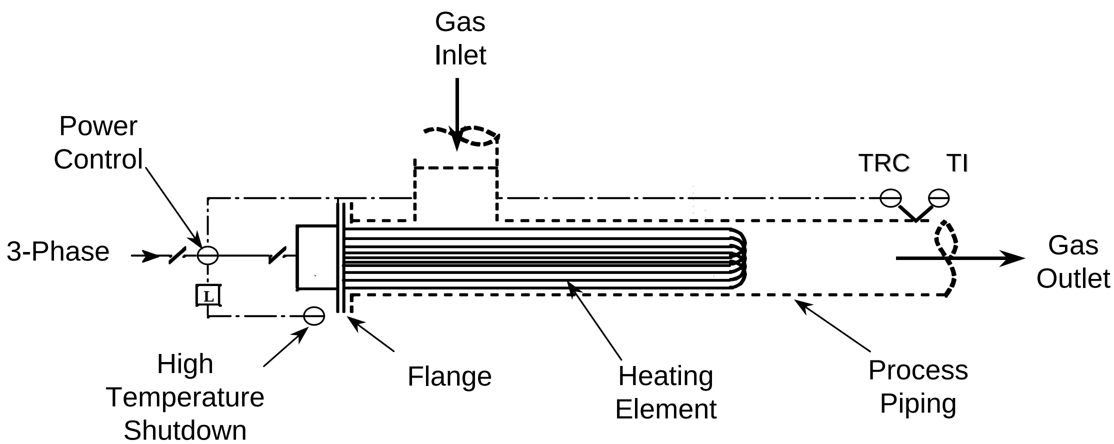


Figure V-8

Upper Regeneration Blower & Lower Regeneration Blower

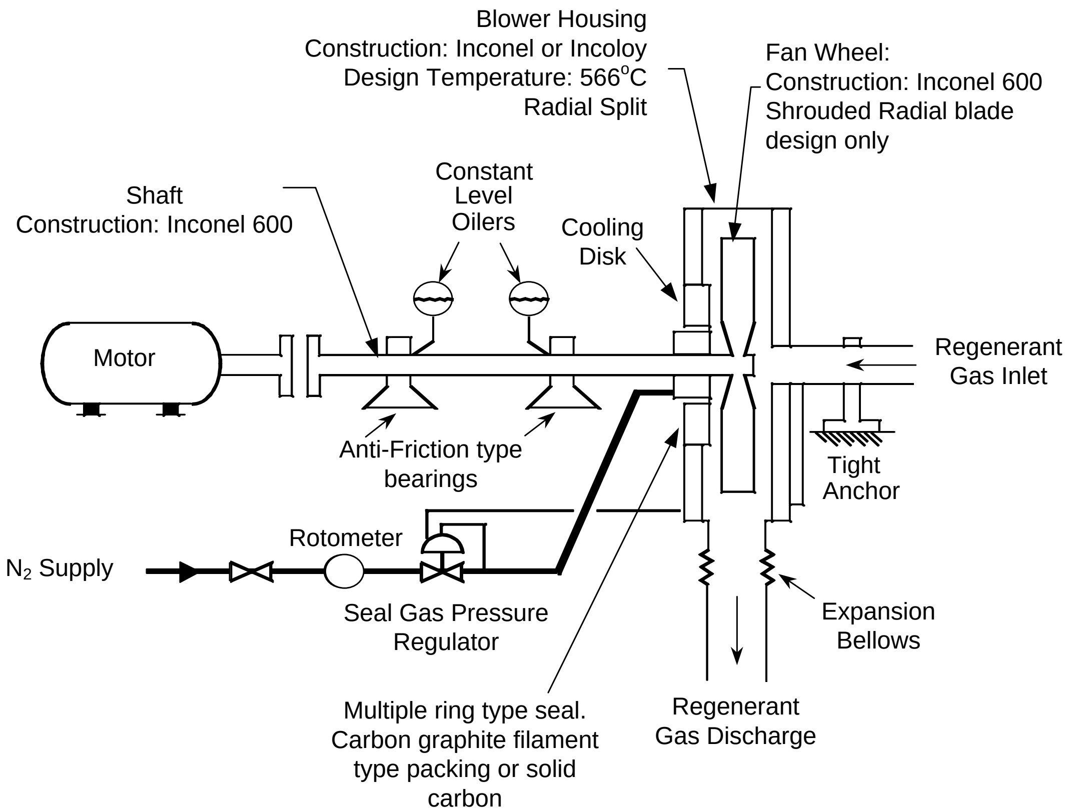


Figure V-9
Upper Regeneration Cooler & Lower Regeneration Cooler

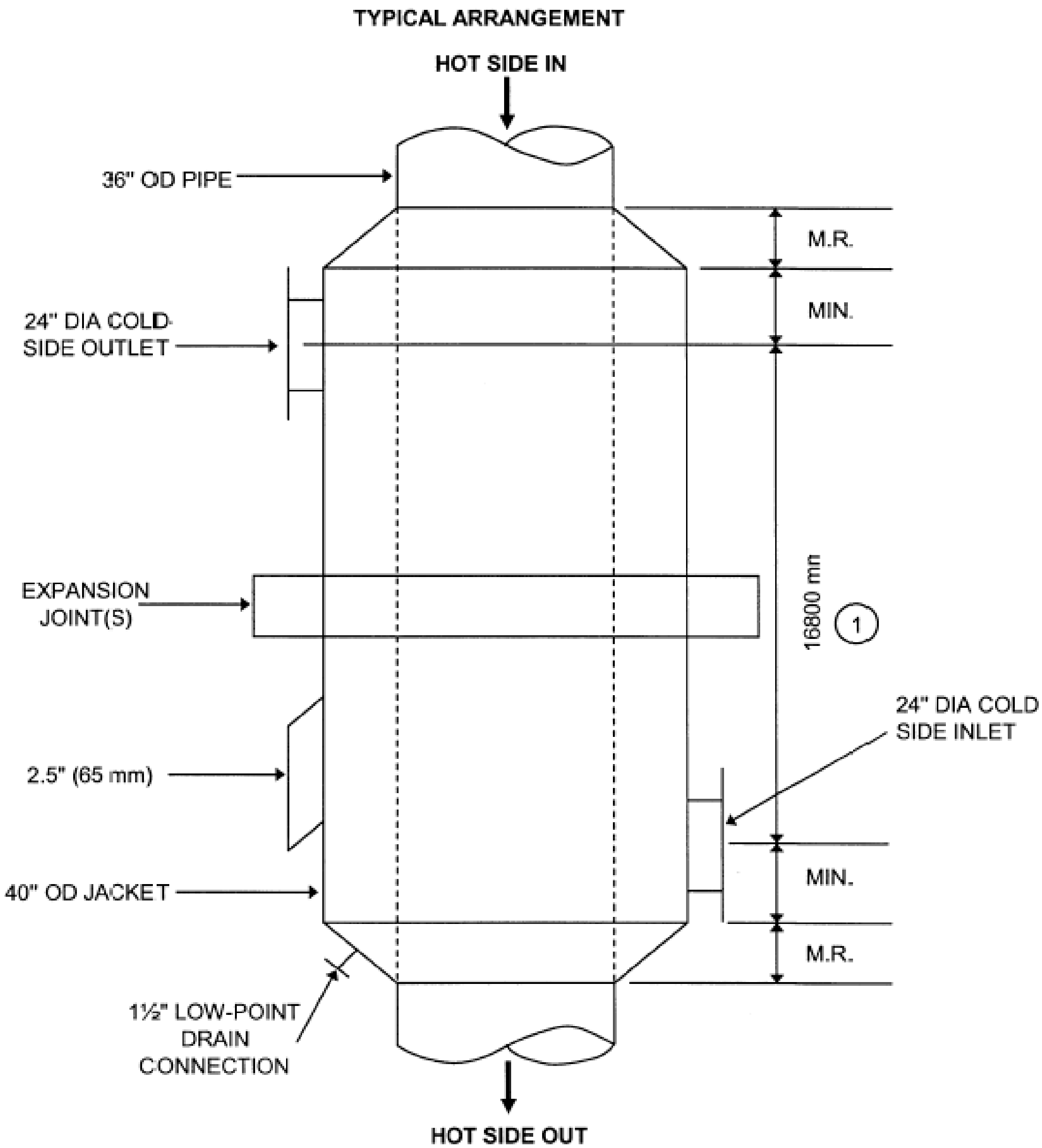


Figure V-10
Air Dryer Package

Figure V-11
Air Heater

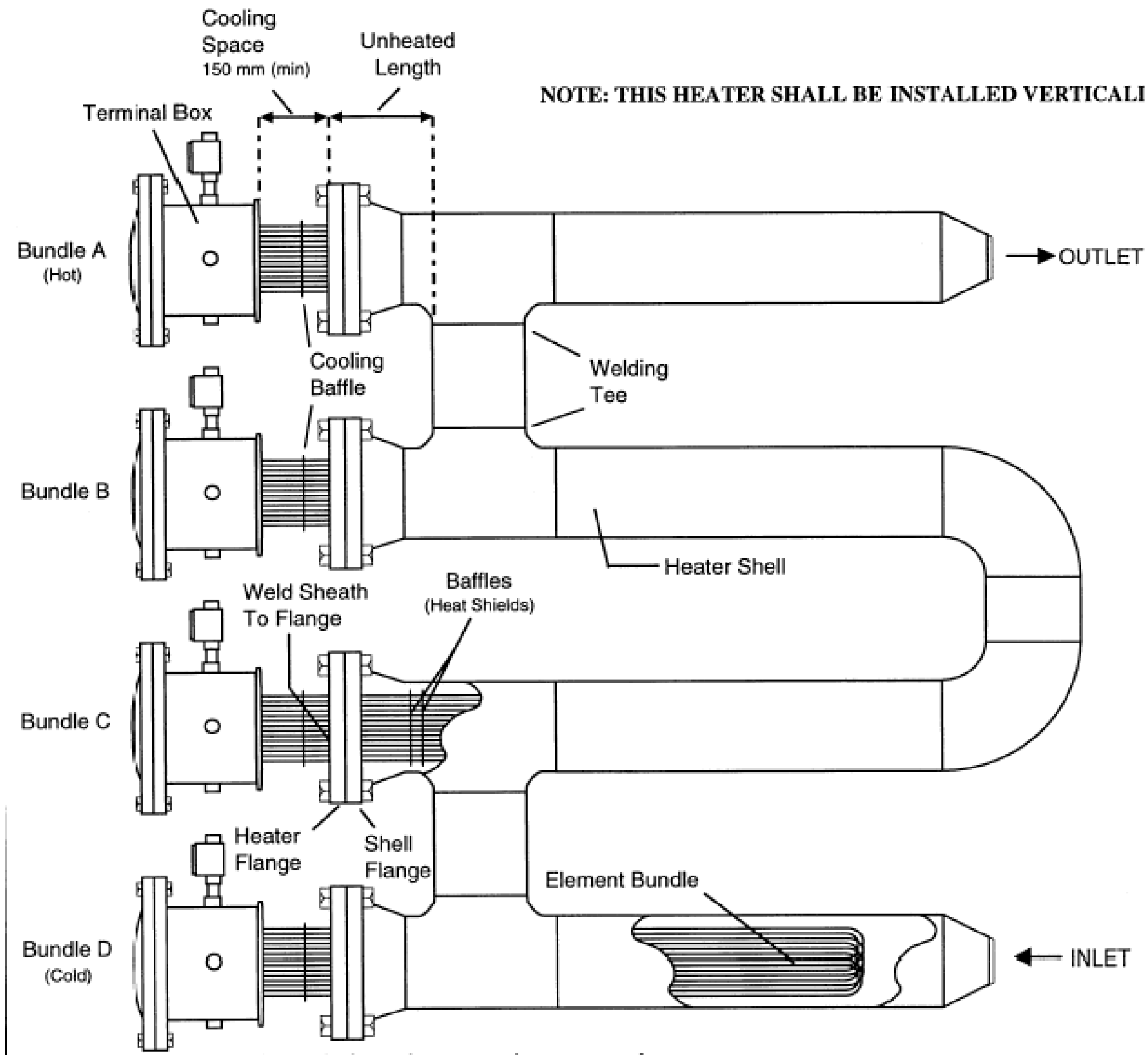
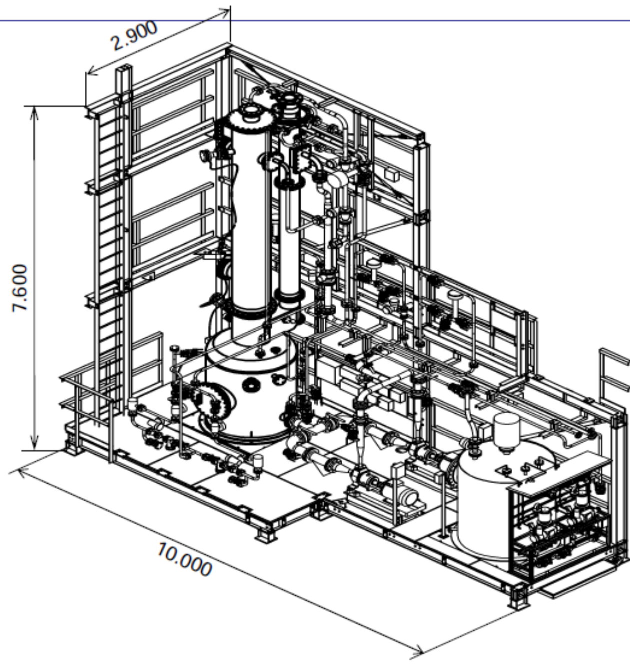


Figure V-12
Vent Gas Treatment System

GEA Jet Pumps GmbH
Process Engineering Division

3D Arrangement
PHD Vent Gas Scrubber



30

GEA Jet Pumps GmbH
Process Engineering Division

Vent Gas Scrubber

31

Figure V-13
Vent Gas Treatment System

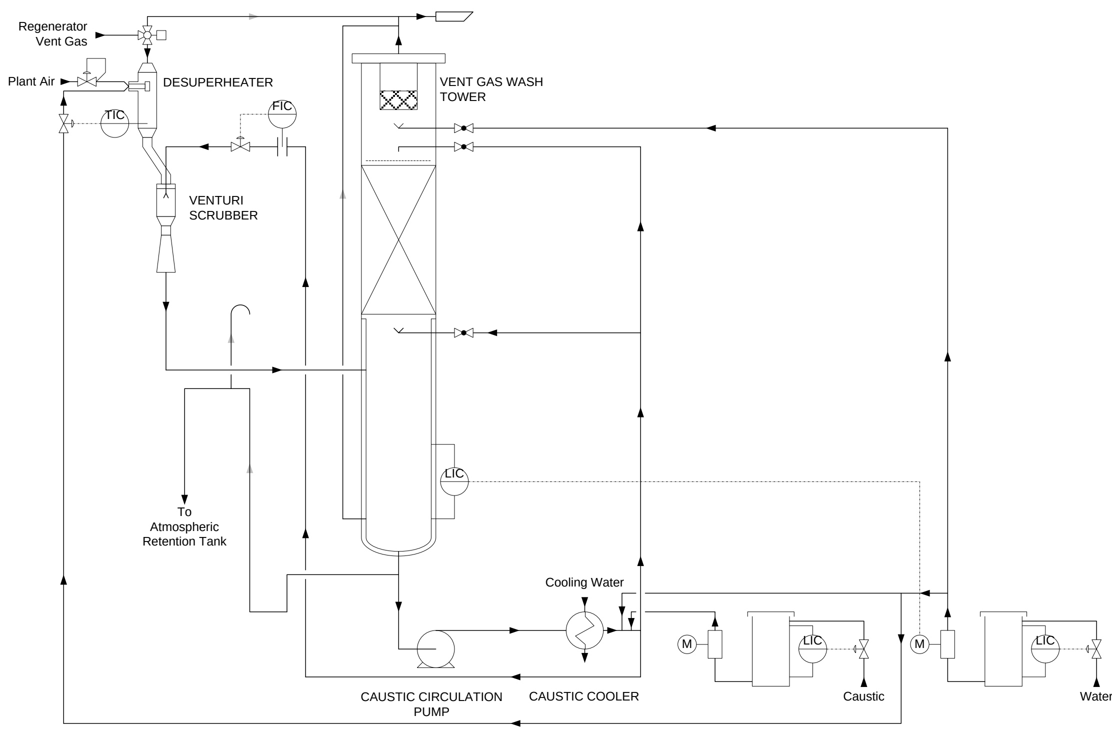


Figure V-14
Flow Control Hopper

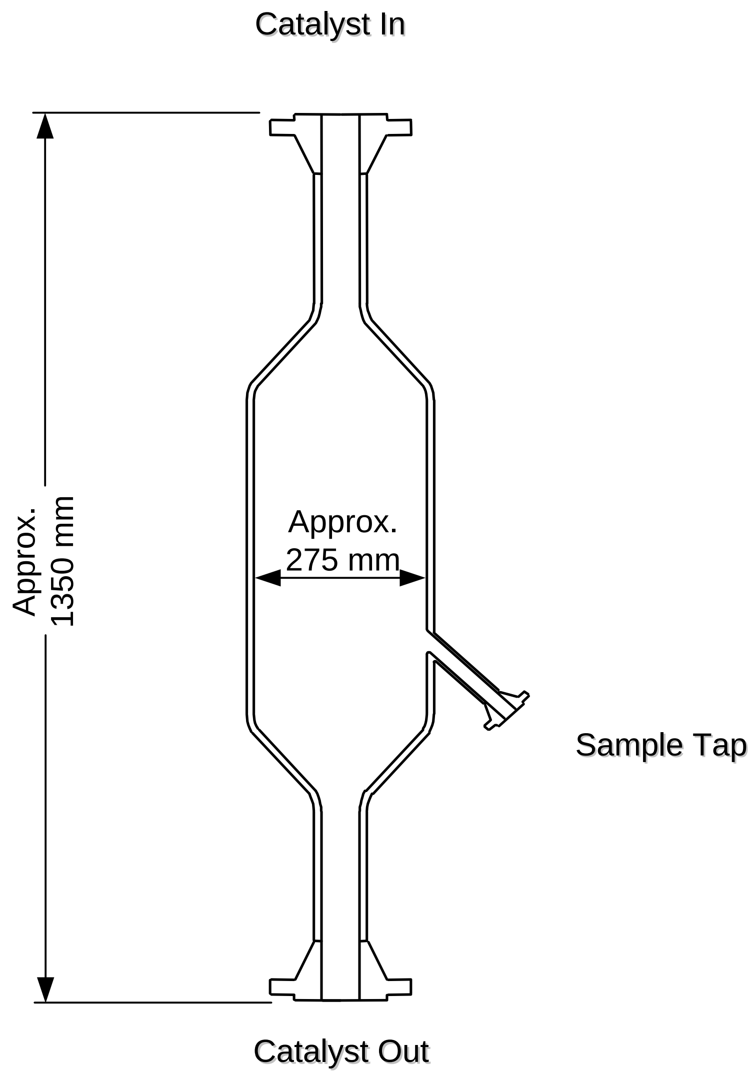
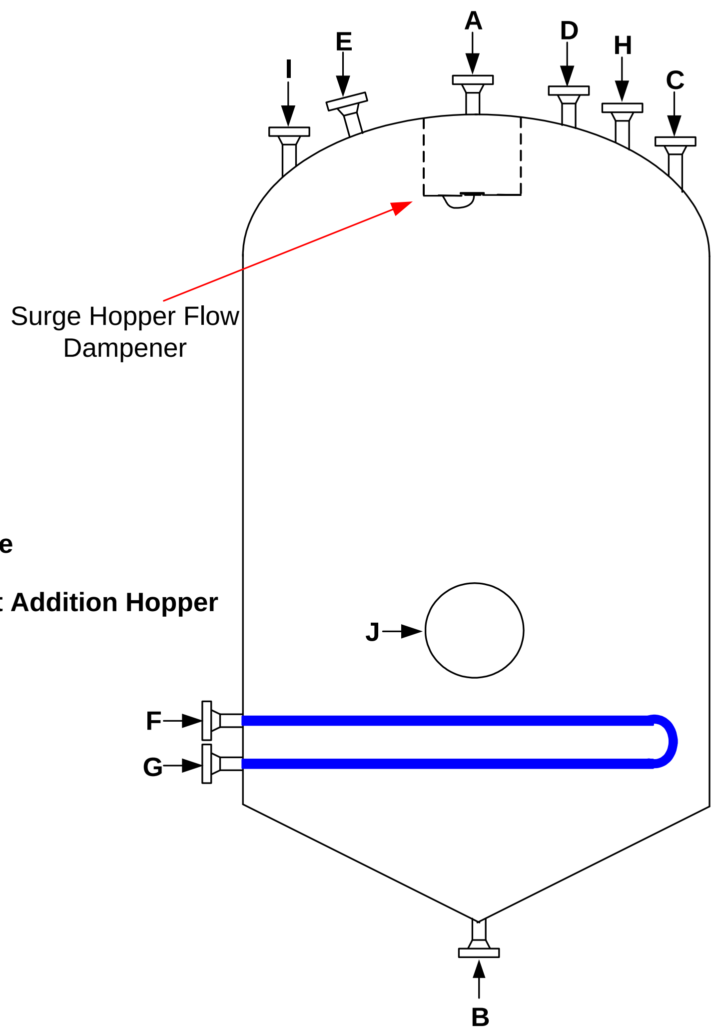


Figure V-15

Surge Hopper



A. Catalyst From FCH

B. Catalyst to Lock Hopper #2

C. H2/Hydrocarbon Analyzer

D. Connection to Equalization Line

E. Catalyst Addition from Catalyst Addition Hopper

F. Cooling Water Supply

G. Cooling Water Return

H. Gauging Hatch

I. Connection to PSV

J. Manway

Figure V-16

Pressure Equalization Line

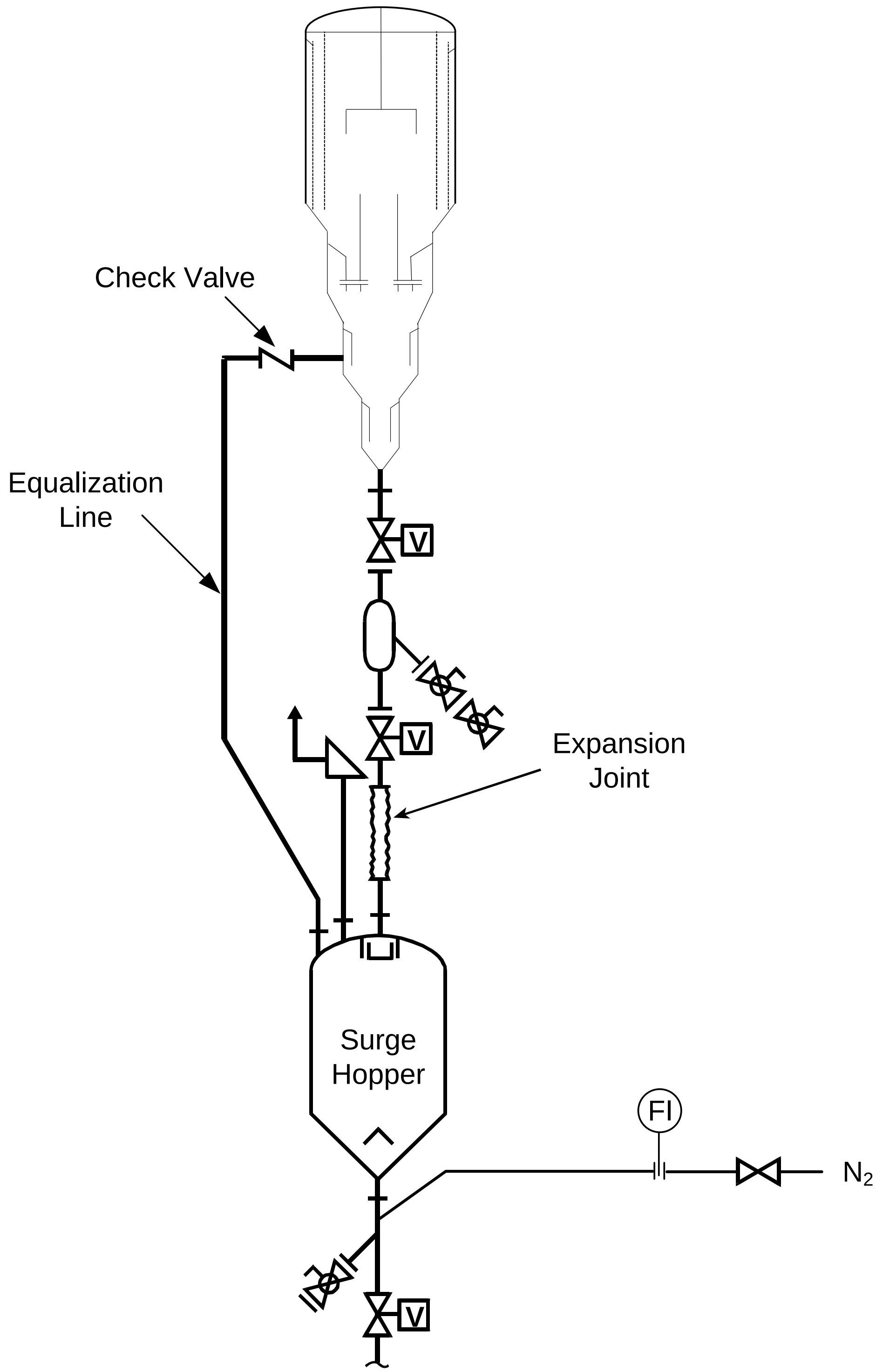
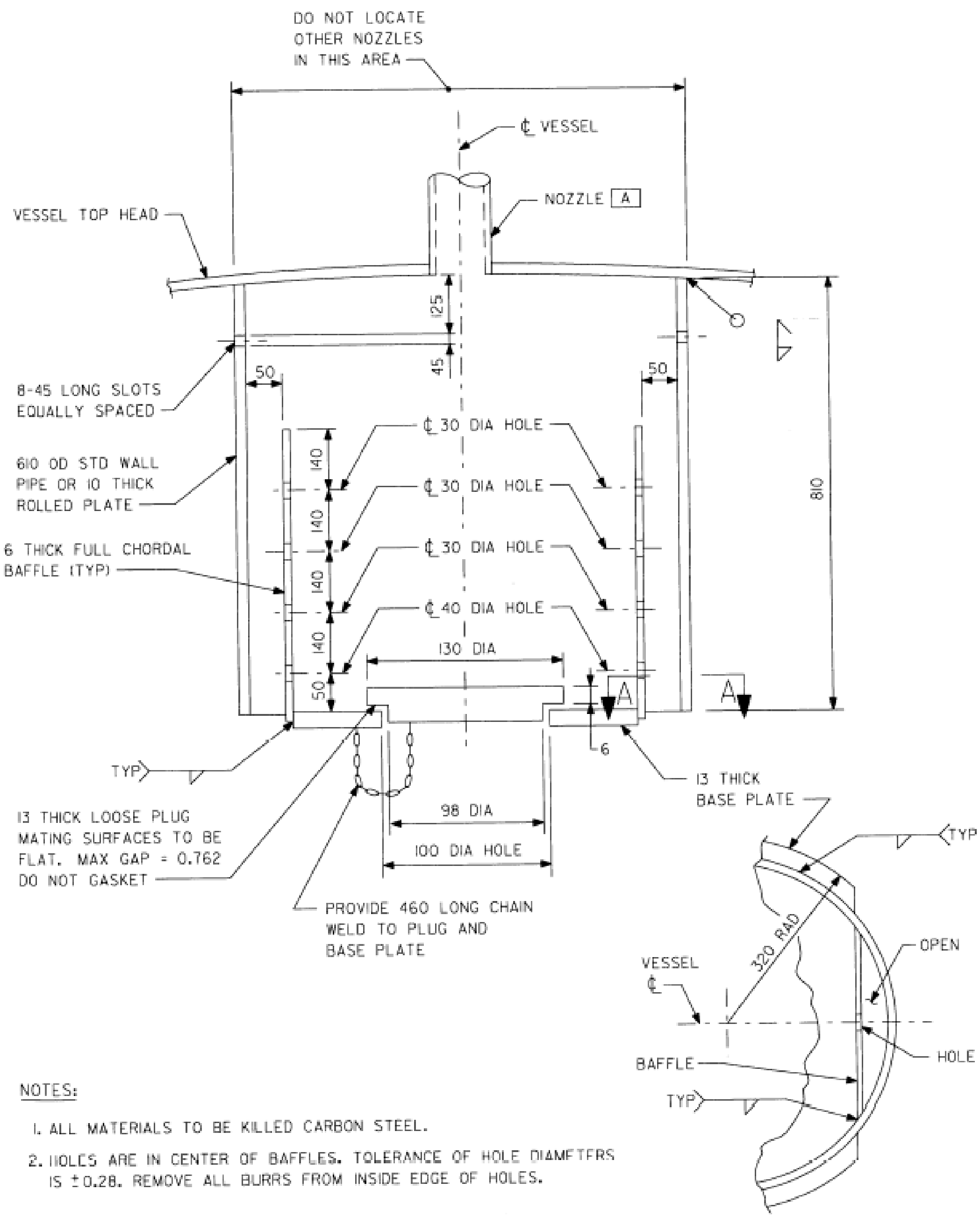


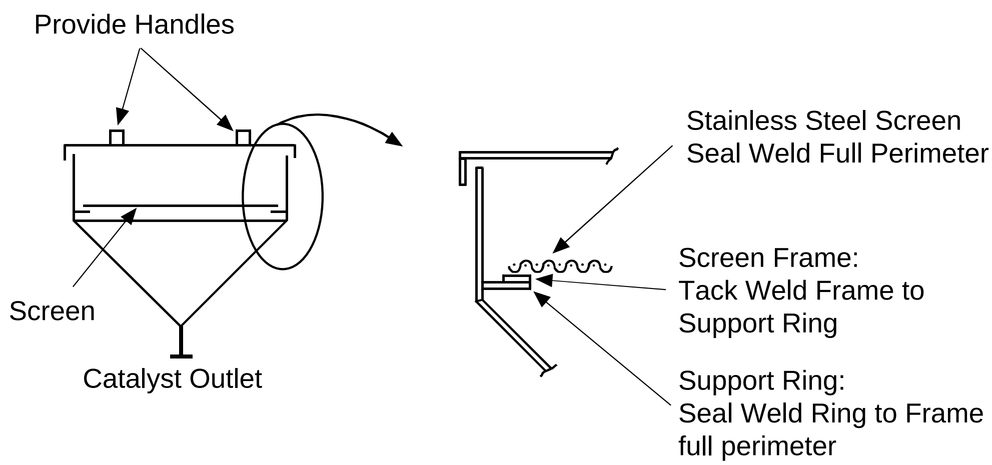
Figure V-17
Surge Hopper Flow Dampener



NOTES:

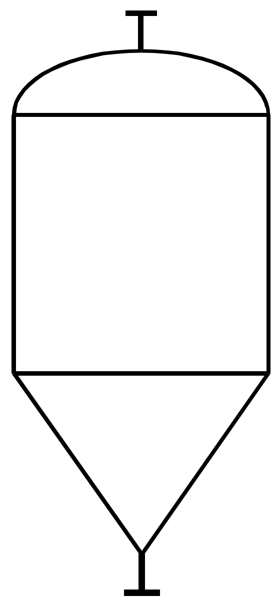
1. ALL MATERIALS TO BE KILLED CARBON STEEL.
2. HOLES ARE IN CENTER OF BAFFLES. TOLERANCE OF HOLE DIAMETERS IS ±0.28. REMOVE ALL BURRS FROM INSIDE EDGE OF HOLES.

Figure V-18
Catalyst Addition Funnel



Note: 1) This is not a code vessel
2) Constructed out of 304 ss

Figure V-19
Catalyst Addition Lock Hopper



Note: 1) This Vessel is sized to hold one drum of catalyst
2) Material of construction is 304 ss

Figure V-20
Lock Hopper

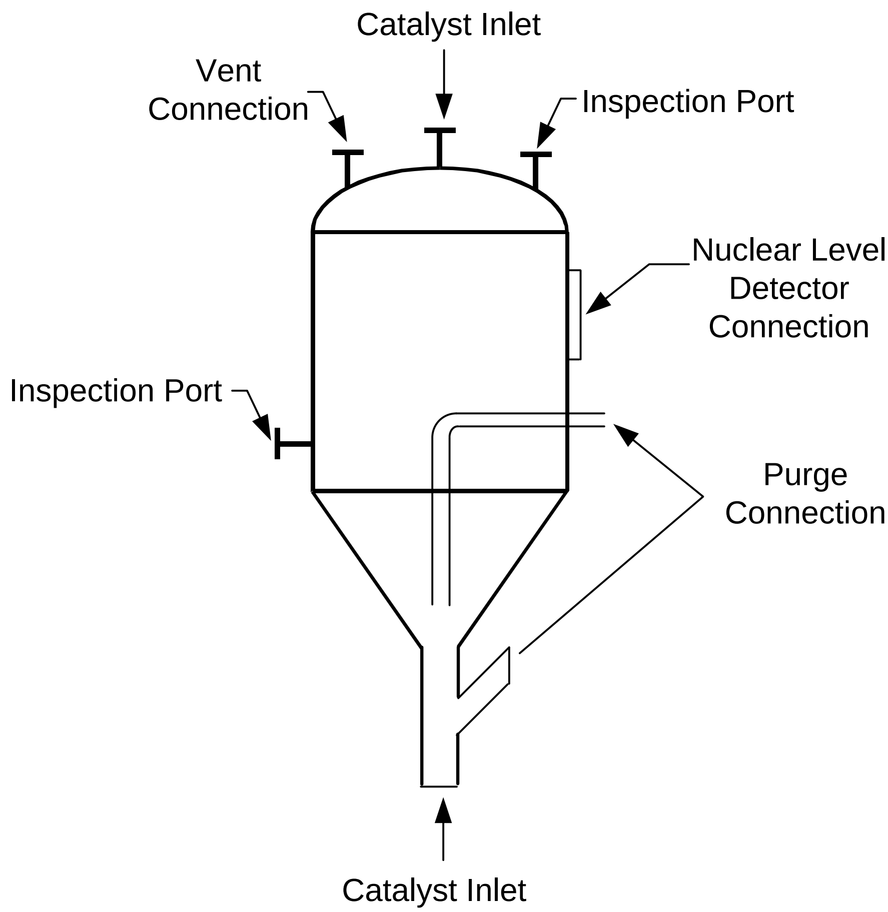


Figure V-21
Lift Engager

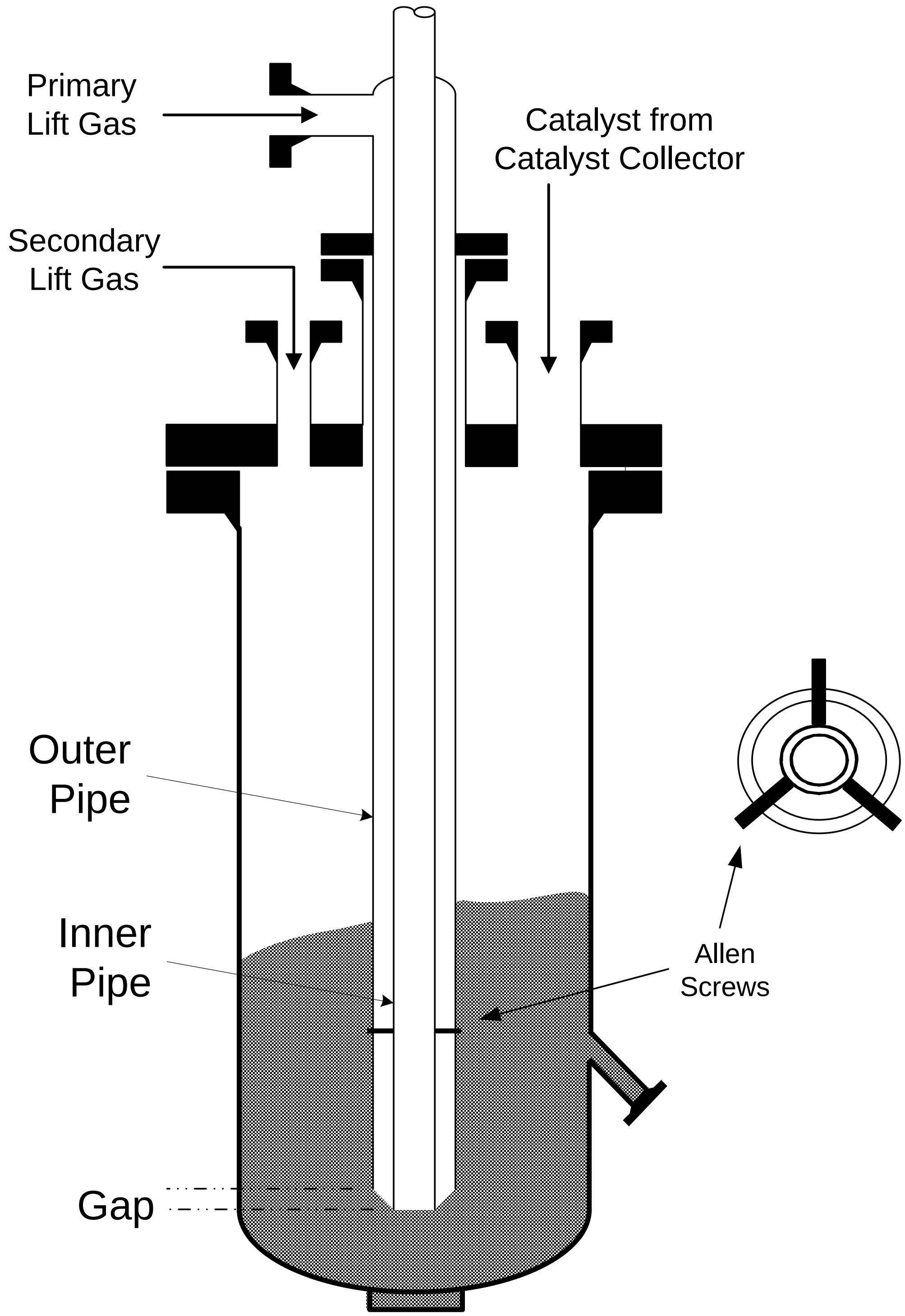


Figure V-22
Dur-O-Lok Coupling

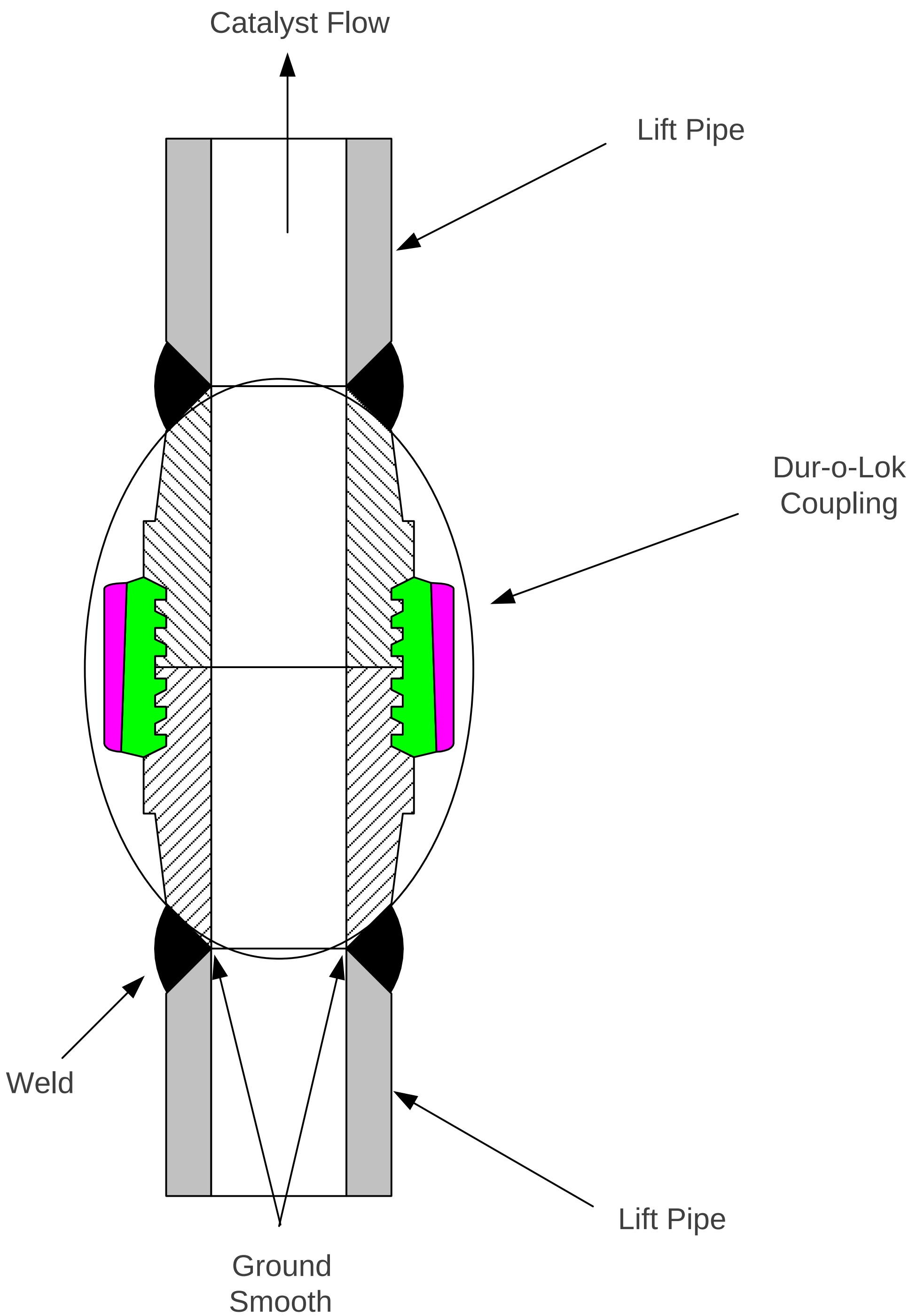


Figure V-23
Reduction Zone/Surge Pot Vessel

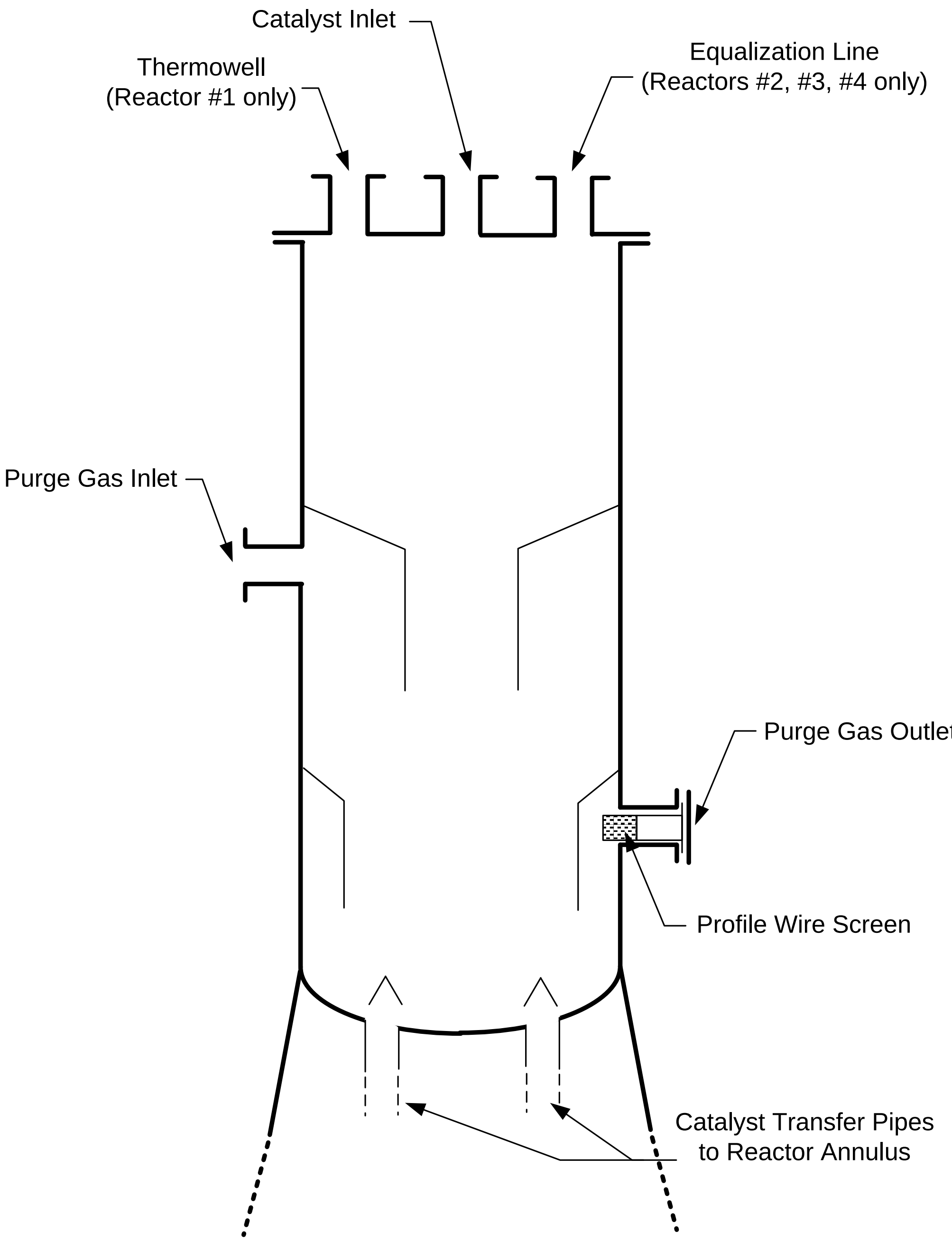


Figure V-24
Catalyst Collector

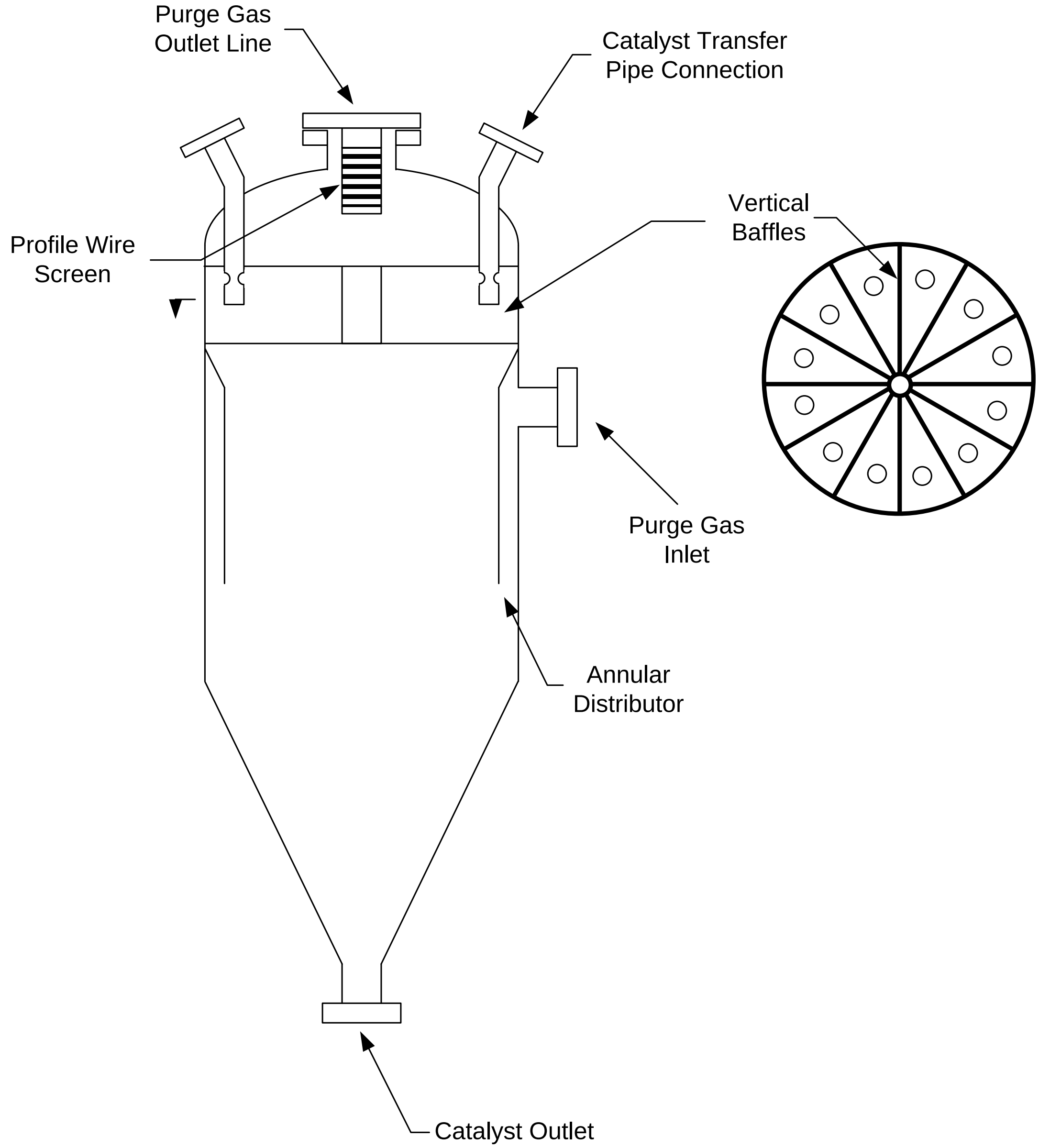
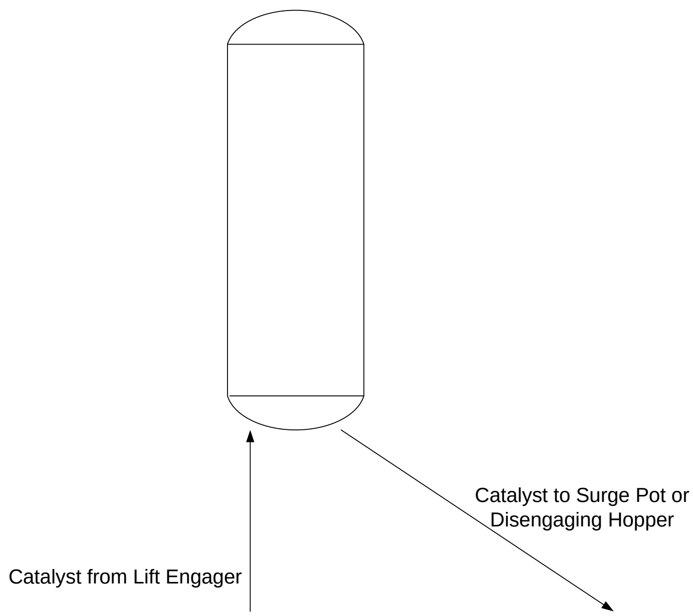
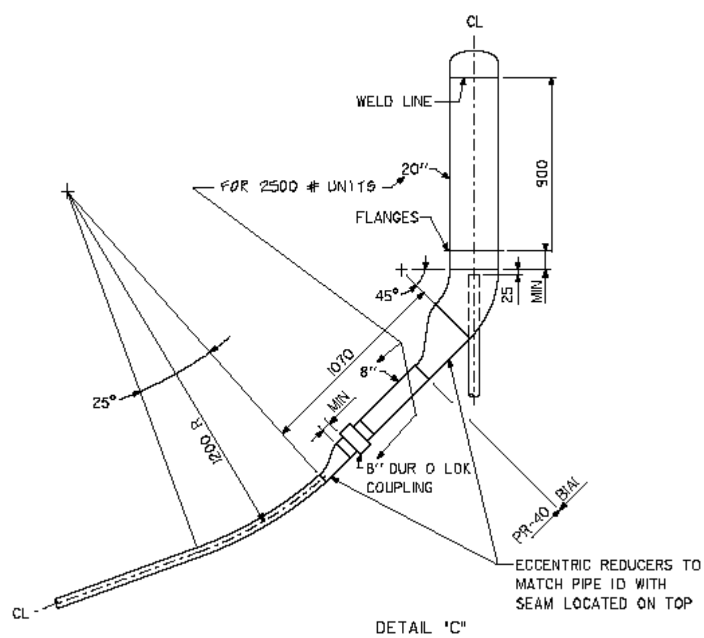


Figure V-25
Impactless Elbows





DETAIL "C"
SPECIAL 110° ELBOW
ALL WELDS TO BE GROUND SMOOTH
EXCEPT PIPE CAP

VI. COMMISSIONING

It is essential that the items summarized below be completed before the Regeneration Section can be considered ready for initial startup. Later startups will not require this detailed preparation. The UOP Chief Technical Advisor will usually provide detailed procedures for this preliminary preparation.

A. Hydrostatic pressure test of pertinent equipment. This is generally handled by the construction contractor.

NOTE: The gas tight ball valves used in the catalyst transfer lines must never be installed before the final assembly of the unit. Free water and/or humidity in the air, and pipe slag or scale can cause damage to the sealing surface. The construction contractor should provide dummy pipe spools to simulate the flange to flange height of the ball valves to obtain proper piping fit-up.

B. Clean and Commission Utility System. This is handled by the construction contractor.

C. Final inspection of all vessels and related equipment.

D. Lock Hopper Control System wiring. Check to see that all electrical connections from the Lock Hopper Control System to the field and to the control board are correct.

E. Valve Mechanics. Check ball to flow ring clearance on the Vee-port valves. The valve clearances should be checked to be as per vendor-specified tolerances. This is generally checked in the shop prior to arrival on-site, but is reconfirmed on the construction site, for possible transportation damage.

F. Bench test relief valves associated with the CCR Regenerator Section.

G. Blow down all lines associated with the CCR Regenerator Section with air to remove trash, scale, and water. A thorough purge of all lines will minimize valve problems and ensure a smooth startup. This is accomplished by dividing the regeneration system into loops, such as:

1. Nitrogen header to all CCR Regenerator Section users.
2. Lock Hopper No 1 and associated equipment.
3. Lock Hopper No 2 and associated equipment.
4. Nitrogen Lift System.
5. Hydrogen Lift System.
6. Upper Air and Lower Air Systems.
7. Chlorine Injection System.
8. Regeneration Tower and associated piping. (See below)

NOTE: Clearing each piping loop must be carefully planned to avoid blowing trash into an area of piping that has already been cleared.

H. Run in all Blowers: Upper Regeneration Blower, Lower Regeneration Blower, Regeneration Cooler Blower, Lift Gas Blower, and Fines Removal Blower. Follow manufacturer's recommendations when commissioning these blowers for the first time. The Upper Regeneration Blower and Lower Regeneration Blower run-in will also serve to blow down the Upper Burn Zone and Lower Burn Zone gas loops. If possible, a screen should be placed at the Regeneration Blower suction to prevent any trash from being pulled into the blower. The flanged joint at the Regeneration Tower inlet should be unbolted and spread apart to prevent trash from being carried into the Regeneration Tower. Furthermore, the Regeneration Tower inspection manway or Disengaging Hopper manway should be opened prior to running in the Upper Regeneration Blower and Lower Regeneration Blower to ensure a vacuum condition does not develop.

I. Install all metering orifices, restriction orifices, flow elements, and filters including the Dust Collector filter bags. Make sure that all orifice diameters have been checked against UOP Project Specifications or vendor's calculations. The flow orifices at the Regeneration Tower for Cooling Zone should be installed. Contact UOP ahead of time to confirm size of orifices.

J. Pressure Test

1. Test the Surge Hopper cooling panel at the rated pressure.

2. Test the Disengaging Hopper, Regeneration Tower, Catalyst Flow Control Hopper, Surge Hopper, Catalyst Addition Hopper, and Nitrogen Lift Gas Circuit including the Spent Catalyst Lift Engager at the design tower pressure with air or nitrogen. Check the manufacturer's pressure rating for the Upper Regeneration Blower and Lower Regeneration Blower before subjecting these fans to the pressure test. The Dust Collector should not be included in the pressure test.

3. Test the Lock Hopper No 1 and 2 systems at the nitrogen header supply pressure.

4. Each reactor Lift Engager, their adjacent catalyst collectors and associated piping are pressure tested with the reactor section.

5. Upper and Lower air system (see below).

K. Prepare the Air Driers

1. Load the driers with the adsorbent provided by the manufacturer.

2. Pressure test the combustion air system at the design air pressure.

L. Check the Logic

1. Hand stroke all the ball valves to check ease of operation. Stroke all valves individually from the Lock Hopper Control System (LHCS).

2. Verify the initial set points for all trips, timers etc within the LHCS. Set radioactive level detectors. For future reference, measure (with a Geiger counter) and record the radiation strength at the detector tubes of each nuclear level source. The radiation strength should be as per recommended by the detector vendor.

3. Cycle the logic with the LHCS. Have the logic take the Lock Hoppers and the Regeneration section through several cycles.

M. Regeneration Tower Dry Out

Dry out the Regeneration Tower and associated equipment before loading catalyst. The Disengaging Hopper, Regeneration Tower, and Nitrogen Lift Gas Circuit will be dried by heating dry instrument air with the Upper Regeneration Heater, Lower Regeneration Heater and Air Heater and circulating it with the Upper Regeneration Blower, Lower Regeneration Blower and Lift Gas Blower. The Catalyst Addition Lock Hopper and Surge Hopper will be dried with nitrogen. Nitrogen is vented from the Surge Hopper through the Catalyst Addition Funnel to the atmosphere.

1. Commission all instrumentation in the Regeneration circuit on the Surge Hopper and the Nitrogen Lift Gas system.

2. Establish design flow of air to the Air Heater.

3. Establish design nitrogen flow to the Surge Hopper purge. Vent this purge gas to the atmosphere via the Catalyst Addition Lock Hopper and Catalyst Addition Funnel. The XV valves on the inlet and outlet of the lock hopper will need to be manually opened to accomplish this.

4. Establish a small nitrogen purge to the nitrogen lift gas circuit via the Disengaging Hopper-Regenerator differential pressure control valve.

5. Startup all blowers: Upper Regeneration Blower, Lower Regeneration Blower, Upper Regeneration Cooler Blower, Lower Regeneration Cooler Blower, Lift Gas and Fines Removal Blowers. Although the blowers will generate some heat for the dry out, this is also convenient time to check the operability of the heaters.

6. Commission the Upper Regeneration Heater, Lower Regeneration Heater and Air Heater and bring all three heaters up to design temperatures at 55°C/hr (100°F/hr). Adjust the speed of the Upper Regeneration Blower and Lower Regeneration Blower motors per the respective vendor recommendations. If the Blowers have motors with two speed modes (change in the number of poles), switch the blower to high speed at the temperature recommended by the blower vendor.

Target the following temperatures:

Upper Regeneration Heater Outlet	477°C (890°F)
Lower Regeneration Heater Outlet	477°C (890°F)
Air Heater Outlet	538°C (1000°F)

Hold for four hours. Check low points in the Regeneration Tower for water.

7. Shut down the heaters and cool down to 200°C (400°F) (or as low as the Upper Regeneration Blower and Lower Regeneration Blower will allow). Adjust the speed on the blowers following the vendor recommendations. If the Upper Regeneration Blower and Lower Regeneration Blower motors have two speed modes, switch to low speed mode at the temperature recommended by the blower vendor.

8. Shut down all blowers.

9. Discontinue the nitrogen purge through the Catalyst Addition Lock Hopper by closing the XV valves. The Surge Hopper nitrogen purge will then be routed to the Regeneration Tower Chlorination Zone.

10. Maintain design flow of air to the Air Heater and design flow of nitrogen to the Surge Hopper until all tower temperatures have cooled down to 38-65°C (100-150°F).

11. Once the Regenerator has cooled down, close the instrument air flow to the Air Heater. Close all other valves that may have been opened during the dryout. Maintain only a small nitrogen purge to the Surge Hopper to keep the Regeneration Tower at a slightly positive pressure. This nitrogen purge will maintain the Surge Hopper, Regeneration Tower and Disengaging Hopper under a slightly positive nitrogen pressure, with excess nitrogen venting through the Vent Gas Treatment System.

12. Maintain the Regeneration Tower and associated equipment and piping under a slightly positive nitrogen pressure until catalyst is loaded.

N. Catalyst Loading

1. Surge Hopper Loading
   Catalyst is loaded to the Surge Hopper via the Catalyst Addition Hopper. Catalyst will be loaded to approximately 6 inches above the cooling coils. During normal operations, this level should be maintained approximately 1 foot above the cooling coils. Once the reactors and regenerators are heated up and catalyst circulation begins, the catalyst density will decrease and the level in the Surge Hopper will rise. The Surge Hopper catalyst level should be routinely checked to confirm it is at the desired height.

a. Stop the nitrogen purge to the Surge Hopper while catalyst is being loaded so that it does not blow catalyst all over and generate fines.

b. Confirm that the XV valves below the Surge Hopper have been installed, are operable and are closed.

c. Lift catalyst drums to the platform where the Catalyst Addition Funnel is located.

d. Confirm that both XV valves above and below the Catalyst Addition Lock Hopper are in working order and can be operated from the local control station.

e. Using a plum-bob, measure the distance from the gauging hatch to the hopper cooling coils. Record this value for future reference.

f. Remove the Catalyst Addition Funnel cover and empty a drum of catalyst into the funnel.

g. Using the local control station, open the XV valve above the Catalyst Addition Lock Hopper. Once all of the catalyst has been drained from the funnel, close the XV valve above the addition hopper, then open the XV valve below the addition hopper.

h. Continue to load catalyst until the catalyst level is approximately 6 inches above the cooling coil, as measured using the plum bob from the gauging hatch.

i. Once catalyst addition is completed, cover the addition funnel and close both of the XV valves around the Catalyst Addition Lock Hopper.

j. Re-establish the nitrogen purge to the Surge Hopper.

2. <u>Regeneration Tower and Disengaging Hopper Loading</u>

Both vessels will be loaded from the Disengaging Hopper. No vessel entry will be necessary, so it is acceptable to maintain both vessels under nitrogen atmosphere.

a. Confirm that the XV valves on the inlet and outlet of the Flow Control Hopper have been installed, are operable and are closed.

b. Confirm that the nuclear level control devise has been installed on the Disengaging Hopper and is has been commissioned.

c. Remove the piping section from the top of the Disengaging Hopper.

d. Catalyst will be loaded using a crane and a catalyst transport hopper. Construct scaffolding as necessary around the top of the Disengaging Hopper so the workers can unload the transport hopper into the Disengaging Hopper.

e. Empty catalyst drums into transport hopper at grade. Once the hopper is filled, lift to the Disengaging Hopper using a crane. Empty the catalyst into the Disengaging Hopper. The catalyst will migrate down the catalyst transfer pipes and inventory the Regeneration Tower.

f. Continue to load catalyst until the nuclear level control devise detects a catalyst level in the Disengaging Hopper.

g. Once catalyst loading has been completed, re-install the piping section to the top of the Disengaging Hopper.

O. Calibrate the Flow Control Hopper

Once the Regeneration Tower and Disengaging Hopper have been loaded with catalyst, the Flow Control Hopper can be calibrated to determine how much catalyst is moved every time the valves above and below the Flow Control Hopper cycle.

1. Remove the expansion joint between the Flow Control Hopper (FCH) and the Surge Hopper.

2. Attach a clean, dry flexible hose from the XV valve below the FCH extending down to the nearest platform.

3. Confirm that the XV valve below the FCH is closed.

4. Force open the XV valve above the FCH. Keep the valve open for 2 minutes, and then close the valve. Two minutes is in excess of the time required for loading the hopper.

5. Record the tare weight of a clean, dry, empty 55 gallon drum.

6. Open the XV valve below the FCH and drain the catalyst into the empty 55 gallon drum. Once the catalyst stops draining, close the valve.

7. Weigh and record the weight of the drum.

8. Repeat steps 4-7 two more times. Average the weight of the three FCH catalyst loads. This is the amount of catalyst that the FCH moves every time the valves cycle.

9. Take a sample to the lab in a sealed container for measurement of LOI (Loss on Ignition at 900°C). Catalyst will absorb moisture over time from the atmosphere, and will increase in weight. Adjust the FCH load size based on the LOI to determine the amount of catalyst the FCH moves on a volatile-free basis.

10. Repeat steps 4-7 several more times; however, during each successive cycle, reduce by 15 seconds the time in step 4 that the XV valve above the FCH remains open. Continue to repeat the cycle until the catalyst load collected at the end of step 7 decreases, implying the FCH was not

completely filled. The minimum time used in step 4 to completely load the FCH will be used as the ‘Catalyst Flow Load Time’ set point in the CRCS logic. This is the amount of time that the XV valve above the FCH is opened each time the FCH is filled with catalyst. This value should never change.

11. Secure the cover on the 55 gallon drum. Load this drum into the Surge Hopper at the first opportunity.

12. Once the FCH load size has been determined on a volatile-free basis, a table should be created showing the catalyst circulation rate for various catalyst flow set point. The catalyst flow set point is the amount of time the FCH is allowed to empty catalyst into the Surge Hopper (i.e., the lower XV valve is open). The longer the valve is open, the slower the catalyst circulates through the reactors and regenerator. Conversely, the shorter the valve is open, the faster the catalyst circulates through the reactors and regenerator.

To create this table, calculate the catalyst circulation rate for circulation rates varying between 50% and 120% of the design circulation rate. The circulation rate, controlled by a timer on XV-2168, is then calculated by the following equation:

$$\text{Catalyst Circulation Rate, lb/hr} = \text{FCH Load Size}\ \frac{\text{lb}}{\text{Load}} \times \left(\frac{1\ \text{Load}}{\text{Catalyst Flow Load Timer, sec}} + \frac{1\ \text{Load}}{\text{Catalyst Flow Set Point, sec}} \right) \times \frac{3600\ \text{sec}}{1\ \text{Hr}}$$

Where:

FCH Load Size - Determined in Step #9, above

Catalyst Flow Load Timer - Determined in Step #10, above, in seconds

Catalyst Flow Set Point - Entered by the operator at the CRCS interface control panel, in seconds

<u>Example</u>:

Assume the following:

a. Flow Control Hopper was calibrated at 30.00 lb.

b. The Catalyst Flow Load Timer is set at 30 seconds

c. The adjustable Catalyst Flow Set Point is currently set at 45 seconds

At these conditions, the catalyst circulation rate would be

$$\text{Catalyst Circulation Rate, lb/hr} = 30.00\ \frac{\text{lb}}{\text{Load}} \times \left(\frac{\text{1 Load}}{\text{30 sec}} + \frac{\text{1 Load}}{\text{45 sec}} \right) \times \frac{\text{3600 sec}}{\text{1 Hr}} = \text{1,440 lb/hr}$$

The curve is prepared by substituting various times for the Catalyst Flow Set Point. An example of a catalyst circulation rate table is shown in Figure VI-1.

Figure VI-1

C3 Oleflex
Flow Control Hopper Calibration

Catalyst Flow Set Point (seconds)	Catalyst Circulation Rate (lbs/hr)	Catalyst Circulation Rate (kgs/hr)
114.0	750	340
105.0	800	363
97.1	850	386
90.0	900	408
83.7	950	431
78.0	1000	454
72.9	1050	476
68.2	1100	499
63.9	1150	522
60.0	1200	544
56.4	1250	567
53.1	1300	590
50.0	1350	612
47.1	1400	635
44.5	1450	658
42.0	1500	680
39.7	1550	703
37.5	1600	726
35.5	1650	748
33.5	1700	771
31.7	1750	794
30.0	1800	817

Note that in some units, the catalyst circulation rate can be set directly as a percent of design catalyst circulation via the LHCS.

P. Calibrate Lock Hoppers

The calibration of Lock Hopper No 2 can be performed once the Surge Hopper has been loaded with catalyst. The calibration of Lock Hopper No 1 should be done once the last reactor has been loaded with catalyst. During this step, the position of the nuclear level source on the side of the Lock Hopper will be adjusted such that a specific volume of catalyst is loaded into the Lock Hopper each time it enters the ‘Load’ step of the catalyst circulation logic. The desired weight of catalyst that should be loaded into the Lock Hopper should be approximately 40% of the hourly design catalyst circulation rate of the unit. These procedures can be used for calibrating either of the Lock Hoppers.

1. Establish the design nitrogen purge flow to the bottom of the Surge Hopper.

2. Force open the two automatic ‘B’ ball valves located above the Lock Hopper to the open position. The ‘Vee port’ valve above the Lock Hopper will remain closed at this time.

3. Force open the two automatic ‘B’ ball valves below the Lock Hopper. The ‘V’ ball valve below the Lock Hopper will remain closed at this time.

4. Remove the blind flange from the bottom of the Lift Engager and install a temporary slide valve in its place.

5. Commission the nuclear level instrument on the Lock Hopper and ensure that it is in working order.

6. Force open the ‘Vee Port’ ball valve above the Lock Hopper and allow catalyst to flow into the Lock Hopper. Immediately shut the ‘V’ ball valve when the level instrument on the Lock Hopper indicates a high level of catalyst. Record the elapsed time between opening the ‘V’ ball valve and achieving a high level indication on the Lock Hopper.

7. Force open the ‘V’ ball valve below the Lift Engager and transfer the catalyst to the Lift Engager.

8. Record the tare weight of three clean, dry 55 gallon drums, then place the first drum under the slide valve at the bottom of the Lift Engager.

9. Open the slide valve and dump the catalyst from the Lift Engager to the 55 gallon drum. Close the slide valve when the catalyst stops flowing. Three drums will be required to collect the contents of the Lift Engager. Do not attempt to totally clean out the Lift Engager since some catalyst will remain in the lift engager following each catalyst lift.

10. Record the weights of each of the 55 gallon drums and calculate the load weight.

11. If the actual weight of catalyst loaded into the Lock Hopper differs significantly (± 3 kg) from the desired weight, adjust the elevation of the nuclear level instrument on the side of the Lock Hopper to achieve the desired load.

12. Repeat steps 7 through 12 until the average of three consecutive measured Lock Hopper loads is equal to desired weight, ± 3kg.

13. Once calibration is complete, reload all catalyst removed during the calibration procedure back into the top of the last reactor (if Lock Hopper No 1 was calibrated) and into the Surge Hopper via the Catalyst Addition Funnel and Catalyst Addition Hopper (if Lock Hopper No 2 was calibrated).

14. Reinstate the blind flange at the bottom of the Lift Engager and remove forces on the automatic ball valves above and below the Lock Hopper.

Q. Calibration of Lift Engagers

The lift engagers beneath all the reactors, except the one below Lock Hopper No 1, are to be calibrated once the reactors have been loaded with catalyst. During this step, the position of the nuclear level source on the side of each Lift Engager will be adjusted such that a specific volume of catalyst is loaded into the Lift Engager each time it enters the 'Load' step of the catalyst circulation logic. The desired weight of catalyst that should be loaded into each Lift Engager should be approximately 40%

of the hourly design catalyst circulation rate of the unit. These procedures can be used for calibrating either of the Lift Engager.

1. Force open the automatic ‘B’ ball valves located above the Lift Engager to the open position. The ‘Vee port’ ball valve above the Lock Hopper will remain closed at this time.

2. Remove the blind flange from the bottom of the Lift Engager and install a temporary slide valve in its place.

3. Commission the nuclear level instrument on the Lift Engager and ensure that it is in working order.

4. Force open the ‘Vee port’ ball valve above the Lock Hopper and allow catalyst to flow into the Lift Engager. Immediately shut the ‘V’ ball valve when the level instrument on the Lift Engager indicates a high level of catalyst. Record the elapsed time between opening the ‘Vee port’ ball valve and achieving a high level indication on the Lock Hopper.

5. Record the tare weight of three clean, dry 55 gallon drums, then place the first drum under the slide valve at the bottom of the Lift Engager.

6. Open the slide valve and dump the catalyst from the Lift Engager to the 55 gallon drum. Close the slide valve when the catalyst stops flowing. Three drums will be required to collect the contents of the Lift Engager. Do not attempt to totally clean out the Lift Engager since some catalyst will remain in the lift engager following each catalyst lift.

7. Record the weights of each of the 55 gallon drums and calculate the load weight.

8. If the actual weight of catalyst loaded into the Lift Engager differs significantly (± 3 kg) from the desired weight, adjust the elevation of the nuclear level instrument on the side of the Lock Hopper to achieve the desired load.

9. Repeat steps 4 through 8 until the average of three consecutive measured Lock Hopper loads is equal to desired weight, ± 3kg.

10. Once calibration is complete, reload all catalyst removed during the calibration procedure back into the top of the reactor from which is was taken from.

11. Reinstate the blind flange at the bottom of the Lift Engager and remove forces on the automatic ball valves above and below the Lock Hopper.

R. Final Startup Preparation

The CCR Regenerator Section must be air freed by purging with nitrogen prior to admitting combustible gases to any part of the system. To accomplish this, the Regeneration Section is divided into several sections, each of which is purged independently until oxygen free. Nitrogen should be purged through all vents, drains, and instrument taps to ensure that no air pockets are missed. Care should be taken not to back purge into a system that has previously been purged. In the case of unavoidable dead ends in the piping system, an effective nitrogen purge can only be realized by repeated pressuring to the nitrogen header pressure and venting to atmospheric pressure.

The CCR Regenerator Section can be broken into the following sections for the purposes of air freeing:

1. Lock Hopper No 1 – Purge the Lock Hopper, Vent Drums and associated piping by using the nitrogen from the nitrogen header connection at Lock Hopper No 1.

2. Spent Catalyst Lift System – Purge the lift engager below Lock Hopper No 1, the Intermediate Disengaging Hopper, the Disengaging Hopper, the Regeneration Tower, the Flow Control Hopper, the Surge Hopper, the Catalyst

Addition Hopper, the Dust Collector, the Lift Gas Blower, the Fines Removal Blower (if provided) and associated piping are all connected and can be air freed at the same time. This section can be nitrogen purged from the following nitrogen header connections:

3. The Disengaging Hopper-Regeneration Tower differential pressure control valve.

4. The bottom of the Surge Hopper.

5. At the inlet of the Air Heater

6. On the suction of the Upper Regeneration Blower

7. On the suction of the Lower Regeneration Blower

8. Lock Hopper No 2 – Purge the Lock Hopper, Vent Drums and associated piping by using the nitrogen from the nitrogen header connection at Lock Hopper No2.

9. The chlorination injection system should be air freed according to the vendors recommended procedures.

10. The lift engagers below the reactors and the lift engager below Lock Hopper No 2 should be air freed when the Reactor Section is air freed.

11. All Catalyst Collectors, the Reduction Zone and Surge Pots should all be air freed along with the Reactor Section.

Once the Regenerator Section has been air freed, it should be maintained under a slightly positive nitrogen pressure until the Regenerator is ready for start-up.

VII. NORMAL STARTUP

This section of the operating manual provides procedures for initiating catalyst circulation for the first time. It also provides procedures for commissioning the Regeneration Tower in Black Burn mode of operation, then transitioning the Regeneration Tower to White Burn mode of operation by implementing the Dual Zone Burn mode operations. This section of the operating manual assumes that all Regeneration Tower commissioning work has been completed.

A. Initiating Catalyst Circulation

During the initial startup, several work activities are performed which will not be performed during subsequent startups. This section is meant to describe those work activities. For subsequent startups, refer directly to the Black Burn Mode, Dual-Zone Burn, or White Burn Mode catalyst startup guidelines described in this section of the manual.

After loading of fresh catalyst into the Oleflex reactors and CCR, the entire unit will be loaded with fresh, coke free catalyst. Once the reactor section is inventoried with hydrocarbons and the reactors are heated up, the dehydrogenation reaction will begin to take place and coke will begin to form on the catalyst. Eventually, enough hydrogen will be produced in the reactor section that the PSA unit can be commissioned and catalyst circulation throughout the Oleflex can be started. It is advisable to get catalyst circulation started as soon as the PSA unit is commissioned so that any catalyst circulation problems can be resolved before reactor temperatures are too high and the coke level on the catalyst begins to increase.

At this stage of the start-up, it is assumed that the PSA unit has been commissioned and net gas purge flows to the Catalyst Collectors and PSA purge gas flows to the Reduction Zone, Surge Pots, Reactor Plug Purges and the Sulfur Stripping Zone of the Catalyst Collector below the last Reactor has been established.

When catalyst circulation is initiated for the first time, the spent catalyst sent to the regenerator will not have enough coke to adequately operate the Regeneration Tower. During this initial cold circulation period, catalyst lift times, load times and unload times will be checked to ensure the catalyst transfer system is operating correctly. It is very common during this period that mechanical adjustments will have to be made to the lift pipe assemblies to achieve proper lift times.

1. Establish Purges to the CCR – the following nitrogen purges should be established:

    a. Surge Hopper nitrogen purge
    b. Upper Regeneration Blower Seal Purge
    c. Upper Regeneration Blower suction pressure transmitter purge
    d. Upper Regeneration gas flow meter purges
    e. Lower Regeneration Blower Seal Purge
    f. Lower Regeneration Blower suction pressure transmitter purge
    g. Lower Regeneration gas flow meter purges
    h. Vent Drums No 1 and No 2 purge

2. Establish the normal operating nitrogen flow rate to the Air Heater.

3. Establish the normal operating differential pressure between the Disengaging Hopper and the Regeneration Tower by commissioning the PDIC on the spent catalyst lift system.

4. Commission the Hydrogen and Hydrocarbon analyzers on the Surge Hopper

5. Commission the Lift Gas Blower and set the spillback pressure controller initially at approximately 0.66 bar (9.5 psi). Confirm that the cooling water to the Lift Gas Blower Spillback Cooler is flowing.

6. Set the lift gas velocity to the lift engager below Lock Hopper No 1 to approximately 7.5 m/s (~25 ft/sec).

7. If provided, commission the Fines Removal Blower and set at the normal operating flow rate. If the Lift Gas Blower is also used for fines removal, set the nitrogen flow at the normal operating flow rate.

8. Commission the lift gas Hydrogen and Hydrocarbon analyzers.

9. Confirm that the Lock Hopper No 2 purge counter is set to three purges.

10. Set the lift gas flow to the lift engager below Lock Hopper No 2 in automatic at the design lift gas flow rate. The superficial gas velocity in the lift pipe should be approximately 15 m/sec (50 ft/sec).

11. Depress the Regenerator “Run” button so that it turns to the green run indicator.

12. Commission Lock Hopper No 2 by depressing the Lock Hopper No 2 "START" button. Lock Hopper No 2 will now cycle on Reduction Zone level demand.

13. Confirm that the Lock Hopper No 1 purge counter is set to 3.

14. Commission Lock Hopper No 1 by depressing the Lock Hopper No 1 "START" and "RUN" buttons. Lock Hopper No 1 will now cycle on Disengaging Hopper Level demand.

15. Commission Lift Engagers No 1, 2, and if provided No 3 by depressing the respective Lift Engager "START" buttons.

16. Open the HV valves on lift gas line for each of the lift engagers. Initially, open each of the HV valves 50%. As each lift engager lifts a load of catalyst, these HV valves will be adjusted so as to either increase or decrease the catalyst lift rate.

17. Begin catalyst circulation by setting the catalyst circulation rate to 60% and pressing the Catalyst Flow Push Button to “START”.

18. Eventually, the level in the Disengaging Hopper will go low, initiating the logic for the L-Valve below the Intermediate Disengaging Hopper, Lock Hopper No 1 and Lift Engager No 3. As these vessels load catalyst, the levels in Reactor No 3 and No 4 Surge Pots will go low, initiating the logic for Lift Engager No 1 and No 2.

19. As each of the lift engagers and lock hoppers cycle through there logic, record the time required to complete each step. It will not be possible to record the logic for each vessel at the same time. It is best to record the times for one vessel at a time, make the necessary adjustments, and then move to the next vessel.

20. It is desirable to have each of the lift engagers able to complete one cycle (load with catalyst, equalize pressure with the downstream Surge Hopper, then complete the catalyst lift) within 20 minutes. This will enable the lift engager to cycle 3 times in one hour and, assuming they have been calibrated as recommended, circulate catalyst at 120% of design circulation.

Approximate times for each step of the lift engager cycle are as follows:

a. Pressure - <30 seconds
b. Load – 2 to 4 minutes
c. Depressure – 30-60 seconds
d. Lift – Approximately 12-15 minutes

If the pressure time takes too long, confirm that the gate valves and the XV valve on the pressure up time are opened completely. If the load step is taking too long, confirm that the valves between the catalyst collector and the life engager are opened.

The most likely adjustments that will be required will be to the time required to complete a catalyst lift. The amount of time that is required to lift catalyst is when the lift gas flow valve opens and the pressure differential transmitter with the downstream

Surge Hopper goes low. It is recommended to allow the lift engager lift three loads of catalyst before making any adjustments.

If the lift time is consistently taking too long, increase the lift gas flow rate a small amount. If increasing the lift gas flow rate does not make a significant improvement in the catalyst lift time, the gap between the inner and outer lift pipe will have to be reduced. To perform this task, catalyst circulation will have to be stopped, the lift engagers properly isolate with blinds, lift pipe assembly remove, the lift pipe gap resized, lift pipe assembly reinstalled, and the Lift Engager system air freed. The lift gap should not be reduced more than 3 mm at a time. During this initial operation, use only the lift gas to the lift pipe to each lift engager, and not the secondary lift gas. Once the gap has been set to the final dimension, minor adjustments to correct slow lift times can be made by increasing the amount of secondary lift gas to a lift engager.

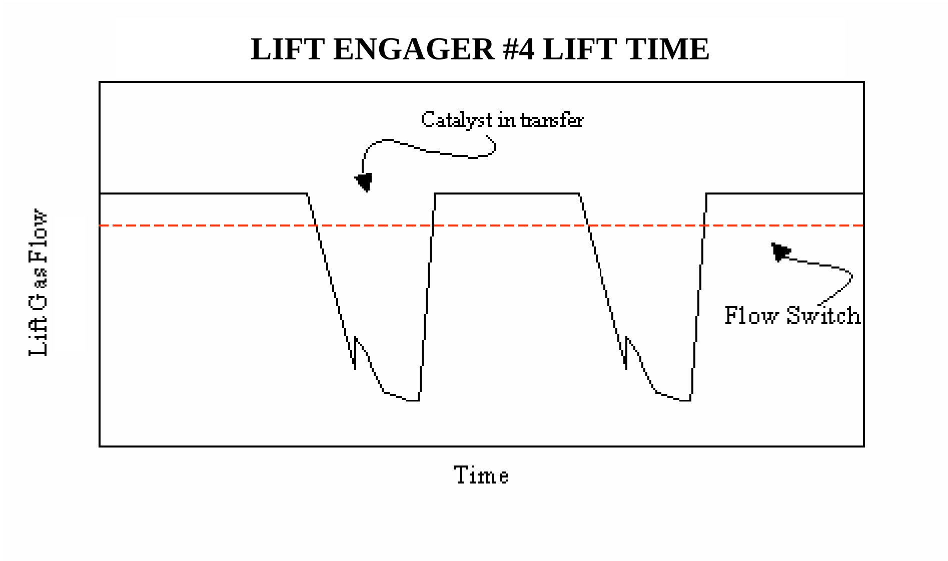
Fast catalyst lift time can result in increased catalyst fines generation. If decreasing the lift gas flow rate does not reduce the catalyst lift time, the gap between the inner and outer lift pipe will have to be increased. The lift gap should not be increased more than 2mm at a time.

21. Each lock hopper should typically cycle within 20 minutes. The approximate times for each step of the Lock Hopper No 1 cycle are as follows:

    a. Purge – The Lock Hopper should be set for 3 purges. Each purge step consists of a 35 second purge followed by a depressure step, which should take approximately 60-90 seconds.
    b. Unload – 2-4 minutes
    c. Pressure - <30 seconds
    d. Load – 2-4 minutes

Monitor the amount of time that is required for the lift engager below Lock Hopper No 1 to lift the load of catalyst to the Intermediate Disengaging Hopper. It is necessary for this lift engager to have completely lifted one load of catalyst before Lock Hopper No 1 returns to the Unload step during its next cycle. The lift time can be monitored from the DCS lift gas trends and is measured from the time the lift gas flow decreases (signifying catalyst being transferred from Lock Hopper No 1 to the lift engager) until the time the lift gas flow returns to its set point (signifying Lift Engager No 3 [C_4 Units] / Lift Engager No 4 [C_3 Units] is empty of catalyst). See Figure VII-1 for an example. Adjust lift gas flow rates and adjust lift gaps in the same manner as was performed for the other lift engagers until the desired lift time is achieved.

Figure VII-1

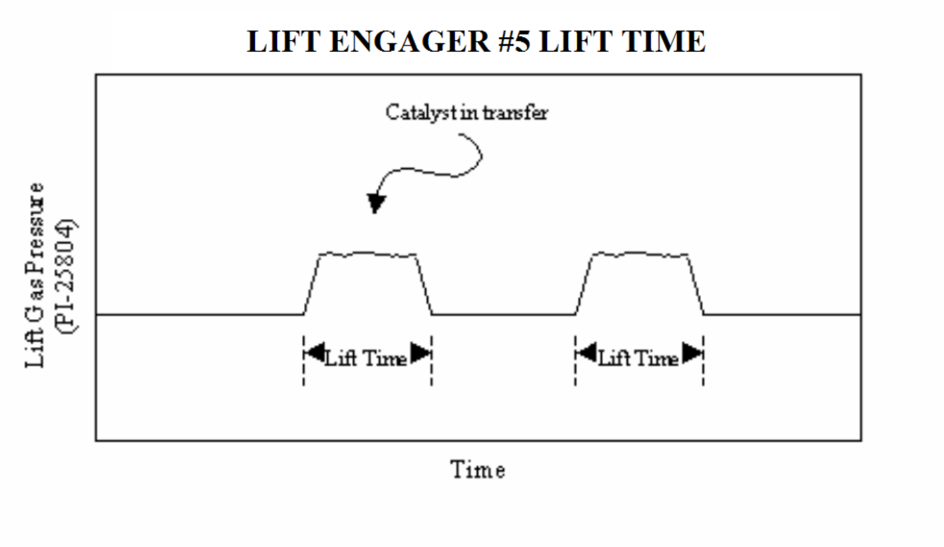


22. The approximate times for each step of the Lock Hopper No 2 cycle are as follows:

    a. Purge 1 – The Lock Hopper should be set for 3 purges. Each purge step consists of a 35 second purge followed by a depressure step, which should take approximately 60-90 seconds.
    b. Pressure - <30 seconds
    c. Unload – 2-4 minutes
    d. Purge 2 – Approximately the same time as the Purge 1 step
    e. Load – 2-4 minutes

Monitor the amount of time that is required for the lift engager below Lock Hopper No 2 to lift the load of catalyst to the Reduction Zone. It is necessary for the lift engager to have completely lifted one load of catalyst before Lock Hopper No 2 returns to the Unload step during its next cycle. The lift time can be monitored from the DCS lift gas trends and is measured from the time the lift gas pressure increases (signifying catalyst being transferred from Lock Hopper No 2 to the lift engager) until the time the lift gas pressure returns to its pre-lift set point (signifying the lift engager is empty of catalyst). See Figure VII-2 for an example. Adjust lift gas flow rates and adjust lift gaps in the same manner as was performed for the other lift engagers until the desired lift time is achieved.

Figure VII-2



23. As catalyst is circulating through the Oleflex unit, monitor the coke level on the catalyst at the lift engager below Lock Hopper No 1 sample point. As the start-up proceeds, the coke level will gradually increase. Once the coke level reaches ~1 wt%, proceed to the Black Burn Start-up procedures.

B. Black Burn Mode Operations

The "Black Burn Mode Operations" procedure must be followed for the initial Regeneration Section startup, as well as all subsequent Regeneration Tower startups. Once the Regeneration Tower has been started up in Black Burn Mode, the operators should then proceed to Dual Zone Burn.

1. Establish Purges to the CCR – the following nitrogen purges should be established:

a. Surge Hopper nitrogen purge
b. Upper Regeneration Blower Seal Purge
c. Upper Regeneration Blower suction pressure transmitter purge
d. Upper Regeneration Blower suction pressure transmitter purge
e. Upper Regeneration gas flow meter purges
f. Upper Regeneration Blower Seal Purge
g. Upper Regeneration Blower suction pressure transmitter purge
h. Upper Regeneration gas flow meter purges
i. Vent Drums No 1 and No 2 purge

2. Establish the normal operating nitrogen flow rate to the Air Heater.

3. Establish the normal operating differential pressure between the Disengaging Hopper and the Regeneration Tower by commissioning the PDIC on the spent catalyst lift system.

4. Commission the Hydrogen and Hydrocarbon analyzers on the Surge Hopper

5. Commission the Lift Gas Blower and set the spillback pressure controller set initially at approximately 0.66 bar (9.5 psi). Confirm that the cooling water to the Lift Gas Blower Spillback Cooler is flowing.

6. Commission the Fines Removal Blower if provided and set at the normal operating flow rate. If the Lift Gas Blower is used to provide nitrogen for fines removal, set the nitrogen flow at the normal operating flow rate.

7. Commission the Upper Regeneration Cooler Blower.

8. Commission the Upper Regeneration Blower. Follow the vendor recommended operating procedures for commissioning this blower.

9. Commission the Lower Regeneration Cooler Blower.

10. Open the vent valve 50% at this time.

11. With the Cooling Zone temperature control in manual, close the valve on the cooling air line to the Cooling Zone cooler

12. Commission the Lower Regeneration Blower. Follow the vendor recommended operating procedures for commissioning this blower.

13. Adjust the speed of the Upper Regeneration Blower to ensure that the Upper Regeneration Flow is satisfactory. During this period, make adjustments to the Lower Regeneration Blower, to ensure that the gas inlet pressure to the Upper Regeneration Zone is at a higher pressure than the gas inlet to the Lower Burn Zone, while ensuring the differential pressure does not exceed 12 mm Water Column (1/2 " Water Column)

14. Commission the lift gas Hydrogen and Hydrocarbon analyzers.

15. Confirm that the Emergency Stop switch is in the "RUN" position. Verify that the remote switch is also in the "RUN" position. Depress the Regenerator "RUN" button so that it turns to the green run indicator.

16. Ensure that all of the cooling water flows are commissioned including the Lift Gas Blower Spillback Cooler, Surge Hopper cooling coils, and to the Vent Gas Treatment System as required.

17. Confirm that there is at least one chlorine cylinder situated on the load cells and is connected to the chlorine injection piping.

18. Open the gate valves that supply nitrogen and instrument air to the Chlorine Eductor. Opening these valves will allow sufficient gas flow to the eductor.

19. Commission the Vent Gas Treatment System according to the vendor's recommendations. Reset the vent gas diversion valves within the Treatment System such that the vent gas flows through the Vent Gas Treatment System.

20. Put the Air Heater temperature controller in manual with 0%.

21. Put the Upper Regeneration Gas temperature controller in manual with 50% output. Note that a 50% output for the Regeneration Gas temperature controller closes the air cooler valve and shuts off power to the Regeneration Heater.

22. Put the Lower Regeneration Heater temperature controller in manual with 0% output.

23. Press the Air Heater Push Button, and Upper Regeneration Heater Push Button, and the Lower Regeneration Heater Push Button to "START" (Regeneration Tower must be in "RUN" first).

24. Heat up the Regeneration Tower at 55°C/hr to the following temperatures:
    a. Upper Regeneration Heater outlet – 477 °C (890 °F).
    b. Lower Regeneration Heater outlet - 477°C (890 °F).
    c. Air Heater outlet - 538°C (1000 °F).

25. Adjust the speed of the Upper and Lower Regeneration Blowers as temperature increases, as recommended by the vendor, while maintaining the differential pressure between the Upper and Lower Regeneration Zones. If the blower motors have two speed modes (based on number of poles), switch to the high speed mode as recommended by the blower manufacturer.

26. Open the valve on the cooling air line to the Cooling Zone Cooler, if needed to keep the gas temperature at 477 °C (890 °F).

27. Approximately 30 minutes before starting catalyst circulation, ensure that the Vent Gas Treatment System is operating and ready to accept hot gas from the

Regeneration Tower. All pumps etc in the System should be commissioned per the vendor recommendation.

28. Confirm that the Upper Air valve (instrument air injected on the suction of the Upper Regeneration Blower) is closed.

29. Confirm that the Lower Burn Zone flow control valve going to the inlet of the Lower Regeneration Heater is closed.

30. Confirm that the Lower Burn Zone Oxygen Analyzer is set for “Dual Zone and Black Burn” operations. This means that the analyzer output of the analyzer controller is cascaded to the Lower Burn Zone air flow controller into the Lower Regeneration Zone.

31. Depress the “Lower Burn Zone Air” pushbutton to the ‘On’ position.

32. Slowly ramp open the output of the Lower Burn Zone combustion air control valve while closely monitoring both the Upper Burn Zone and Lower Burn Zone bed thermocouples and gas oxygen levels. Care should be taken not to overshoot either temperature or oxygen levels: Maximum bed temperature not to exceed 627 °C (1160 °F). Maximum oxygen concentration not to exceed 1 mol%.

33. Once the oxygen concentration in the Lower Burn Zone is stable (when starting up with fresh catalyst, this may only need a small amount of Lower Burn Zone Air), depress the “Upper Burn Zone Air” pushbutton to the ‘On’ position.

34. Slowly ramp open the output of the Upper combustion air control valve while closely monitoring Upper Burn Zone and Lower Burn Zone bed thermocouples and gas oxygen levels. Care should be taken not to overshoot either temperature or oxygen levels: Maximum bed temperature not to exceed 627 °C (1160 °F). Maximum oxygen concentration not to exceed 1 mol%.

35. The bed temperatures will start to increase after a few minutes. Adjust the Upper Burn Zone Air flow to achieve 0.8 mol% oxygen on regeneration gas oxygen analyzer. Line out the air rate and establish a constant oxygen concentration. Switch the oxygen controllers in the Upper Burn Zone and in the Lower Burn Zone to automatic mode.

36. Slowly ramp up the temperature at the exit of the Lower Regeneration Heater towards 527 °C (980 °F). While increasing temperature on the Lower Regeneration Heater, make adjustments to the cooling air flow to the Cooling Zone Cooler to keep the temperature at 477 °C (890 °F). When the cooling air flow valve is opened to more than 15%, set the Cooling Zone temperature controller to automatic mode with a set point of 477°C (890 °F). When the temperature of the Lower Regeneration Heater has reached the target, switch the controller to automatic mode.

37. Once the oxygen concentration in the Upper Burn Zone is stable, begin catalyst circulation by pressing the Catalyst Flow Push Button to “START” and setting the catalyst circulation rate at 60%. Also start both Lock Hoppers and Lift Engager catalyst transfer operation by pressing the respective push buttons to "START".

38. Start Chlorine injection by pressing the Chlorine Injection Push Button to “ON”.

39. Adjust the globe valve on the chlorine injection line so that the chlorine injection rate is 0.6 wt% of catalyst circulation. Record the weight of the chlorine cylinder. After approximately 8 hours, compare the weight of the cylinder with the earlier reading to confirm that the chlorine injection rate is at 0.6 wt% of catalyst circulation.

40. Maintain the following conditions:

Upper Regeneration Heater Outlet – 477 °C (890 °F)
Lower Regeneration Heater Outlet – 527 °C (980 °F)
Cooling Zone Cooler Outlet – 477 °C (890 °F)

Air Heater Outlet – 538-550°C (1000 - 1022 °F).
Upper Burn Zone Bed TIs – 627°C (1160 °F) maximum
Lower Burn Zone Bed TIs – 627°C (1160 °F) maximum
Oxygen in the Upper Regeneration Gas – 0.8 mol%
Oxygen in the Lower Regeneration Gas – 0.8 mol%
Chlorine Injection Rate – 0.6 wt% of catalyst circulation

An initial stable peak temperature should be between 500 and 590 °C (932 and 1094 °F), and should be between the 3rd (from the top) and 10th catalyst bed temperature indicators.

41. Once catalyst circulation and operations in the Upper Burn Zone and Lower Burn Zone are stable, gradually begin increasing in increments of 10%. The steps to take when increasing catalyst circulation rate are as follows:

    a. Increase catalyst circulation rate by 10%.
    b. Increase chlorine injection such that chlorine injection remains at 0.6 wt% of catalyst circulation.
    c. Adjust chemical addition rates, flows, temperatures etc for the Vent Gas Treatment System per the vendor recommendations.
    d. Wait one hour before making the next increase in catalyst circulation rate.

42. After one Regeneration Tower catalyst inventory has passed through, begin taking regenerated catalyst samples and measuring the coke level. It will take approximately 500 FCH cycles to turn over catalyst inventory in the Regeneration Tower. However, this value should be confirmed during commissioning.

43. Monitor the appearance of the catalyst samples. If the samples have a gray color, this is a sign of insufficient chlorine injection and the chlorine injection rate should be confirmed. Also break open 50-100 pills and check the check the centers of the pill for any signs of core coke. Core coked pills tend to have black (not dark gray) centers.

44. After the Regeneration Tower catalyst inventory has passed through, proceed to start Dual Zone Burn Operations.

C. Dual Zone Burn Operations and White Burn Operations

Dual Zone Burn operations utilizes two valves downstream of the Air Dryer Package that allows the operator to control the instrument air flow to the Chlorination Zone such that the oxygen concentration can be maintained between 0 to 21 mol% oxygen. The smaller of the two valves allows the operator to control the oxygen concentration between 0 to 2 mol% and the larger of the two valves allows the operator to control the oxygen concentration between 2 to 21 mol%. These two valves will be used to transition the Regeneration Tower from Black Burn mode to White Burn mode in a controlled manner, minimizing the potential for exposing coked catalyst to high concentrations of oxygen. As the instrument air flow to the Chlorination Zone is increased, the nitrogen flow will automatically be decreased such that the gas flow to the Air Heater will remain constant. Dual Zone Burn mode should be implemented after the Regeneration Tower has already been started up in Black Burn.

As the instrument air valves are opened and the Regeneration Tower is transitioned from Black Burn to White Burn, the temperatures in the Chlorination Zone should be monitored closely. The Regeneration Tower will go to a cold shutdown if the temperature differential between the Air Heater outlet and any of these seven thermocouples exceeds a preset value, initially set at + 10°C. The rate at which the Regeneration Tower will be transitioned to White Burn mode will depend on the amount of coke that is on the regenerated catalyst. If the coke level is more than 0.2 wt.%, the rate at which instrument air is introduced will be much slower than if the coke level is less than 0.2 wt.%.

If one of the situations listed below has occurred, commission the Lower Burn Zone Operations (Section XIII, Special Operations, of this manual) prior to starting the Dual-Zone Burn Operations:

1. If the Regenerator is being restarted following a shutdown of the Oleflex Reactors.

2. If there has been an upset in the Reactor Section that may have generated higher than normal coke (such as stoppage of catalyst circulation, Turbo Expander trip, etc.)

3. If prior to the restart, Lower Burn Zone air flow was being used.

If the coke on regenerated catalyst is more than 0.2 wt%, perform the following procedures to transition the Regeneration Tower to White Burn:

1. Confirm that both of the Lower Air flow control valves are closed.

2. Depress the Lower Air pushbutton to the open position.

3. Slowly begin opening the smaller of the two air valves, targeting an oxygen concentration in the Chlorination Zone of 0.1 mol%. Use the calculation sheet in Figure VII-3 to determine what the Lower Air flow rate should be to achieve the appropriate oxygen concentration.

4. After starting air flow to the Chlorination Zone, monitor the temperatures in the Transition Zone (at the bottom of the Regeneration Zone) and the six temperature indicators in the Chlorination Zone.

5. If after 60 minutes the temperature in the Transition Zone or the six temperature indicators in the Chlorination Zone do not show any sign of increasing temperature, increase the oxygen concentration an additional 20% (i.e. from 0.1 mol% to 0.12 mol%).

6. If any of the temperature indicator in the Transition Zone or the six temperature indicators in the Chlorination Zone show signs of increasing temperatures, gradually reduce the instrument air flow until these temperature indicators stabilize. Hold at the present instrument

air flow rate until the catalyst inventory in the Chlorination Zone has been displaced, which should take approximately 7.5 hours at design catalyst circulation rates.

7. Repeat steps 5 and 6 until the oxygen concentration in the Chlorination Zone reaches 1 mol%, then increase the oxygen concentration in increments of 50% rather than 20%.

8. As the instrument air flow to the Chlorination Zone increases, the oxygen supplied to the Regeneration Zone will be supplied primarily from oxygen migrating from the Chlorination Zone into the Upper Burn Zone and Lower Burn Zone. As this occurs, the upper air valve will gradually close. Once the upper air valve is substantially closed, it is recommended to switch the Lower Burn Zone Oxygen Analyzer to “White Burn” operations. This means that the analyzer controller output will adjust the position of the vent valve, rather than the upper air flow rate and will allow for more stable control of the oxygen concentration in the Regeneration Zone. Even though the upper air valve is closed, do not depress the upper air pushbutton at this time.

9. Once all nitrogen flow to the Chlorination Zone is stopped and only instrument air is flowing to the Chlorination Zone, the Regeneration Tower is in White Burn Mode of operations. The nitrogen push button can be depressed to close nitrogen valve. The upper air push button can also be depressed to close the upper air valve.

If the coke on regenerated catalyst is less than 0.2 wt%, perform the following procedures to transition the Regeneration Tower to White Burn mode:

1. Slowly begin opening the smaller of the two air valves, targeting an oxygen concentration in the Chlorination Zone of ~0.5 mol%.

2. After starting air flow to the Chlorination Zone, monitor the temperatures in this section of the tower.

3. If after 30 minutes there is no sign of increasing temperature in the Chlorination Zone, increase the oxygen concentration an additional 50% (i.e. from 0.5 mol% to 0.75 mol%).

4. As the instrument air flow to the Chlorination Zone is increased, the nitrogen flow will be decreased the same amount so as to maintain a constant gas flow to the Air Heater.

5. Continue to increase the oxygen concentration in increments of 50%, holding for 30 minutes and monitoring temperatures in the Chlorination Zone, until eventually all of the nitrogen flow to the Air Heater has stopped and only instrument air is being sent to the Chlorination Zone. The Regenerator is then in White Burn Mode Operations.

6. As the instrument air flow to the Chlorination Zone increases, the oxygen supplied to the Regeneration Zone will be supplied primarily from oxygen migrating from the Chlorination Zone into the Regeneration Zone. As this occurs, the upper air valve will gradually close. Once the Lower Burn Zone air valve is substantially closed, it is recommended to switch the Lower Regeneration Zone Oxygen Analyzer to “White Burn” operations. This means that the analyzer controller output will adjust the position of the vent valve rather than the upper air flow rate and will allow for more stable control of the oxygen concentration in the Regeneration Zone. Even though the upper air valve is closed, do not depress the upper air pushbutton at this time.

7. If there is sign of increasing temperatures in the Chlorination Zone as the oxygen concentration is being increased, do not increase oxygen any further. Hold at the present instrument air flow rate until the catalyst inventory in the Chlorination Zone has been displaced, which should take approximately 7.5 hours at design catalyst circulation rates.

8. Once the nitrogen flow to the Chlorination Zone is stopped and only instrument air is flowing to the Chlorination Zone, the Regeneration Tower is in White Burn Mode of operations. The nitrogen push button can be depressed to close nitrogen valve. The upper air push button can also be depressed to close the upper air valve.

VIII. NORMAL OPERATIONS

This section of the operating manual provides recommendations for the daily operations of the Regeneration Tower. It is assumed that the Regeneration Tower has been commissioned and is in Black Burn, Dual Zone, or White Burn mode of operation.

The primary responsibility of the operator should be ensuring that the operating conditions in the Regeneration Tower are being maintained such that properly regenerated catalyst can maintain stable reactor section operating conditions. The operations in the reactor section will be negatively impacted if the catalyst is not being regenerated satisfactorily due to insufficient coke burning or insufficient platinum distribution.

A. Catalyst Circulation Rate

The Regeneration Tower is designed to be able to burn off as much as 5 wt% coke from the spent catalyst when circulating the catalyst at the design rate. Typically, the actual coke on catalyst should be somewhat lower, between 2 and 4 wt% when operating at normal temperatures and flow rates in the reactor section.

The operator should routinely monitor the location of the peak temperature in the Upper Burn Zone and Lower Burn Zone. The peak temperature should be located in the top 1/3 of the Upper Burn Zone (between the 3rd and the 10th thermocouple from the top), allowing the remaining portion of the two zones to burn off the remaining coke. Also, the lowest two temperature indicators in the Lower Burn Zone (does not include temperature indicator in Cooling Zone) should be showing the same value as the gas inlet temperature to the zone, indicating that all of the coke has been burned off the catalyst prior to it being exposed to the higher oxygen concentrations in the Chlorination Zone. A diagram showing an ideal temperature profile is shown in Figure VIII-1.

If the peak temperature begins to migrate into the lower section of the Upper Burn Zone or into the Lower Burn Zone, catalyst circulation should be decreased. Decreasing catalyst circulation will increase the time that the catalyst remains in the Upper Burn Zone and the Lower Burn Zone and cause the peak temperature to migrate up. The operator must realize that reducing the catalyst circulation rate will result in higher residence time of the catalyst in the reactors, and thus increase the amount of coke on the spent catalyst entering the Regeneration Tower. Other changes to process conditions in the reactor section, such as reducing reactor inlet temperatures or increasing the H_2/HC ratio, should be considered such that the catalyst can be regenerated satisfactorily.

If the peak temperature begins to migrate above the 3rd temperature indicator in the Upper Burn Zone, this is a sign that the coke on spent catalyst is decreasing. Catalyst circulation should be increased. Increasing the catalyst circulation rate will reduce the time that the catalyst remains in the Upper Burn Zone and will cause the peak temperature to migrate down the Upper Burn Zone and into the Lower Burn Zone. However, the increased catalyst circulation rate will eventually result in an overall lower coke level on the spent catalyst because the catalyst will be spending less time in the reactor circuit.

B. Oxygen Concentration

The oxygen concentration in the Upper Burn Zone should be controlled between 0.6 and 1.0 mole% during normal operations. The lower the oxygen concentration, the lower the peak temperature will be in the Upper Burn Zone. It is advisable to maintain the oxygen concentration at the lowest concentration required to satisfactorily burn the coke off the catalyst.

It is recommended that the peak temperature been maintained between 530 and 590 °C (986 to 1094 °F) during normal operation. Since the thermocouples in the Upper Burn Zone and Lower Burn Zone are actually measuring the temperature of the circulating regeneration gas at the inner screen and not the actual temperature of the catalyst between the inner and outer screens, it is important to realize that the actual catalyst temperatures may be much higher, especially if the concentration of coke on the catalyst is not uniform as it enters the Regeneration Tower. Actual catalyst bed temperatures can exceed 800 °C, which can then result in damage to the catalyst itself. Also, such high temperatures can, in combination with high concentrations of sulfur and oxygen in the circulating regeneration gas, cause corrosion of the profile wires of the inner screen. For that reason, it is recommended not to exceed 590 °C (1094 °F) peak temperature during normal operation, to avoid high catalyst temperatures which can damage the catalyst.

During normal operation in White Burn, the oxygen analyzer controller on the circulating regeneration gas to the Lower Burn Zone will control the oxygen content by adjusting the position of the vent gas, venting gas from the Lower Burn Zone to the Vent Gas Treatment System. This will draw more gas up from the Chlorination Zone where the oxygen content is 21 mole%. The valve opening should be between 30 and 70% open. If there is too much or too little coke on the spent catalyst, the demand for oxygen for the regenerant gas may cause the oxygen analyzer to either open the vent valve fully or close it completely; when this happens, it may not be possible to control the oxygen content of the Upper Burn Zone. To avoid this, the following should be done:

If the vent valve is less than 30% open, indicating low coke on the incoming spent catalyst and a low oxygen demand, add nitrogen to the circulating regeneration gas to lower the oxygen concentration in the circulating regeneration gas, causing more oxygen to be drawn up from the Chlorination Zone, by opening the flow control valve on the Lower Burn Zone nitrogen supply until the vent valve is more than 30% opened.

If the vent valve is more than 70% open, indicating high coke on the incoming spent catalyst and a high oxygen demand, add Lower Burn Zone air to the circulating regeneration gas to increase the oxygen concentration in the circulating regeneration gas, causing less oxygen to be drawn up from the Chlorination Zone, by opening the flow control valve on the upper air supply until the vent valve is less than 70% opened.

Adding Lower Burn Zone nitrogen or air should be done while maintaining the recommended Upper Burn Zone oxygen concentration, and peak burn zone temperature and location as discussed above.

Operation with higher peak temperatures should only be done when attempting to remove low concentrations of slow and hard-to-burn “core coke.”

C. Operation with hard-to-burn “Core Coke” Catalyst

Spent catalyst which has coke present which does not burn at the typical Upper Burn Zone temperatures and oxygen concentrations is typically referred to as having “core coke.” This coke is thought to be located further into the center (or “core”) or the catalyst pills, and thus has limited access to the oxygen in the regenerant gas needed for combustion. Core coke can be produced in several ways, such as:

- Processing feed across the catalyst that contains high amounts of coke precursors, such as n-butane, methyl acetylene, propadiene, 1 and 2 butane, or butadiene.

- Having catalyst with extremely long residence times in the reactors. This can occur if the unit experiences a trip of the reactor effluent compressor, which then traps the reactor effluent within the reactors while still at operating temperatures. This can also occur if catalyst circulation is interrupted for an extended period of time without reducing the reactor inlet temperatures.

The presence of core coke is evidenced by the following symptoms:

- An increase in the amount of coke on the regenerated catalyst from the flow control hopper.

- An increase in catalyst bed temperatures in the Transition Zone or Chlorination Zone while in White Burn, such that lower air addition must be discontinued and the regeneration tower be operated in either Black Burn or Dual Zone.

- The presence of black centers inside regenerated catalyst pills when cut apart. A concentration of more than 1 % of catalyst pills having black centers is considered to indicate core coke. Note: the visual identification of dark gray centers can also be due to low concentrations of chlorine in the Chlorination Zone, which will result in platinum agglomeration. See the following section on chlorine addition.

If left untreated, catalyst containing core coke which is circulated back to the reactors can result in increasing concentrations of coke on spent catalyst which each subsequent cycle of catalyst regeneration. Eventually, the increasing concentration of coke on catalyst can result in excessive burn zone peak temperatures, requiring a reduction in reactor inlet temperatures and decrease in production.

In order to remove the core coke from the catalyst in the Regeneration Tower, the following steps should be taken.

- If not done already, stop lower air and switch to Black Burn. Begin adding Lower Burn Zone air in order to maintain the desired oxygen concentration in the Lower Burn Zone. At this point, no air and only nitrogen should be added to the Chlorination Zone.

- Reduce catalyst circulation to between 70 and 80% of design.

- At the same time, reduce the reactor inlet temperature on the last reactor, and additional reactors as needed, such that the coke on spent catalyst entering the Regeneration Tower is less than 2.5 wt% at the reduced catalyst circulation.

- Increase oxygen concentration in the Upper Burn Zone, by increasing the amount of upper air added, as much as possible (but no higher than 1.2 mol%) while maintaining the peak temperature below 590 °C (1094 °F).

- Increase the Lower Regeneration Heater outlet temperature to 530 °C (986 °F). Increase the oxygen concentration in the Lower Burn Zone temperature to keep the peak temperature in the Lower Burn Zone below 590 °C (1094 °F), but in all cases do not to exceed 5 mol %.

- Maintain the temperature of gas to the Cooling zone at 477 °C (890 °F).

- Maintain the above conditions until the temperatures in the Transition Zone and Chlorination Zone are below that of the Air Heater outlet, and until the entire catalyst inventory has completed one complete cycle through the unit.

- Operating in Black Burn should be minimized due to potential tramp metal accumulation on the catalyst. After the Regeneration Tower has stabilized, begin Dual Zone and slowly begin adding lower air to the Chlorination Zone. Target an oxygen concentration at the Chlorination Zone inlet of between 0.5 and 1.0 mole%. Maintain this condition for an additional catalyst regeneration cycle.

- Gradually increase the amount of lower air, monitoring the temperatures in the Transition Zone and Chlorination Zone. If the temperatures begin to increase in the Transition Zone or Chlorination Zone decreasing the amount of lower air. It may be necessary to increase and decrease the amount of air during a single catalyst regeneration cycle if the catalyst containing core coke is not even among the entire catalyst inventory. It may take up to two regeneration cycles before the amount of lower air is increased to the point that White Burn can be reestablished.

- Once White Burn is reestablished and the coke on regenerated catalyst is confirmed to be less than 0.01 wt% or at pre-upset conditions, reduce the oxygen concentration in the Upper Burn Zone and Lower Burn Zone, and the temperature of the Upper Regeneration Heater and Lower Regeneration Heater outlet to pre-upset conditions. Increase catalyst circulation to pre-upset conditions.

Once the oxygen concentration and temperatures in the Regeneration Tower have been reduced to pre-upset values, the reactor inlet temperatures can be gradually increased to pre-upset conditions.

D. Chlorine Injection Rate

Chlorine injection is adjusted as necessary to maintain between 0.6-0.8 wt% of the catalyst circulation rate. Every time the catalyst circulation rate is changed, the operator must adjust the chlorine injection rate using the local globe valve and flow transmitter so that the proper injection rate can be maintained. However, due to inaccuracies in measuring small flow rates, the chlorine injection rate must be monitored based on the change in weight of the chlorine cylinders rather than using the flow transmitter. The chlorine cylinder weight should be recorded at least twice per day to confirm that the desired chlorine injection rate is being maintained.

E. Air to the Chlorination Zone

In the Chlorination / Drying Zone, hot dry air is used to strip residual moisture from the oxidized catalyst. Excessive moisture on the catalyst results in loss of chloride from the catalyst during reduction and could add excessive moisture to the reactor circuit. To ensure proper drying of the catalyst in the Drying Zone, the lower air flow via should be maintained at design flow rates at all times and must not be adjusted.

The moisture content of the air stream to the Air Heater is continuously monitored using an on-line moisture analyzer. A value of 5 mol ppm (-85°F dew point) water is acceptable for the air stream. An appreciably higher value would indicate that the Air Dryers are not operating properly, and can result in excessive moisture in the reactor section and corrosion in the Regeneration Tower.

Finally, the drying air temperature should always be maintained at 538°C. Lower temperatures will adversely affect the quality of the platinum dispersion, which may negatively affect catalyst performance. Poor dispersion is indicated by a gray or dark gray regenerated catalyst color, and dark (not black) catalyst centers.

F. Monitoring Catalyst Transfer by Flow Control Hopper, Lock Hopper and Lift Engager Counts

The Flow Control Hopper, Lift Engagers No 1, No 2, No 3 and Lock Hopper No 1 and No 2 each have a counter that records the number of times each of these vessels has cycled through its respective logic. These counters should be used to record how many time the catalyst has circulated through the entire reactor-regenerator circuit. They can also allow the operator to estimate when catalyst currently in one section of the unit will enter another section of the unit. Since the Flow Control Hopper is the smallest of these vessels and can be more accurately calibrated, it is used for determining the amount of catalyst that has been circulated over a period of time.

The transfer counters associated with each lift engager and Lock Hopper should be recorded at the same time each day. Based on the calibrated weight of each of these vessels, and the number of loads transferred over the 24-hour period, there should be good agreement between the lift engagers and Lock Hoppers with the Flow Control Hopper.

G. Spent Catalyst Lift Engager Lift Gas Flow Rate

The nitrogen lift gas, which pneumatically transports spent catalyst to the Intermediate Disengaging Hopper and then finally the Disengaging Hopper, should have its velocity calculated and adjusted to about 25 ft/sec (7.6 m/sec) based on actual conditions. Higher gas velocities will significantly increase catalyst attrition and erosion of the lift pipe. The measured gas flow rate while the catalyst is being lifted must be corrected to the actual temperature and pressure of the last reactor lift engager and L-Valve under the Intermediate Disengaging Hopper. The corrected volumetric flow rate is divided by the inside cross-sectional area of the lift pipe to determine the gas velocity.

Once the proper gas velocity is set by sizing the flow transmitter orifice, the velocity should be relatively constant. The discharge pressure of the Lift Gas Blower and the temperature of the catalyst as it enters the Lift Engager will affect the lift gas velocity. For this reason, the gas velocity should be calculated and monitored daily.

H. Regeneration Section and Inter-Reactor Lift Engager Flow Rates

The superficial velocity of the hydrogen-rich lift gas which lifts regenerated catalyst to the Reduction Zone should be calculated and adjusted to about 50 ft/sec (15 m/sec) based on actual conditions. Higher velocities will significantly increase catalyst attrition and erosion of the lift pipe. The measured flow rate during catalyst lifting must be corrected to the actual temperature and pressure at Lift Engager No 5 and corrected for the molecular weight of the gas. The corrected volumetric flow rate is divided by the inside cross-sectional area of the lift pipe to determine the gas velocity. The gas velocity should be calculated and monitored daily.

The proper gas velocity is established by the PSA lift gas flow control valve. A significant change in the operating pressure of the reactors will change the lift velocity. Normally, the catalyst temperature exiting the Surge Hopper will be stable, and will not affect the lift gas velocity. If the ambient temperature decreases substantially, or if catalyst circulation is stopped for an extended period of time, the catalyst being lifted from the lift engager below Lock Hopper No 2 may be cooler, resulting in difficulty lifting. Once catalyst circulation is restored, the temperature of the regenerated catalyst will increase and lifts from the lift engager will become easier.

Each inter-reactor lift engager uses a lift system of hydrogen-rich net gas. Each supply line has an independent flow indicator on it. The gas velocity should be adjusted to about 30 ft/sec and monitored daily. A hand operated valve is provided in each lift gas supply line for flow adjustment. If the time required to complete a lift is gradually increasing, then the use of secondary lift gas may be required. The secondary lift gas directs a portion of the lift gas to each lift engager from the lift pipe to the top of the catalyst inside the lift engager and provides additional force to move the catalyst out of the lift engager.

I. Catalyst Fines Collection

Catalyst fines, elutriated from the circulating catalyst in the Disengaging Hopper, are continuously collected on the Dust Collector filter bags. Approximately once every 8 hours, the pressure drop across the Dust Collector will alarm high, indicating that the catalyst chips and dust must be removed from the filter bags. In order to prevent upsetting the elutriation process or the lifting process from Lift Engager No 4 to the Disengaging Hopper, the control room operator must place Lock Hopper 1 in the "HOLD" step and confirm that Lift Engager No 4 and the L-Valve below the Intermediate Disengaging Hopper has complete lifting catalyst. Once the control room operator has confirmed each of these, the outside operator can initiate the Dust Collector blow down, which will remove the catalyst chips and dust from the bags by a reverse pulse of nitrogen. The catalyst fines and dust will then collect in the bottom of the Dust Collector. Once the filter bags have been blown down, the outside operator must inform the inside operator to take Lock Hopper No 1 out of the "HOLD" step and allow it to cycle through its logic.

After blowing down the Dust Collector, the outside operator should unload the catalyst fines and chips into a fines collection drum. Using the local control station, the outside operator should open the XV valve located directly below the Dust Collector for 10-15 seconds, allowing the catalyst chips and dust into the 8" eccentric pipe. This XV valve should then be closed and the lower XV valve opened for 10-15 seconds. The collected catalyst and fines are transferred to the fines collection drum.

The amount of fines collected, when expressed as a weight percent of the catalyst circulation rate, is a helpful feedback indicator of several problems. During the initial three catalyst circulation cycles with fresh catalyst, the weight percent of fines is high but will become constant after this initial period. Changes in the weight percent of fines of catalyst circulation after the initial period indicate non-optimum operation.

Normally, catalyst fines should be approximately 0.1-0.2 wt. % of the catalyst circulation rate.

During the course of normal operation, there are two variables which affect the weight per cent of fines collected; the amount of fines created in the system and the removal efficiency of the fines generated. If the amount of fines collected increases as a weight percent of the catalyst circulation rate, this indicates that something caused more catalyst attrition, such as a high lift gas velocity. If the amount of fines (as wt% of CCR) decreases, along with a decrease in the amount of whole catalyst in the fines, this indicates poor removal efficiency due to high catalyst flux or low elutriation gas velocity in the elutriation tube. Daily monitoring and plotting of the fines collected will provide excellent long-term trending for analysis of possible problems. To insure that all of the fines are satisfactorily removed from the circulating catalyst, it is recommended to maintain 20-30 wt% whole pills in the material collected in the Dust Collector.

J. Elutriation Gas Flow

The superficial velocity of the elutriation gas and the catalyst flux, both measured in the elutriation tube, are the primary variables affecting the separation efficiency of fines from whole catalyst pills. The desired velocity is about 15 ft/sec, based on actual flow conditions, inside the elutriation tube. The discussion about conducting a fines survey describes the method of determining the proper elutriation velocity. The elutriation gas velocity should be calculated and monitored daily. Note that the elutriation gas flow transmitter is measuring the flow at essentially the discharge pressure and temperature at the Lift Gas Blower, while the desired velocity is at the elutriation tube conditions. Therefore, measured elutriation gas flow rate must be corrected to the elutriation tube conditions. The corrected volumetric flow rate is divided by the inside cross-sectional area of the elutriation tube to determine the gas velocity.

K. Monitoring Vent Gas Treatment System Operations

Every time the catalyst circulation rate is changed, the amount of HCl, Cl_2 and SO_2 in the Regenerator vent gas will also change. For this reason, operations of the Vent Gas Treatment System should be monitored one hour after the catalyst circulation rate has been changed to prevent precipitation of caustic salts in the system which can cause plugging within the system and result in damage to the fiberglass reinforced plastic (FRP) material used in the system due to high temperatures. The circulating caustic stream should be monitored and controlled per the vendor's recommendation.

L. Sampling Catalyst

A sample of spent catalyst can be taken from the sample tap located on the side of the lift engager below Lock Hopper No 1. To ensure that an accurate sample of spent catalyst is taken, empty any catalyst in the sample tap after the lift engager has completed a lift. During the next Lock Hopper 1 unload step, a sample of spent catalyst can be taken from the lift engager

The Disengaging Hopper catalyst is sampled at the tap provided on one of the Regeneration Tower catalyst inlet lines. This sample is used when performing a catalyst fines survey. See Section XIII, Special Procedures, of this manual for instructions on performing a catalyst fines survey.

A catalyst sample can be taken at the Transition Zone. This sample is taken to confirm if there is any core coked catalyst in the Regeneration Tower. Following an upset in the reactor section, a sample of catalyst should be taken at this location and 50-100 pills should be randomly broken open to check for the presence of hard-to-burn core coke.

The regenerated catalyst is sampled from the tap on the Flow Control Hopper. To ensure that an accurate sample of regenerated catalyst from the Flow Control Hopper is taken, empty any catalyst in the sample tap after the Flow Control Hopper has emptied a load of catalyst into the Surge Hopper. During the next cycle, a sample of regenerated catalyst can be taken from Flow Control Hopper.

The inter-reactor lift engagers also have catalyst sample points. These sample points should be utilized during periods when coke can become excessively high, such as periods following upsets in the reactor section, or when the catalyst is being changed out on-the-fly. If the coke on catalyst exiting a particular reactor is higher than expected, it is recommended to reduce downstream reactor inlet temperatures and prevent excessively coked catalyst eventually reaching the Regeneration Tower. In general, expected catalyst coke levels exiting the reactors for a C3 Oleflex unit will be as follows:

Lift Engager No 1:	less than 0.05 wt% coke
Lift Engager No 2:	less than 0.1 wt% coke
Lift Engager No 3:	less than 1.0 wt% coke
Lift Engager No 4	less than 5 wt% coke

For C4 Oleflex units, expected catalyst coke levels exiting the reactors will be as follows:

Lift Engager No 1:	less than 0.05 wt% coke
Lift Engager No 2:	less than 1.0 wt% coke
Lift Engager No 3:	less than 5.0 wt% coke

Catalyst that has been taken from sample locations should be added to the fines collection drum and not returned to the circulating catalyst.

M. Combustion Air Moisture Sampling

Combustion air is sampled downstream of the Air Dryer after the filter, and is monitored using an on-line analyzer.

TABLE VIII-1

DRYING AIR DEWPOINT and V-PPM MOISTURE

°F	°C	Water (v-ppm)
-100	-73	1.50
- 95	-71	2.4
- 90	-68	3.5
- 85	-65	5.3
- 80	-62	7.8
- 75	-59	11.4
- 70	-57	16.6
- 65	-54	23.6
- 60	-51	34.0
- 55	-48	48.0
- 50	-46	67.0
- 45	-43	92.0
- 40	-40	128.0

N. Catalyst Inventory

Although the Surge Hopper has a continuous catalyst level recorder, the level should be gauged periodically via the gauging hatch to provide a cross-check on the catalyst inventory of the unit. The catalyst level can be measured by dropping a plum-bob into the gauging hatch on the Surge Hopper. In general, the catalyst level should be maintained >300 mm above the cooling coils. If the catalyst level is low, fresh catalyst should be added to the Surge Hopper. Please follow the instructions in Section XIII, Special Procedures, for adding fresh catalyst to the Surge Hopper.

O. Blower Flow, Screen Pressure Drop, and Pressure Survey

The circulating regeneration gas flow through the Regeneration Tower should be monitored periodically. A change in flow rate may indicate plugging of the inner screen in the Regeneration Tower due to catalyst chips or fines. Such plugging can impact the flow of regeneration gas in both the Upper Burn Zone and Lower Burn Zone and cause inadequate burning of the coke from the catalyst. Poor gas flow distribution due to screen plugging can also result in localized high catalyst bed temperatures, especially in the Upper Burn Zone where the majority of the coke is burned from the catalyst. The flow rate of circulating regeneration gas is determined by measuring the pressure drop across both the Upper Regeneration Heater and Lower Regeneration Heater. It is recommended that the inner screen be cleaned once per year, or if the pressure drop has declined to 80% of the initial pressure drop when the inner screen was clean. Refer to Section XIII, Special Procedures, for the procedure for accessing and cleaning the inner screen.

In addition, a pressure survey of the Regeneration Tower should be taken periodically to determine if there are any issues with gas flow through the Tower which might impact catalyst regeneration. Pressure readings should be taken at the following locations, using a single, calibrated pressure gauge or portable pressure transmitter:

- Circulating gas from Regeneration Tower, upstream of the Regeneration Cooler
- Regeneration Blower Suction
- Upper Burn Zone inlet
- Lower Burn Zone inlet
- Chlorination Zone vent
- Surge Hopper

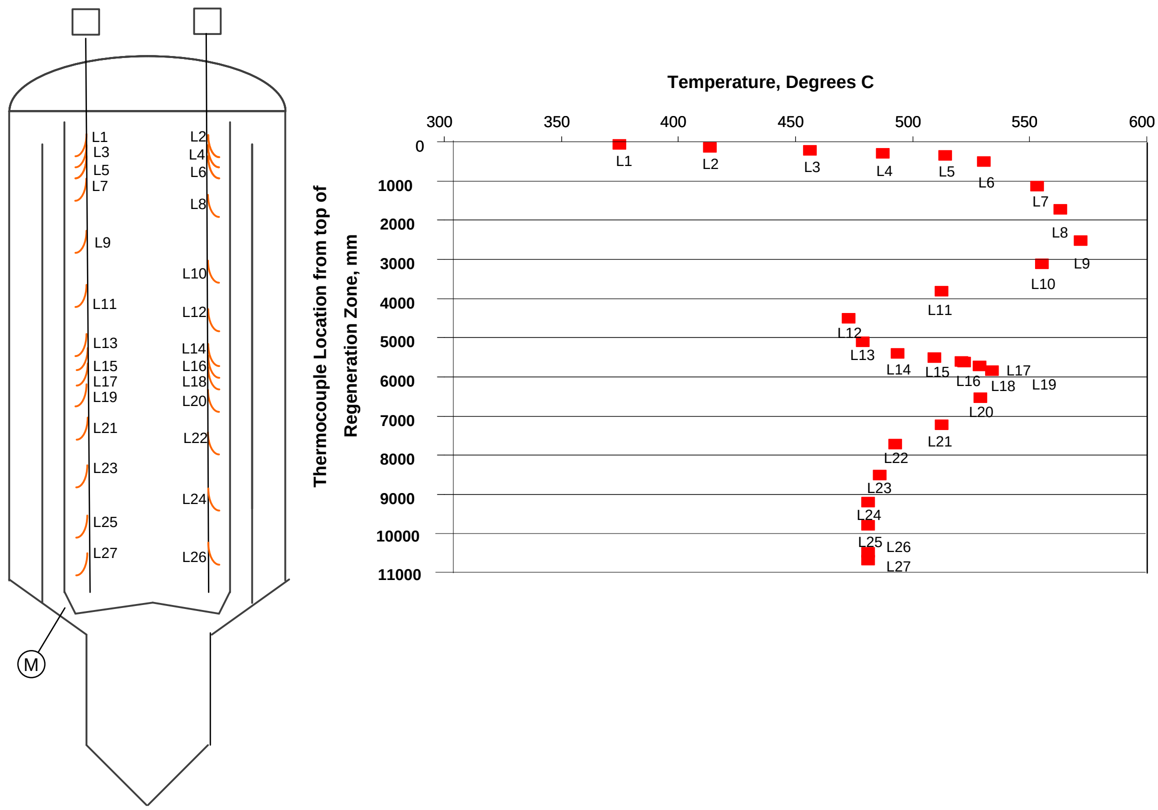
A pressure survey should be done following initial start up of the Regeneration Tower, once White Burn mode of operation at design catalyst circulation rate has been established, following any cleaning of the Regeneration Tower inner screen, following any maintenance of the Regeneration Blower or the Vent Gas Treatment System, or as needed.

P. Vent Drums

The bleed lines between the B-type ball valves above and below Lock Hopper No 1 and No 2 are not vented to the relief header normally, but are vented to the fired heaters in the reactor section, which operate under a negative atmospheric pressure. This is done to ensure no hydrogen or hydrocarbon from the relief header can be pressured into the Lock Hoppers. The vent lines are routed through Vent Drums, which are designed to knock out catalyst dust and fines before the vent gas reaches the fired heaters. Once a month, the vent drums should be inspected and emptied of any dust or fines present. Excessive amounts of dust in any vent drum may be an indication of problems with the upstream Lock Hopper and should be investigated.

Figure VIII-1

Regeneration Zone Temperature Profile



Q. Spent Catalyst Transfer System - Lock Hopper 1

This section of the manual briefly describes the logic steps which occur during the transfer of catalyst from the last reactor to the Regeneration Tower. The logic steps are shown as graphics depicting the valve positions of Lock Hopper No 1 transfer valves. Additionally, key process indicators of pressure, flow, and level are discussed. These steps are simplified to include only those items that the operator can check for proper operation. Refer to the Equipment Instruction and Data Book for the Lock Hopper Control System (LHCS) supplied by UOP for unit-specific details.

Note: For C3 Oleflex units, there are four reactors, with the spent catalyst lift engager below Lock Hopper No 1 designated as “Lift Engager No 4,” and the regenerated catalyst lift engager below Lock Hopper No 2 designated as “Lift Engager No 5.” For C4 Oleflex units, there are three reactors, with the spent catalyst lift engager below Lock Hopper No 1 designated as “Lift Engager No 3,” and the regenerated catalyst lift engager below Lock Hopper No 2 designated as “Lift Engager No 4.”

The remainder of this Chapter will be based on the lift engagers for a C3 Oleflex unit. The logic steps involved in catalyst transfer are the same for either type of Oleflex unit.

The basic steps of Lock Hopper No 1 logic are the following:

Step	Operation
Ready	Lock Hopper 1, full of catalyst and under hydrogen pressure, waits for a signal to start the cycle.
Purge	Lock Hopper 1 is depressured and purged with nitrogen.
Unload	Catalyst is unloaded to the lift engager and transferred to the Regeneration Section.
Pressure	Lock Hopper 1 is pressured with nitrogen.

Load Catalyst is loaded from the Catalyst Collector to Lock Hopper 1.

At the end of the Load step, Lock Hopper 1 returns to the Ready step.

To avoid the chance of a hazardous condition caused by malfunctioning of any of the logic system components, the Catalyst Regeneration Control System (CRCS) contains hardware and software systems that will prevent erroneous signals from reaching field devices. In addition, the following safety checks are built into the Lock Hopper Controller:

1. Valve Verification: A valve verification system is included in each controller. The program output is compared continuously with the actual positions of all the valves in the system. Any discrepancy stops the cycle and sounds an alarm. (NOTE: in certain steps, conditions other than valve position are more important; thus, verification is not a requirement to move to the next step.)

2. Valve Interlock System: The Valve Interlock System is used in Lock Hoppers 1 and 2 for system safety and to prevent undue loss of material. The Interlock System prevents an unsafe or incorrect combination of valve positions. It will inhibit the solenoid valve commands if these combinations are detected due to valve failure or an erroneous input.

3. Lock Hopper 1 Start-Stop Button: The Lock Hopper Controller has a “Start-Stop” button. There is also an indicator associated with this button that indicates the status of Lock Hopper 1. It can be running, stopped or in delayed stop.

4. Lock Hopper 1 Selector System (Run-Hold): The Lock Hopper Selector System permits Lock Hopper 1 to operate continuously or to be held in the “READY” step. If this switch is in the “RUN” position, the logic cycles continuously on demand from the downstream level indicator. If the “HOLD” position is on, the logic will hold Lock Hopper 1 in the “READY” step. If the

operator presses this switch during the cycle, that cycle will finish. Lock Hopper 1 will then wait in the “READY” step until the button is depressed again.

5. Purge Selector: The Purge Selector is used to set the number of times the purge subroutine is repeated in the nitrogen purge step of Lock Hopper 1 logic cycle. The selector is adjustable from 0 to 9. In the zero setting, no purges would be performed which would defeat the purpose of the purge step. Therefore, the transfer cycle will not start when the selector is set at zero. Normally, three purges are sufficient.

6. Abnormal Load Alarm: The Abnormal Load Alarm sounds if Lock Hopper 1 does not fill in the normal time. The time to fill Lock Hopper 1 is determined in the field during the startup. If no problems arise, this time should remain somewhat constant.

To detect problems in loading Lock Hopper 1, an “Abnormal Load Minimum” timer starts the instant the load V-ball valve starts to open. The “Abnormal Load Minimum” timer is set so that it will time out before the normal Lock Hopper loading time. The “Abnormal Loading Range” timer starts timing when the "Abnormal Loading Minimum" timer times out. This timer is set to time out after a typical loading time. If Lock Hopper 1 level is not satisfied when the Abnormal Loading Range Timer times out, an alarm will sound. Thus, if Lock Hopper 1 takes either a longer or shorter time to load than normal, an alarm sounds.

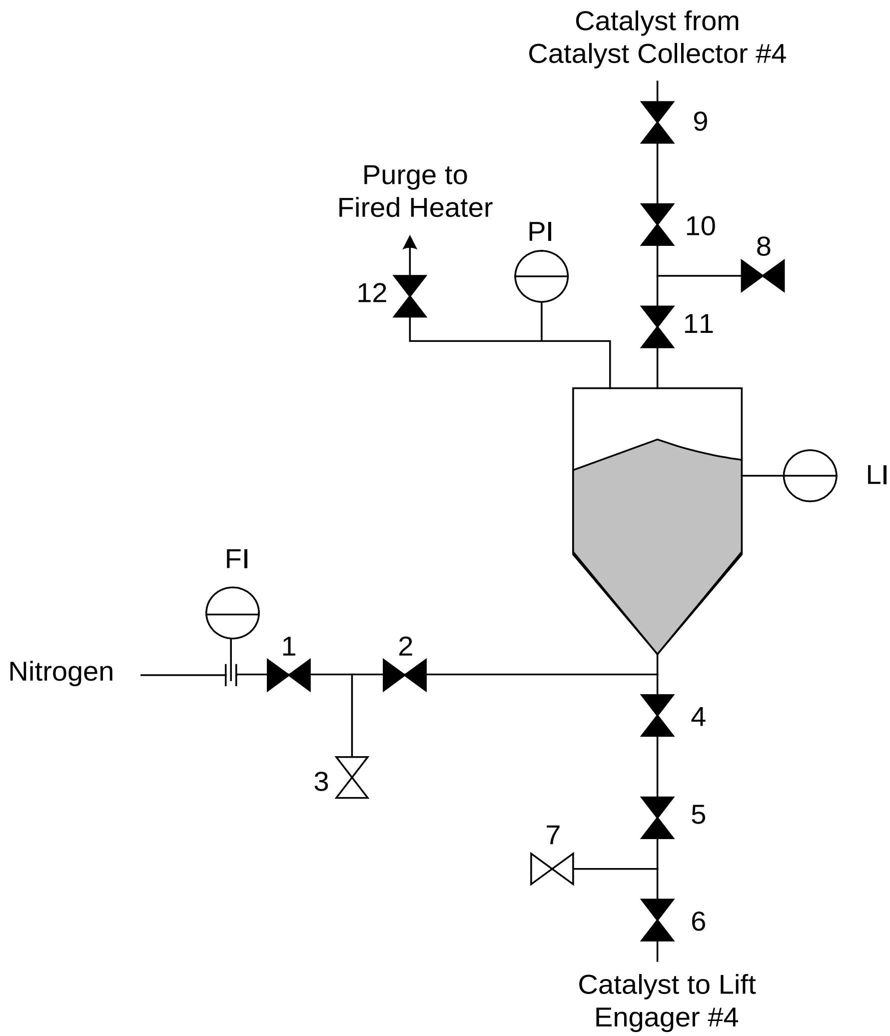
7. Long Cycle Alarm: The Long Cycle Alarm alerts the operator of problems with Lock Hopper 1 sequence. The alarm is activated by the “LONG CYCLE” timer which is set for a time slightly longer than the time required to complete a normal cycle. The timer starts when the transfer sequence begins (Step 1) and stops and resets itself at the end of the sequence when Lock Hopper 1 returns to the “READY” step. If the timer times out before the cycle is complete, the Long Cycle Alarm sounds. The cycle time is relatively constant. However, due to the system of checks that exists in the logic, the cycle will take longer if a problem develops somewhere in the cycle. The “Long Cycle Alarm” will notify the operator of such an occurrence.

8. Delayed Stop Sequence: To avoid possible damage to the ball valve seating surfaces of the gas tight valves, a timer is used to offset the time between when the V-ball valves close to stop catalyst flow, and when the B-ball valves close. The Delayed Stop Sequence circuit is activated whenever the operator pushes the button to stop Lock Hopper 1.

The delay allows catalyst flow to stop and the catalyst volume to flow out of the B-valve area. This allows the B-valves to close on gas only. Should these valves close on catalyst, their usable service life is significantly reduced.

The following outline describes the complete sequence of events which occur during the transfer of catalyst from the last reactor to the Regeneration Section (spent catalyst transfer system). The logic steps are shown as graphics depicting the valve positions of Lock Hopper 1 transfer valves. Additionally, key process indicators of pressure, flow, and level are discussed. These steps are simplified to include only those items that the operator can check for proper operation.

Step 0 (Normal operation)



If Step 0 is entered from Step 22 (Load Stage), Valve 11 closes to further isolate the lock hopper from the catalyst collector and to conclude the lock hopper loading process.

The Long Cycle Timer resets.

* The DCS LH-1 Cycle Time updates

The sequence advances to Step 1 when:

the Lock Hopper 1 Purge Selector is greater than zero

Disengaging Hopper indicates low level

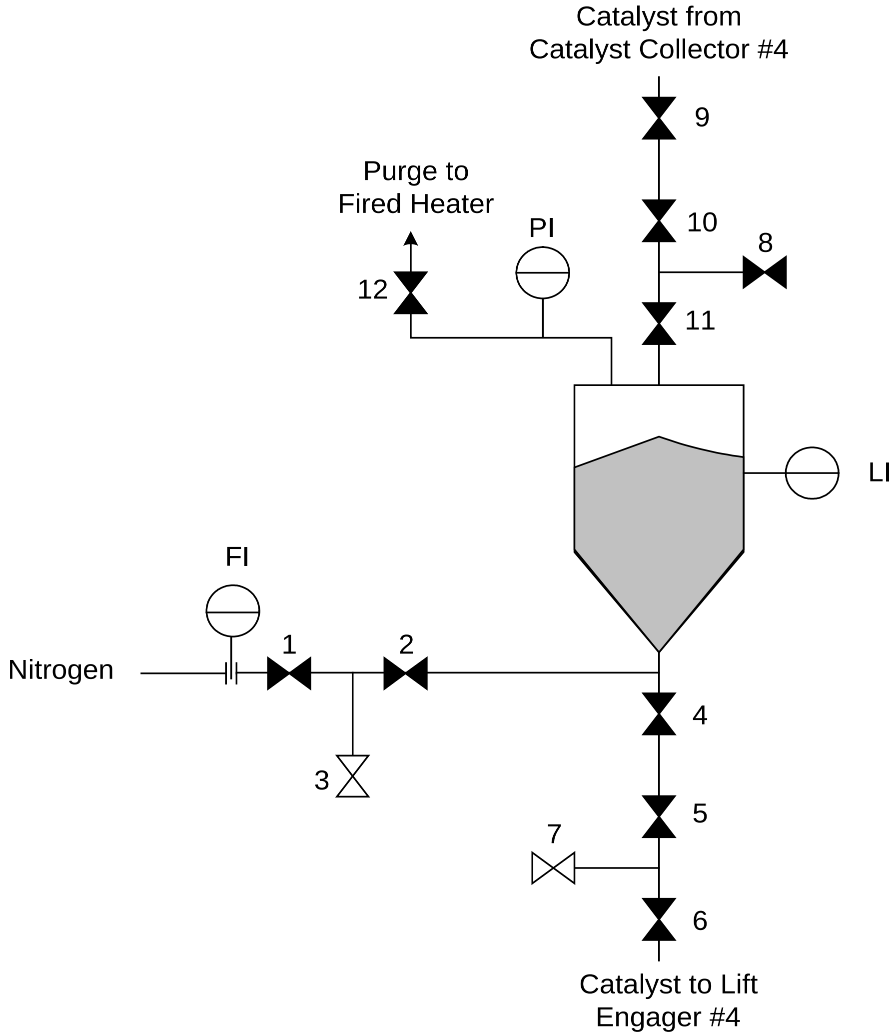
the Lock Hopper 1 Run/Hold Pushbutton is in the Run (green) position

Valve 11 is confirmed closed

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 0 (Trickle Mode)



If Step 0 is entered from Step 22 (Load Stage), Valve 11 closes to further isolate the lock hopper from the catalyst collector and to conclude the lock hopper loading process.

The Long Cycle Timer resets.

* The DCS LH-1 Cycle Time updates

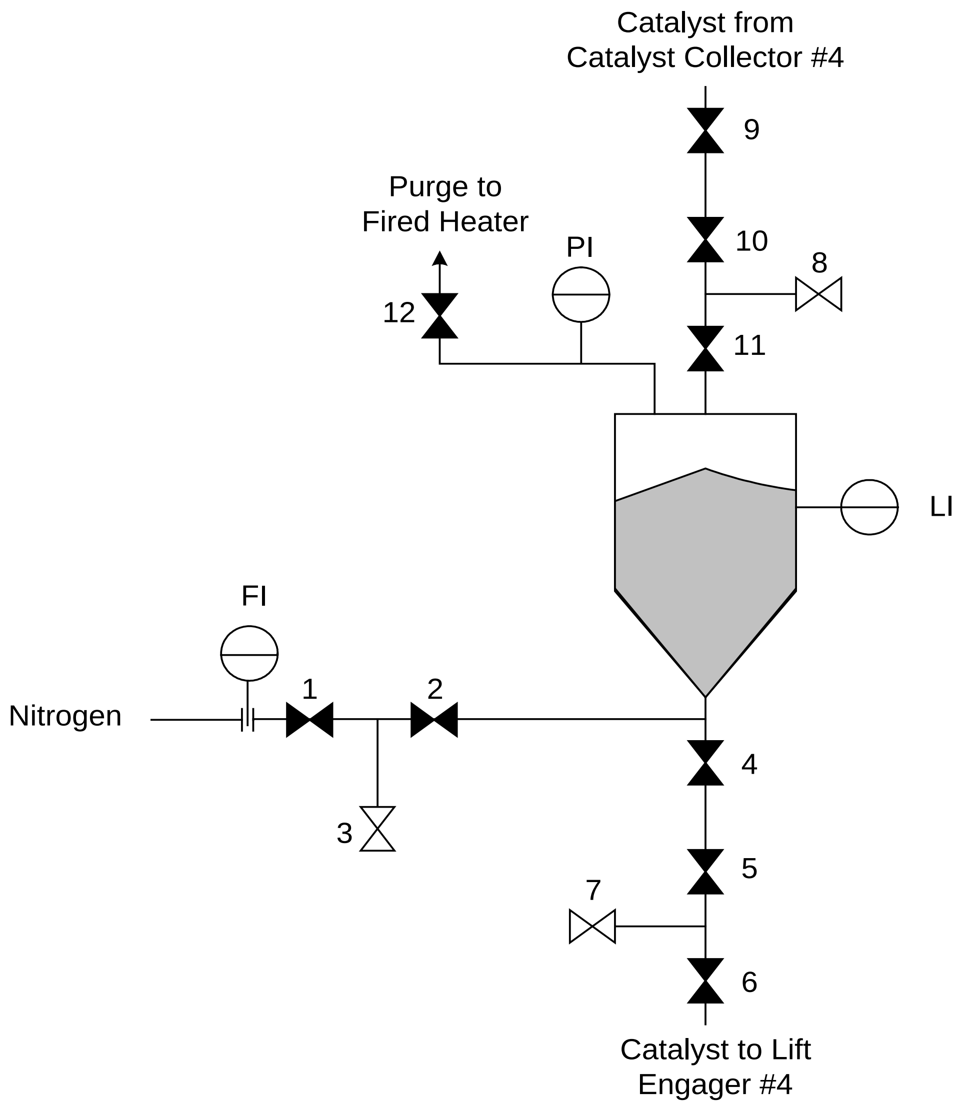
The sequence advances to Step 1 when:

the Lock Hopper 1 Purge Selector is greater than zero
Disengaging Hopper indicates low level
the Lock Hopper 1 Run/Hold Pushbutton is in the Run (green) position
XV20237 is open
Lock Hopper 1 Trickle Load Counter has counted less than 6.
Valve 11 is confirmed closed

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 1



Valve 8 opens to further isolate the lock hopper from the reactor.

The Long Cycle Timer starts.

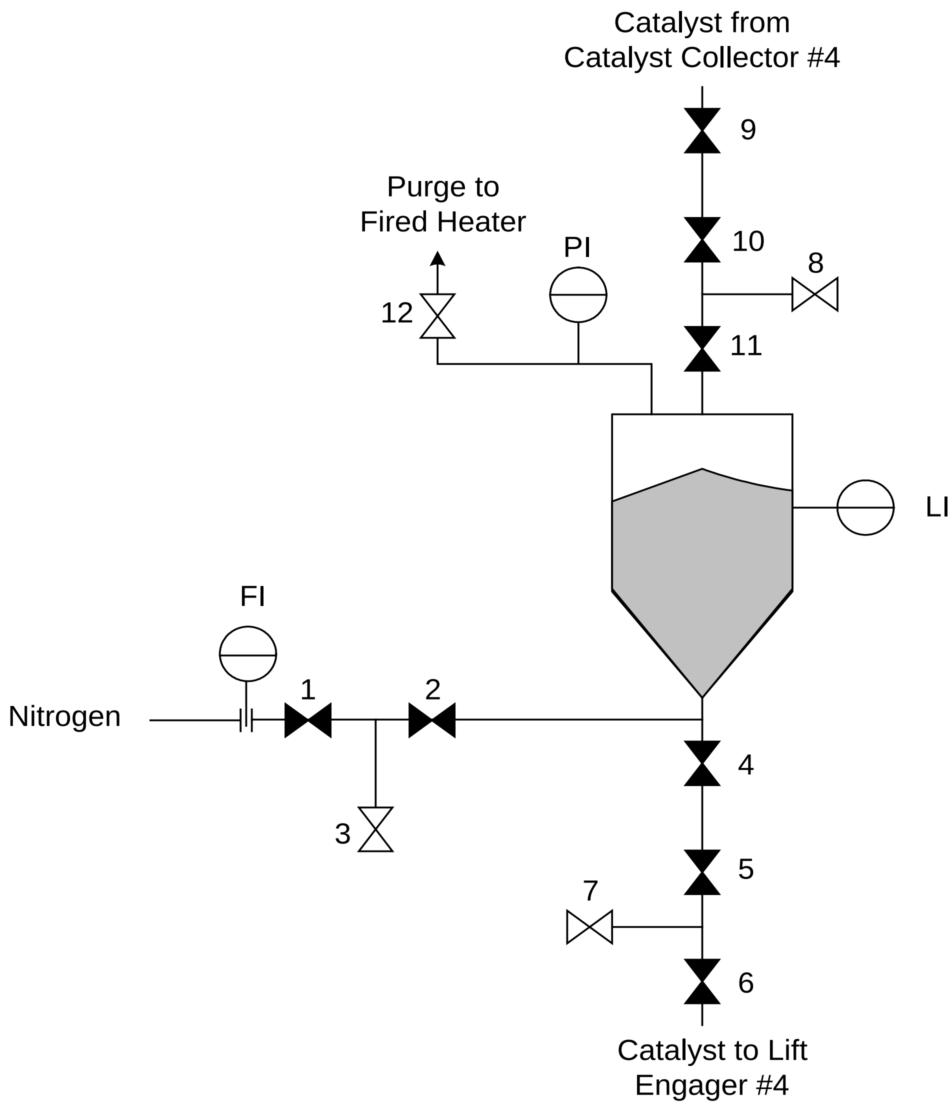
The sequence advances to the next step when:

Valve 8 is confirmed open

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 2



Valve 12 opens to lower the lock hopper's pressure. The gas exhausts to the heater in normal operation or to the Flare in Trickle Mode.

*The DCS LH-1 Depressure Timer starts.

The sequence advances to the next step when:

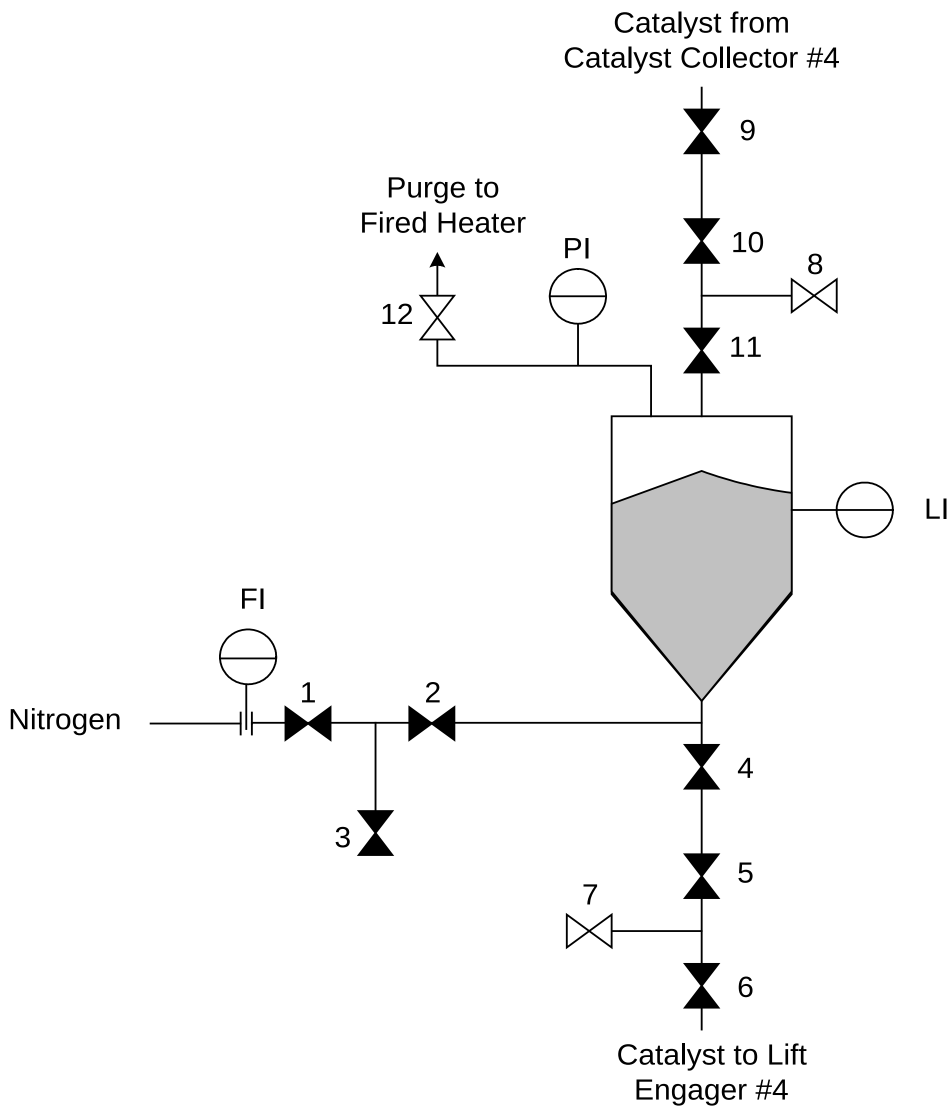
Valve 12 is confirmed open

The PI indicates low lock hopper pressure

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 3



Valve 3 closes to start setting up the nitrogen purge.

*The LH-1 Depressure Time updates.

The sequence advances to the next step when:

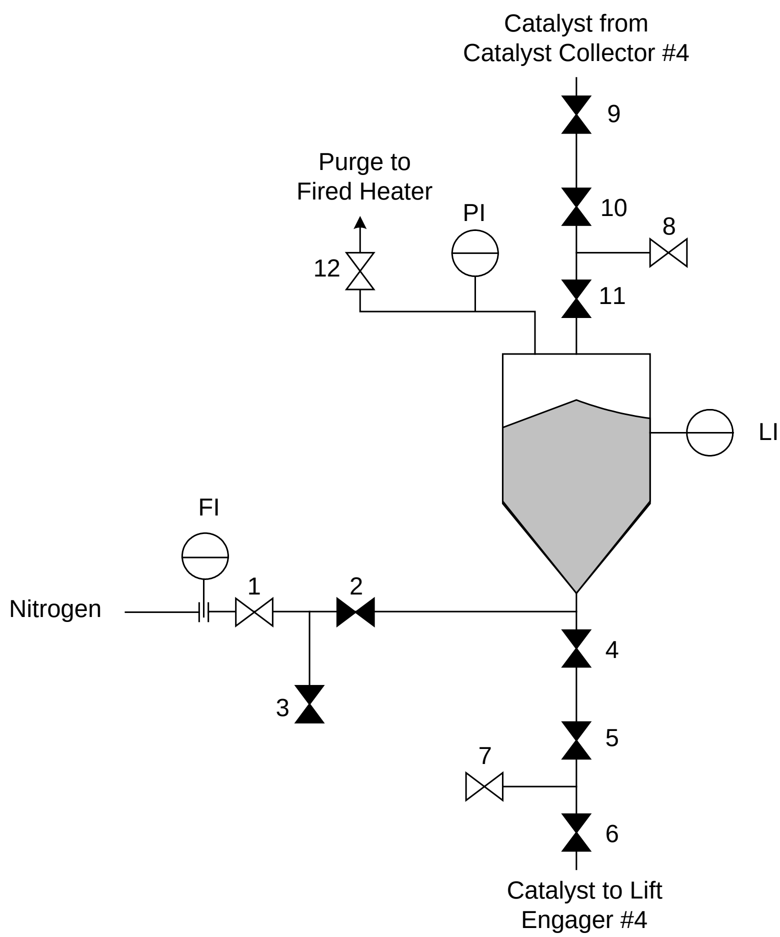
Valve 3 is confirmed closed

the Lock Hopper 1 Purge Selector is greater than zero

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 4



This step removes hydrogen from the lock hopper by repetitively pressuring and venting the lock hopper. Nitrogen flows through the lock hopper and builds pressure. The gas exhausts to the heater in normal operation or to the Flare in Trickle Mode.

Valve 1 opens to set up the nitrogen purge.

The Purge Subroutine (following this step) repeats for each count of the Lock Hopper 1 Purge Selector.

Each execution of the Purge Subroutine starts when:

Valve 1 is confirmed open

The FI indicates no nitrogen flow to the lock hopper

The PI indicates low lock hopper pressure

The Lock Hopper 1 Purge Counter is less than the number of purges set by Lock Hopper 1 Purge Selector

AND

All Lock Hopper 1 Sequence valve positions are verified.

The sequence advances to Step 5 when:

The Lock Hopper 1 Purge Selector is greater than zero

the Purge Subroutine has executed the number of times set by the Purge Selector

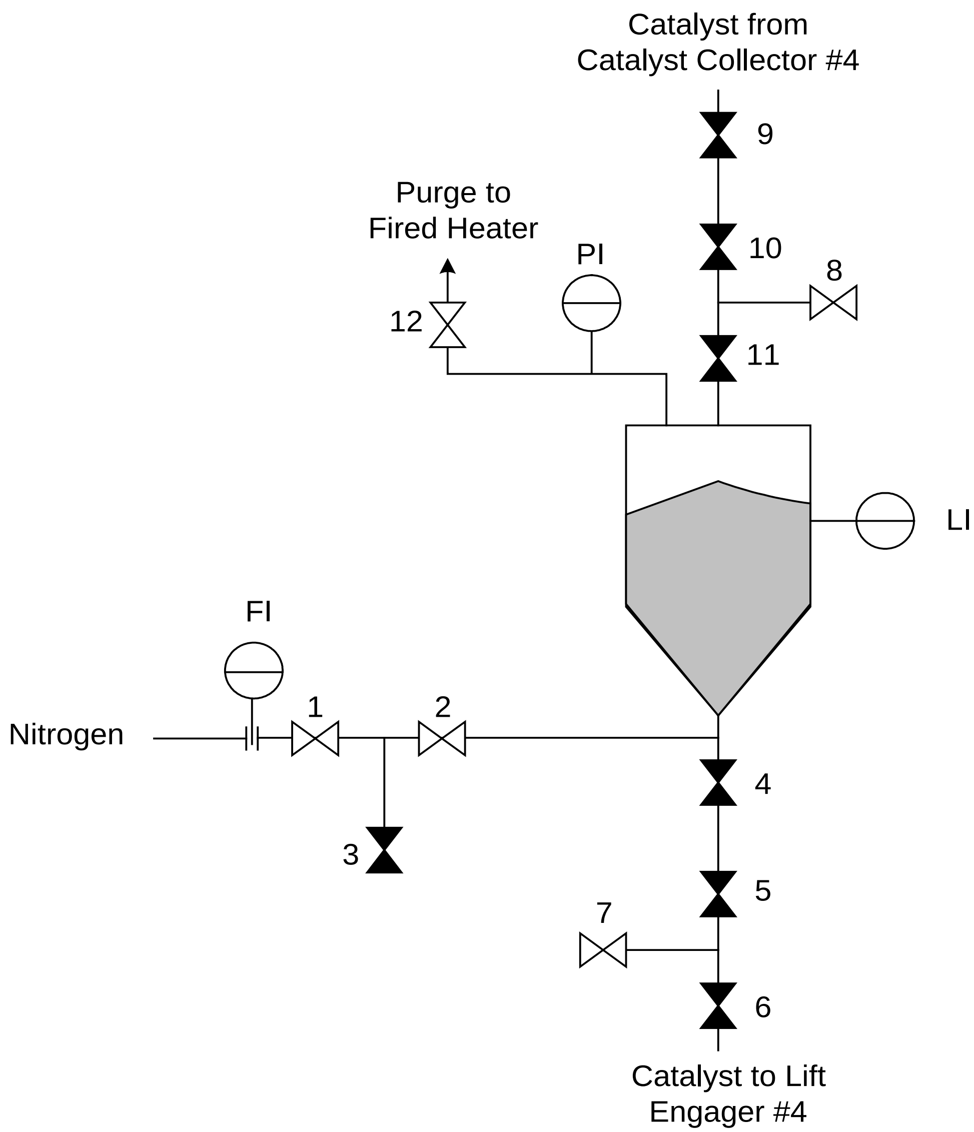
Valve 2 is confirmed closed

The PI indicates low lock hopper pressure

AND

All Lock Hopper 1 Sequence valve positions are verified.

Purge Subroutine

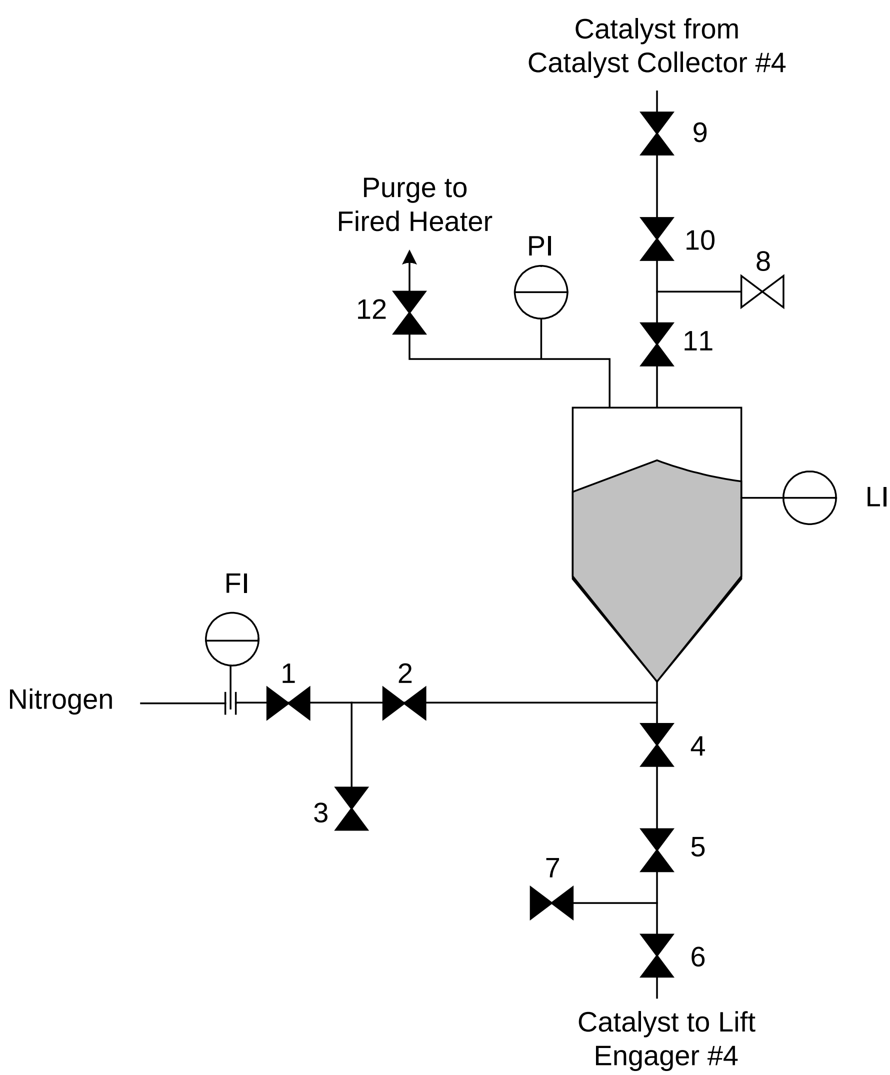


The Purge Subroutine executes during Step 4.

The Purge Subroutine:

1) Valve 2 to allow nitrogen to flow into the lock hopper
2) Waits for 35 seconds (Purge Timer) of continuous nitrogen flow through the FI
   before closing Valve 2
3) Increments the Purge Counter by 1 each time the Purge Timer times out.
4) Returns to Step 4

Step 5



Valve 1 closes to isolate the lock hopper from the nitrogen supply.

Valve 7 closes to start setting up the catalyst transfer path between the lock hopper and the lift engager.

Valve 12 closes to isolate the lock hopper from the heater.

The sequence advances to the next step when:

Valve 1 is confirmed closed

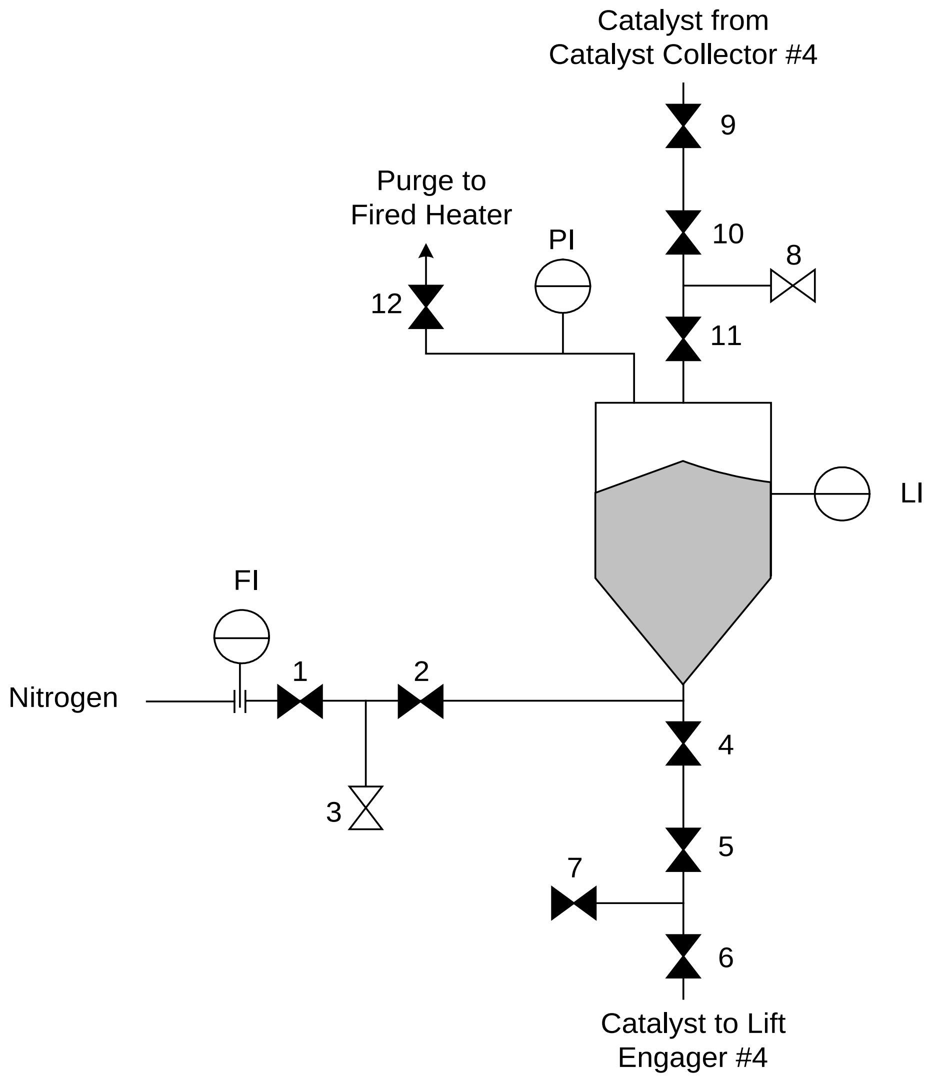
Valve 7 is confirmed closed

Valve 12 is confirmed closed

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 6



Valve 3 opens to completely isolate the lock hopper from the nitrogen supply.

The Long Cycle Timer pauses to avoid a nuisance Long Cycle Alarm.

The sequence advances to the next step when:

Valve 3 is confirmed open

The Disengaging Hopper indicates low level

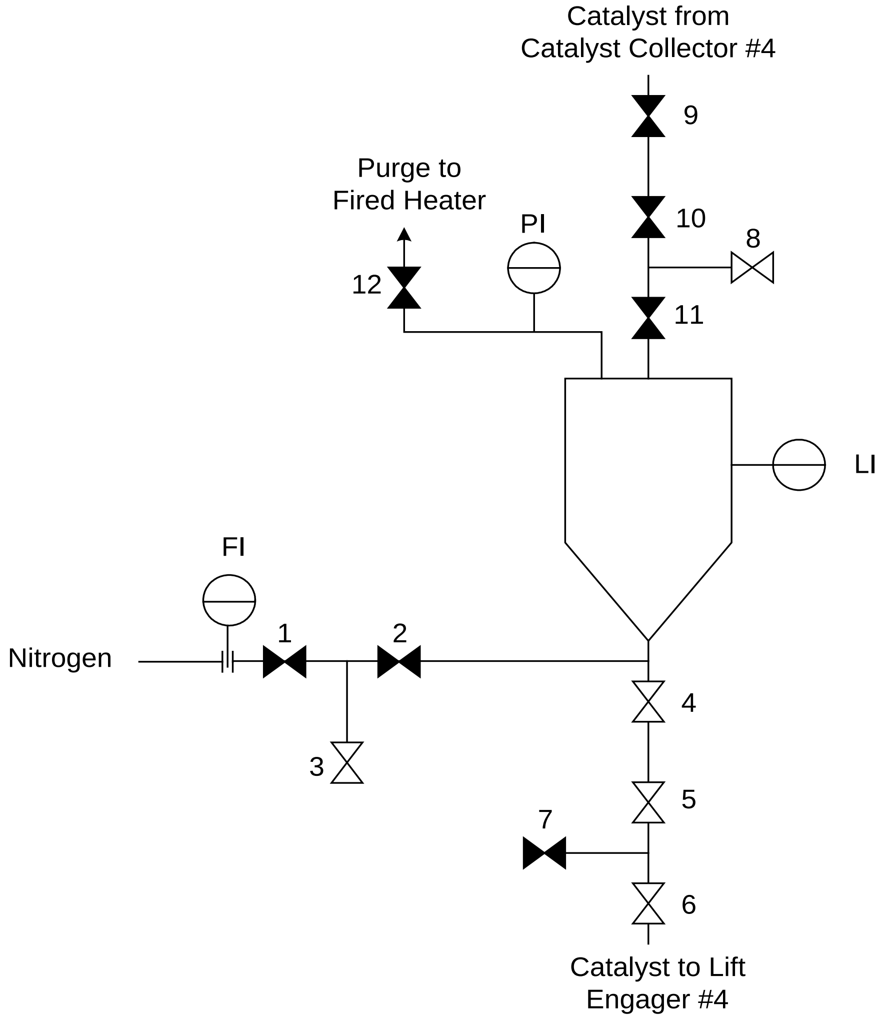
Lift Engager gas flow indicates high

AND

All Lock Hopper 1 Sequence valve positions are verified.

By confirming that the Lift Engager gas flow is high, the controller insures that Lift Engager #4 is empty.

Step 8



If the Lock Hopper 1 Start/Stop Pushbutton indicator turns red during this step, the sequence goes immediately to the next step.

Advancing to the Stop Position could close ball valves, Valve 5 and Valve 6, on catalyst and could damage the ball valves.

Valve 4 opens to allow catalyst to flow from the lock hopper to the lift engager.

When Valve 4 is confirmed open, the Lock Hopper 1 Unload Timer starts.

*The DCS LH-1 Lift Timer starts when logic contact closes.

*The DCS LH-1 Lift Timer updates when Lift Engager #4 lift gas drops low.

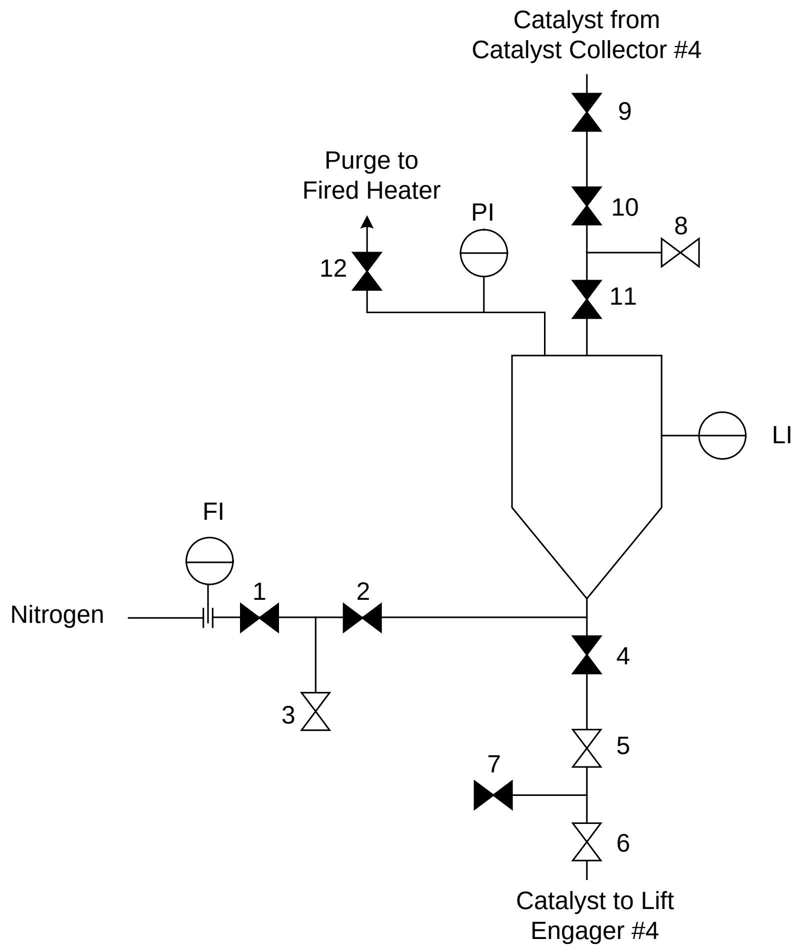
The sequence advances to the next step when:

the Lock Hopper 1 Unload Timer expires

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 9



If the Lock Hopper 1 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the next step. Advancing immediately to the Stopped position could close ball valves, Valve 5 and Valve 6, on catalyst and could cause valve damage.

Valve 4 closes to stop catalyst flow. When it is confirmed closed, the Dust Settling Timer starts.

The sequence advances to the next step when:

the Dust Settling Timer expires

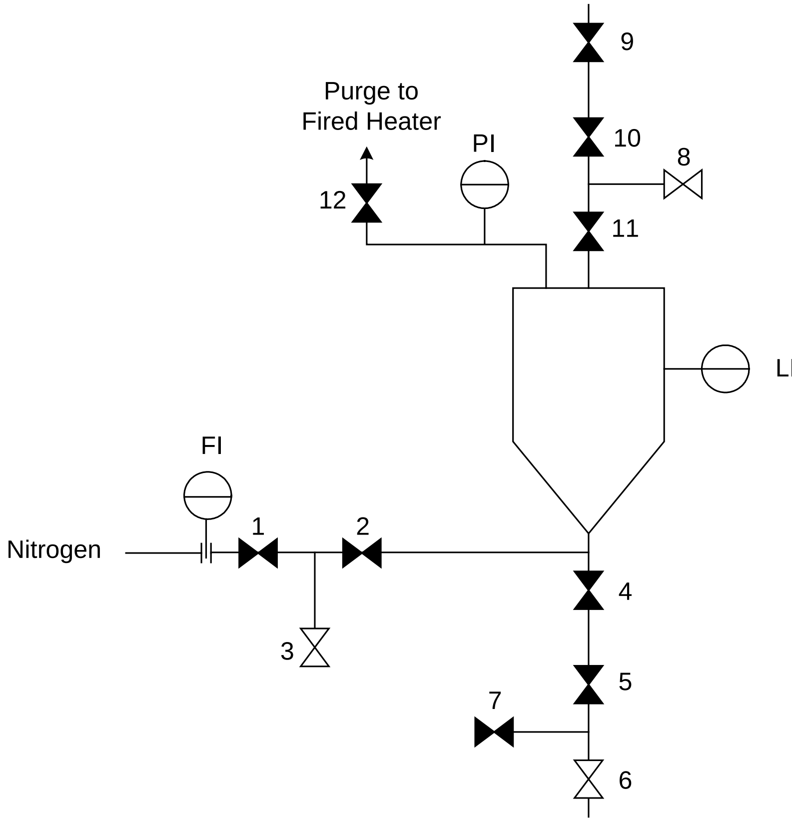
Valve 4 is confirmed closed

AND

All Lock Hopper 1 Sequence valve positions are verified.

Closing a ball valve on catalyst dust particles may damage the valve seat. The Dust Settling Timer insures that catalyst and dust has cleared XV20233 (5) to avoid valve damage.

Step 10



If the Lock Hopper 1 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the next step. Advancing immediately to the Stopped position could close ball valve, Valve 6, on catalyst dust, and could cause valve damage.

Valve 5 closes to start isolating the lock hopper from the lift engager.

When Valve 5 is confirmed closed, the Dust Settling Timer 2 starts.

The sequence advances to the next step when:

Valve 5 is confirmed closed

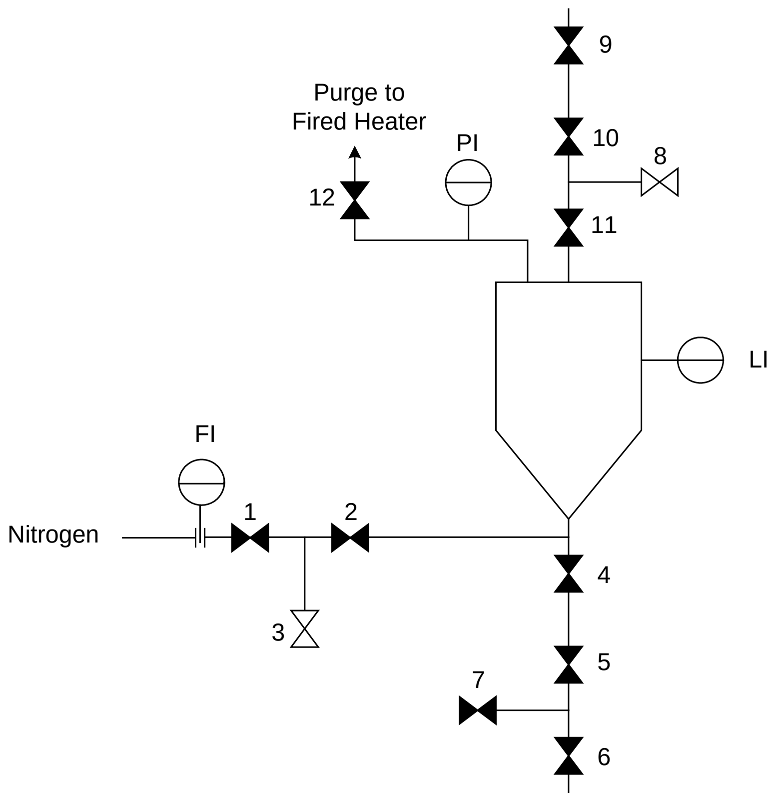
The Dust Settling Timer 2
(ten seconds) has expired

AND

All Lock Hopper 1 Sequence valve positions are verified.

Closing a ball valve on catalyst dust particles may damage the valve seat. The Dust Settling Timer 2 insures that catalyst and dust has cleared Valve 6 to avoid valve damage.

Step 11



If the Lock Hopper 1 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the Stop position. Advancing immediately to the Stopped position would defeat a double block and bleed by opening Valve 7 at the same time Valve 6 was closing.

Valve 6 closes to continue isolating the lock hopper from the lift engager.

The Abnormal Loading Alarm clears, if active.

(If in Trickle Mode, the Abnormal Loading Alarm is not enabled).

The Lock Hopper 1 Counter increments if Step 20 was executed in the previous cycle. The counts and the actual amount of catalyst transferred will then remain the same.

The sequence advances to the next step when:

Valve 6 is confirmed closed

AND

All Lock Hopper 1 Sequence valve positions are verified.

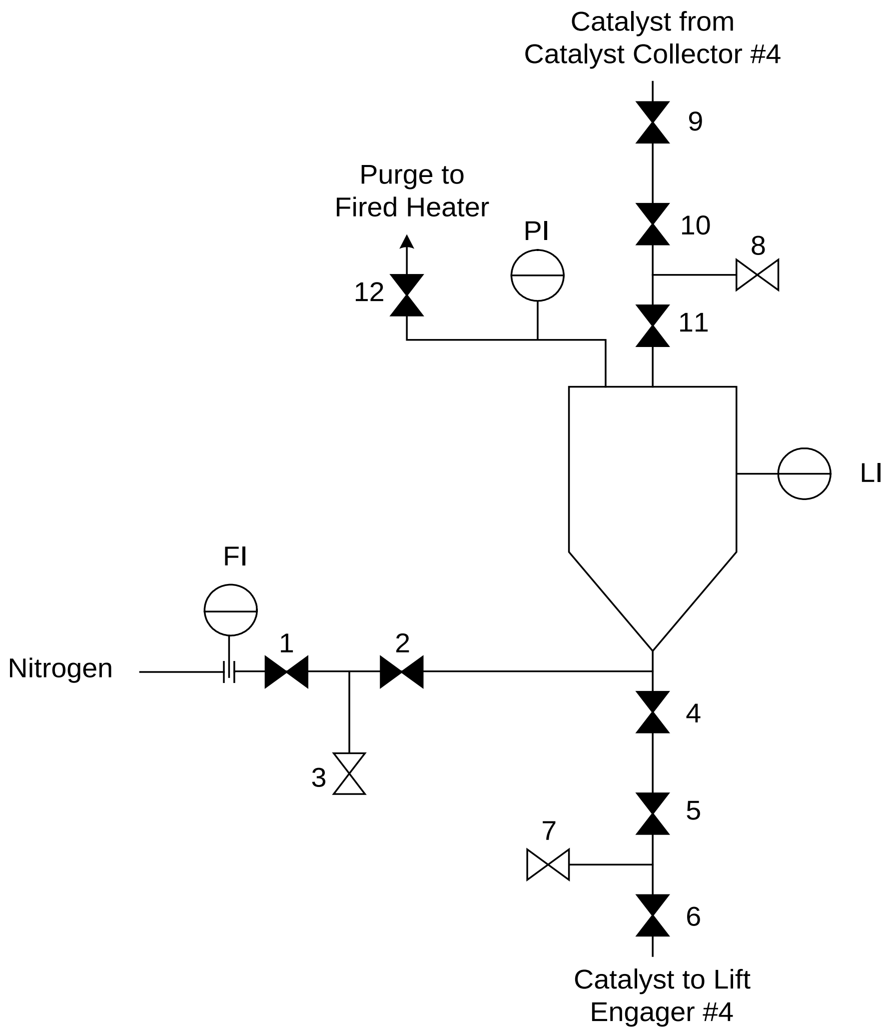
The sequence goes to the Stop position when:

The Lock Hopper 1 Start/Stop Pushbutton indicator is in the Stopped (red) position

AND

Valve 6 is confirmed closed.

Step 12 (Normal Mode)



Valve 7 opens to completely isolate the lock hopper from the lift engager.

The Long Cycle Timer pauses to avoid a nuisance Long Cycle Alarm.

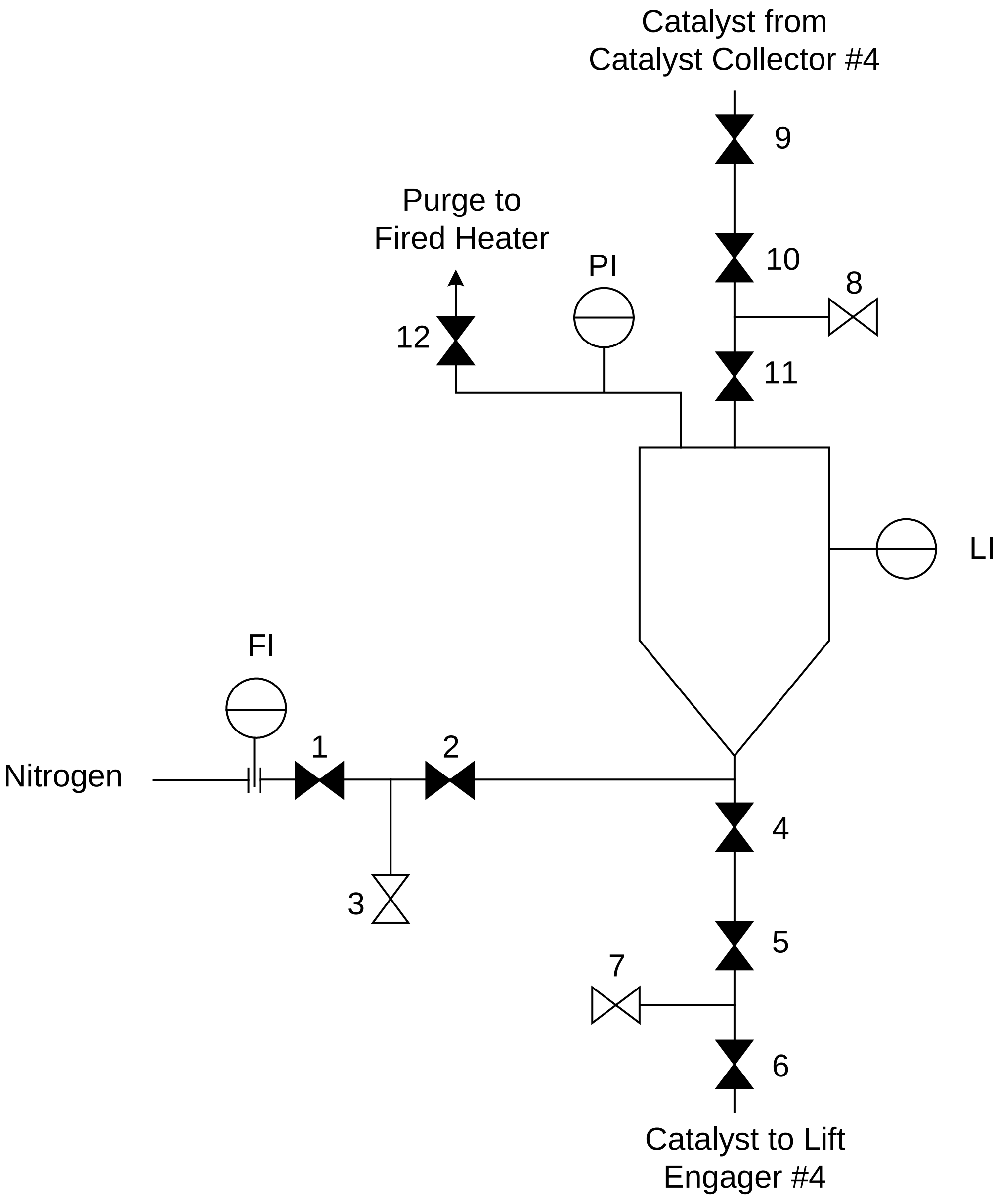
The sequence advances to the next step when:

Valve 7 is confirmed open
Reactor 4 level indicates high level
The differential pressure between the Reactor 4 Surge Pot and Reactor 4 is normal
There is sufficient temperature and flow for the previous 15 minutes to Surge Pot #4

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 12 (Trickle Mode)



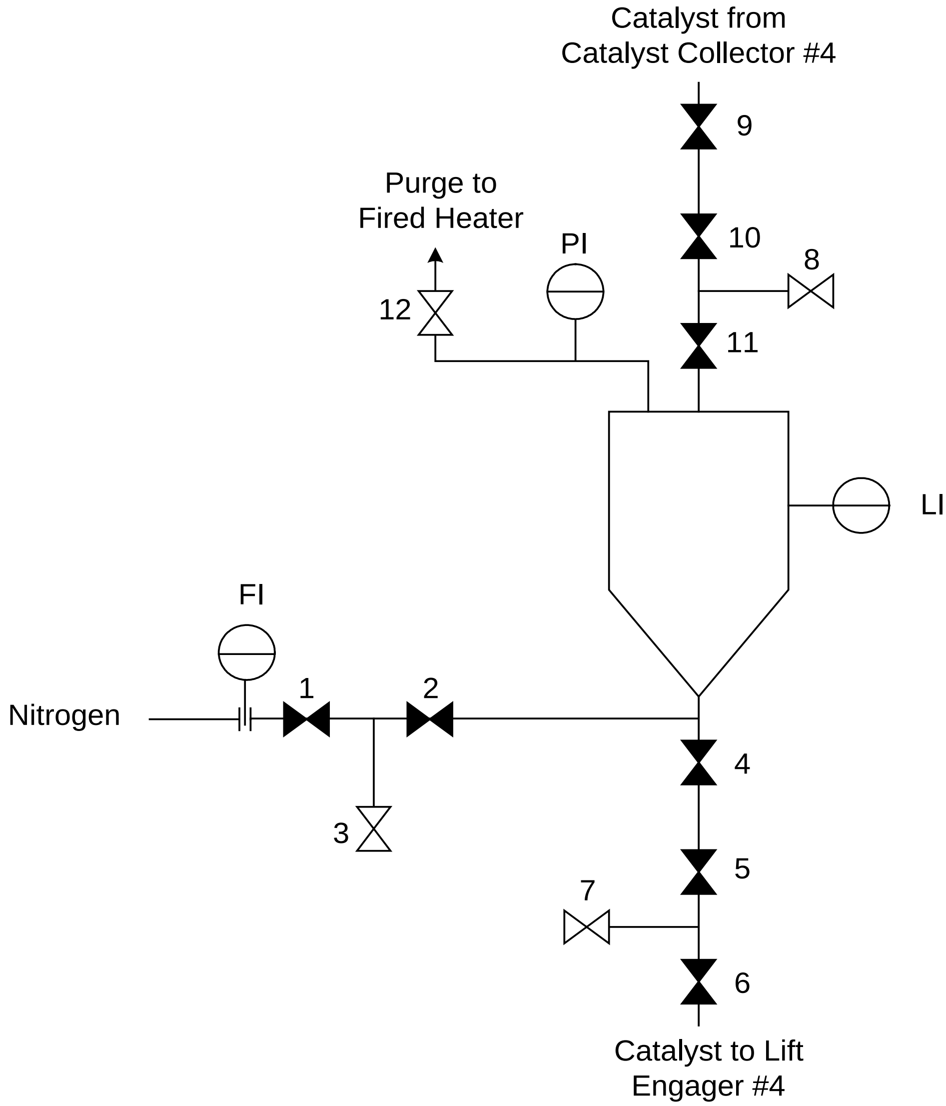
Valve 7 opens to completely isolate the lock hopper from the lift engager.

The sequence advances to the next step when:

Valve 7 is confirmed open

All Lock Hopper 1 Sequence valve positions are verified.

Step 13



Valve 12 opens to depressure the lock hopper.

In Normal Mode, the Long Cycle Timer restarts.

The sequence advances to the next step when:

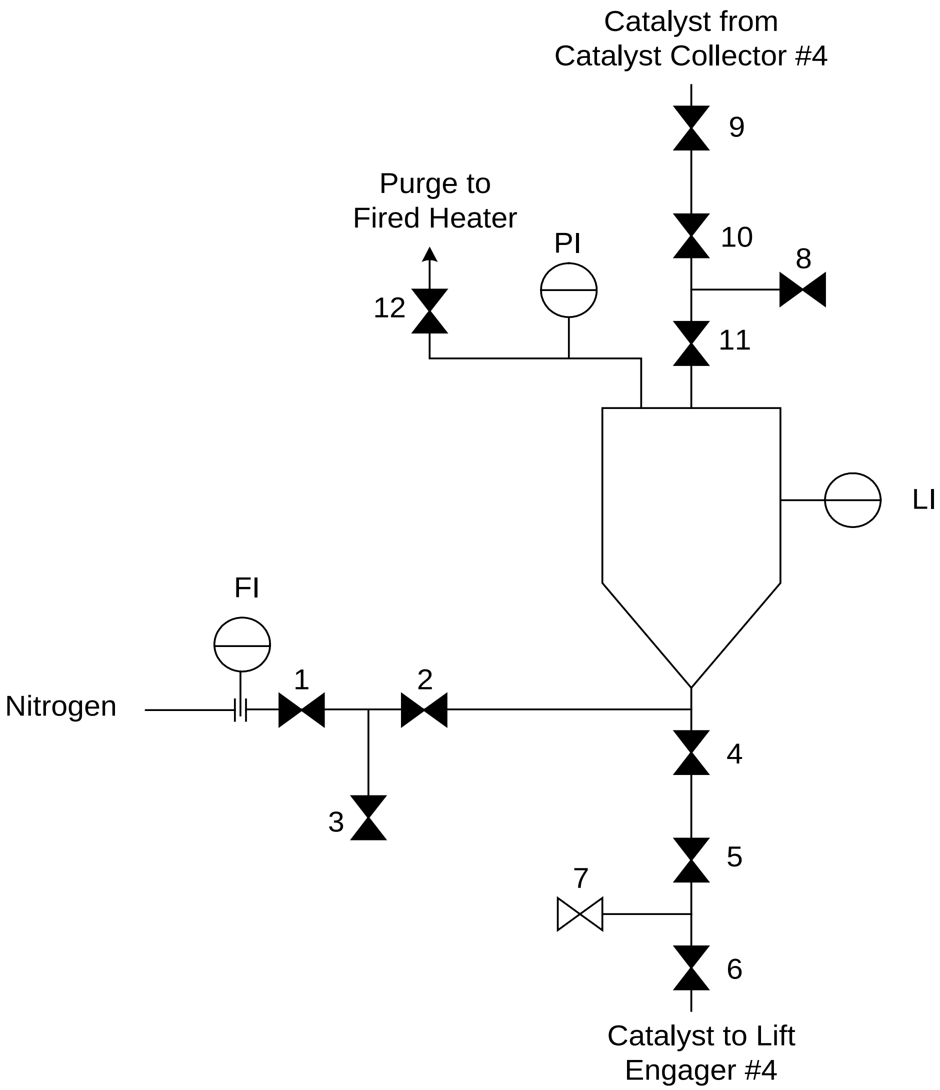
Valve 12 is confirmed open

The PI indicates low lock hopper pressure

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 14



Step 3 closes to set up the nitrogen line for pressuring the lock hopper.

Step 8 closes to set up the catalyst transfer path for loading the lock hopper.

Step 12 closes to allow pressuring of the lock hopper.

The sequence advances to the next step when:

Step 3 is confirmed closed

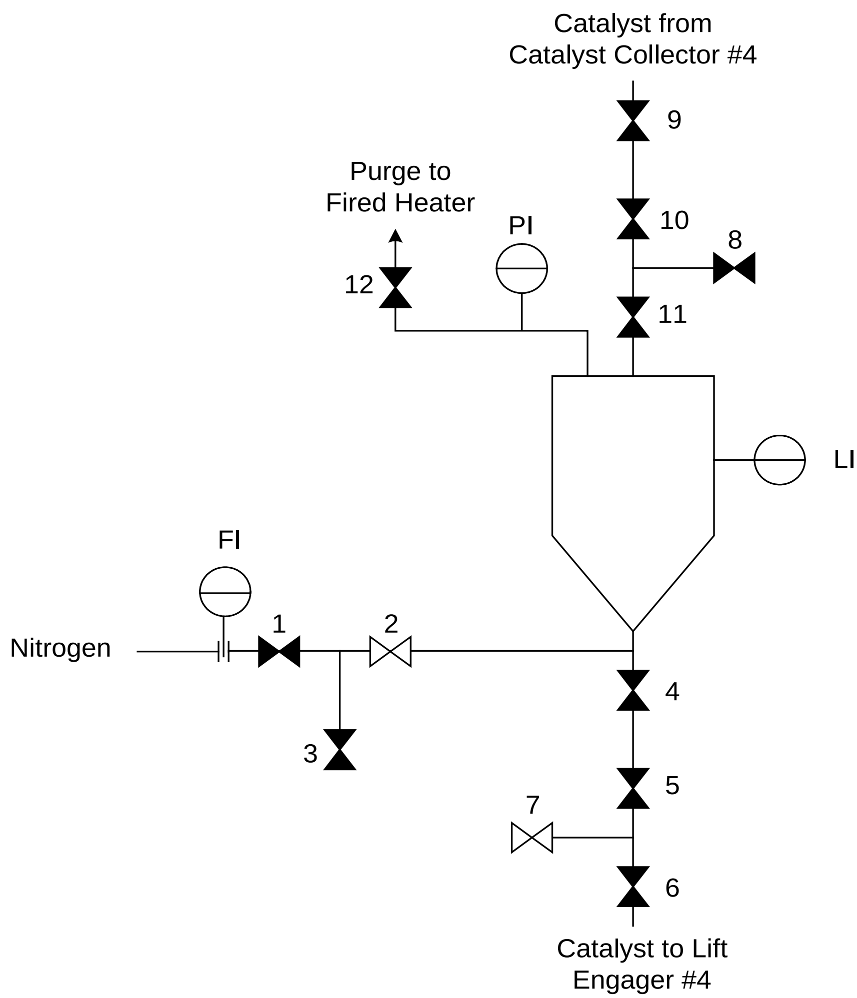
Step 8 is confirmed closed

Step 12 is confirmed closed

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 15



Valve 2 opens to further prepare for pressuring the lock hopper with nitrogen.

Catalyst Collector #4 Purge Gas Flow is checked to be present for at least 15 minutes to insure that the catalyst is adequately purged of hydrocarbons.

Logic confirms that the lock hopper pressure is lower than the catalyst collector pressure.

The sequence advances to the next step when:

Valve 2 is confirmed open

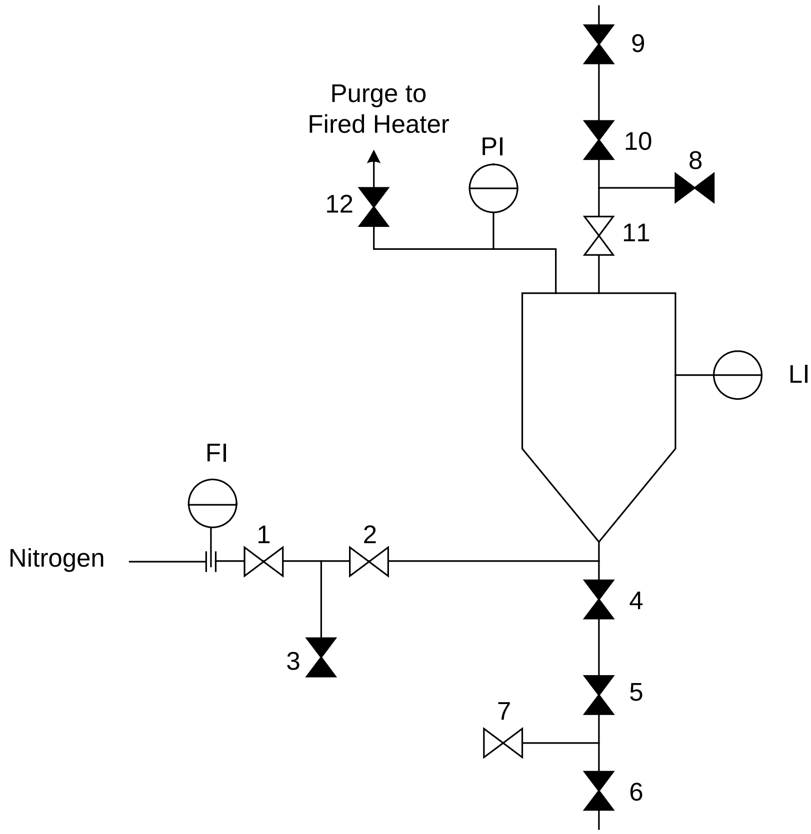
The lock hopper pressure is lower than the catalyst collector pressure

Catalyst Collector #4 Purge Gas Flow is checked to be present for at least 15 minutes

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 16



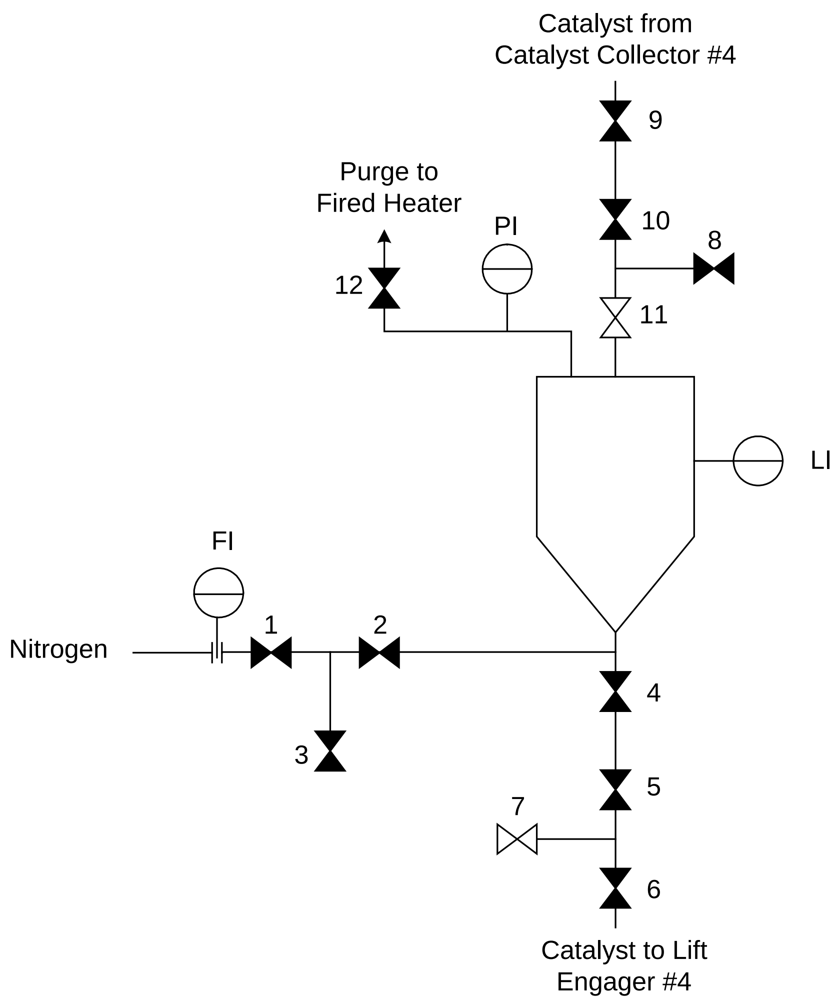
Valve 1 opens to pressure the lock hopper with nitrogen.

Valve 11 opens to equalize the catalyst transfer line pressure with the lock hopper.

In this step, the sequence ignores the open valve verification to prevent overpressuring the lock hopper. *The DCS LH-1 Pressure Timer starts.

The sequence advances to the next step when:
The differential pressure between the lock hopper and the catalyst collector is approximately equal.

Step 17



Valve 1 and Valve 2 close to stop nitrogen flow and to hold the lock hopper's pressure.Valve 11 is verified open from the previous step.

*The DCS LH-1 Pressure Time updatesThe Lock Hopper level transmitter is checked to insure that the lock hopper is empty.The Lock Hopper pressure transmitter is checked to confirm that the lock hopper has been pressurized.

The sequence advances to the next step when:

Valve 11 is confirmed open

Valve 1 is confirmed closed

Valve 2 is confirmed closed

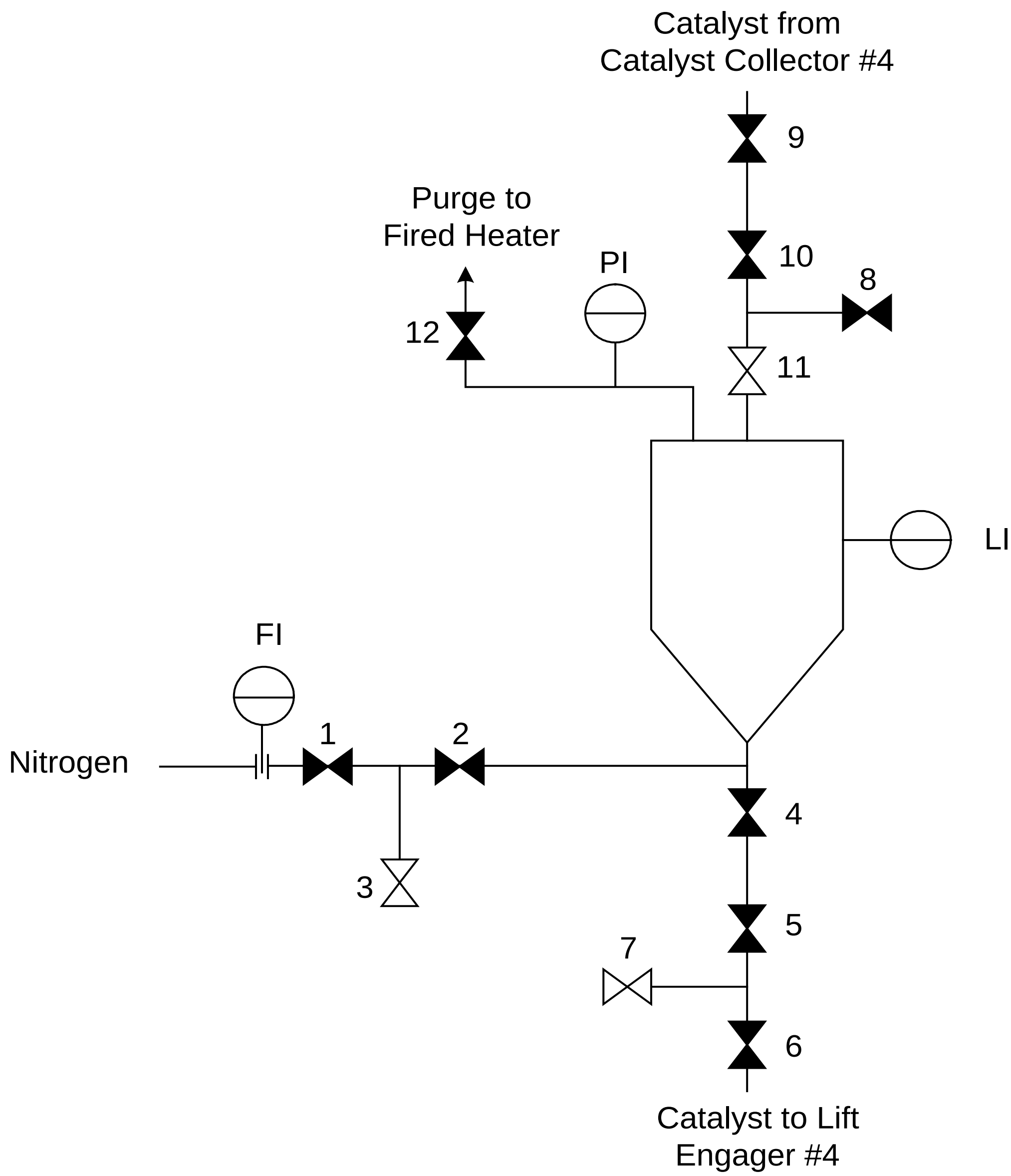
The Lock Hopper pressure transmitter indicates high lock hopper pressure

The Lock Hopper level tranmistter indicates low level or empty lock hopper

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 18



Valve 3 opens to completely isolate the nitrogen supply from the lock hopper.

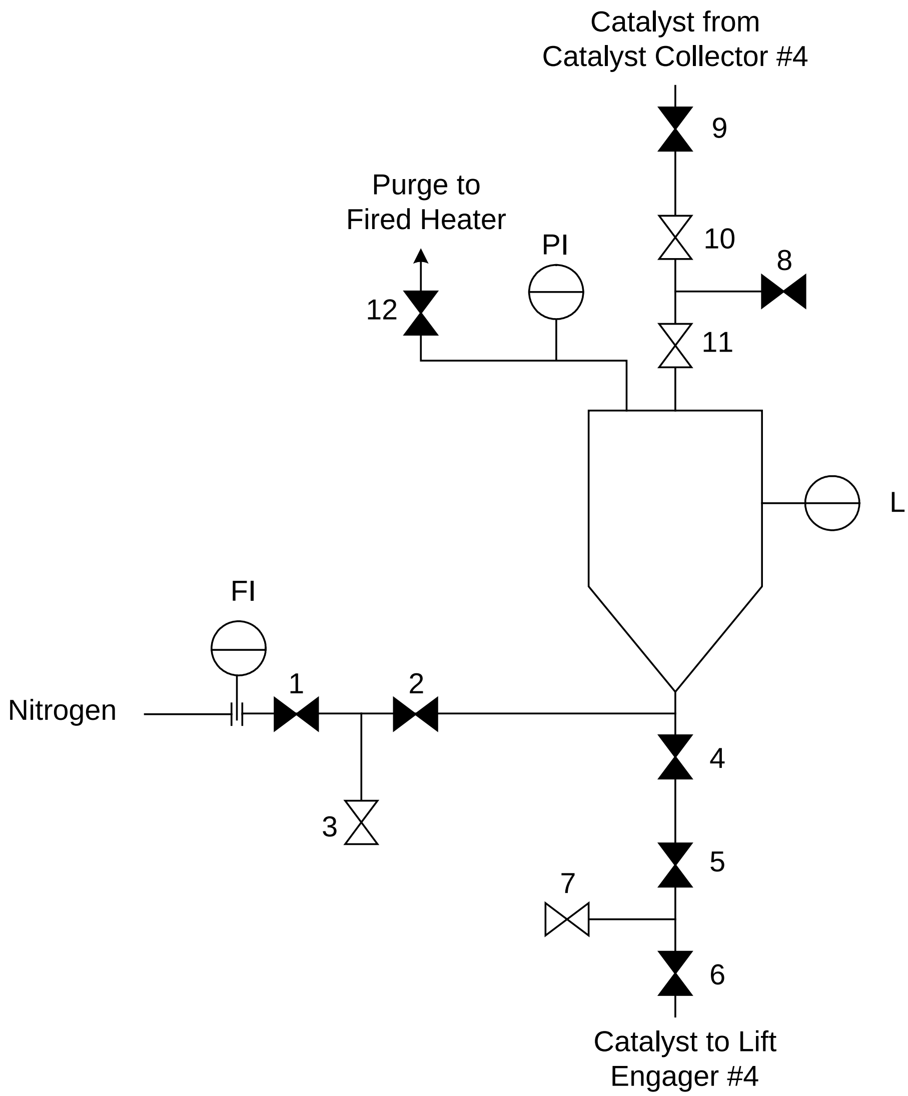
The sequence advances to the next step when:

Valve 3 is confirmed open

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 19



Valve 10 opens to further set up the catalyst transfer path between the lock hopper and the reactor's catalyst collector. The closed V-notch ball valve, Valve 9, prevents catalyst flow.

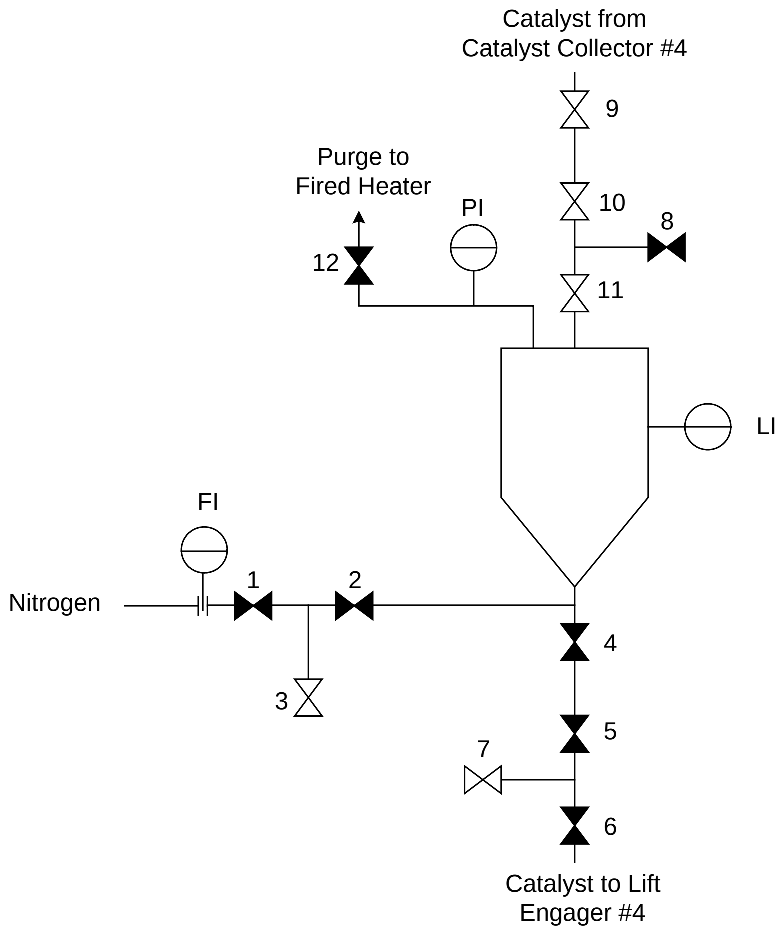
The sequence advances to the next step when:

Valve 10 is confirmed open

AND

All Lock Hopper 1 Sequence valve positions are verified.

Step 20 (Normal Operations)



If the Lock Hopper 1 Start/Stop Pushbutton indicator turns red during this step, the sequence goes immediately to the next step. Advancing to the Stop position immediately could close ball valves, Valves 10 and Valve 11, on catalyst, and could cause valve damage.

In this step, the sequence ignores valve verification to prevent overfilling the lock hopper.

Valve 9 opens to allow catalyst to flow into the lock hopper.

The Lock Hopper 1 Abnormal Loading Minimum Timer starts. If the timer expires during this step, the Abnormal Loading Range Timer starts.

The Lock Hopper 1 Abnormal Loading Alarm activates during this step if:

The Lock Hopper level transmitter indicates high lock hopper level before the Abnormal Loading Minimum Timer expires

OR

the Abnormal Loading Range Timer expires *The DCS LH-1 Load Timer starts.

The sequence advances to the next step when:

The Lock Hopper level transmitter indicates high lock hopper level

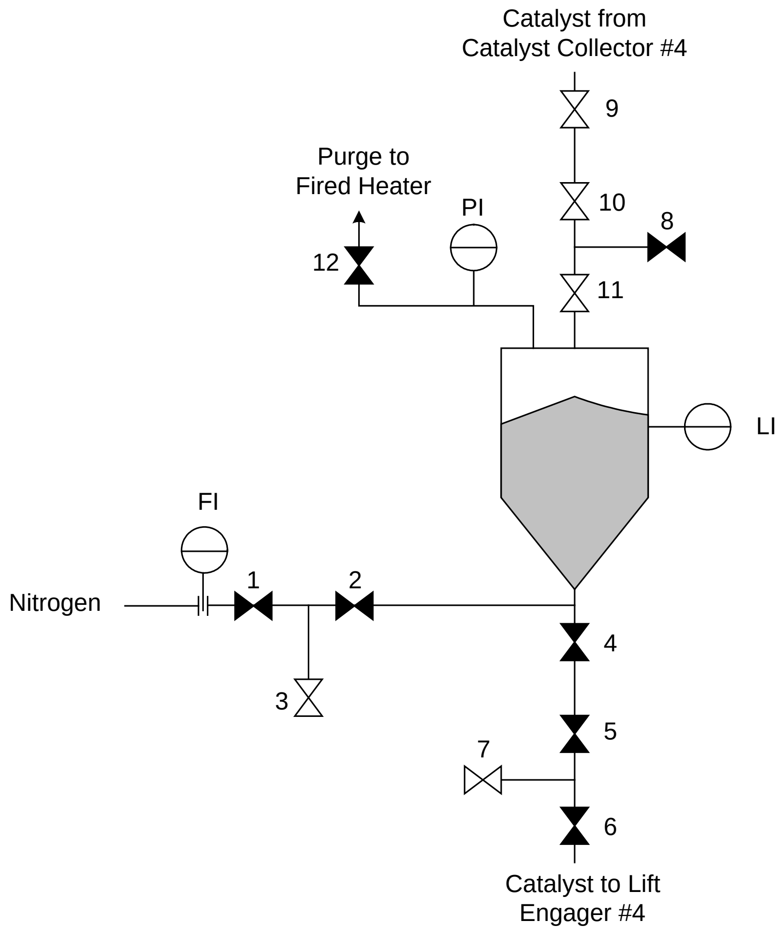
OR

the Abnormal Loading Range Timer expires

OR

the Lock Hopper 1 Start/Stop Pushbutton indicator turns red

Step 20 (Normal Operations)



If the Lock Hopper 1 Start/Stop Pushbutton indicator turns red during this step, the sequence goes immediately to the next step. Advancing to the Stop position immediately could close ball valves, Valves 10 and Valve 11, on catalyst, and could cause valve damage.

In this step, the sequence ignores valve verification to prevent overfilling the lock hopper.

Valve 9 opens to allow catalyst to flow into the lock hopper.

The Lock Hopper 1 Abnormal Loading Minimum Timer starts. If the timer expires during this step, the Abnormal Loading Range Timer starts.

The Lock Hopper 1 Abnormal Loading Alarm activates during this step if:

The Lock Hopper level transmitter indicates high lock hopper level before the Abnormal Loading Minimum Timer expires

OR

the Abnormal Loading Range Timer expires *The DCS LH-1 Load Timer starts.

The sequence advances to the next step when:

The Lock Hopper level transmitter indicates high lock hopper level

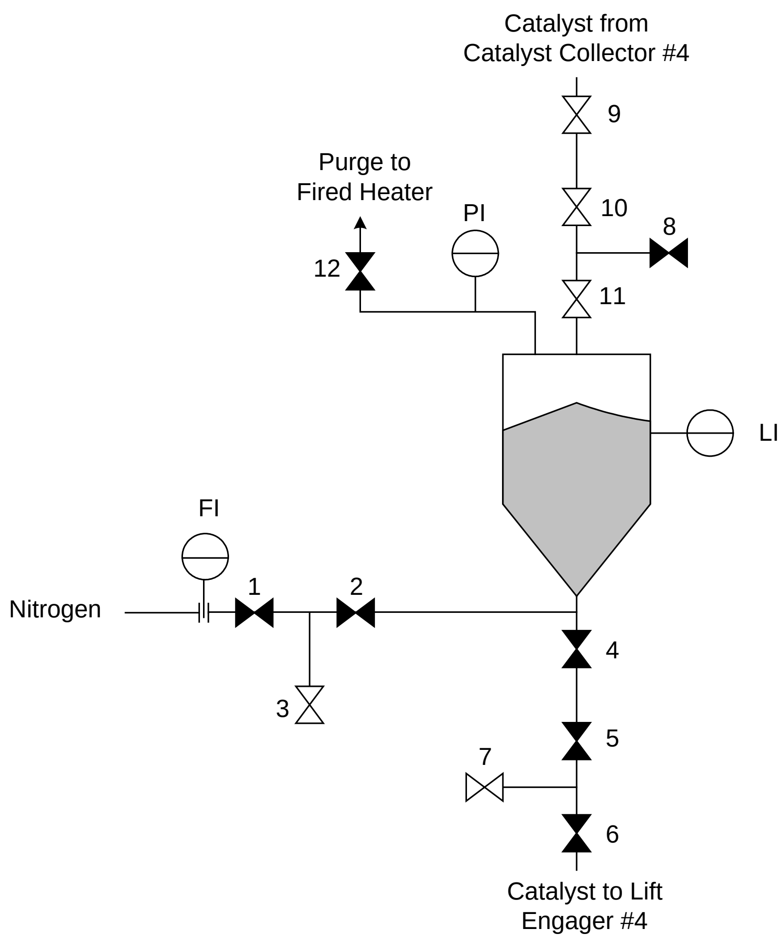
OR

the Abnormal Loading Range Timer expires

OR

the Lock Hopper 1 Start/Stop Pushbutton indicator turns red

Step 20 (Trickle Mode)



If the Lock Hopper 1 Start/Stop Pushbutton indicator turns red during this step, the sequence goes immediately to the next step. Advancing to the Stop position immediately could close ball valves, Valve 10 and Valve 11, on catalyst, and could cause valve damage.

In this step, the sequence ignores the open valve verification to prevent overfilling the lock hopper.

The Abnormal Loading Alarm is disabled.

The Long Cycle Timer pauses.

Valve 9 opens to allow catalyst to flow into the lock hopper.

The Trickle Mode Load Timer starts.

The Trickle Mode Subroutine starts.

The sequence advances to the next step when:

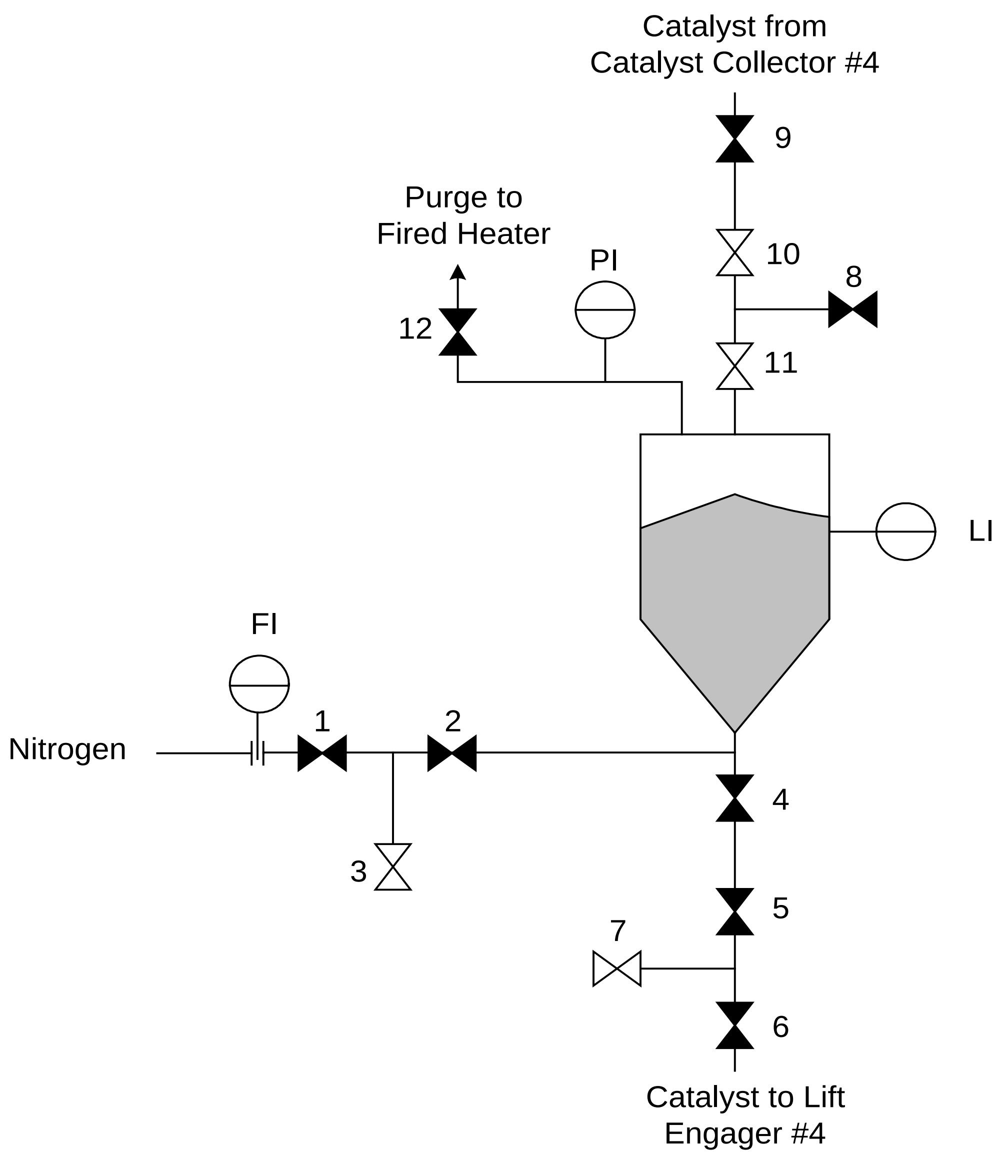
The Lock Hopper level transmitter indicates high lock hopper level

The Trickle Mode Load Timer expires

OR

The Lock Hopper 1 Start/Stop Pushbutton indicator turns red.

Trickle Mode Subroutine

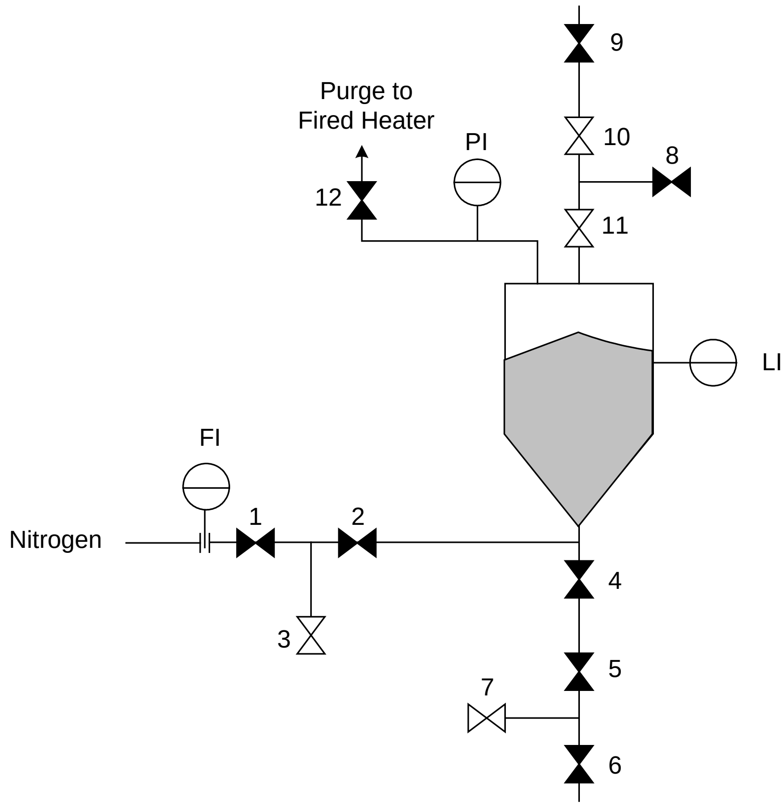


This subroutine executes during Step 20 (Trickle Mode).

The Trickle Mode Subroutine:

1) Valve 9 closes after the Trickle Load Timer expires
2) Starts Trickle Load Delay Timer after valve Valve 9 is verified closed
3) Returns to Step 20 (Trickle Mode) after Trickle Load Delay Timer expires

Step 21



If the Lock Hopper 1 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the next step. Advancing immediately to the Stopped position could close ball valves, Valve 10 and Valve 11, on catalyst.

If Lock Hopper level transmitter indicates low lock hopper level in this step , the Abnormal Loading Alarm activates.

Valve 9 closes to stop catalyst flow. When it is confirmed closed, the Dust Settling Timer starts.

(If in Trickle Mode, the Long Cycle Timer restarts).

(If the Lock Hopper 1 Start/Stop Pushbutton indicator is in the Run (green) position in this step during Trickle Mode, the Trickle Mode Load Counter increments by 1).*The DCS LH-1 Load Time updates.

The sequence advances to the next step when:

Valve 9 is confirmed closed

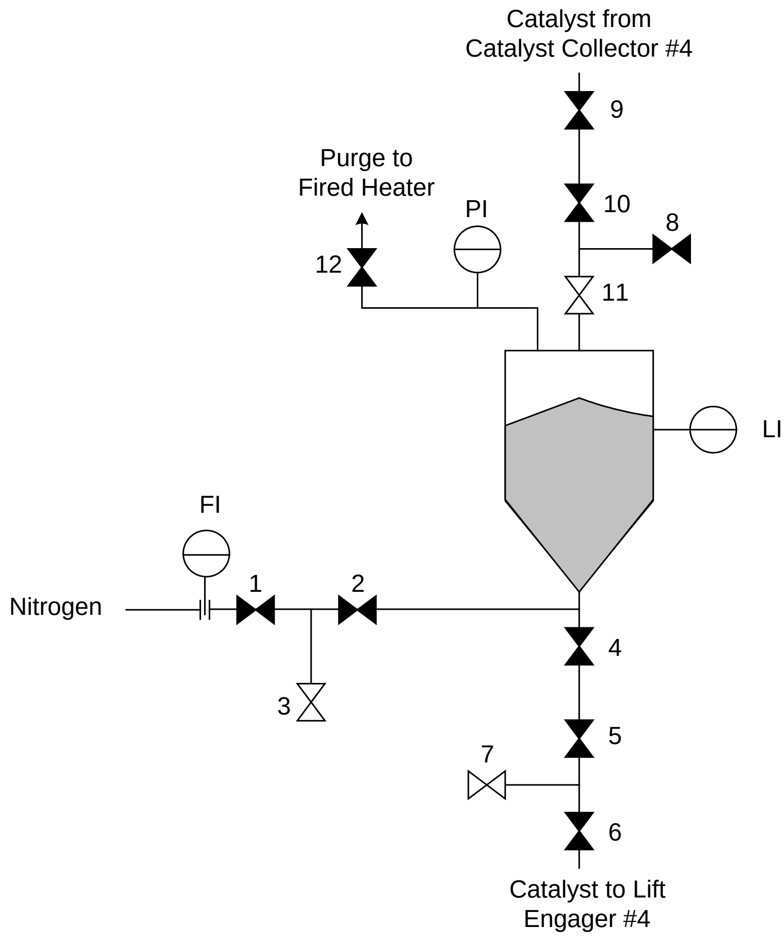
the Dust Settling Timer expires

AND

All Lock Hopper 1 Sequence valve positions are verified.

R. Closing the ball valve on catalyst dust particles may damage the valve seat. The Dust Settling Timer insures that catalyst and dust has cleared valve Valve 10 to avoid valve damage.

Step 22



If the Lock Hopper 1 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the Stop position. Advancing immediately to the Stopped position could close ball valve, Valve 11, on catalyst dust, and could cause valve damage. Valve 10 closes to start isolating the lock hopper from the catalyst collector. When Valve 10 is confirmed closed, the Dust Settling Timer 2 starts.

The sequence returns to Step 0 when:

The Lock Hopper 1 Start Pushbutton is in the Running (green) position

Valve 10 is confirmed closed

The Dust Settling Timer 2 (10 seconds) has expired.

AND

All Lock Hopper 1 Sequence valve positions are verified.

The sequence goes to the Stop position when:

the Lock Hopper 1 Start/Stop Pushbutton indicator is in the Stopped (red) position

AND

Valve 10 is confirmed closed

The Dust Settling Timer 2 (10 seconds) has expired.

Closing a ball valve on catalyst dust particles may damage the valve seat. The Dust Settling Timer 2 insures that catalyst and dust has cleared Valve 11 to avoid valve damage.

Step 0 or the Stop position closes Valve 11.

R. Regenerated Catalyst Transfer System

The regenerated catalyst transfer system transfers regenerated catalyst in the oxidized state from the Surge Hopper to the top of Reactor 1 where it is reduced with pure hydrogen gas at a high temperature.

Note: For C3 Oleflex units, there are four reactors, with the spent catalyst lift engager below Lock Hopper No 1 designated as “Lift Engager No 4,” and the regenerated catalyst lift engager below Lock Hopper No 2 designated as “Lift Engager No 5.” For C4 Oleflex units, there are three reactors, with the spent catalyst lift engager below Lock Hopper No 1 designated as “Lift Engager No 3,” and the regenerated catalyst lift engager below Lock Hopper No 2 designated as “Lift Engager No 4.”

The remainder of this Chapter will be based on the lift engagers for a C3 Oleflex unit. The logic steps involved in catalyst transfer are the same for either type of Oleflex unit.

Regenerated catalyst is transferred from the Surge Hopper to Lock Hopper 2 via a system of control valves operated by Lock Hopper 2 Logic Controller. Lock Hopper 2 is nitrogen purged and pressured with hydrogen before safely unloading catalyst to the lift engager directly beneath it. A continuous stream of pure hydrogen gas (PSA quality) flowing through the lift engager picks up the catalyst and carries it to the Reduction Zone on top of Reactor 1.

The step-wise operation of the transfer cycle is divided into six basic operations tabulated below:

Basic Step	Operation
Ready	Lock Hopper 2 is full of catalyst and under slight positive, nitrogen pressure.
Purge 1	Lock Hopper 2 is purged with nitrogen.

Pressure	Lock Hopper 2 is pressured with hydrogen.
Unload	The catalyst is unloaded to the lift engager and transferred to the Reduction Zone.
Purge 2	Lock Hopper 2 is depressured and purged with nitrogen.
Load	Catalyst is loaded into Lock Hopper 2 from the Surge Hopper.

At the end of the “LOAD” step, Lock Hopper 2 returns to the “READY” condition. A program panel on the control board indicates the basic steps. As Lock Hopper 2 cycles, the lights in the panel indicate which basic step the cycle is in.

To avoid the chance of a hazardous condition caused by malfunctioning of any of the logic system components, the following safety checks are built into the Lock Hopper Controller.

1. Valve Verification: A valve verification system is included in each controller. The program output is compared continuously with the actual positions of all the valves in the system. Any discrepancy stops the cycle and sounds an alarm. (NOTE: in certain steps, conditions other than valve position are more important; thus, verification is not a requirement to move to the next step.)

2. The bleeder vent line from Lock Hopper 2 to the Oleflex heater firebox is purged with nitrogen to ensure that the gases venting Lock Hopper 2, which could contain air, does not mix with the hydrogen rich gases from the other bleeder vents. If the purge gas flow drops, the cycle will halt until the purge flow is restored.

3. Valve Interlock System: The Valve Interlock System is used in Lock Hoppers 1 and 2 for system safety and to prevent undue loss of material. The Interlock System prevents an unsafe or incorrect combination of valve positions. It will inhibit the solenoid valve commands if these combinations are detected due to valve failure or an erroneous input.

4. Lock Hopper 2 Start-Stop Button: The Lock Hopper controller has a “Start-Stop” button. There is also an indicator associated with this button that indicates the status of Lock Hopper 2. It can be running stopped or in delayed stop.

5. Purge Selector: The Purge Selector is used to set the number of times the purge subroutine is repeated in the nitrogen purge step of the Lock Hopper logic cycle. The selector is adjustable from 0 to 9. In the zero setting, no purges would be performed which would defeat the purpose of the purge step. Therefore, the transfer cycle will not start when the selector is set at zero. Normally, three purges are sufficient.

6. Abnormal Load Alarm: The Abnormal Load Alarm sounds if Lock Hopper 2 does not fill in the normal time. The time to fill Lock Hopper 2 is determined in the field during the start up. If no problems arise, this time should remain somewhat constant.

To detect problems in loading Lock Hopper 2, an “Abnormal Load Minimum” timer starts the instant the load V-ball valve above Lock Hopper 2 opens. The “Abnormal Load Minimum” timer is set so that it will time out before the normal Lock Hopper loading time.

The “Abnormal Loading Range” timer starts timing when the”Abnormal Loading Minimum” timer times out. This timer is set to time out after a typical loading time. If Lock Hopper 2 level is not satisfied when the Range timer times out, an alarm will sound. Thus, if Lock Hopper 2 takes a either a longer or shorter than normal time to load, an alarm sounds.

7. Long Cycle Alarm: The Long Cycle Alarm alerts the operator of problems with the Lock Hopper 2 sequence. The alarm is activated by the “Long Cycle” timer which is set for a time slightly longer than the time required to complete a normal cycle. The timer starts when the transfer sequence begins (Step 1) and stops and resets itself at the end of the sequence when Lock Hopper 2 returns

to the “READY” step. If the timer times out before the cycle is complete, the Long Cycle Alarm sounds. The cycle time is relatively constant. However due to the system of checks that exist in the logic, the cycle will take longer if a problem develops somewhere in the cycle. The “Long Cycle Alarm” will notify the operator of such an occurrence.

8. Delayed Stop Sequence: To avoid possible damage to the ball valve seating surfaces of the gas tight valves, a timer is used to offset the time when the V-ball valves close to stop catalyst flow, and the time the B-ball valves close. The Delayed Stop Sequence circuit is activated whenever the operator pushes the button to stop the Lock Hopper system. The delay allows catalyst flow to stop and the catalyst volume to drop out of the B-valve area. This allows the B-valves to close on gas only. Should these valves close on catalyst, their usable service life is reduced significantly.

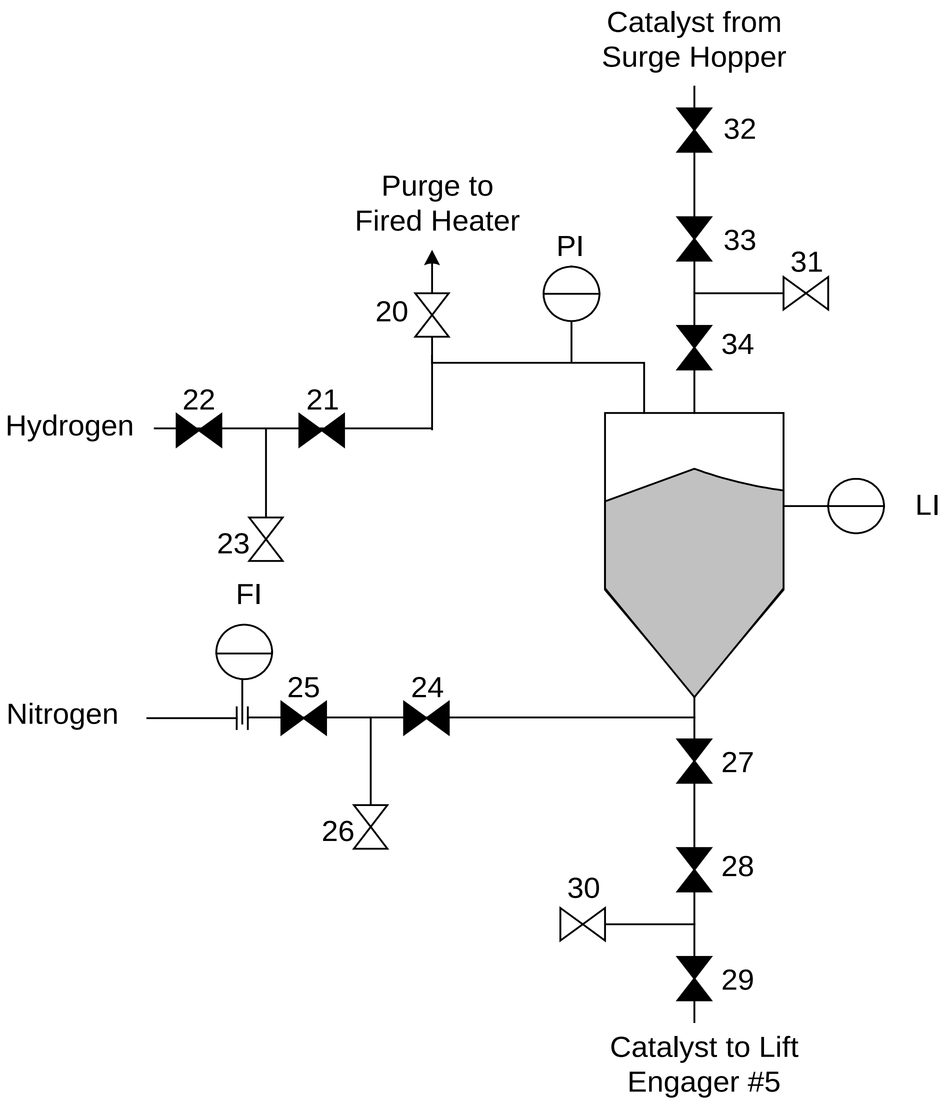
9. Reactor Level Alarm: To ensure proper operation, the reactors must be full of catalyst. If some malfunction causes Lock Hopper 2 controller to stop operation and Lift Engager No 1 controller operation continues, the level in the top of Reactor 1 will become low. The Reactor Level Switch is used to prevent this. When the level in Reactor 1 goes low as indicated by the Reduction Zone level transmitter, the reactor level timer starts timing (usually set for 40 minutes). If the level stays low, the timer will time out and sound the LAHL alarm.

10. Reactor Backflow Alarm: If the Lock Hopper system should develop a serious leak in any of its isolation valves between Lock Hopper 2 and the lift system, a potential exists where reactor vapors could flow backwards to the Lift Engager and out the vent system. The Backflow Alarm prevents this from occurring. The alarm is a temperature indicator/alarm located at the top of the Reduction Zone. If vapors were to flow up the reactor and out the lift line, the temperature at the top of the reactor would heat up. If the temperature hits a preset alarm point, the enable is removed from the Lock Hopper 2 controller. Lock Hopper 2 will go to the “STOP” step after the delayed timer sequence has timed out. This isolates the reactor from the vent system by closing the

double blocks and opens the bleed on the catalyst outlet line of Lock Hopper 2.

The following outline describes the complete sequence of steps which occur during the transfer of catalyst from the Regeneration Section to the first reactor. The logic steps are shown as graphics depicting the valve positions of the Lock Hopper 2 transfer valves. Additionally, key process indicators of pressure, flow, and level are discussed. These steps are simplified to include only those items that the operator can check for proper operation.

Step 1



Valve 20 opens to lower the lock hopper's pressure.

The Long Cycle Timer starts.

** The DCS LH-2 Cycle Timer starts. The sequence advances to the next step when:*

Valve 20 is confirmed open

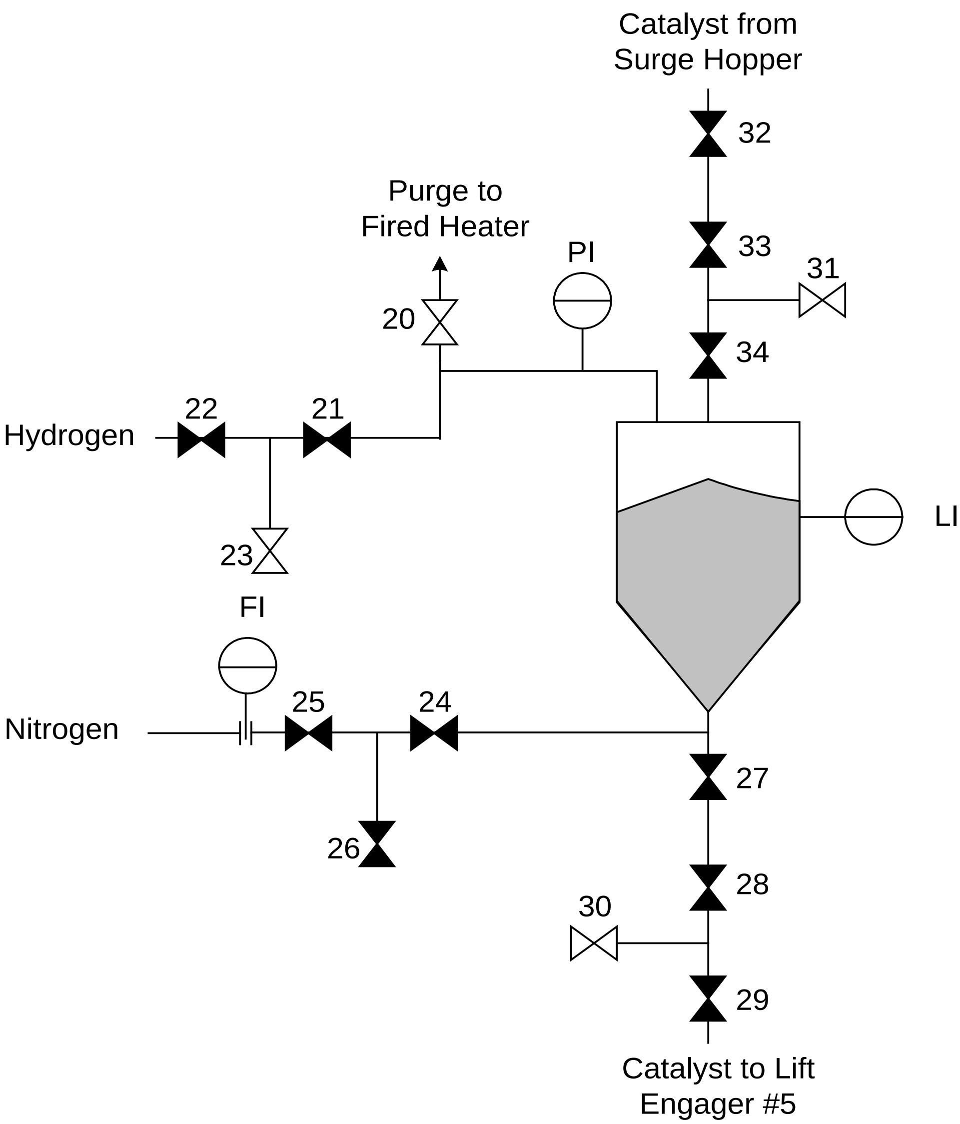
The Lock Hopper pressure transmitter indicates low lock hopper pressure

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 2

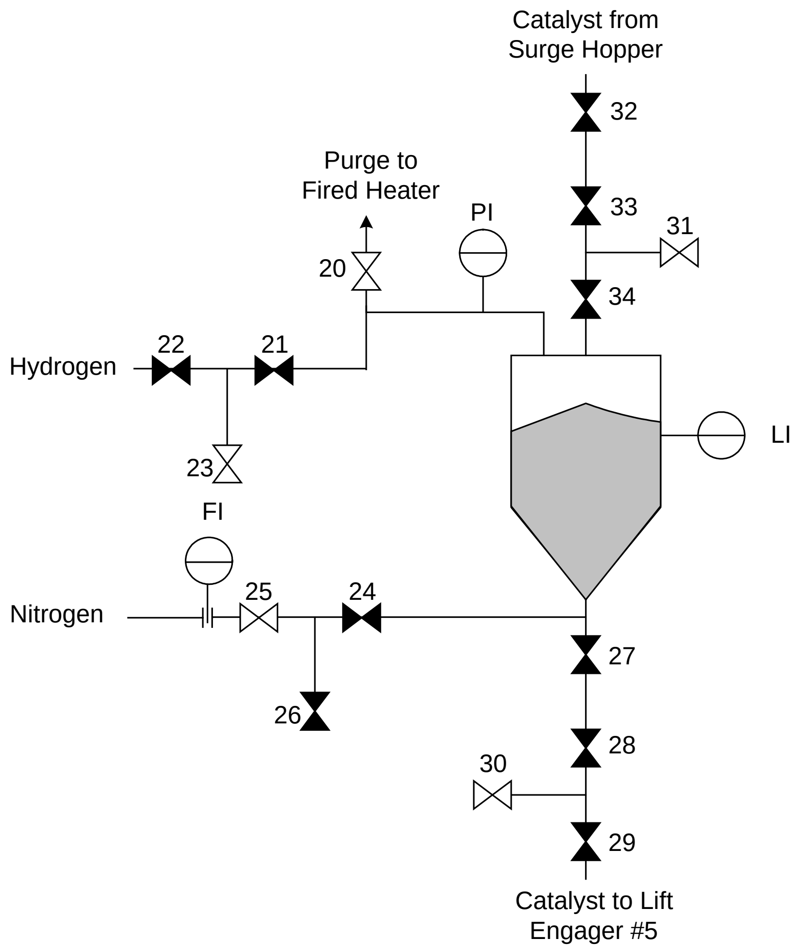


Valve 26 closes to start setting up the nitrogen purge.

The sequence advances to the next step when:

Valve 26 is confirmed closed
The Lock Hopper 2 Purge Selector is greater than zero
There is sufficient bleeder line nitrogen purge flow
AND
All Lock Hopper 2 Sequence valve positions are verified

Step 3



This step removes oxygen from the lock hopper by repetitively pressuring and venting the lock hopper. Nitrogen flows through the lock hopper and builds pressure. The gases exhaust to the heater.

Valve 25 opens to set up the nitrogen purge.

The Purge Subroutine (following this step) repeats for each count of the Purge Selector.

Each execution of the Purge Subroutine starts when:

Valve 25 is confirmed open

The Nitrogen flow transmitter indicates no nitrogen flow to the lock hopper

The lock hopper pressure transmitter indicates low lock hopper pressure

There is sufficient bleeder line nitrogen purge flow

Lock Hopper 2 Purge Counter is less than the number of purges set by the Lock Hopper 2 Purge Selector

AND

All Lock Hopper 2 Sequence valve positions are verified

The sequence advances to Step 4 when:

The Lock Hopper 2 Purge Selector is greater than zero

The Purge Subroutine has executed the number of times set by the Lock Hopper 2 Purge Selector.

Valve 24 is confirmed closed

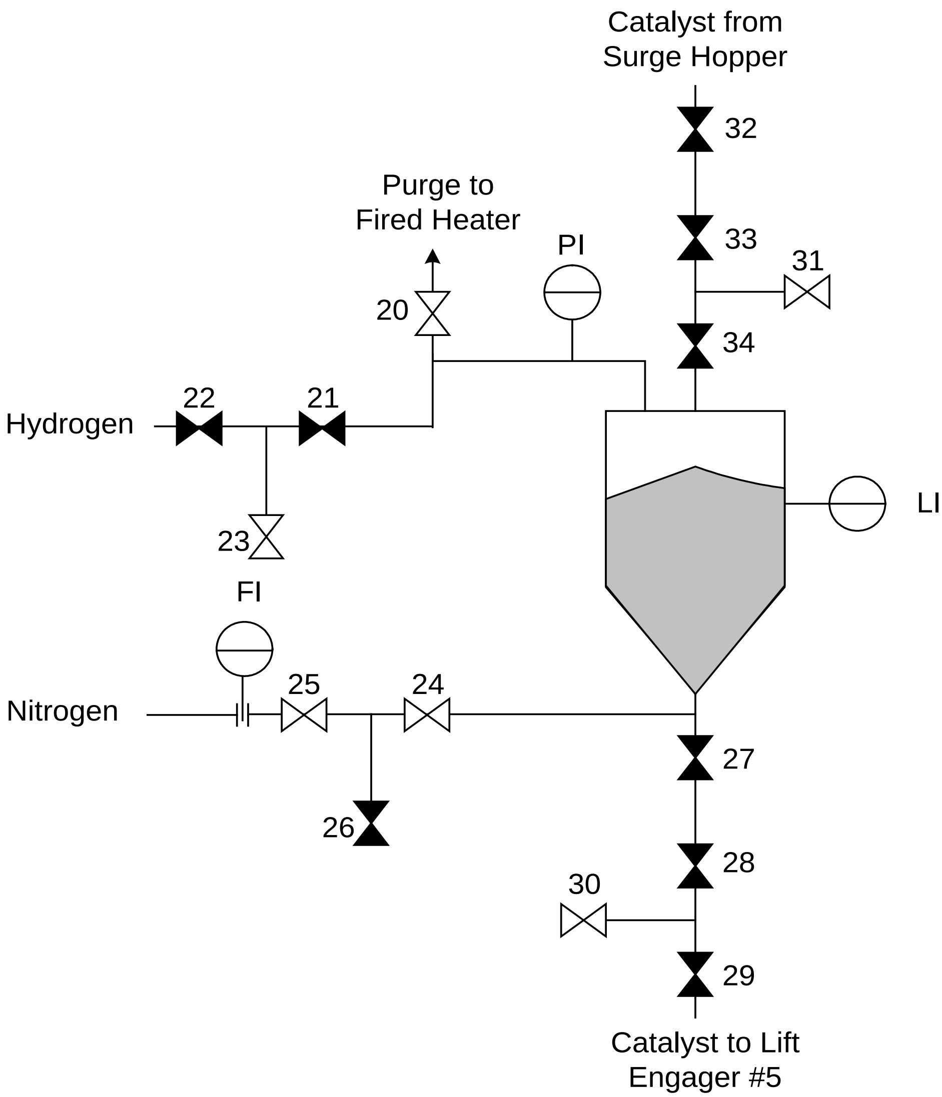
The lock hopper pressure transmitter indicates low lock hopper pressure

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Purge Subroutine

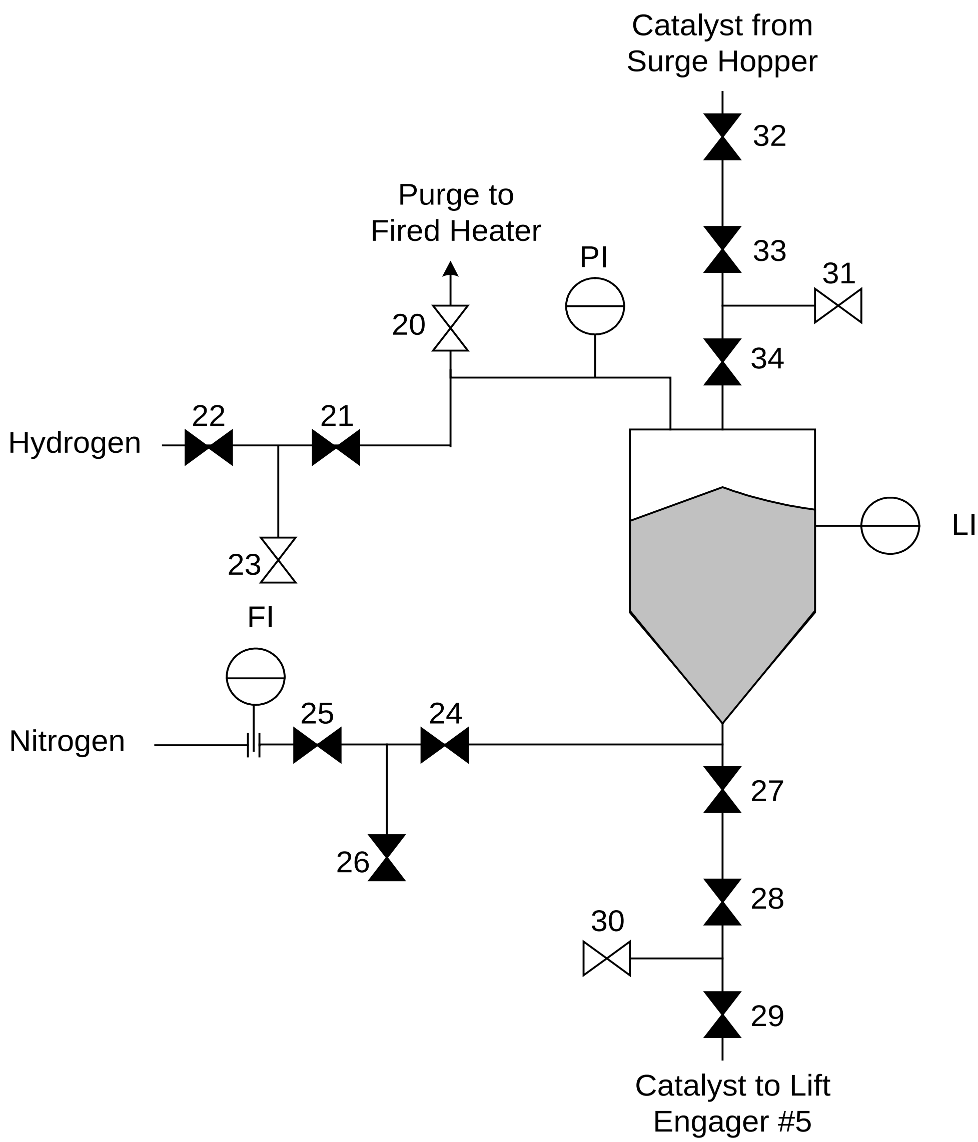


The Purge Subroutine executes during Step 3.

The Purge Subroutine:

1) Opens Valve 24 to allow nitrogen flow into the lock hopper
2) Waits for 35 seconds (Purge Timer) of continuous nitrogen flow through the nitrogen flow transmitter before closing Valve 24
3) Purge Counter increments by 1 each time the Purge Timer times out.
4) Returns to Step 3

Step 4



Valve 25 closes to further isolate the lock hopper from the nitrogen supply.

The sequence advances to the next step when:

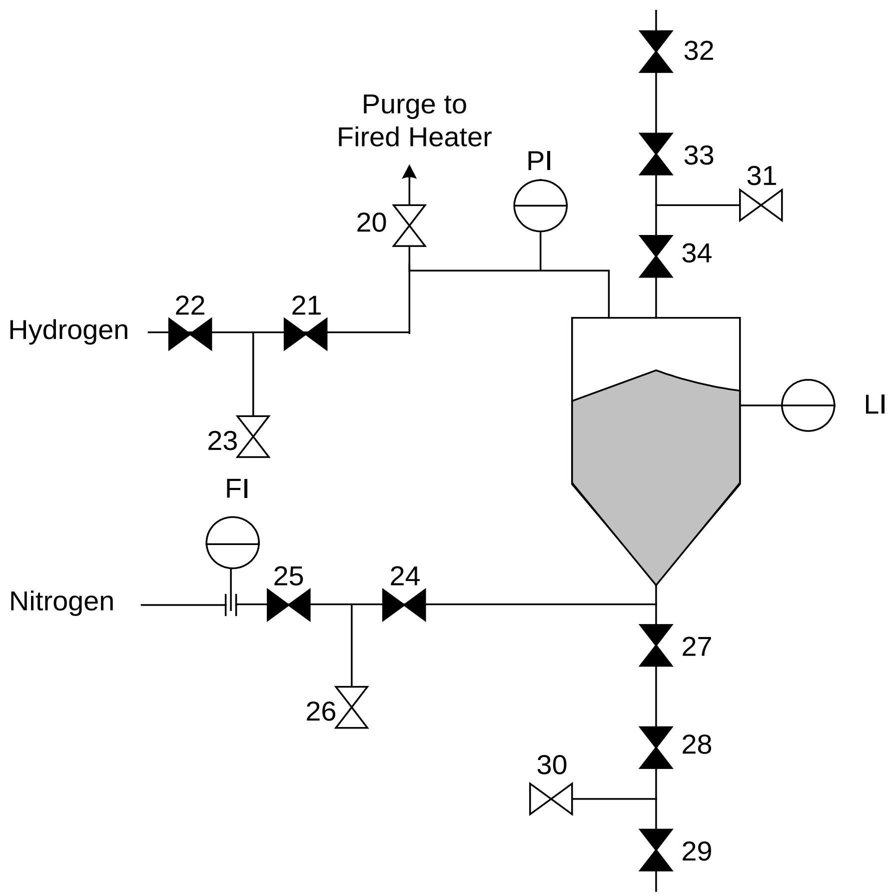
Valve 25 is confirmed closed

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 5



Valve 26 opens to completely isolate the lock hopper from the nitrogen supply.

The Long Cycle Timer pauses to avoid a nuisance Long Cycle Alarm if Lift Engager #5 level transmitter indicates a high lift engager level or if the Reduction Zone level transmitter indicates high Reactor 1 level

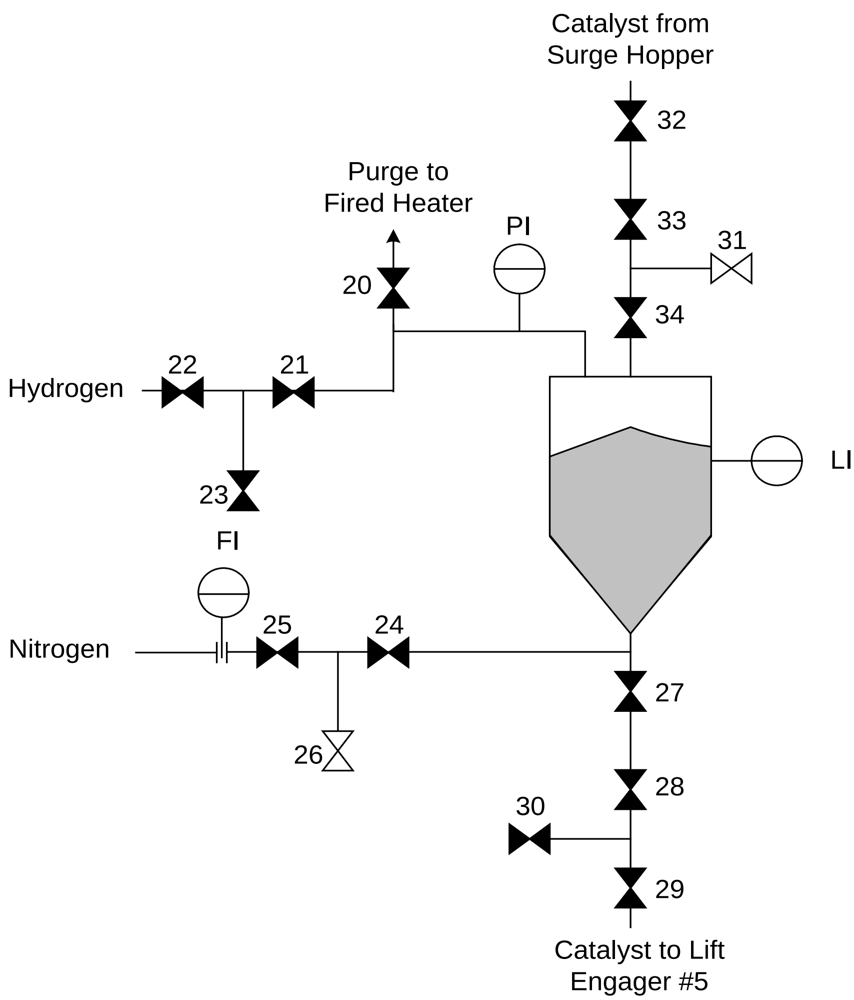
The sequence advances to the next step when:

Valve 26 is confirmed open
Lift Engager #5 level transmitter indicates low lift engager level
Reduction Zone level transmitter indicates low Reactor 1 level
There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 6



Valve 20 closes to isolate the lock hopper from the heater.

Valve 23 closes to start setting up the hydrogen supply.

Valve 30 closes to start setting up the catalyst transfer path between the lock hopper and Lift Engager 5.

The Long Cycle Timer restarts.

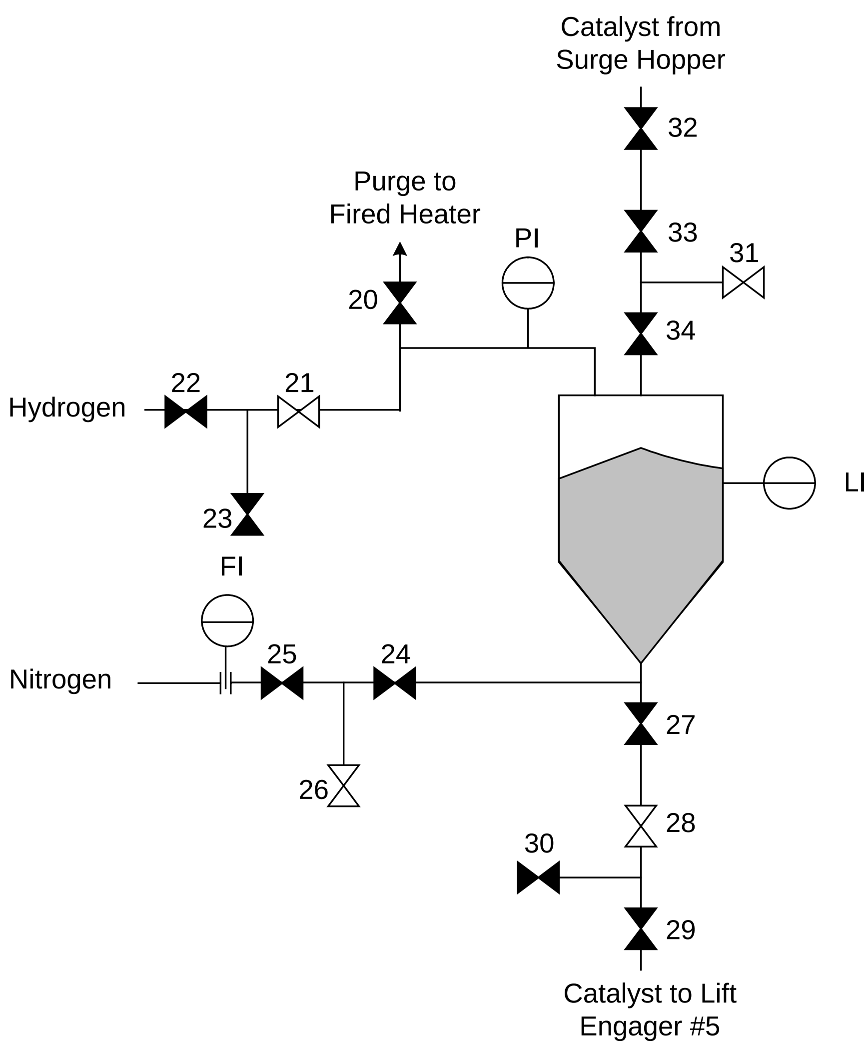
The sequence advances to the next step when:

Valve 20 is confirmed closed
Valve 23 is confirmed closed
Valve 30 is confirmed closed
There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 7



Valve 21 opens to further prepare for pressuring the lock hopper with hydrogen.

Valve 28 opens to equalize the catalyst transfer line pressure with the lock hopper. Valve 27 prevents catalyst flow but is not gas tight.

The sequence advances to the next step when:

Valve 21 is confirmed open

Valve 28 is confirmed open

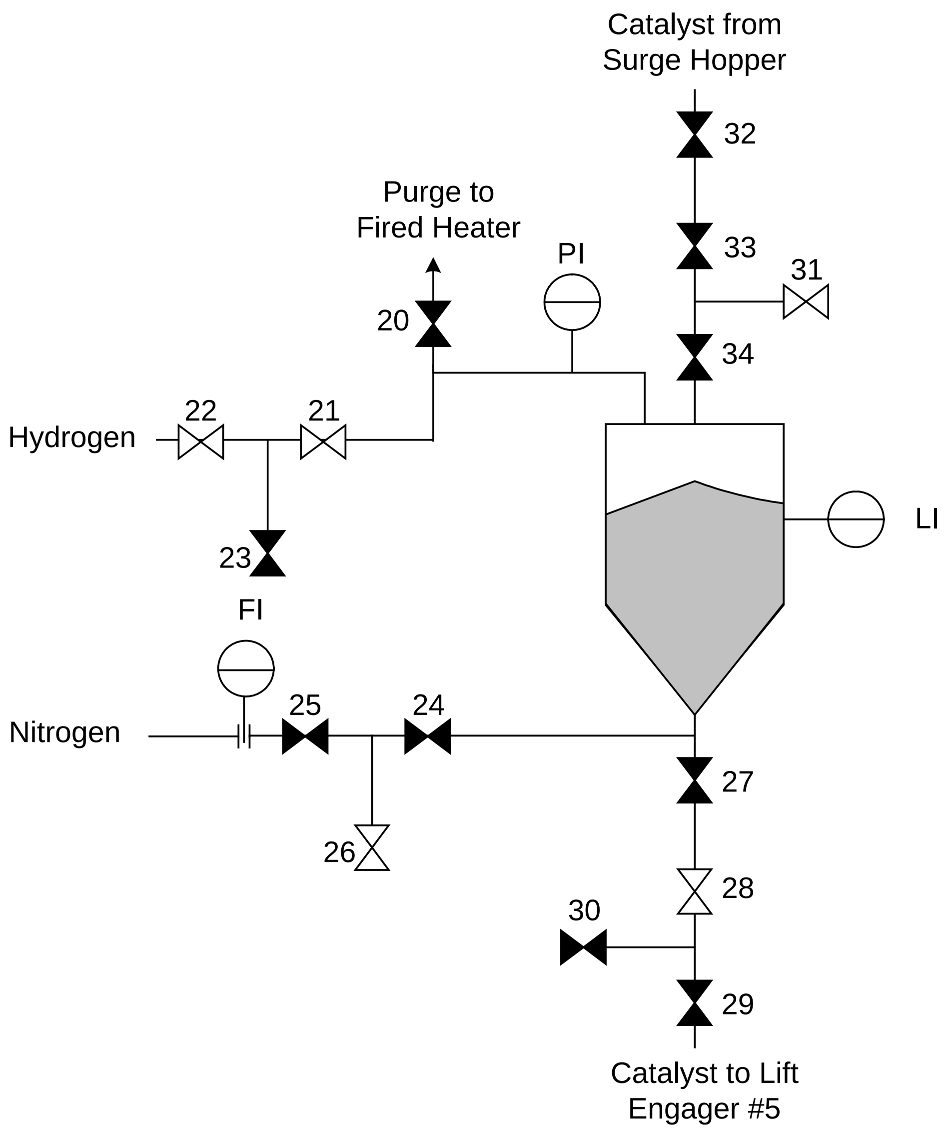
The pressure differential transmitter indicates higher pressure in the lift engager than the lock hopper

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 8



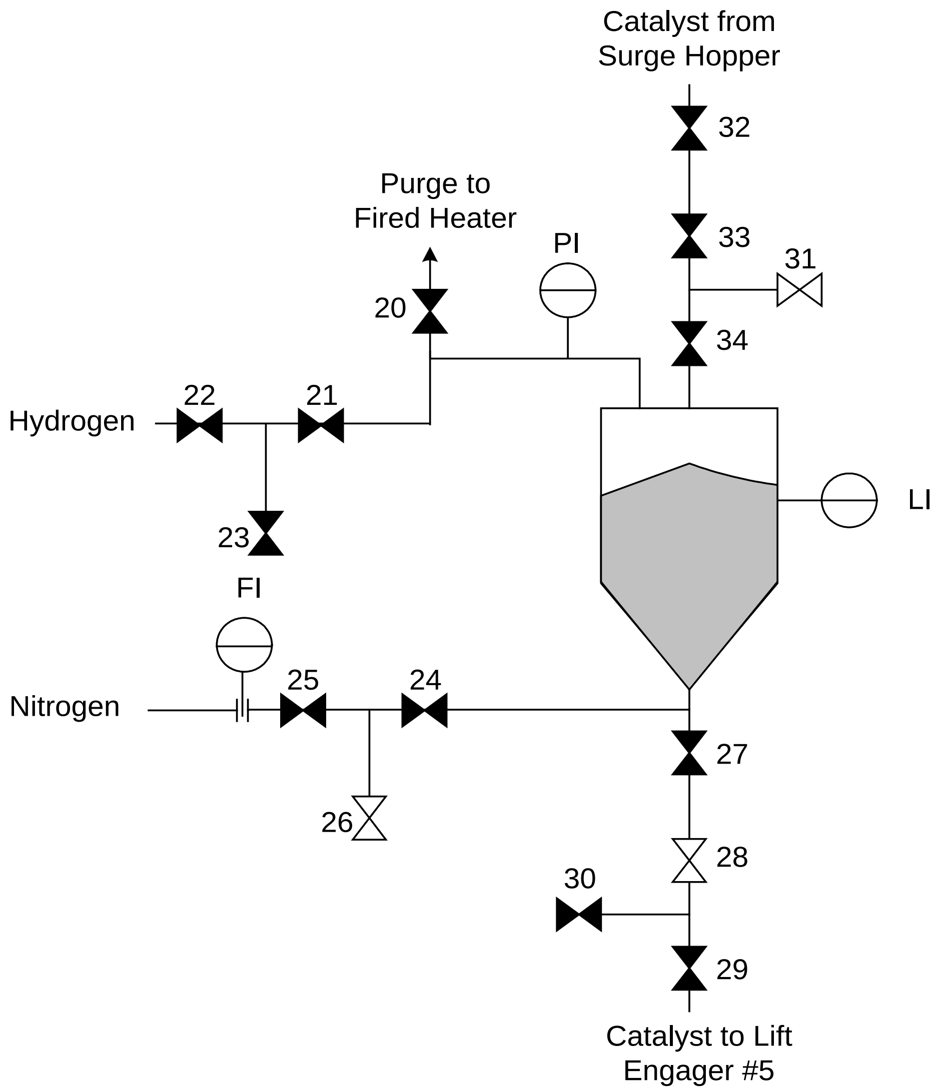
Valve 22 opens to pressure the lock hopper with hydrogen.

In this step, the sequence ignores the open valve verification to prevent overpressuring the lock hopper. *The DCS LH-2 Pressure Timer starts.

The sequence advances to the next step when:

The pressure differential transmitter indicates approximately equal lock hopper-lift engager pressures

Step 9



Valve 22 and Valve close to stop the hydrogen flow and isolate the lock hopper from the hydrogen supply. The DCS LH-2 Pressure Time updates.

The sequence advances to the next step when:

Valve 22 is confirmed closed

Valve 21 is confirmed closed

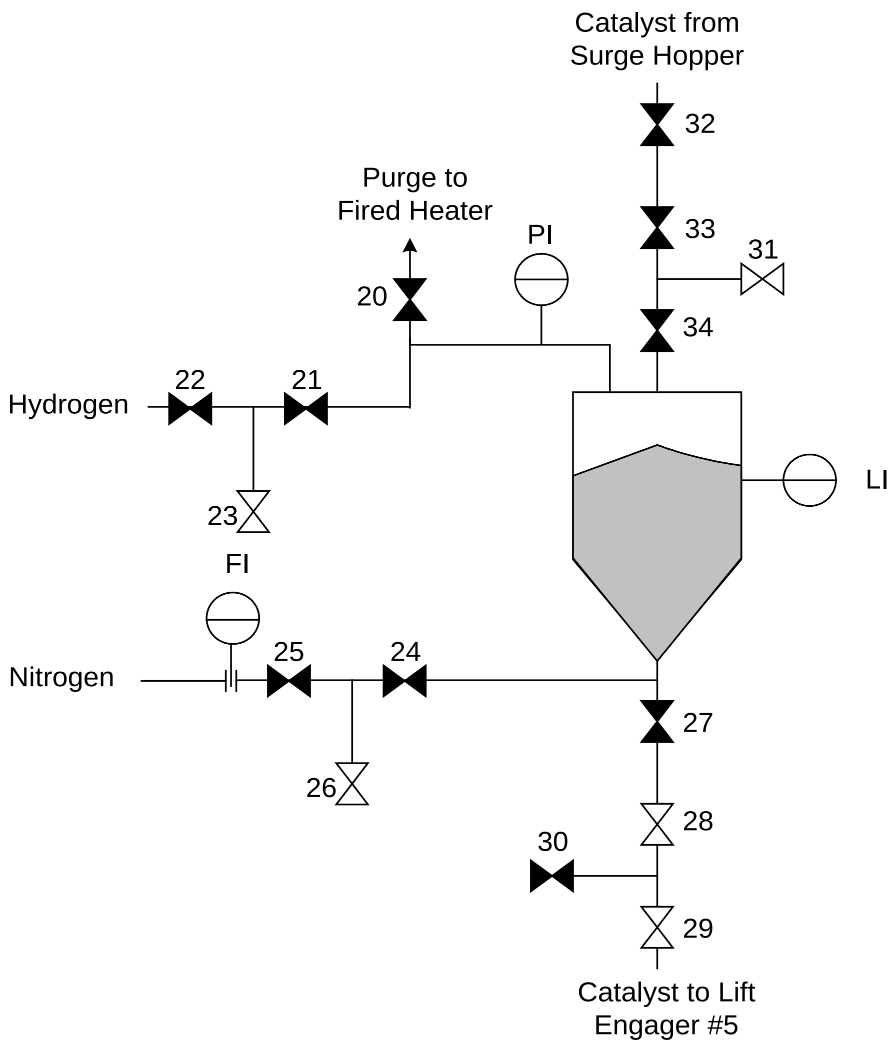
The pressure transmitter indicates high lock hopper pressure

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 10



Valve 23 opens to completely isolate the lock hopper from the hydrogen supply.

Valve 29 opens to set up the catalyst transfer path. The closed V-notch ball valve, Valve 27, prevents catalyst flow.

If active, the Lift Engager 5 level alarm resets.

The sequence advances to the next step when:

Valve 23 is confirmed open

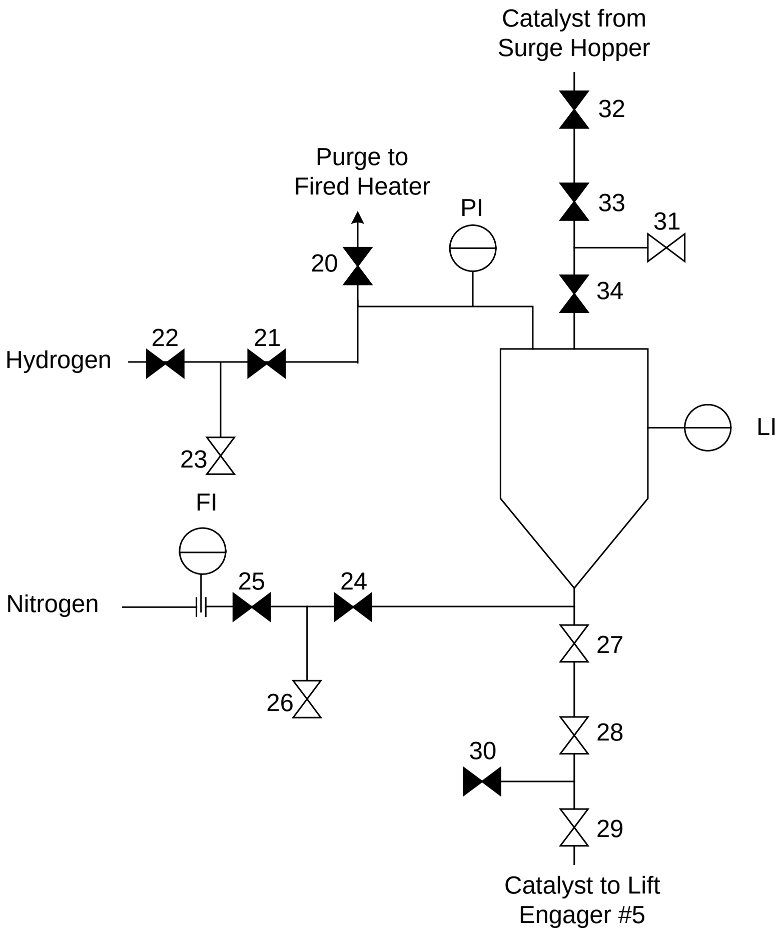
Valve 29 is confirmed open

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 11



If the Lock Hopper 2 Start/Stop Pushbutton indicator turns red during this step, the sequence goes immediately to the next step. This prevents ball valves, Valve 28 and Valve 29, from closing on catalyst. Advancing immediately to the Stop position could close ball valves on catalyst and could damage the valves. The dust-settling timer insures that catalyst and dust has cleared Valve 28 to avoid valve damage.

Valve 27 opens to allow catalyst to flow from the Lock Hopper 2 to the Lift Engager 5. When Valve 27 is confirmed open, the Unload Timer starts.

*The DCS LH-2 Lift Timer starts when indicates a high level

*The DCS LH-2 Lift Time updates when indicates a low level

The sequence advances to the next step when:

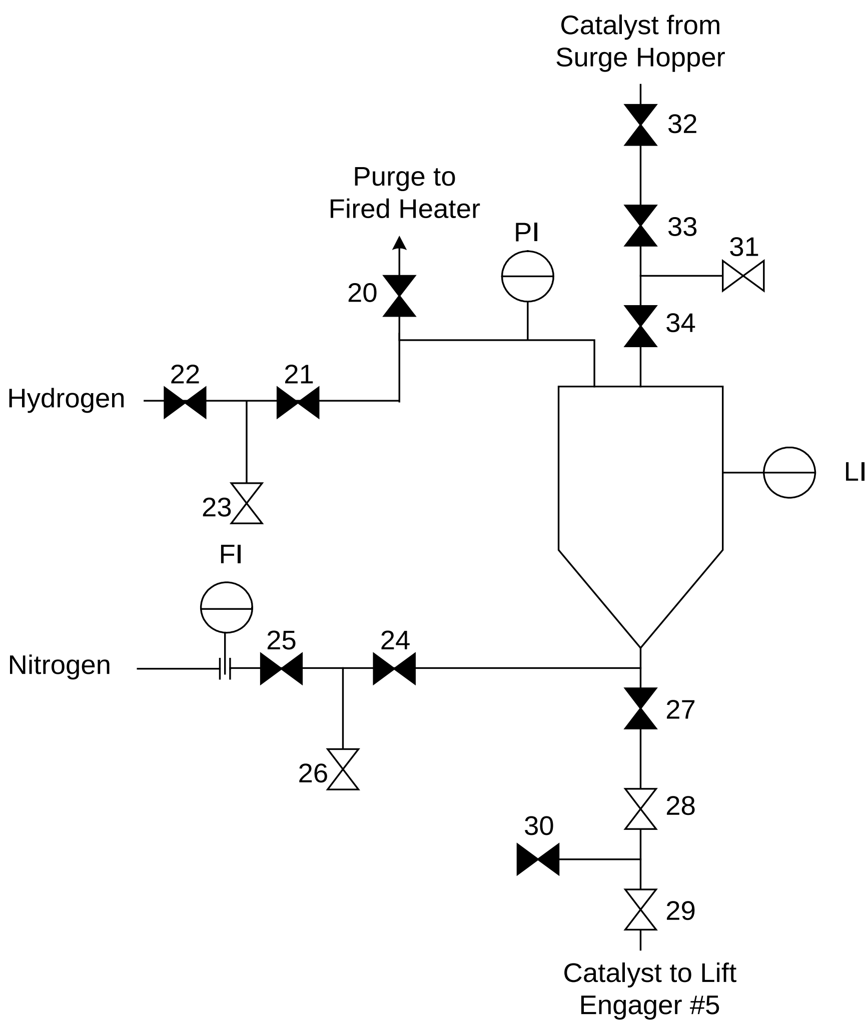
the Lock Hopper 2 Unload Timer expires

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 12



If the Lock Hopper 2 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the next step. Advancing immediately to the Stopped position could close ball valve, Valve 28, on catalyst or dust.

Valve 27 closes to stop catalyst flow.

When Valve 27 is confirmed closed, the Lock Hopper 2 Dust Settling Timer1 starts.

The sequence advances to the next step when:

Valve 27 is confirmed closed

The Lock Hopper 2 Dust Settling Timer 1 expires

There is sufficient bleeder line nitrogen purge flow

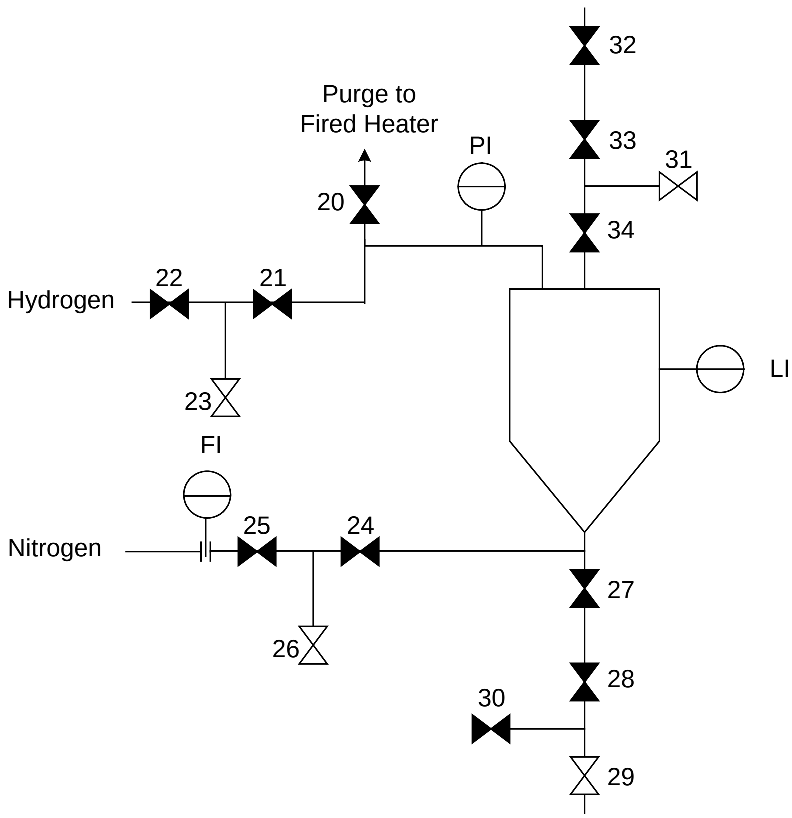
(FALL25901 contact closed alarm not active)

AND

All Lock Hopper 2 Sequence valve positions are verified

Closing a ball valve on catalyst dust particles could damage the valve seat. The Dust Settling Timer 1 insures that catalyst and dust has cleared Valve 28 to avoid valve damage.

Step 13



If the Lock Hopper 2 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the Stop position. Advancing immediately to the Stopped position could close ball valves Valve 29, on catalyst dust.

Valve 28 closes to start isolating the lock hopper from the lift engager.

When Valve 28 is confirmed closed, the Lock Hopper 2 Dust Settling Timer 2 starts.

The sequence advances to the next step when:

Valve 28 is confirmed closed

The Dust Settling Timer 2 (10 seconds) has expired.

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

The sequence goes to the Stop position when:

the Lock Hopper 2 Stop Pushbutton is in the Stopped (red) position

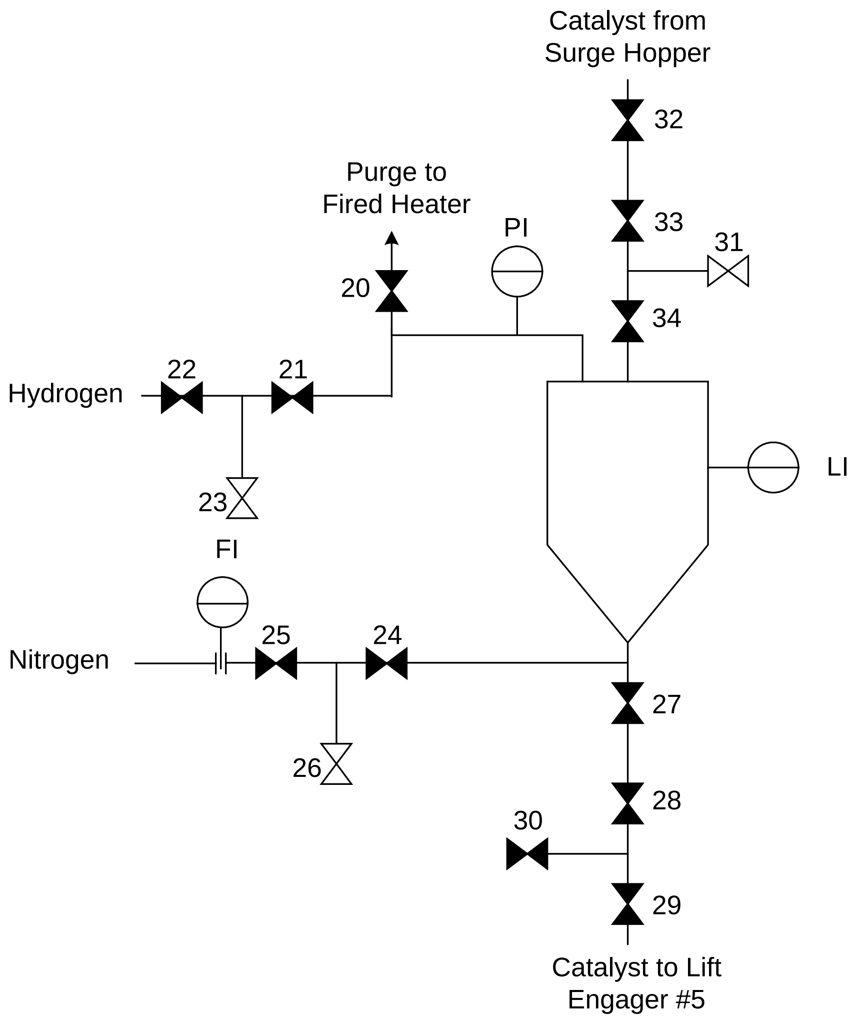
AND

Valve 28 is confirmed closed

The Dust Settling Timer 2 (10 seconds) has expired.

Closing a ball valve on catalyst dust particles could damage the valve seat. The Dust Settling Timer 2 insures that catalyst and dust has cleared Valve 29 to avoid valve damage.

Step 14



Valve 29 closes to further isolate the lock hopper from the lift engager.

The Abnormal Loading Alarm clears, if active.

The Lock Hopper 2 Counter increments if Step 22 was executed in the previous cycle. This way, the counts and the actual amount of catalyst transferred remain the same.

The sequence advances to the next step when:

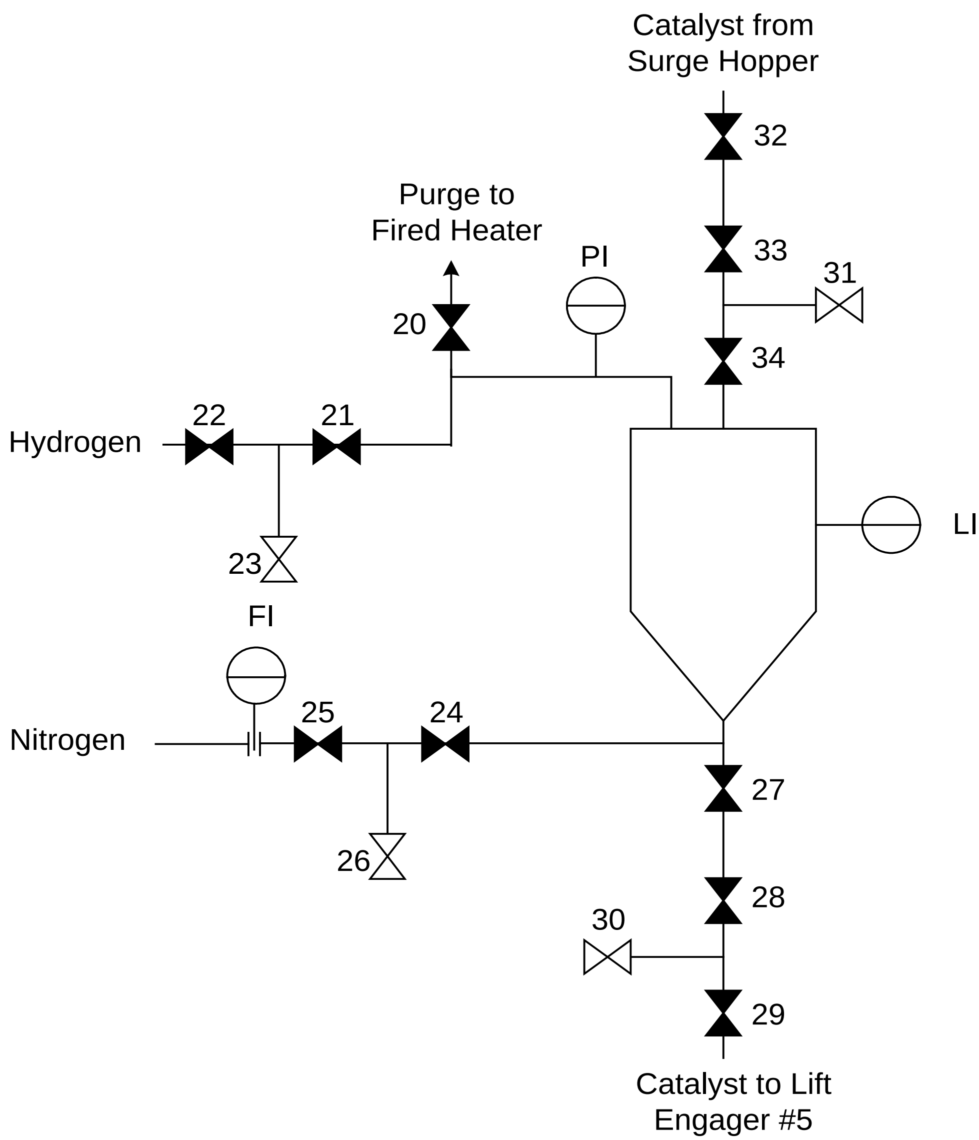
Valve 29 is confirmed closed

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 15



Valve 30 opens to completely isolate the lock hopper from the lift engager.

The sequence advances to the next step when:

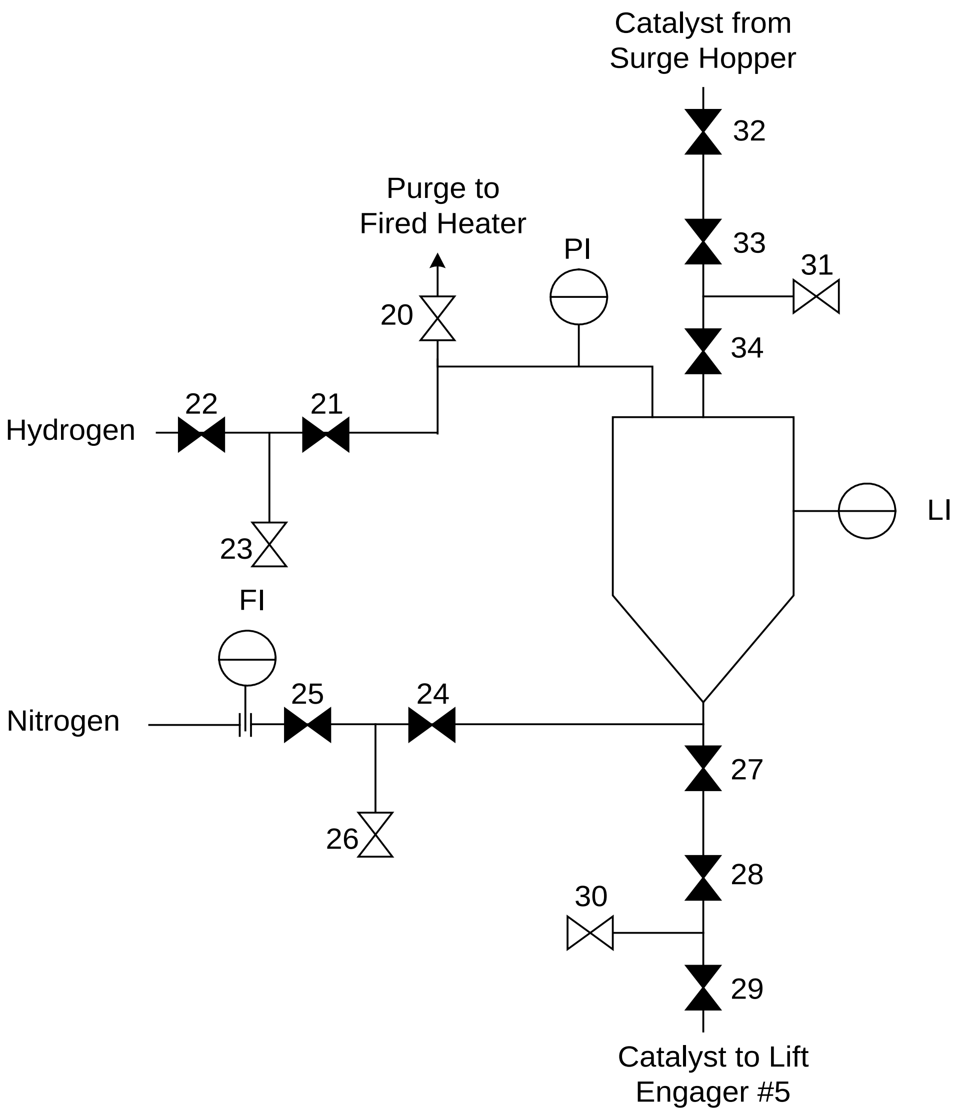
Valve 30 is confirmed open

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 16



Valve 20 opens to depressure the lock hopper. *The DCS LH-2 Depressure Timer starts.

The sequence advances to the next step when:

Valve 20 is confirmed open

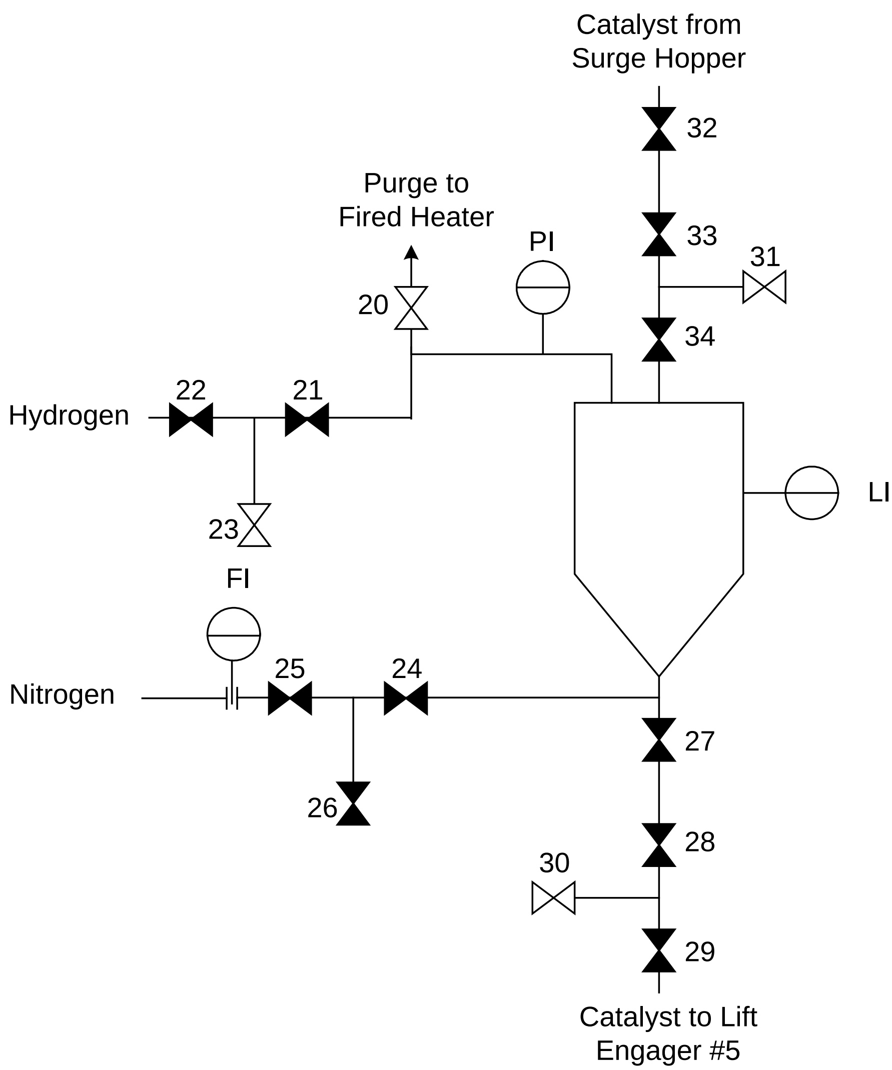
The Lock Hopper pressure transmitter indicates low lock hopper pressure

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 17



Valve 26 closes to start setting up for the nitrogen purge. *The DCS LH-2 Depressure Time updates.

The sequence advances to the next step when:

Valve 26 is confirmed closed

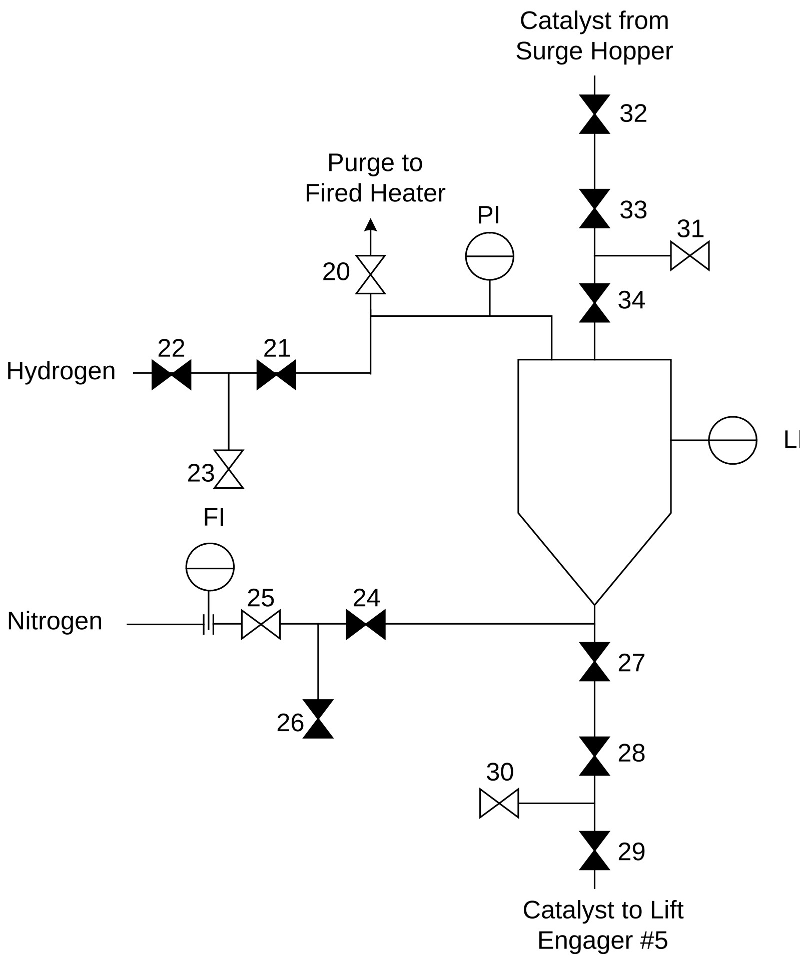
There is sufficient bleeder line nitrogen purge flow

AND

The Lock Hopper 2 Purge Selector is greater than zero

All Lock Hopper 2 Sequence valve positions are verified

Step 18



This step removes hydrogen from the lock hopper by repetitively pressuring and venting the lock hopper. Nitrogen flows through the lock hopper and builds pressure. The gases exhaust to the heater.

Valve 25 opens to set up the nitrogen purge.

The Purge Subroutine (following this step) repeats for each count of the Purge Selector.

Each execution of the Purge Subroutine starts when:

Valve 25 is confirmed open

The nitrogen flow transmitter indicates no nitrogen flow to the lock hopper

The Lock Hopper pressure transmitter indicates low lock hopper pressure

There is sufficient bleeder line nitrogen purge flow

Lock Hopper 2 Purge Counter is less than the number of purges set by Lock Hopper 2 Purge Selector

AND

All Lock Hopper 2 Sequence valve positions are verified

The sequence advances to Step 19 when:

Lock Hopper 2 Purge Selector is greater than zero

Purge Subroutine has executed the number of times set by the Lock Hopper 2 Purge Selector

Valve 24 is confirmed closed

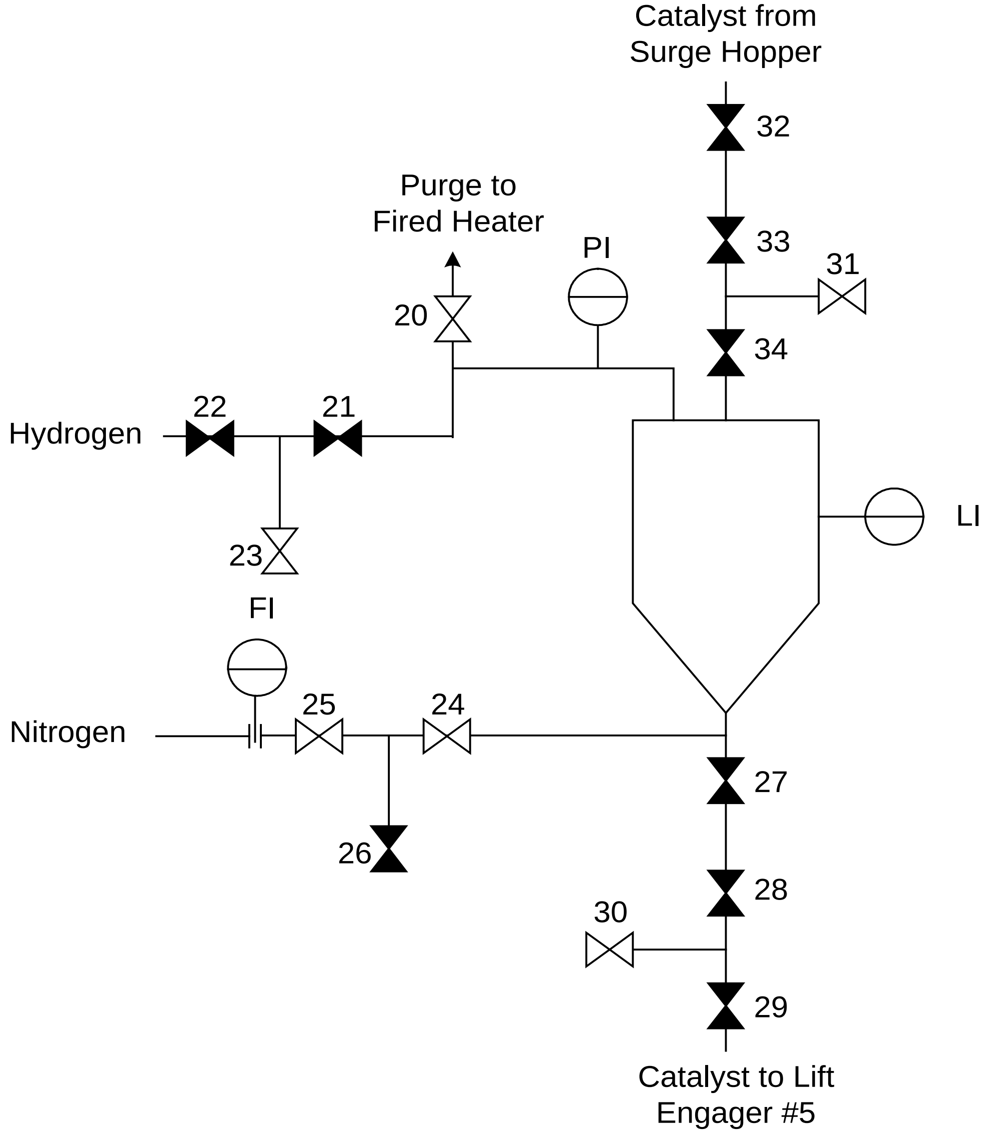
The Lock Hopper pressure transmitter indicates low lock hopper pressure

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verifiedThe Purge Subroutine executes during Step 18.

Purge 2 Subroutine

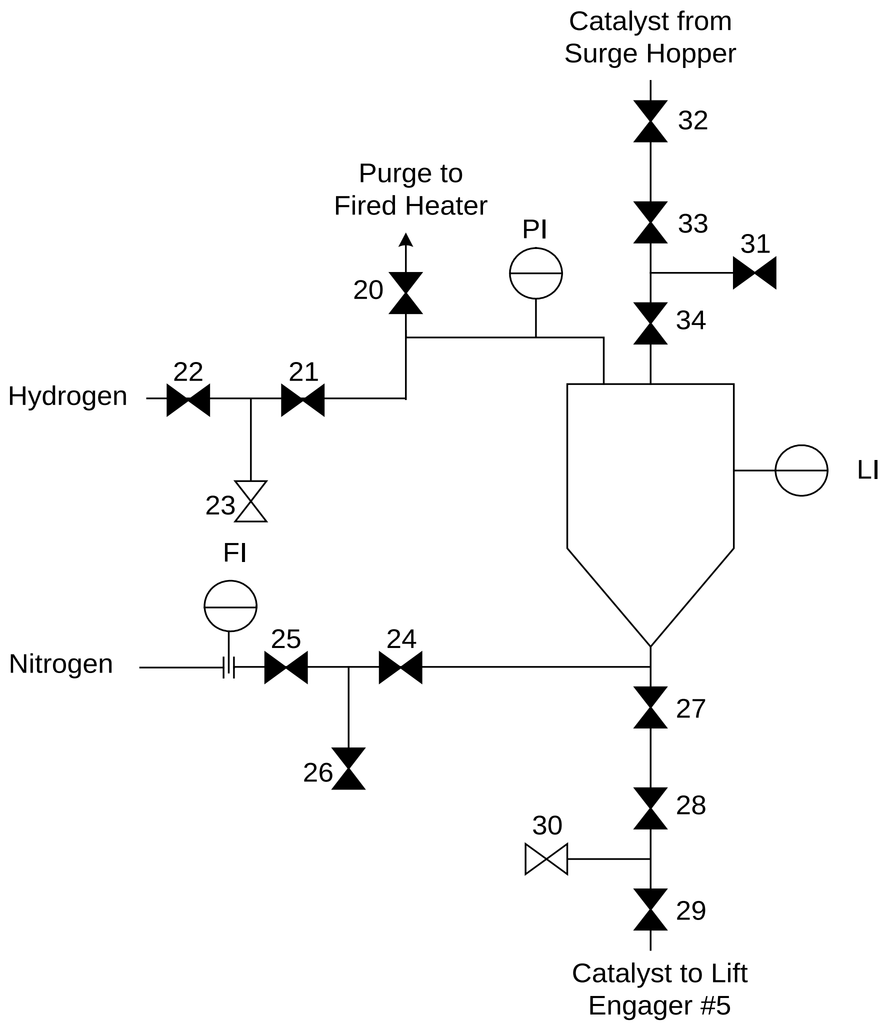


The Purge Subroutine executes during Step 18.

The Purge Subroutine:

1) Valve 24 opens to allow nitrogen to flow into the lock hopper
2) Waits for 35 seconds (Purge Timer) of continuous nitrogen flow through the nitrogen flow transmitter before closing Valve 24
3) Increments the Purge Counter by 1 each time the Purge Timer times out
4) Returns to Step 18

Step 19



Valve 20 closes to isolate the lock hopper from the heater.

Valve 31 closes to start setting up the catalyst transfer path between the lock hopper and the surge hopper.

Valve 25 closes to further isolate the nitrogen supply.

The sequence advances to the next step when:

Valve 20 is confirmed closed

Valve 31 is confirmed closed

Valve 25 is confirmed closed

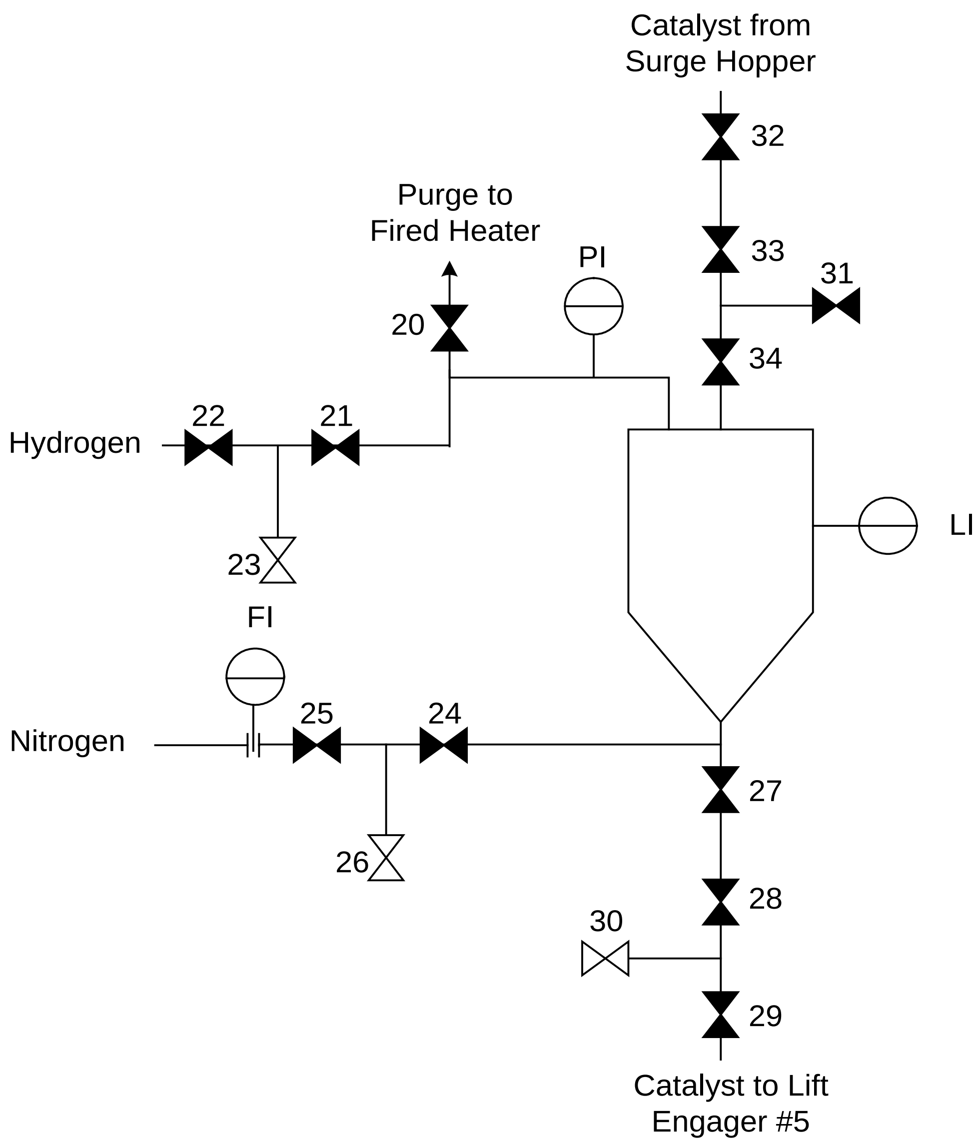
Lock Hopper level tranmistter indicates low level in the Lock Hopper 2

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 20



Valve 26 opens to completely isolate the lock hopper from the nitrogen supply.

The sequence advances to the next step when:

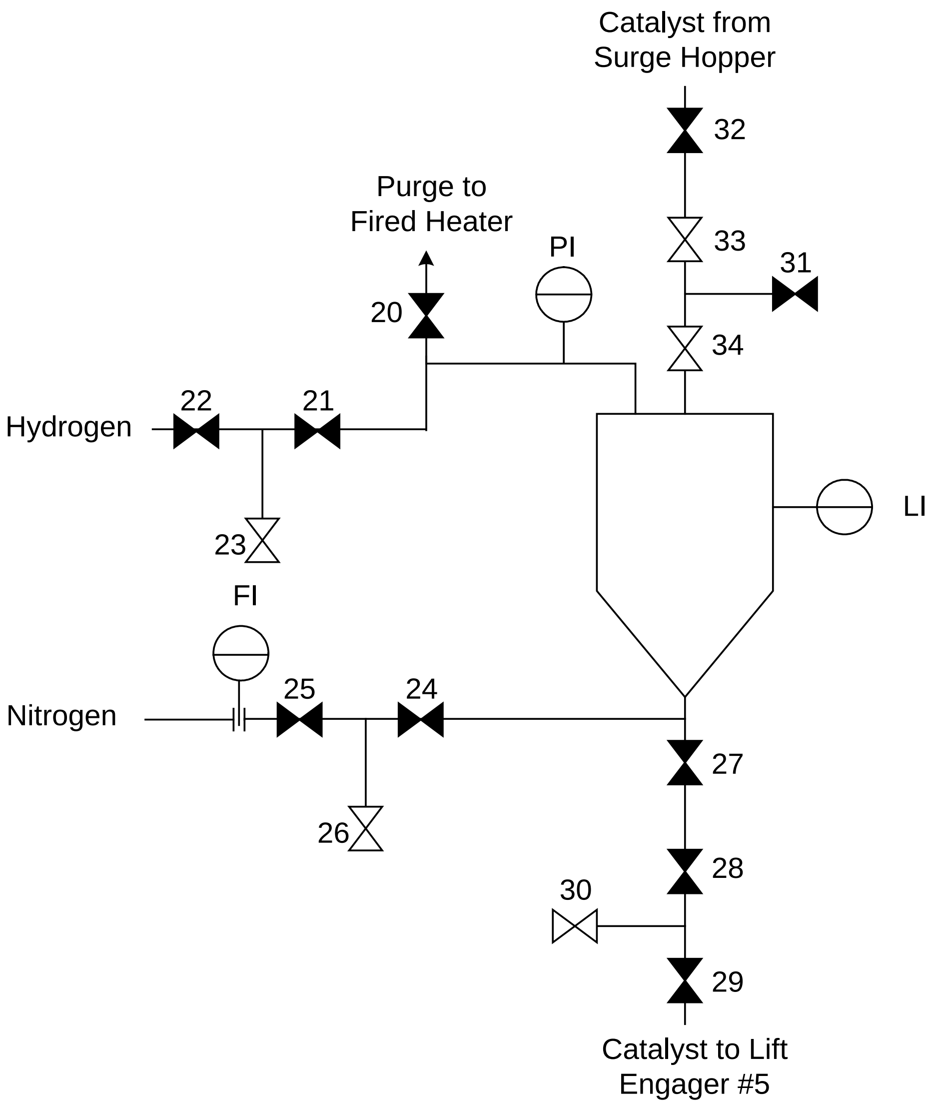
Valve 26 is confirmed open

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 21



Valve 33 and Valve 34 open to further set up the catalyst transfer path between the lock hopper and the surge hopper. The closed V-notch ball valve, Valve 32, prevents catalyst flow.

The sequence advances to the next step when:

Valve 33 is confirmed open

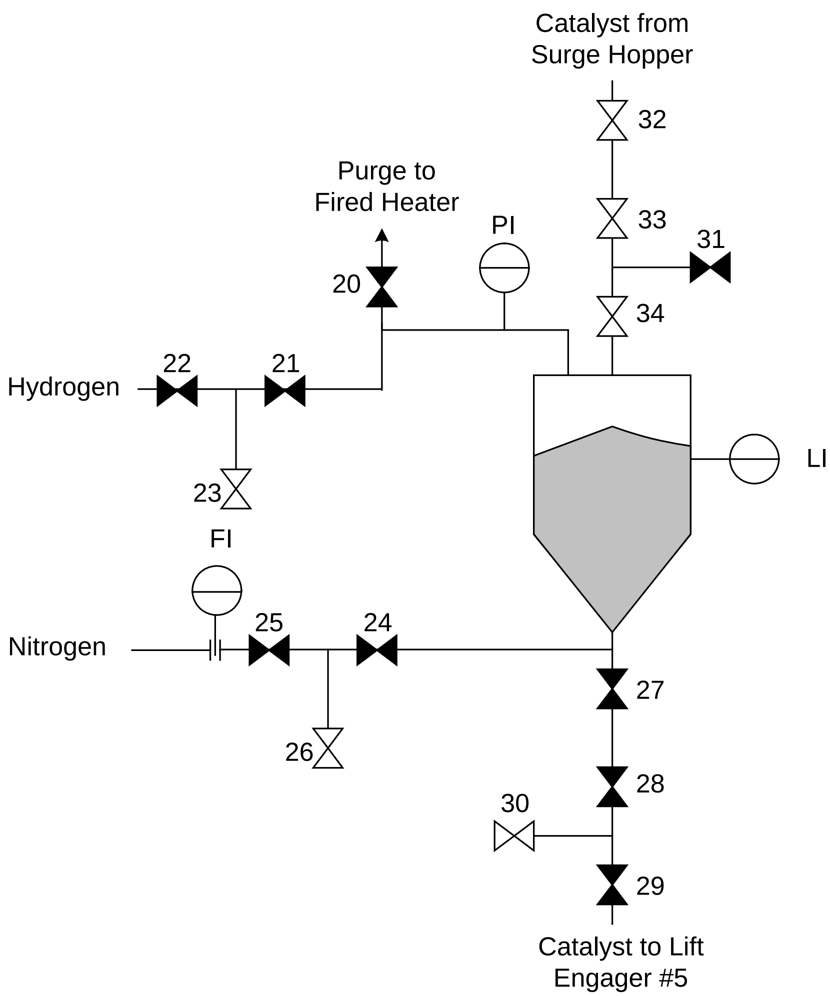
Valve 34 is confirmed open

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Step 22



If the Lock Hopper 2 Start/Stop Pushbutton indicator turns red during this step, the sequence goes immediately to the next step. Advancing immediately to the Stopped position could close ball valves, Valve 33 and Valve 34, on catalyst or dust and could damage the valves.

In this step, the sequence ignores the open valve verification to prevent overfilling the lock hopper.

Valve 32 opens to allow catalyst to flow into the lock hopper.

The Abnormal Loading Minimum Timer starts. If the timer expires during this step, the Abnormal Loading Range Timer starts.

*The DCS LH-2 Load Timer starts.

The Abnormal Loading Alarm activates during this step if:

Lock Hopper level transmitter indicates high lock hopper level before the Abnormal Loading Minimum Timer expires or the Abnormal Loading Range Timer expires

The sequence advances to the next step when:

Lock Hopper level tranmistter indicates high lock hopper level

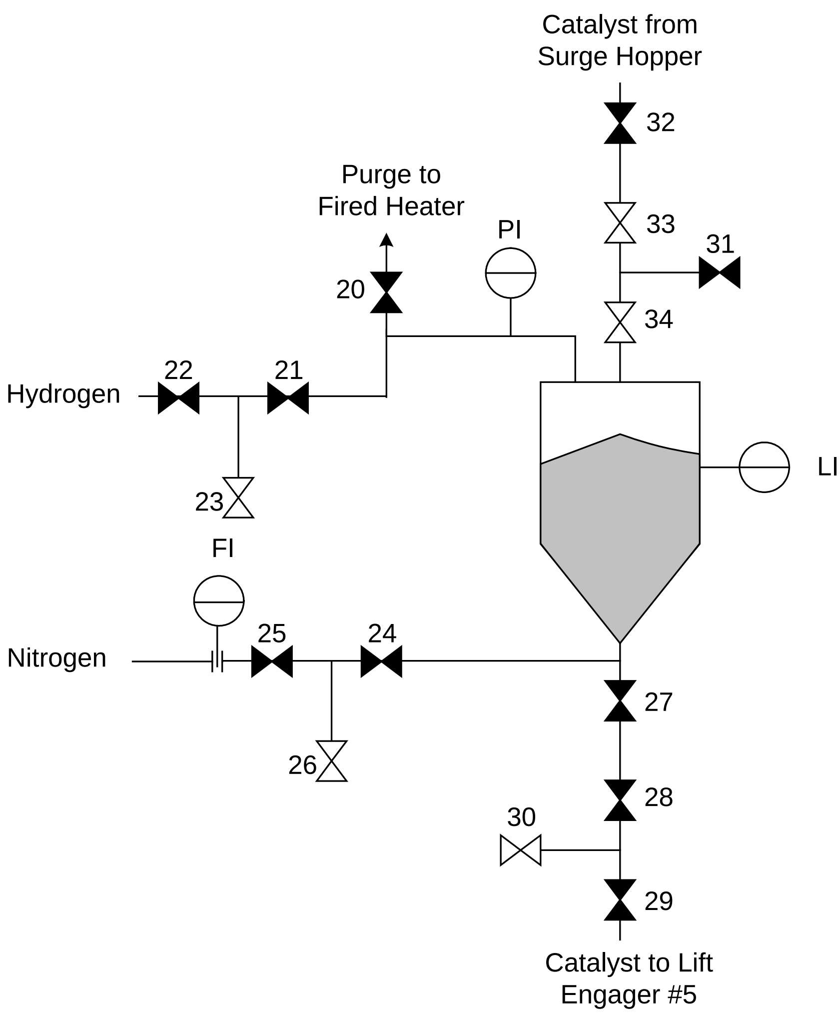
OR

the Abnormal Loading Range Timer expires

OR

the Lock Hopper 2 Stop Pushbutton indicator turns red

Step 23



If the Lock Hopper 2 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the next step. Advancing immediately to the Stopped position could close ball valves, Valve 33 and Valve 34, on catalyst or dust and could cause valve damage.

Valve 32 closes to stop catalyst flow. When it is confirmed closed, the Lock Hopper 2 Dust Settling Timer 1 starts.

*The DCS LH-2 Load Time updates.

The sequence advances to the next step when:

Valve 32 is confirmed closed

The Lock Hopper 2 Dust Settling Timer 1 expires

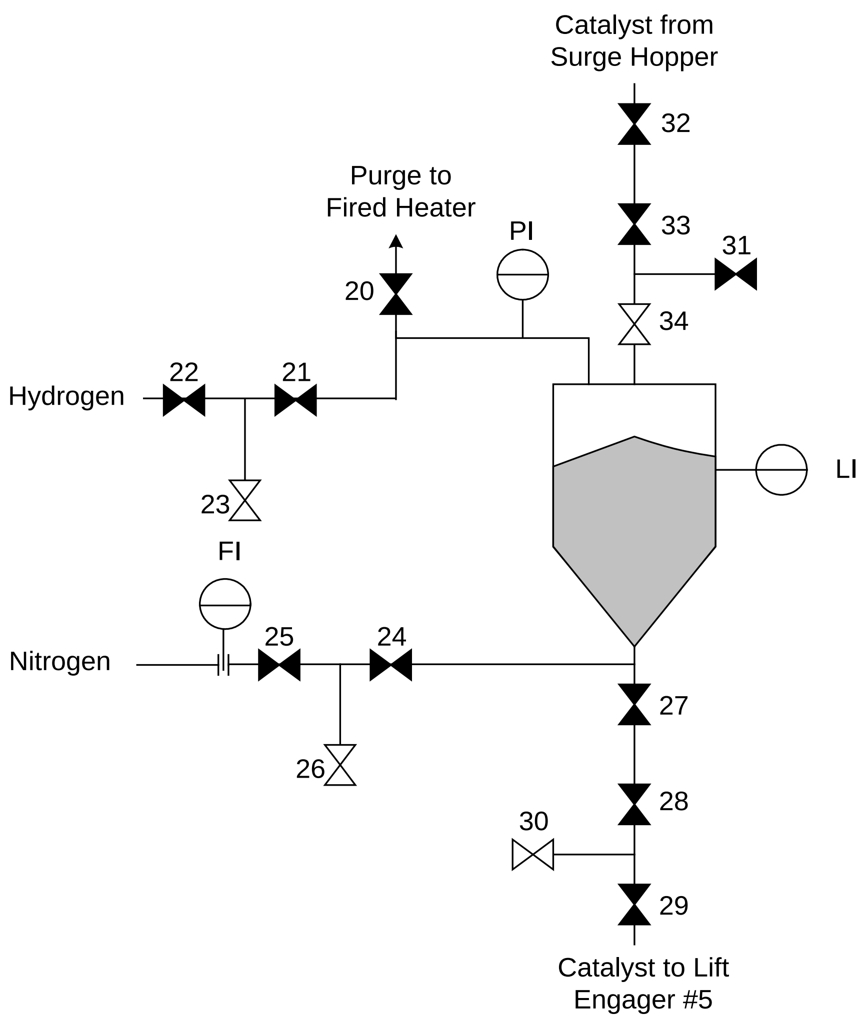
There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

Closing a ball valve on catalyst dust particles could damage the valve seat. The dust-settling timer insures that catalyst and dust has cleared Valve 33 to avoid valve damage.

Step 24



If the Lock Hopper 2 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the next step. Advancing immediately to the Stopped position could close ball valve, Valve 34, on catalyst dust and could cause valve damage.

Valve 33 closes to start isolating the lock hopper from the surge hopper.

When Valve 33 is confirmed closed, the Lock Hopper 2 Dust Settling Timer 2 starts

The sequence advances to the next step when:

Valve 33 is confirmed closed

The Lock Hopper 2 Dust Settling Timer 2 (10 seconds) has expired.

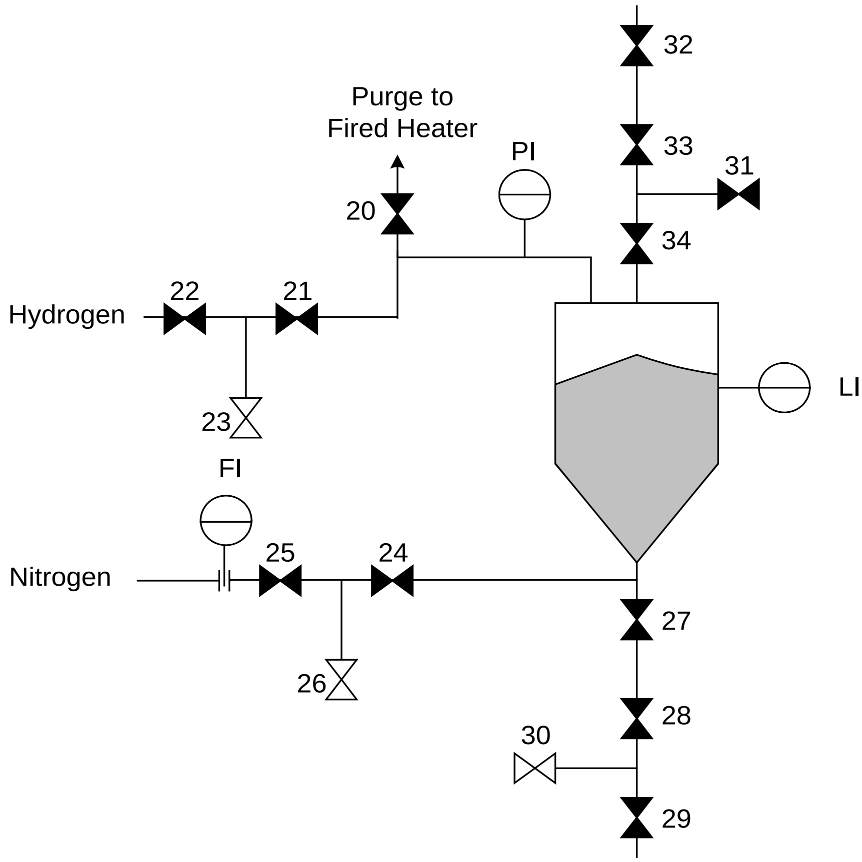
There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

A. Closing a ball valve on catalyst dust particles could damage the valve seat. The dust-settling timer insures that catalyst and dust has cleared Valve 34 to avoid valve damage.

Step 25



If the Lock Hopper 2 Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the sequence waits for Valve 34 to close before going to the Stop position. Advancing immediately to the Stopped position would defeat a double block and bleed by opening Valve 31 at the same time Valve 34 was closing.

Valve 34 closes to further isolate the lock hopper from the catalyst collector.

The sequence returns to Step 0 when:

the Lock Hopper 2 Start/Stop Pushbutton indicator is in the Running (green) position

Valve 34 is confirmed closed

There is sufficient bleeder line nitrogen purge flow

AND

All Lock Hopper 2 Sequence valve positions are verified

The sequence advances to the Stop position when:

the Lock Hopper 2 Stop Pushbutton indicator is in the Stopped (red) position

AND

Valve 34 is confirmed closed

S. Inter-reactor Catalyst Transfer System

The catalyst transfer from reactor to reactor is handled via the Inter-reactor Catalyst Transfer System. This system is much like the Lock Hopper systems in that it controls valves, monitors process conditions, and maintains the safety of the unit. However, the one main difference is the absence of a Lock Hopper. The environment between reactors is the same hydrogen and hydrocarbon atmosphere. Furthermore, the lift is made with hydrogen so there is no need to isolate between the reactor atmospheres.

Note: For C3 Oleflex units, there are four reactors, with the spent catalyst lift engager below Lock Hopper No 1 designated as “Lift Engager No 4,” and the regenerated catalyst lift engager below Lock Hopper No 2 designated as “Lift Engager No 5.” For C4 Oleflex units, there are three reactors, with the spent catalyst lift engager below Lock Hopper No 1 designated as “Lift Engager No 3,” and the regenerated catalyst lift engager below Lock Hopper No 2 designated as “Lift Engager No 4.”

The remainder of this Chapter will be based on the lift engagers for a C3 Oleflex unit. The logic steps involved in catalyst transfer are the same for either type of Oleflex unit.

The step-wise operation of the transfer cycle is divided into five basic operations tabulated below:

Basic Step	Operation
Ready	Lift Engager is empty and under positive hydrogen pressure.
Pressure	The Lift Engager is pressured with hydrogen to the same pressure as the reactor above.
Load	The catalyst is loaded into the Lift Engager.
Depressure	The Lift Engager is depressured to the downstream reactor pressure.

Lift Catalyst is lifted to the downstream reactor.

At the end of the “LIFT” step, the lift engager returns to the “READY” condition. There is a program panel on the control board with these basic steps. As the lift engager cycles, the lights in this panel indicate which basic step the cycle is in.

To avoid the chance of a hazardous condition caused by malfunctioning of any of the logic system components, the following safety checks are built into the lift engager controller.

1. Valve Verification: A valve verification system is included in each controller. The program output is compared continuously with the actual positions of all the valves in the system. Any discrepancy stops the cycle and sounds an alarm. (NOTE: in certain steps, conditions other than valve position are more important; thus, verification is not a requirement to move to the next step.)

2. Start-Stop Button: The lift engagers have a ‘Start-Stop’ button. There is also an indicator associated with this button that indicates the status of the lift engager. It can be running, stopped or in delayed stop.

3. Abnormal Load Alarm: The Abnormal Load Alarm sounds if the lift engager does not fill in the normal time. The time to fill the Lift Engager is determined in the field during the start up. If no problems arise, this time should remain somewhat constant.

To detect problems in loading the Lift Engager, an “Abnormal Load Minimum” timer starts the instant the load V-ball valve starts to open. The “Abnormal Load Minimum” timer is set so that it will time out before the normal lift engager loading time. The “Abnormal Loading Range” timer starts timing when the”Abnormal Load Minimum” timer times out. This timer is set to time out after a typical loading time. If the lift engager level is not satisfied when the Range timer times out, an alarm will sound. Therefore, if the lift engager takes either longer or shorter to load than normal, an alarm sounds.

4. Long Cycle Alarm: The Long Cycle Alarm alerts the operator of problems with the lift engager sequence. The alarm is activated by the "LONG CYCLE" timer which is for a time slightly longer than the time required to complete a normal cycle. The timer starts when the transfer sequence begins (Step 1) and stops and resets itself at the end of the sequence when the lift engager returns to the "READY" step. If the timer times out before the cycle is complete, the Long Cycle Alarm sounds. The cycle time is relatively constant. However due to the system of checks that exist in the logic, the cycle will take longer if a problem develops somewhere in the cycle. The "Long Cycle Alarm" will notify the operator of such an occurrence.

5. Delayed Stop Sequence: To avoid possible damage to the ball valve seating surfaces of the gas tight valves, a timer is used to offset the time when the V-ball valves close to stop catalyst flow, and the time the B-ball valves close. The Delayed Stop Sequence circuit is activated whenever the operator pushes the button to stop the lift engager system. The delay allows catalyst flow to stop and the catalyst volume to drop out of the B-valve area. This allows the B-valves to close on gas only. Should these valves close on catalyst, their usable service life is greatly diminished.

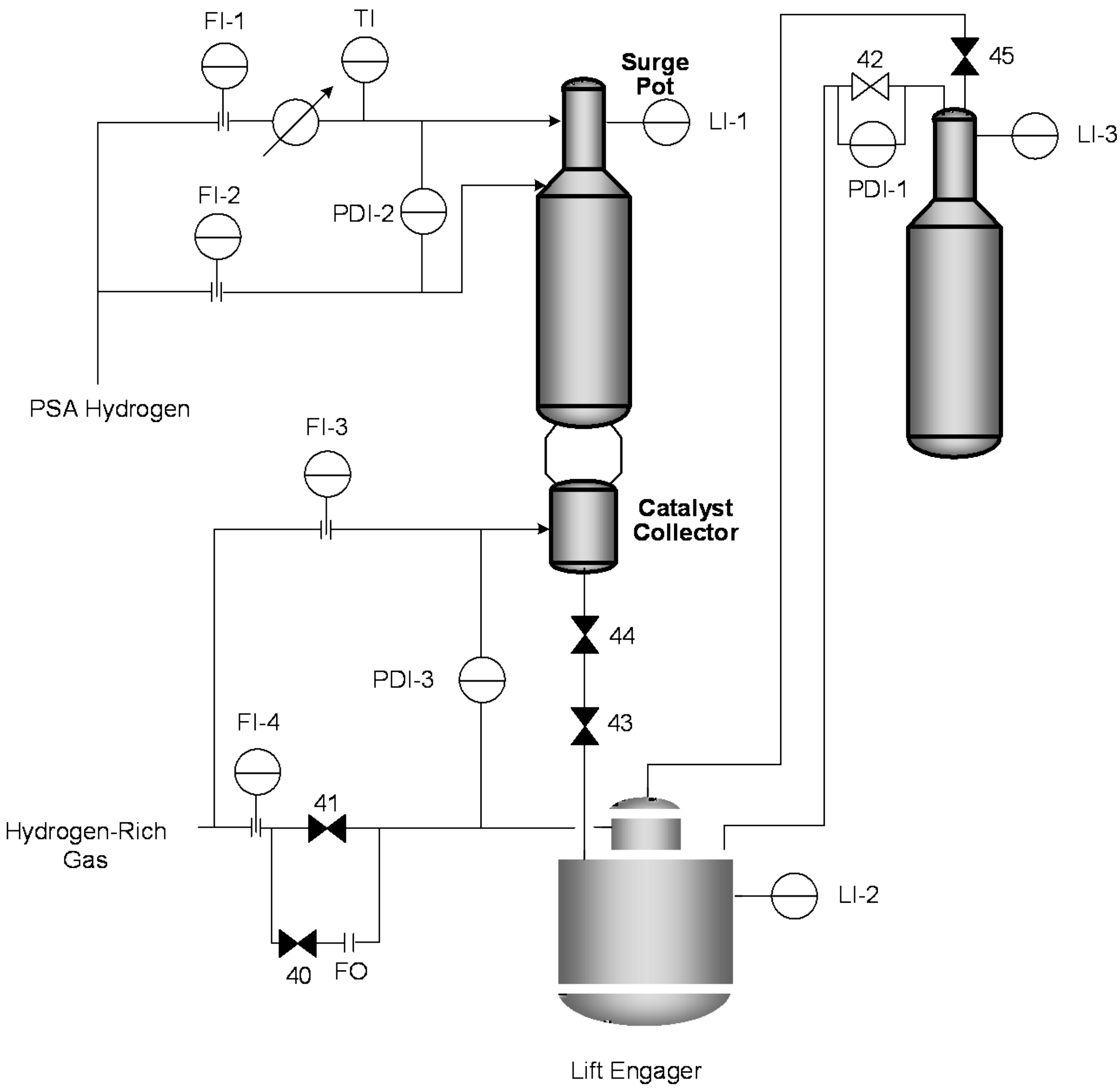
6. Lift Delay Timer: To avoid closing the gas tight ball valve located on top of each reactor on flowing catalyst, lift gas continues to flow after the PDSL (measuring the delta P across the lift line) has indicated no additional catalyst is being lifted. The time that the lift gas continues to flow is set by the Lift Delay Timer.

7. Reactor Level Alarm: When a reactor level light goes out (contact open), the lift engager (or Lock Hopper) cycle counter is reset and the low level timer starts timing. If the timer times out (40 minutes) before the reactor level is satisfied, the level alarm will sound. The timer is reset if the reactor level light comes on. If the reactor catalyst level is high (contact closed), the number of times the Lift Engager (or Lock Hopper No. 1) transfers a load of catalyst is monitored. If the counter counts two load cycles with no change in the level

light, the level alarm will sound, and the lift engager sequence will be held in the Ready step. This logic assures that the unit cannot operate with a faulty level detector in the reactor surge pots.

The following outline describes the complete sequence of steps which occur during the transfer of catalyst from one reactor to the next reactor. The logic steps are shown as graphics depicting the valve positions of the Lift Engager. Additionally, key process indicators of pressure, flow, and level are discussed. These steps are simplified to include only those items that the operator can check for proper operation.

Step A



Valve 42 opens to equalize pressure between the lift engager and the downstream reactor surge pot.

The sequence advances to Step B when:

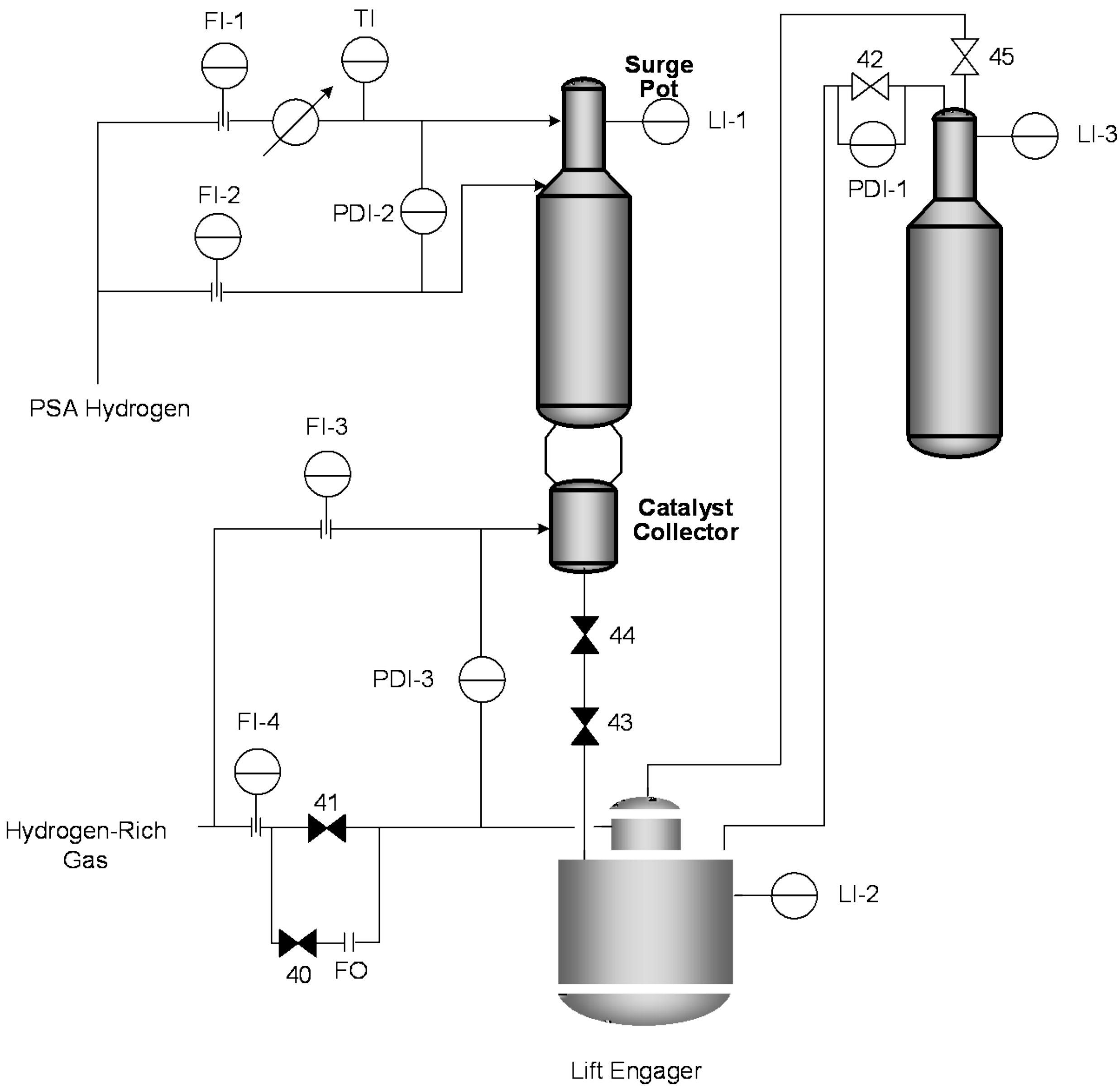
PDI-1 indicates equal lift engager-surge pot pressures

Valve 42 is confirmed open

AND

All Lift Engager 1 Sequence valve positions are verified

Step B



Valve 45 opens to provide a catalyst transfer path between the lift engager and the reactor surge pot.

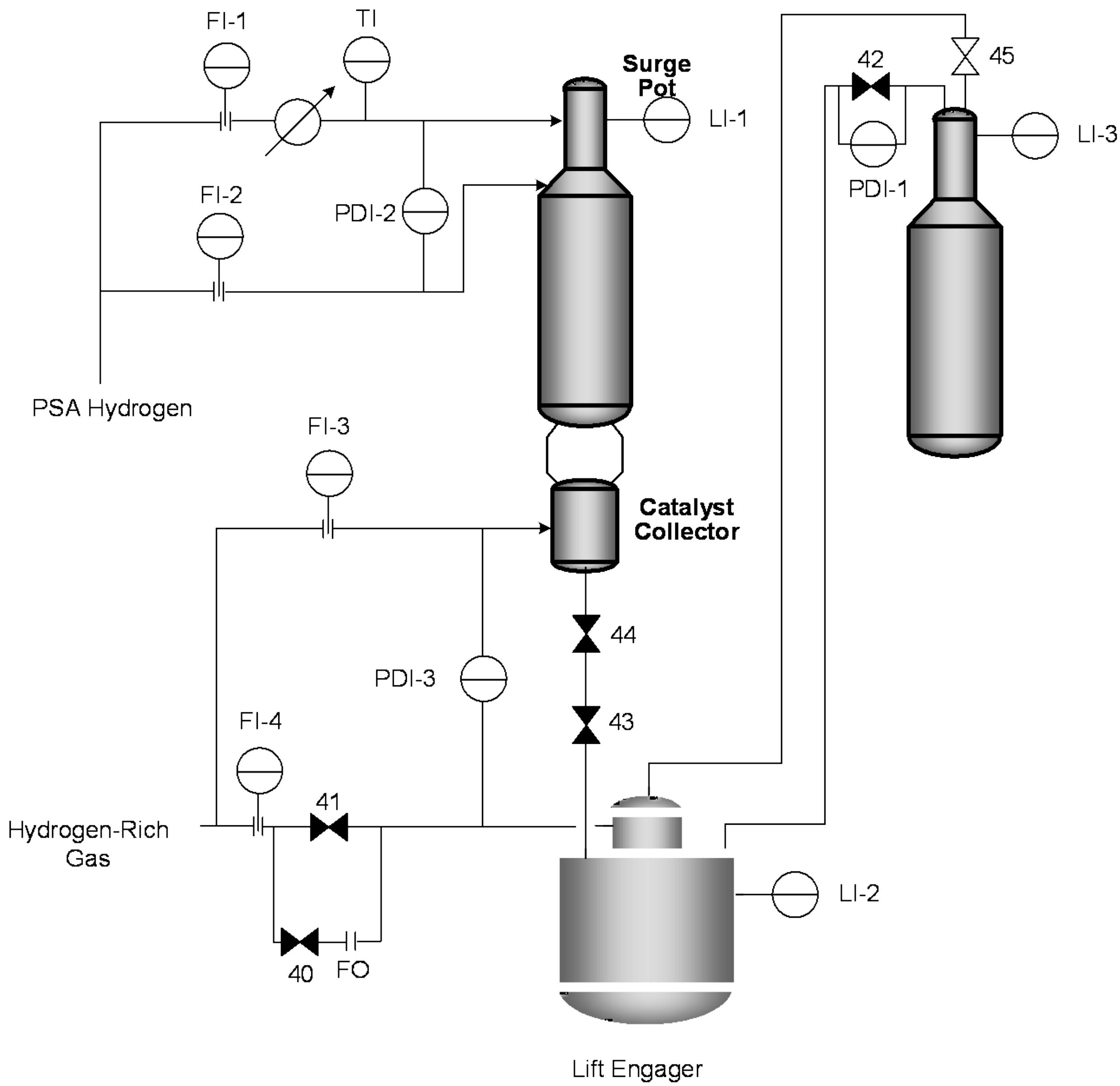
The sequence advances to Step C when:

Valve 45 is confirmed open

AND

All Lift Engager 1 Sequence valve positions are verified

Step C



Valve 42 closes since Valve 45 is open to maintain equal lift engager-surge pot pressures.

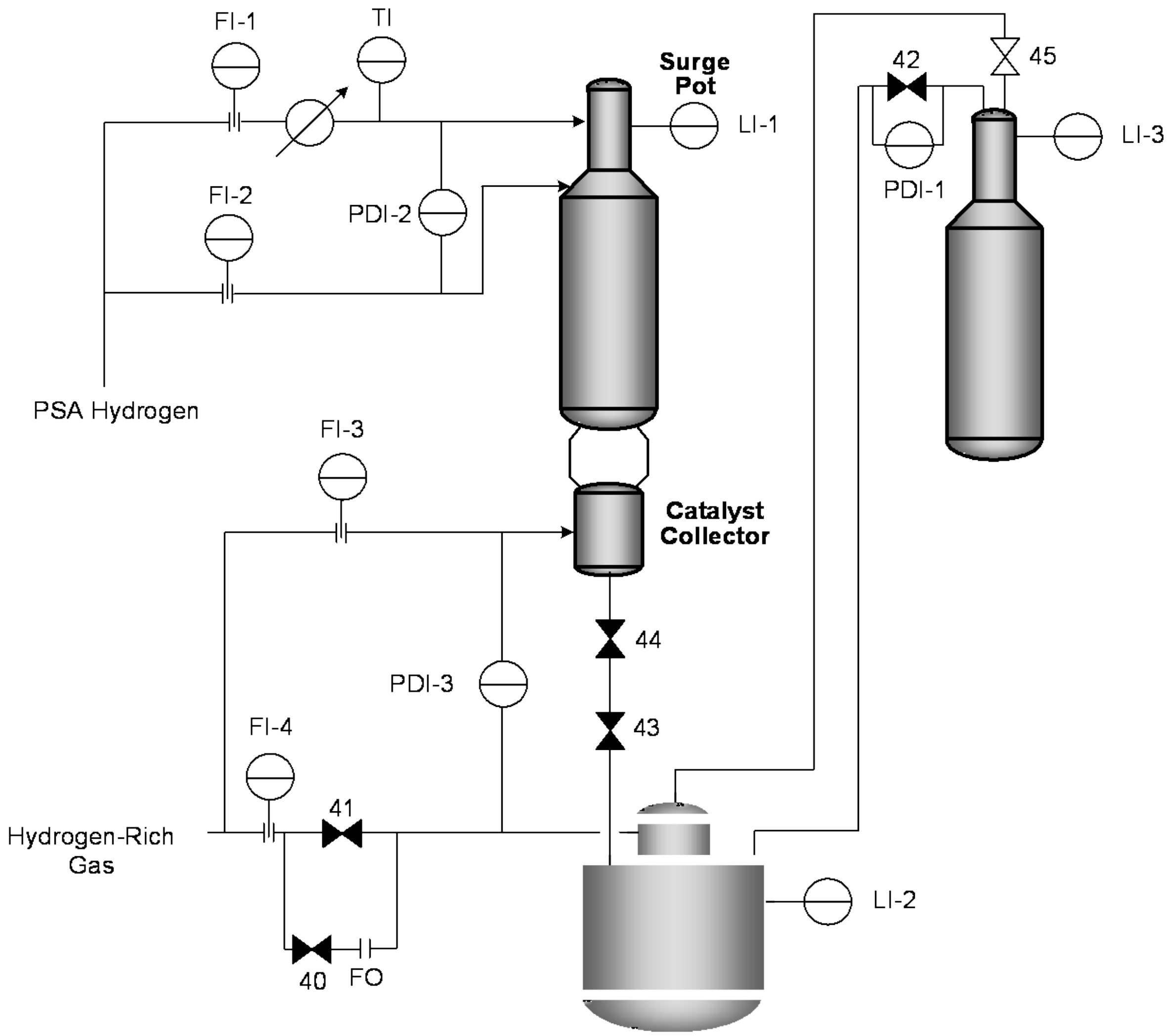
The sequence advances to Step 0 when:

Valve 42 is confirmed closed

AND

All Lift Engager 1 Sequence valve positions are verified

Step 0 (Normal Operations)



The sequence waits in this step until the downstream reactor requires catalyst.

The Long Cycle Timer resets if entering from Step 11.

Common conditions:

Low level in downstream Reactor Surge Pot, LI-3
Low level in Lift Engager, LI-2
For Reactor #3 Only - Lift Engager 4 is not lifting as indicated by high lift gas flow and LH-1 is running

AND

Reactor Surge Pot shows High Level, LI-1
Reactor Level Alarm is inactive
PDI-3 indicates low lift engager-catalyst collector differential pressure
FI-3 has indicated sufficient catalyst collector purge flow for at least 15 minutes
PDI-2 indicates a normal differential pressure between the Reactor Surge Pot and the Reactor
FI-1 and TI-1 to the Reactor Surge Pot have been sufficient for 15 minutes

AND

All Lift Engager Sequence valve positions are verified.

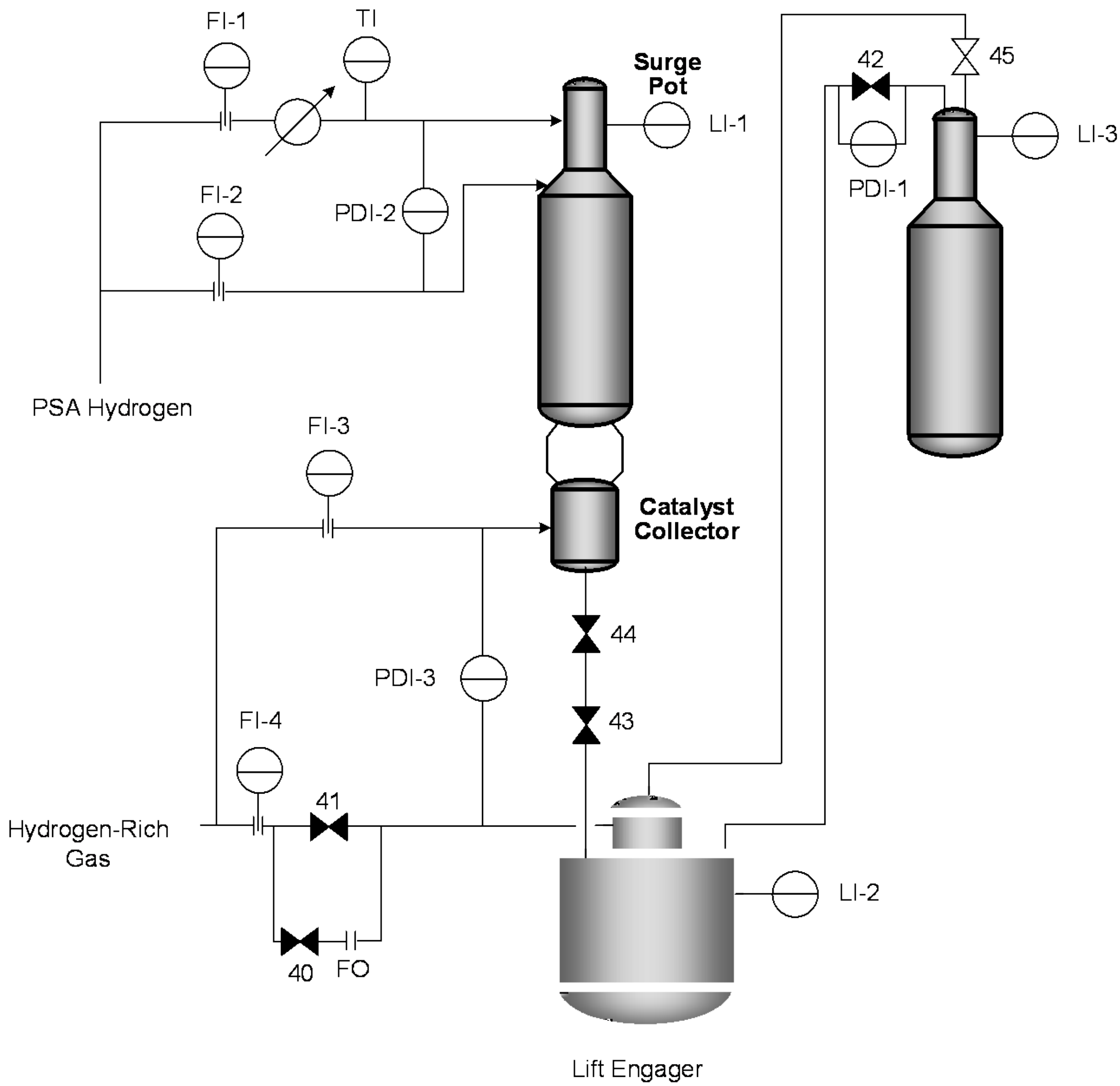
The sequence advances to Step 1 if

LI-2 indicates low lift engager level
common conditions are met (see above)

The sequence advances directly to Step 10 if:

LI-2 indicates high lift engager level

Step 0 (Trickle Mode)



The sequence waits in this step until the downstream Reactor requires catalyst.

The Long Cycle Timer resets if entering from Step 11.

The sequence advances to the next step when:

LI-2 indicates low lift engager level

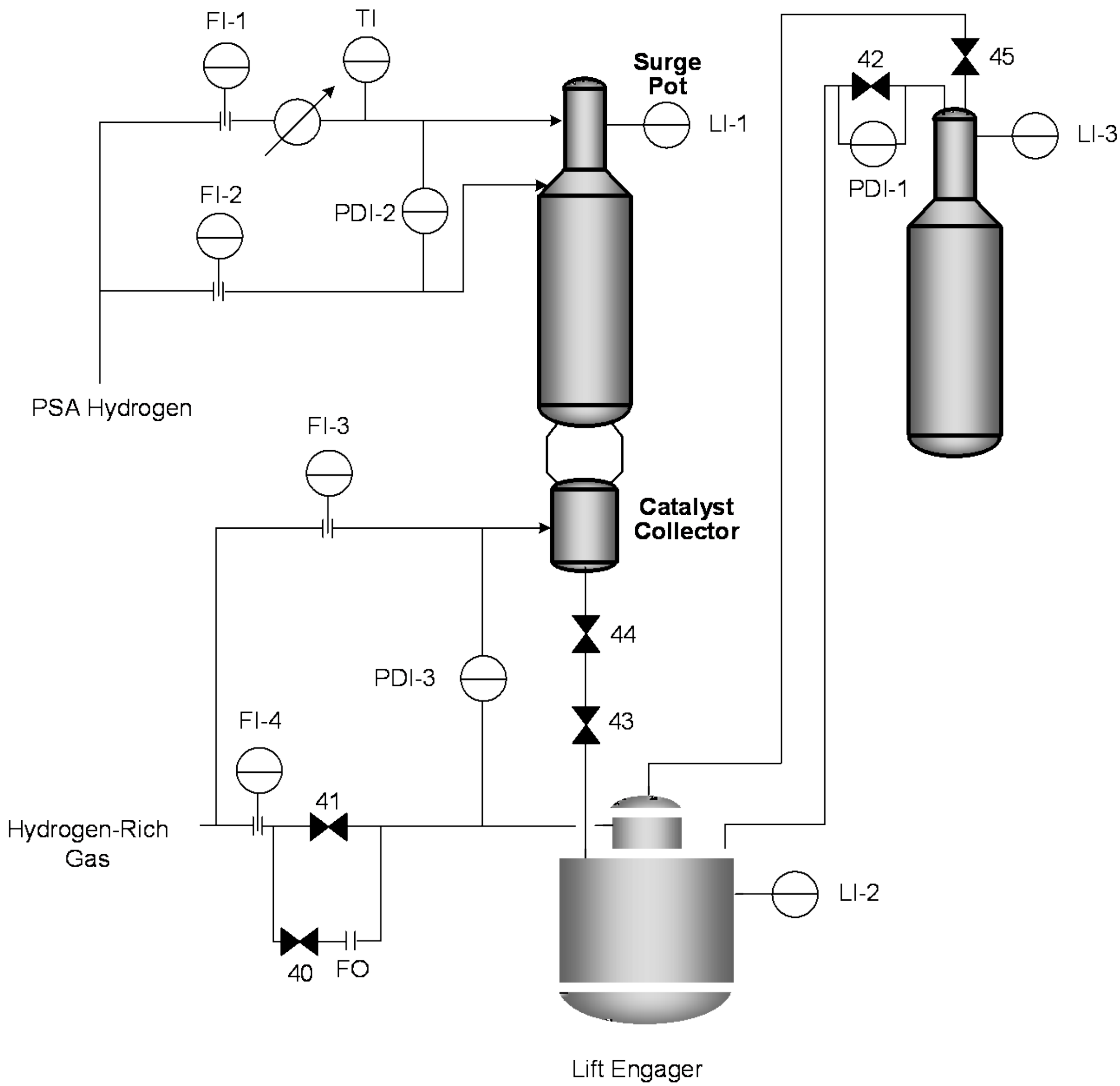
FI-3 has indicated sufficient catalyst collector purge flow for at least 15 minutes

The Lift Engager Trickle Load Counter has counted less than the required amount

AND

All Lift Engager Sequence valve positions are verified.

Step 1 (Normal Operations)



Valve 45 closes to isolate the lift engager from the reactor surge pot.

The Long Cycle Timer starts.

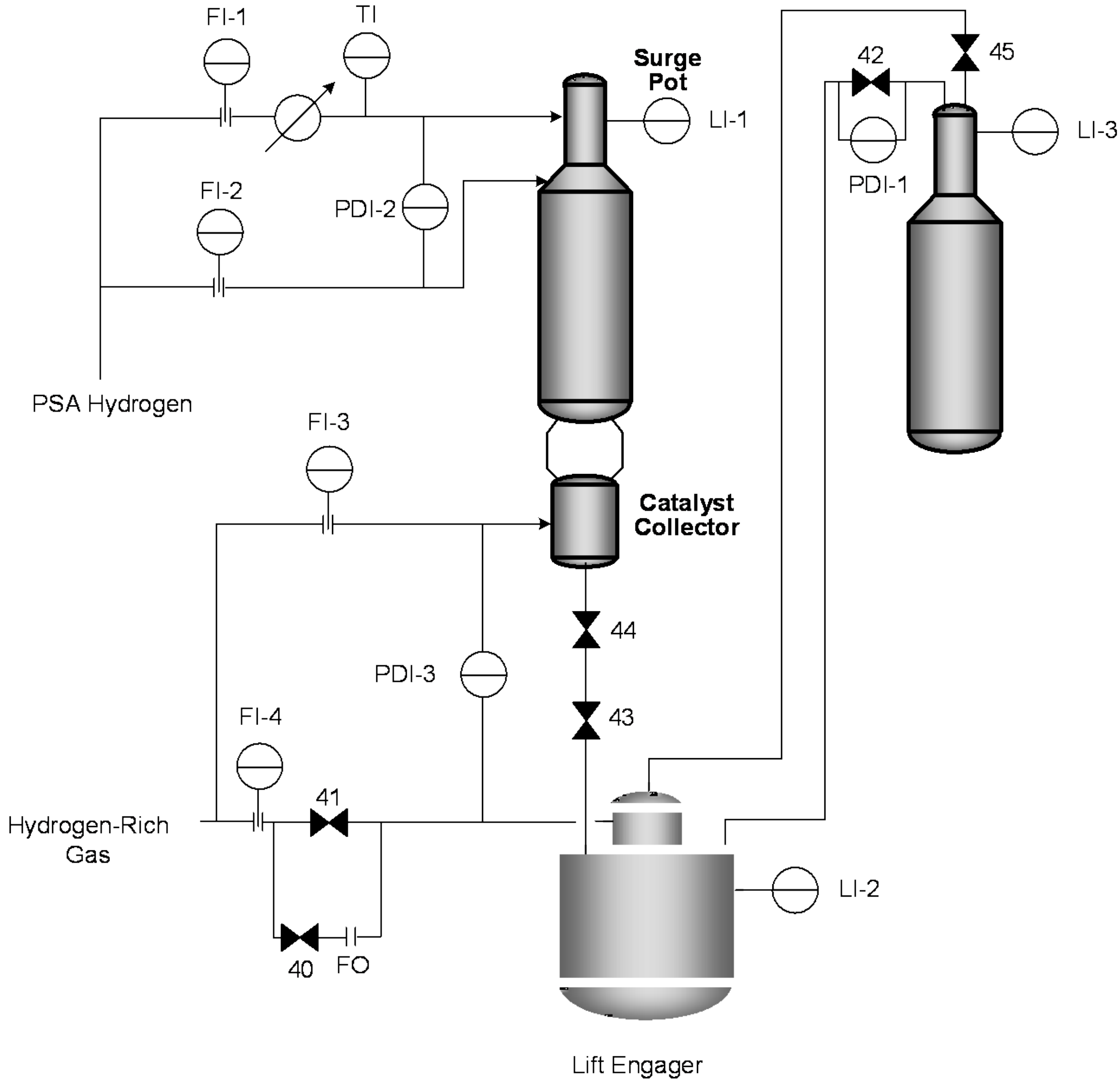
The sequence advances to Step 2 when:

Valve 45 is confirmed closed

AND

All Lift Engager Sequence valve positions are verified.

Step 1 (Trickle Mode)



Valve 45 closes to isolate the lift engager from the reactor surge pot.

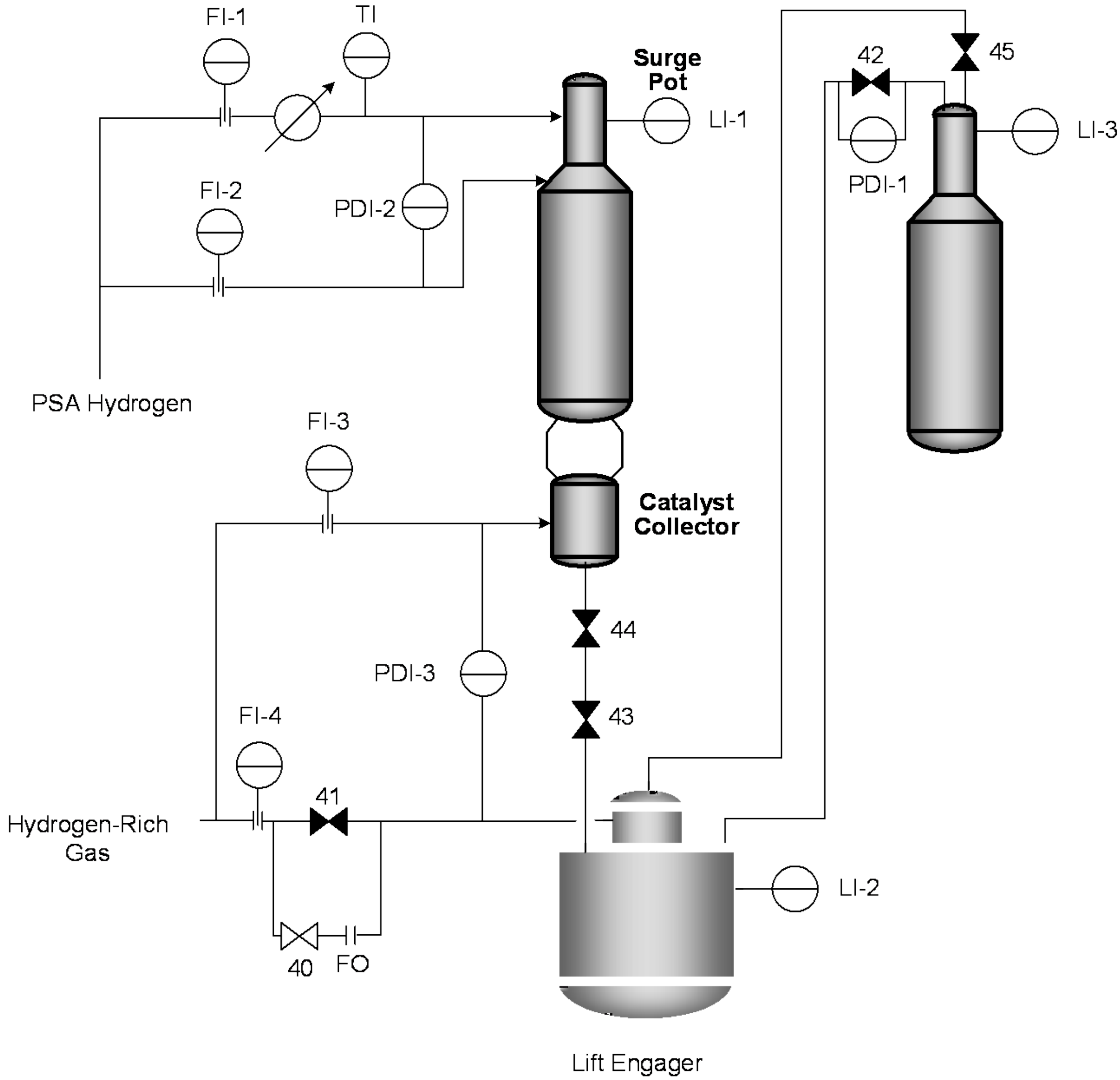
The Long Cycle Timer starts.

The sequence advances to Step 3 when:

Valve 45 is confirmed closed and

All Lift Engager Sequence valve positions are verified.

Step 2



Valve 40 opens to equalize pressure between lift engager and catalyst collector.

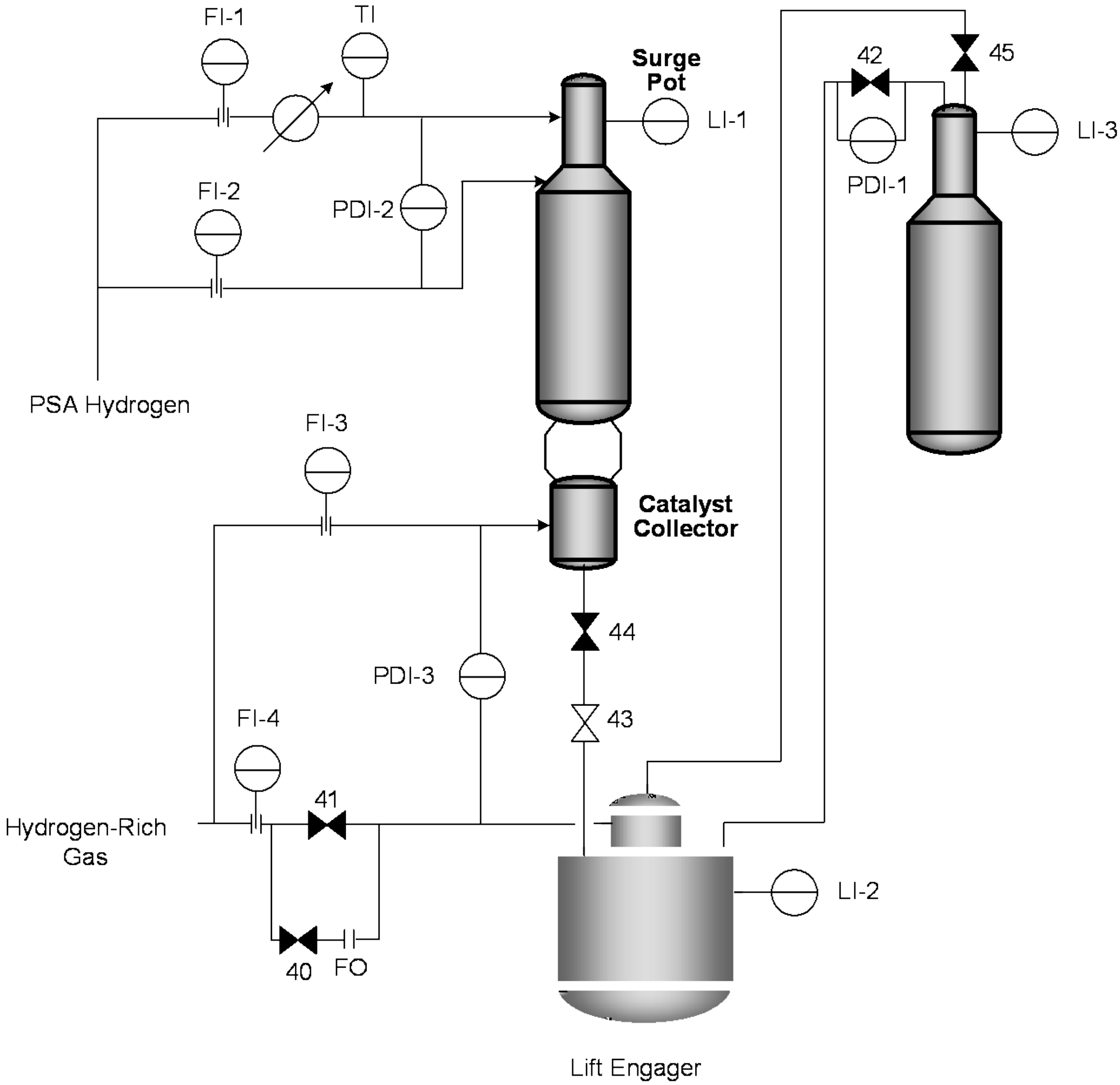
In this step, the sequence ignores valve verification to prevent overpressuring of the lift engager.

The sequence advances to the next step when:

PDI-3 indicates equal pressure between lift engager and catalyst collector

PDI-1 indicates high lift engager-surge pot differential pressure

Step 3



Valve 40 closes to stop the flow of hydrogen to the lift engager.

Valve 43 opens to set up the catalyst transfer path between the lift engager and the catalyst collector. The closed V-notch ball valve Valve 44 prevents catalyst flow.

The Abnormal Loading Alarm clears, if active.

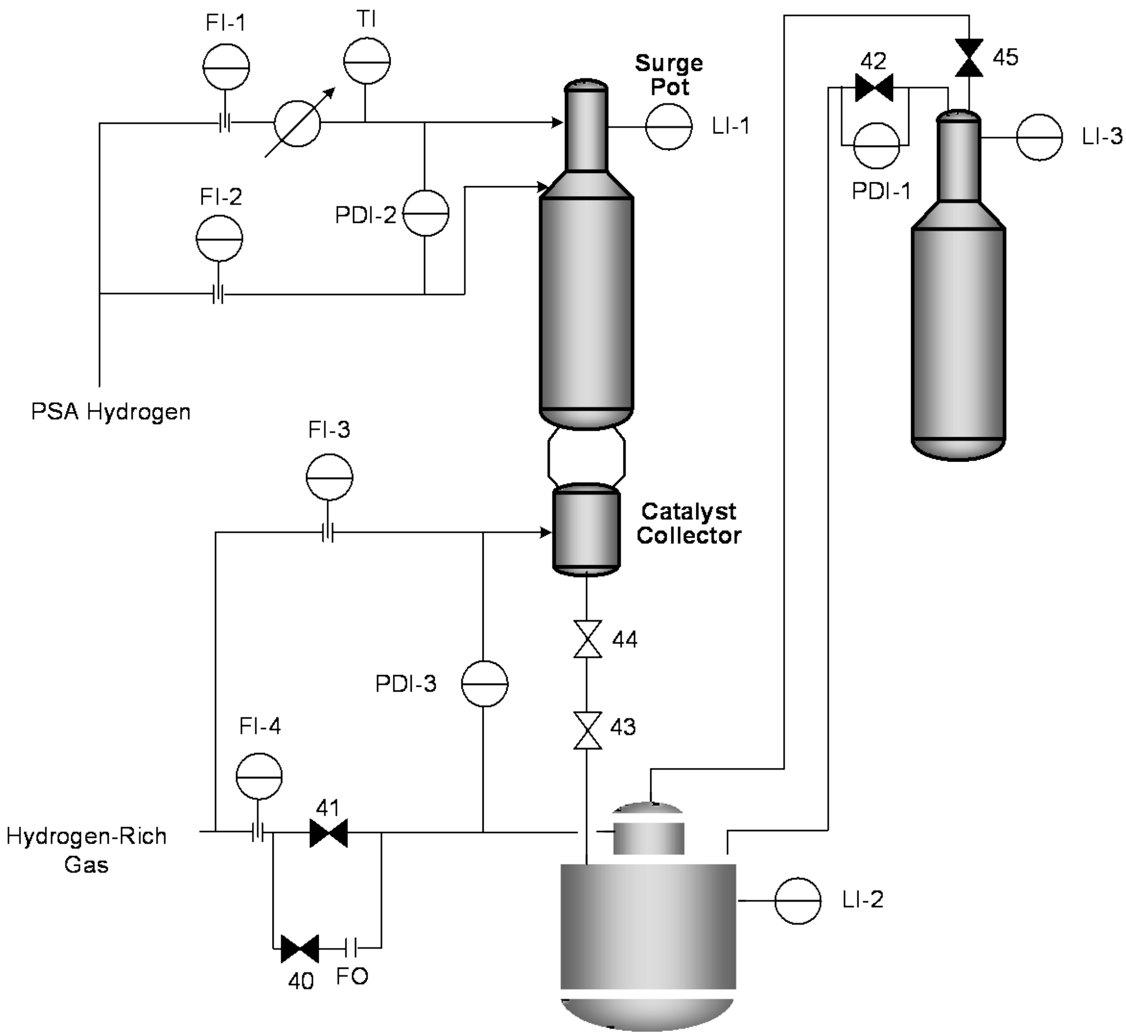
The sequence advances to the next step when:

Valve 40 is confirmed closed

Valve 43 is confirmed open

All Lift Engager Sequence valve positions are verified.

Step 4 (Normal Operations)



Lift Engager

If the Lift Engager Start/Stop Pushbutton Indicator turns red during this step, the sequence goes immediately to the next step. Advancing to the Stop position could close ball valve Valve 43 on catalyst, which could cause valve damage.

In this step, the sequence ignores valve verification to prevent overloading the lift engager with catalyst.

Valve 44 opens to start catalyst flow into the lift engager.

The Abnormal Loading Minimum Timer starts. If the timer expires during this step, the Abnormal Loading Range Timer starts.

The Abnormal Loading Alarm activates during this step if:

LI-2 indicates high lift engager level before the Abnormal Loading Minimum Timer expires

OR

the Abnormal Loading Range Timer expires

The sequence advances to the next step when:

LI-2 indicates high lift engager level

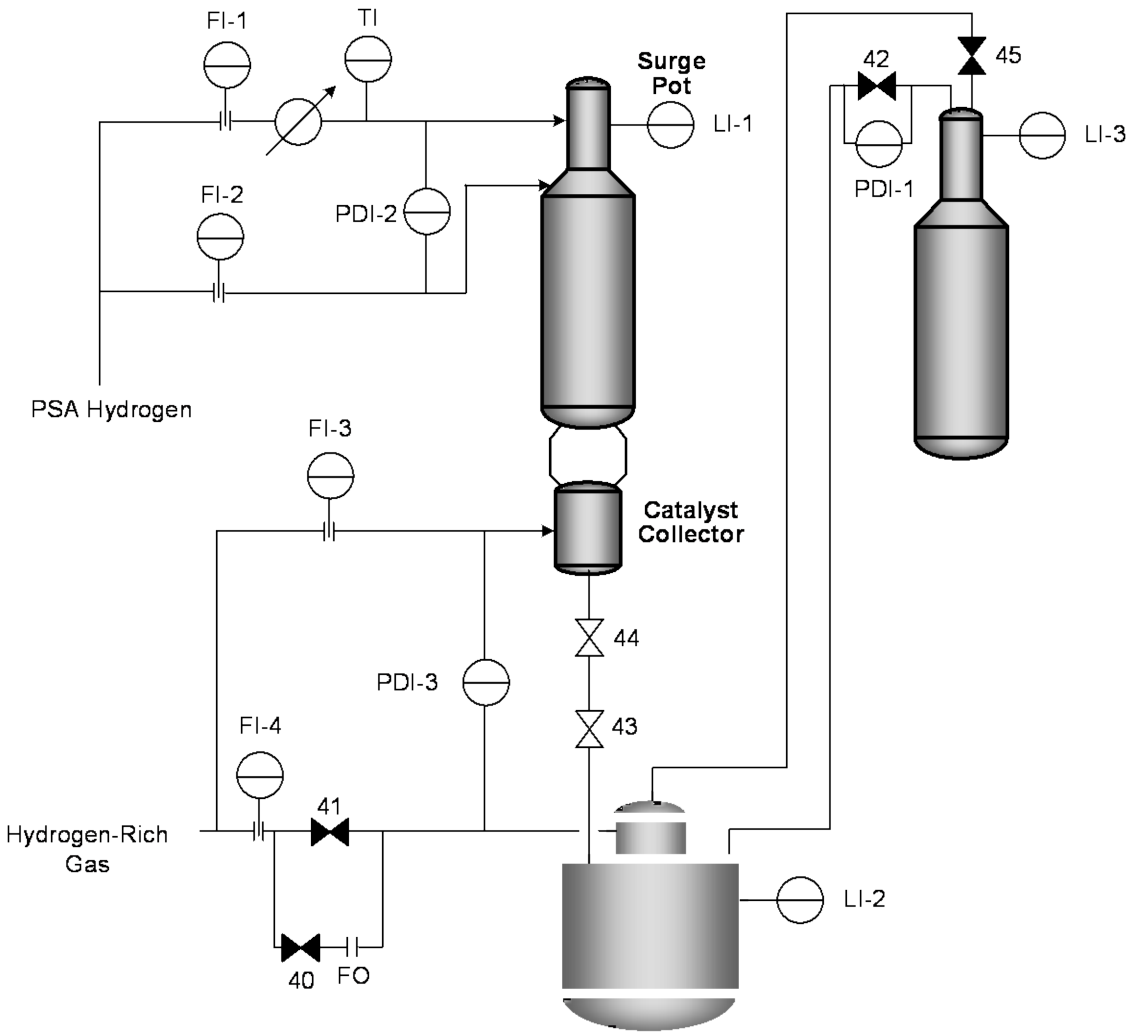
OR

the Abnormal Loading Range Timer expires (activates the Abnormal Loading Alarm)

OR

the Lift Engager Start/Stop Pushbutton indicator turns red.

Step 4 (Trickle Mode)



Lift Engager

If the Lift Engager Start/Stop Pushbutton indicator turns red during this step, the sequence goes immediately to the next step. Advancing to the Stop position could close ball valve Valve 43 on catalyst, which could cause valve damage.

In this step, the sequence ignores valve verification to prevent overloading the lift engager with catalyst.

The Long Cycle Timer pauses to avoid a Long Cycle Alarm.
The Abnormal Loading Alarm is disabled.
The Trickle Mode Load Delay Timer is reset.

Valve 44 opens to start catalyst flow into the lift engager.

The Trickle Mode Load Timer starts timing.

The Trickle Mode Subroutine starts.

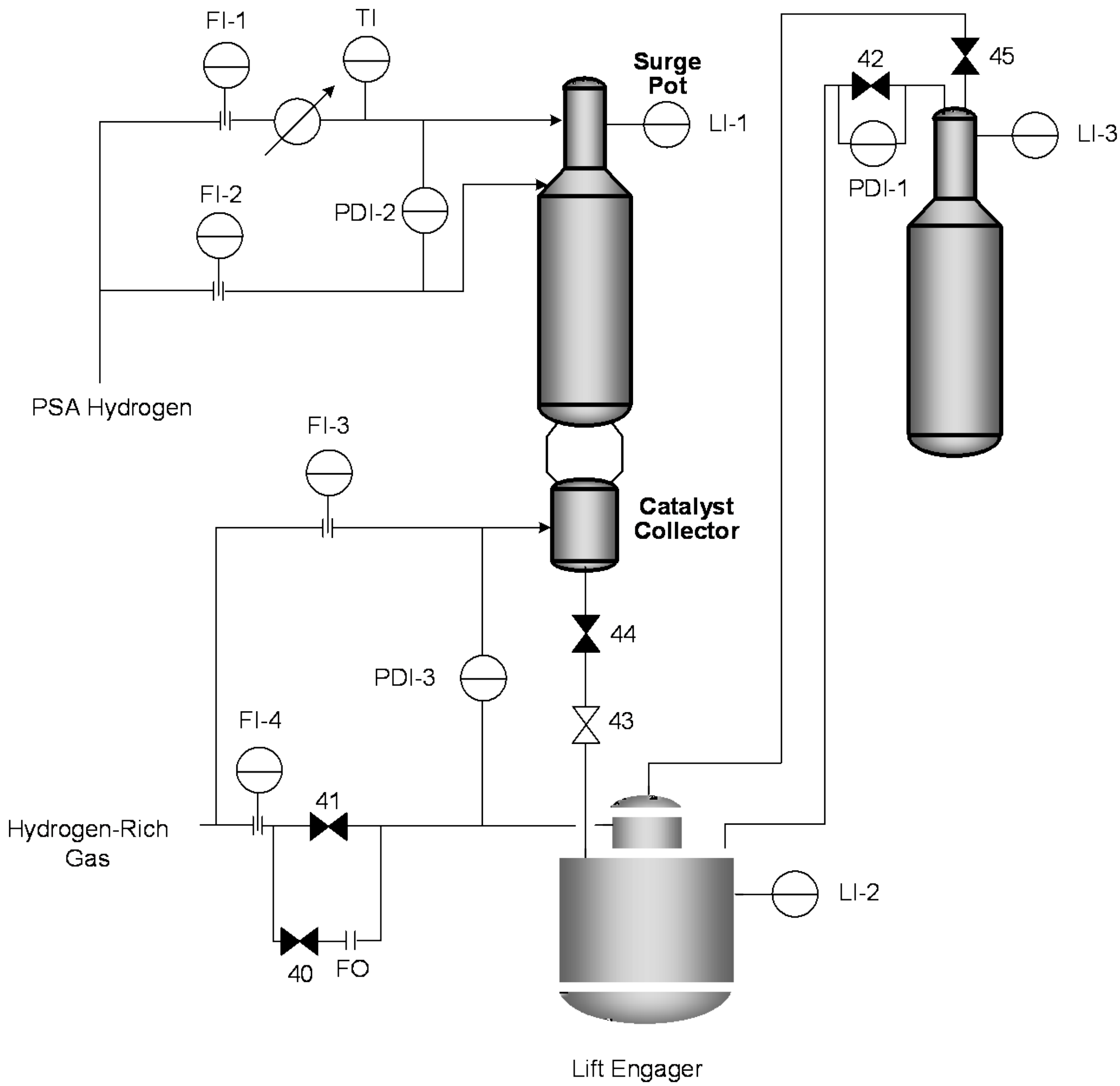
The sequence advances to the next step when:

LI-2 indicates high lift engager level

OR

the Lift Engager Start/Stop Pushbutton indicator turns red.

Step 4 (Trickle Mode Subrouteine)

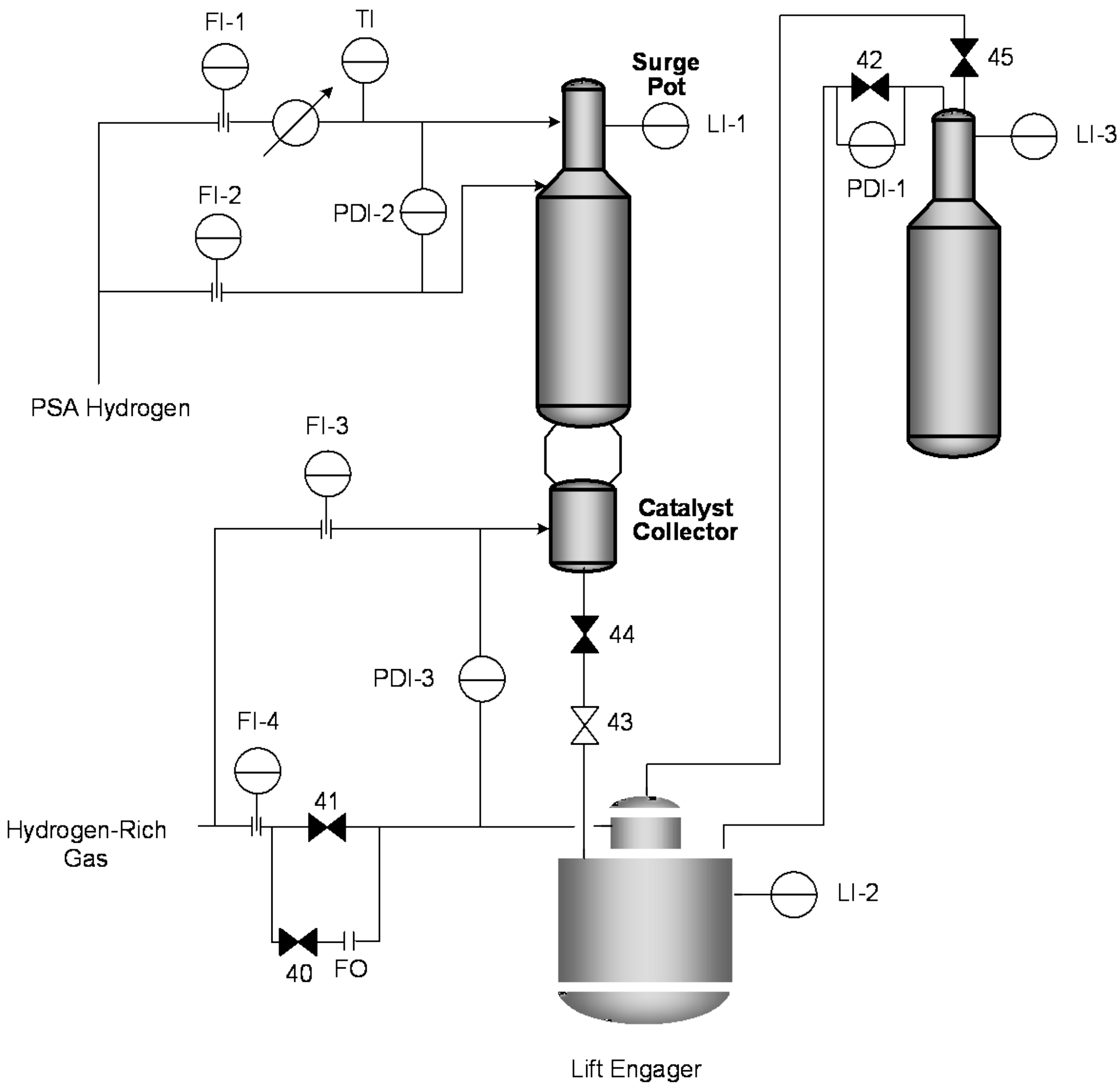


This subroutine executes during Step 4 (Trickle Mode) if the Trickle Mode Load Timer expires or the Valve Verification Alarm is tripped.

The Trickle Mode Subroutine:

1) Valve 44 closes to stop catalyst flow to the lift engager
2) Resets the Trickle Load Timer
3) Starts Trickle Mode Load Delay Timer after Valve 44 is verified closed
4) Returns to repeat Step 4 (Trickle Mode) after Trickle Load Delay Timer expires.

Step 5 (Normal Operations)



If the Lift Engager Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the Stop position. Advancing immediately to the Stopped position could close ball valve Valve 43 on catalyst, which could cause valve damage.

If LI-2 indicates low lift engager level in this step, the Abnormal Loading Alarm activates.

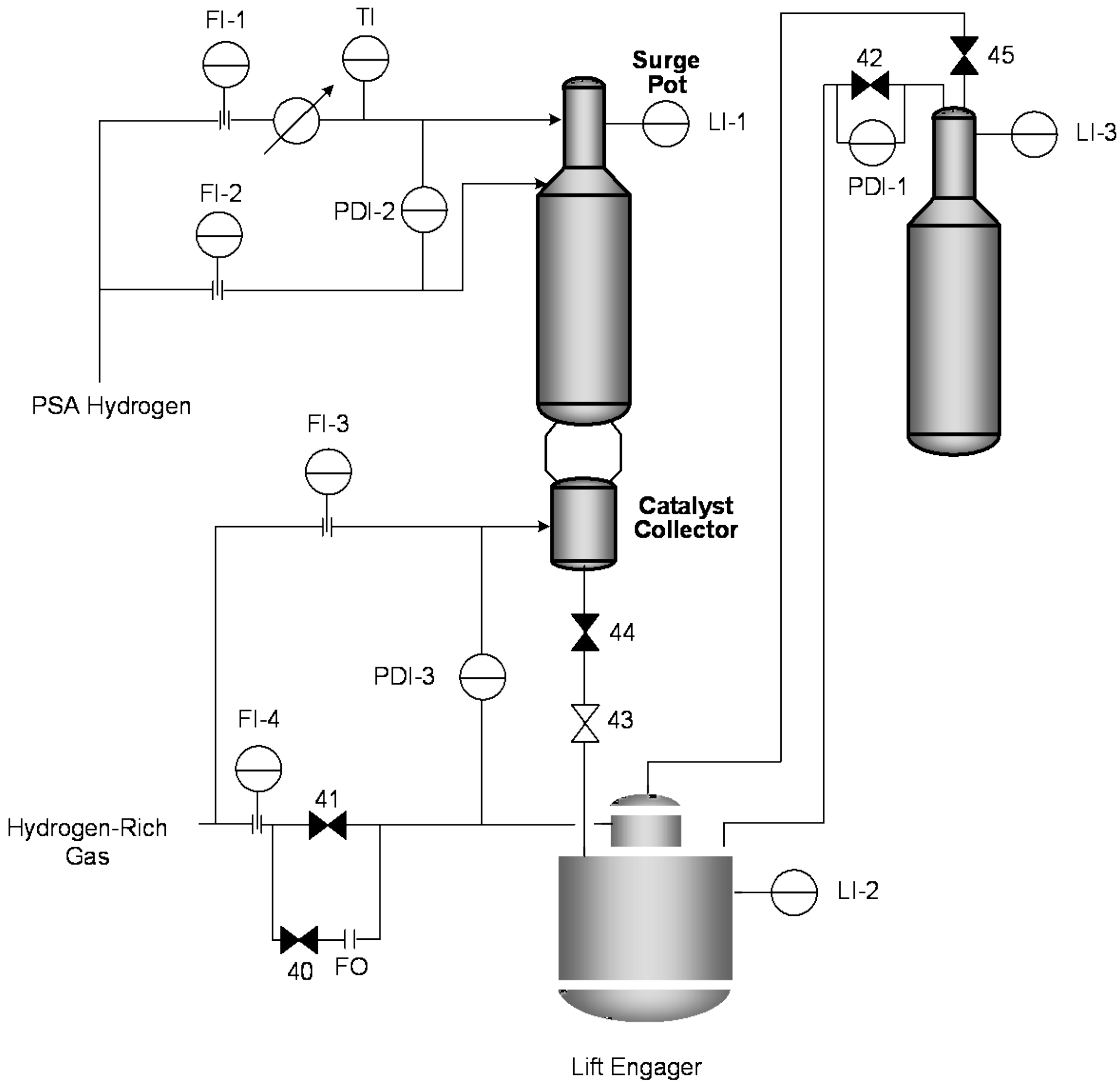
Valve 44 closes to stop catalyst flow to the lift engager.

When Valve 44 is confirmed closed, the Dust Settling Timer starts.

The sequence advances to the next step when:
the Lift Engager Start/Stop Pushbutton indicator is in the Running (green) position
Valve 44 is confirmed closed
the Dust Settling Timer expires
AND
All Lift Engager Sequence valve positions are verified.

The sequence goes to the Stop position when:
the Lift Engager Start/Stop Pushbutton indicator is in the Stopped (red) position
Valve 44 is confirmed closed
AND
the Dust Settling Timer expires. The Dust Settling Timer delay ensures that catalyst and dust has cleared Valve 43. Closing a ball valve on dust particles could damage the valve.

Step 5 (Trickle Mode)



If the Lift Engager Start/Stop Pushbutton indicator is in the Stopped (red) position during this step, the step completes before going to the Stop position. Advancing immediately to the Stopped position could close ball valve Valve 43 on catalyst, which could cause valve damage.

If the Lift Engager Start/Stop Pushbutton indicator is in the Run (green) position, the Trickle Load Counter increments by 1.

The Long Cycle Timer resumes counting.

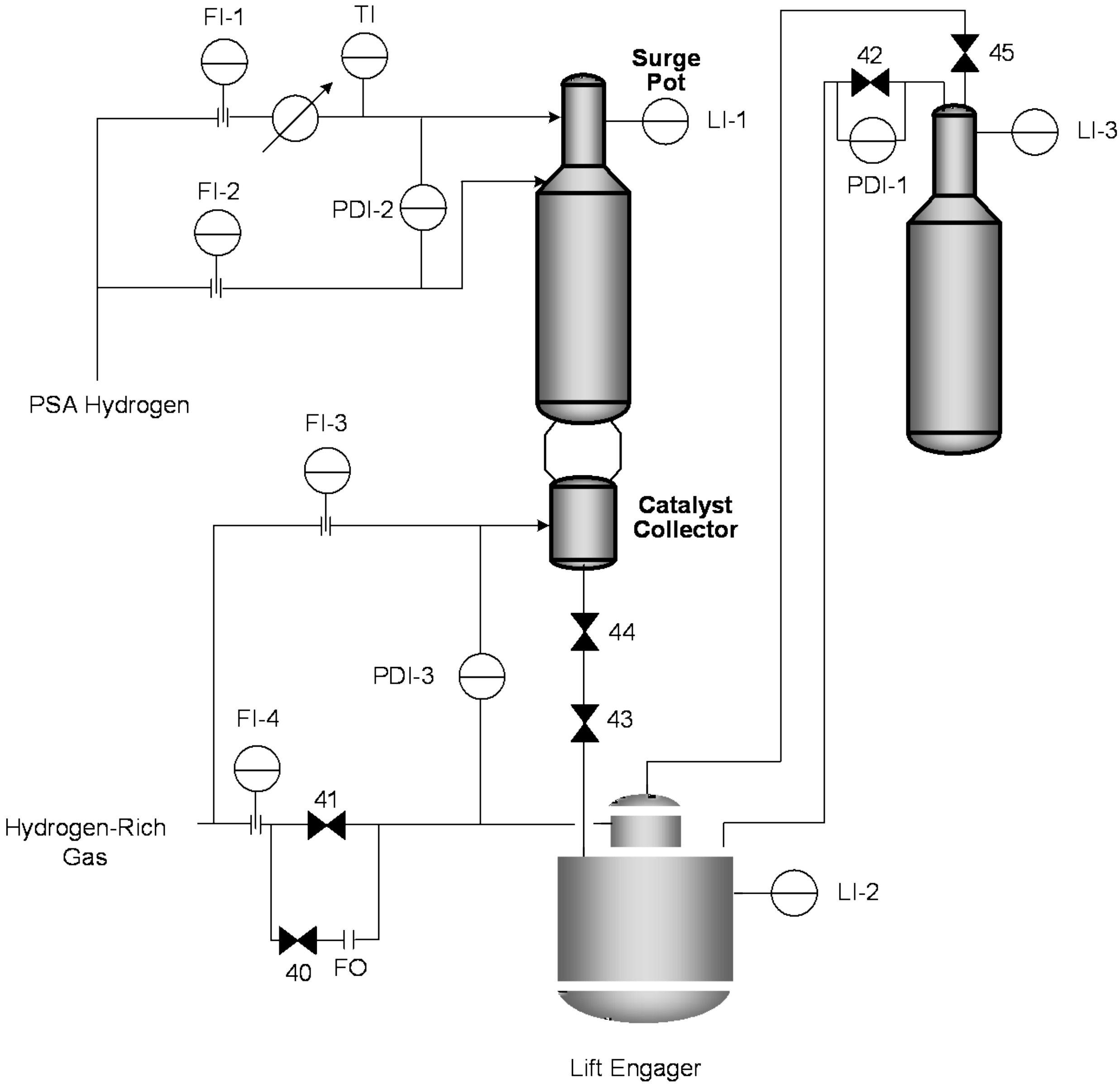
Valve 44 closes to stop catalyst flow to the lift engager.

When Valve 44 is confirmed closed, the Dust Settling Timer starts.

The sequence advances to the next step when:
the Lift Engager Start/Stop Pushbutton is in the Running (green) position
Valve 44 is confirmed closed
the Dust Settling Timer expires
AND
All Lift Engager Sequence valve positions are verified.

The sequence goes to the Stop position when:
the Lift Engager Start/Stop Pushbutton is in the Stopped (red) position
AND
the Dust Settling Timer expires. The Dust Settling Timer delay ensures that dust has cleared Valve 43). Closing a ball valve on dust particles may damage the valve.

Step 6



Valve 43 closes to isolate the lift engager from the catalyst collector.

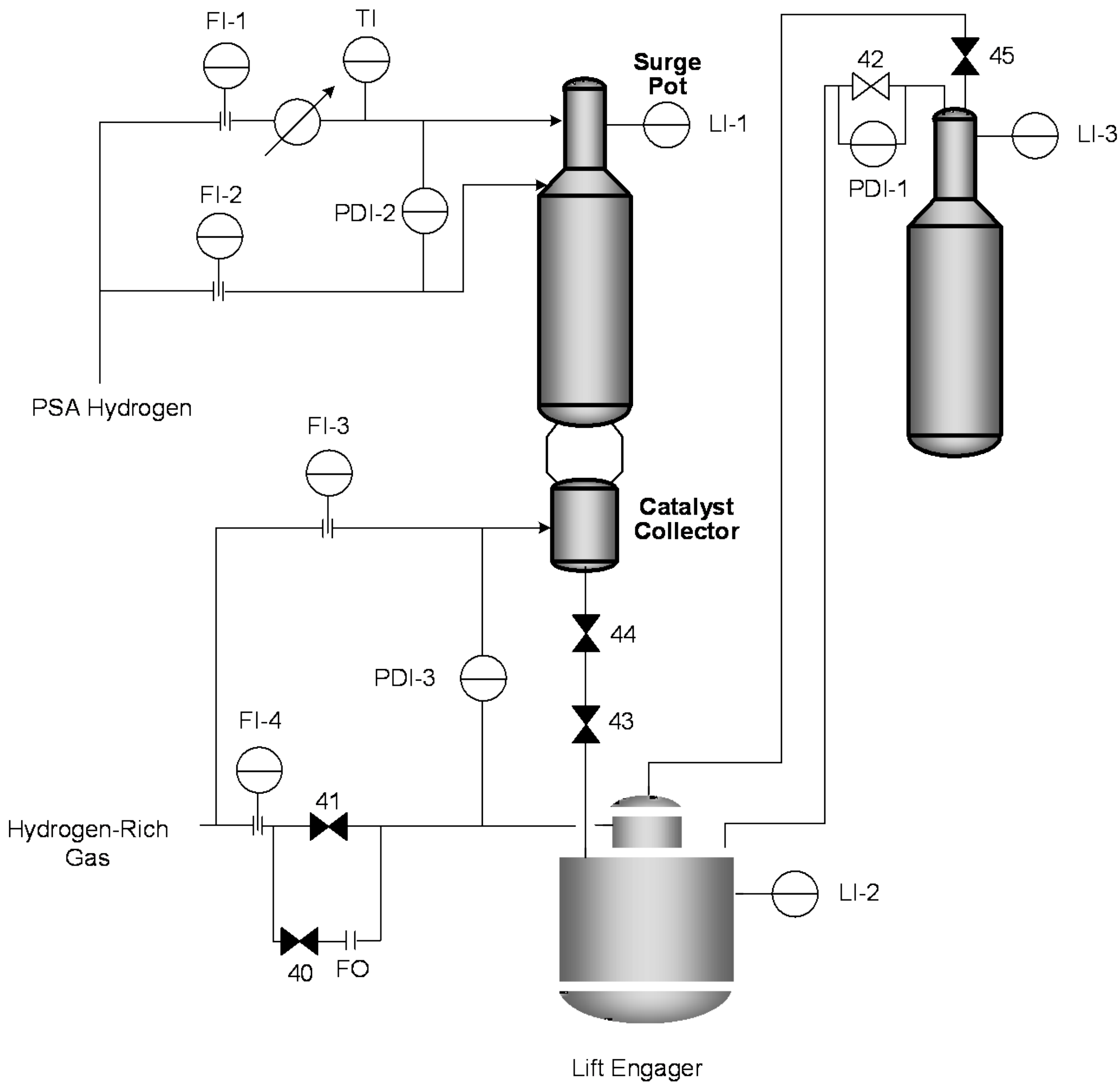
The sequence advances to the next step when:

Valve 43 is confirmed closed

AND

All Lift Engager Sequence valve positions are verified.

Step 7 (Normal Operations)



Valve 42 opens to equalize the pressure between the reactor surge pot and the lift engager.

The sequence advances to the next step when:

PDI-1 indicates equal pressure between the lift engager and reactor surge pot

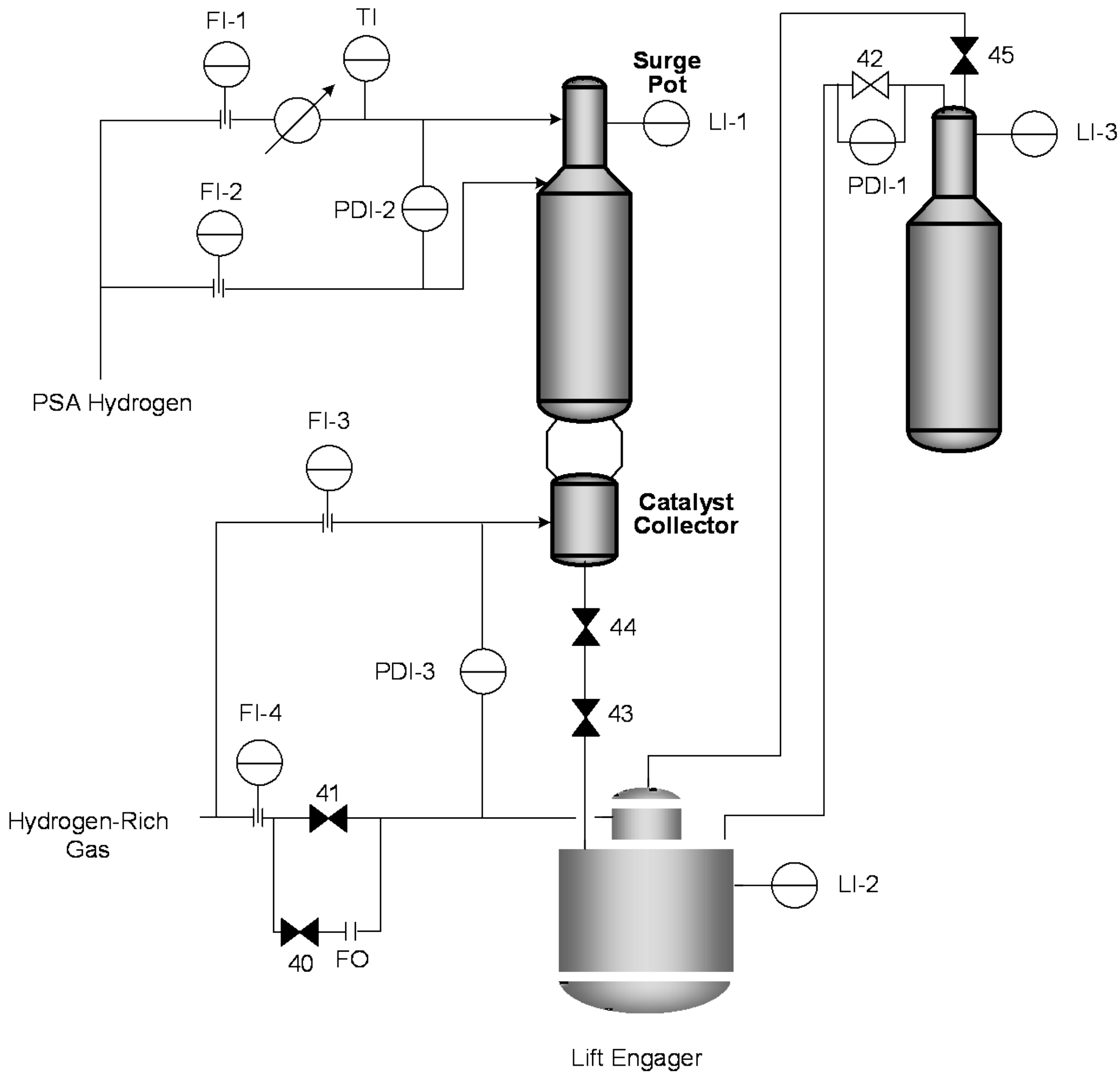
Valve 42 is confirmed open

LI-3 indicates a low level in downstream Reactor Surge Pot

AND

All Lift Engager Sequence valve positions are verified.

Step 7 (Trickle Mode)



Valve 42 opens to equalize the pressure between the reactor surge pot and the lift engager.

If coming from Step 0, the Long Cycle Timer starts.

To avoid a Long Cycle Alarm, the Long Cycle Timer is paused until LI-3 indicates a low level in the downstream Reactor Surge Pot .

The sequence advances to the next step when:

LI-3 indicates a low level in the downstream Reactor Surge Pot

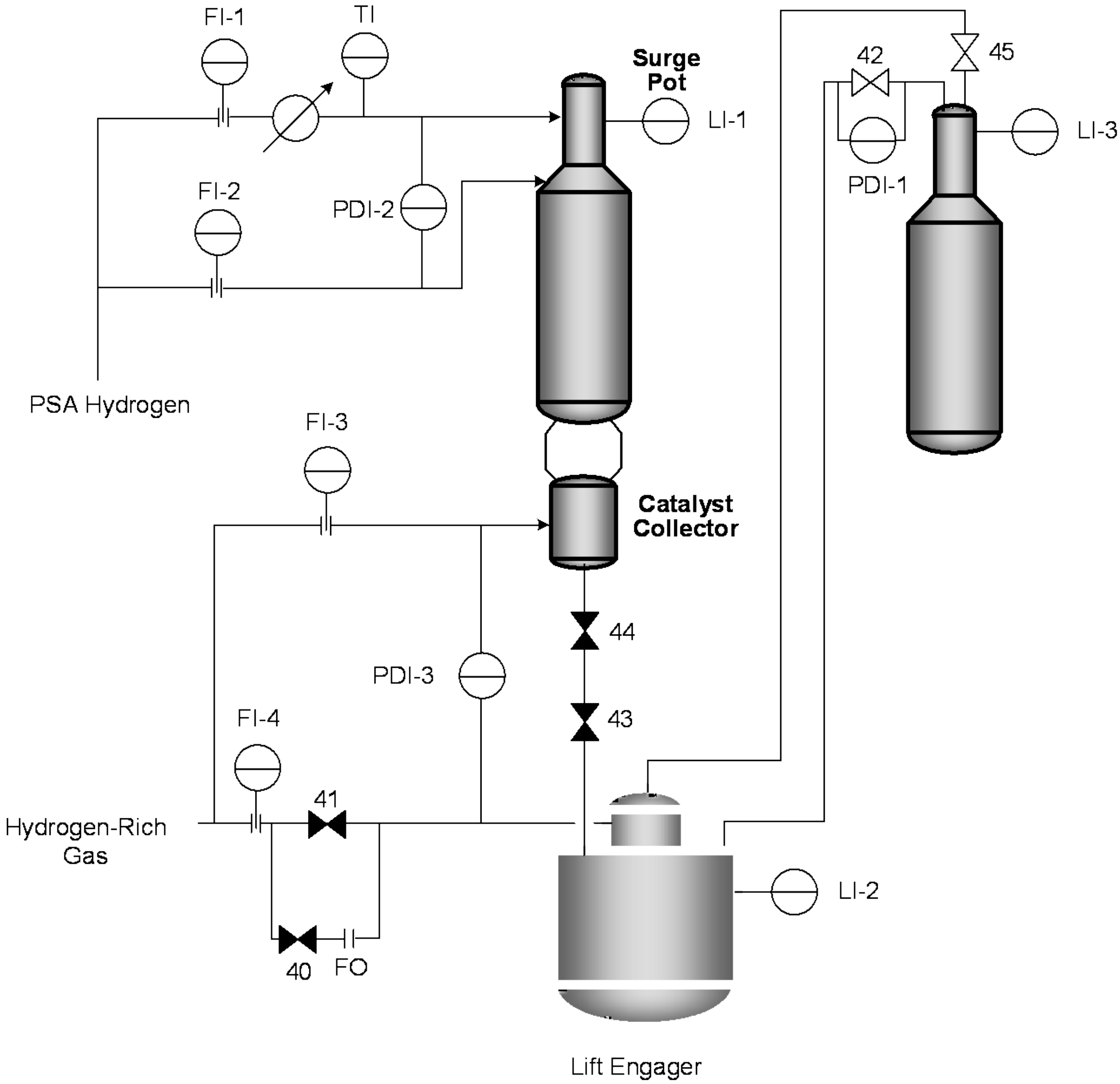
PDI-1 indicates equal pressure between the lift engager and reactor surge pot

Valve 42 is confirmed open

AND

All Lift Engager Sequence valve positions are verified.

Step 8



Valve 45 opens to set up the catalyst transfer path between the lift engager and the reactor surge pot.

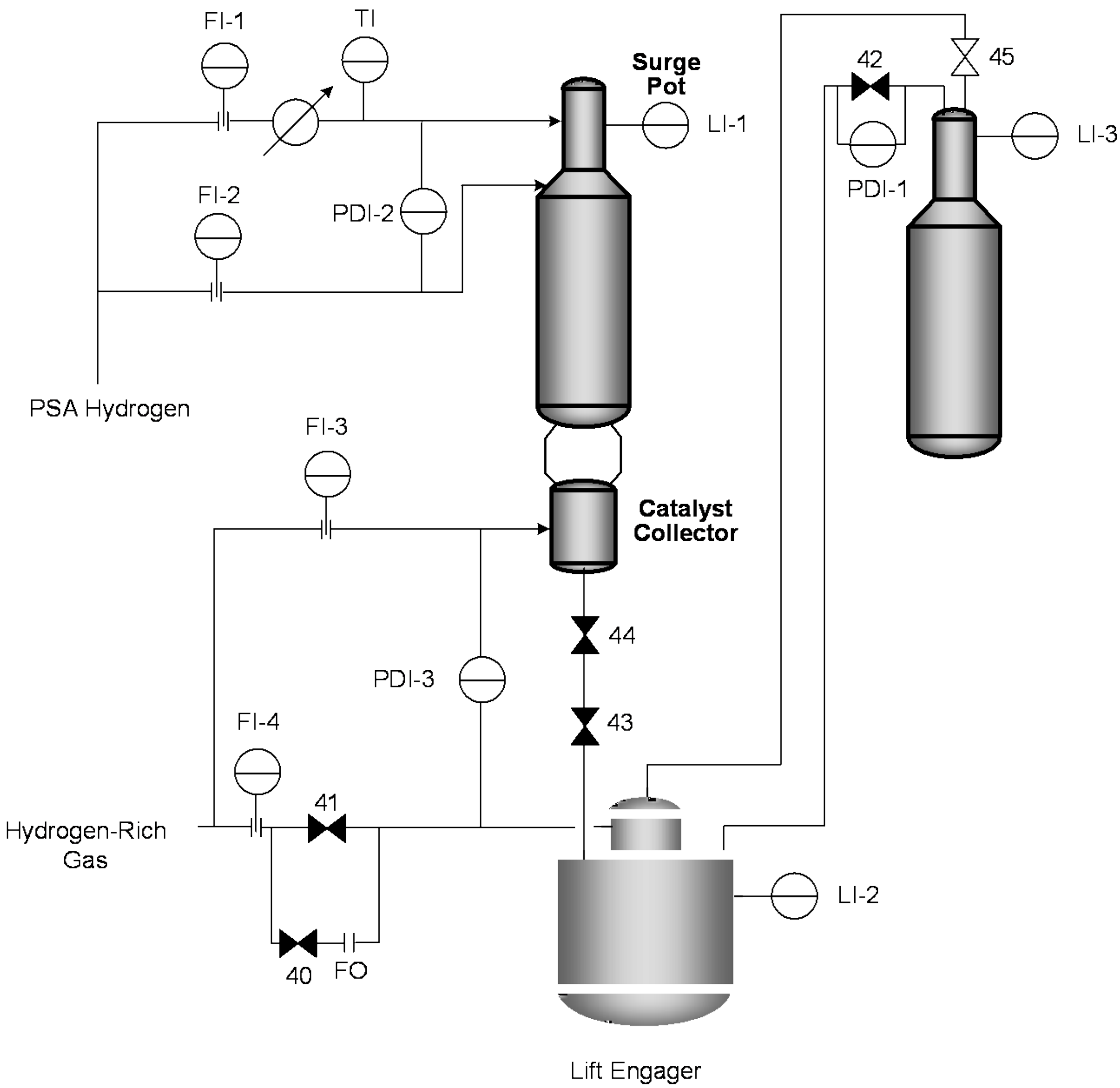
The sequence advances to the next step when:

Valve 45 is confirmed open

AND

All Lift Engager Sequence valve positions are verified.

Step 9



Valve 42 closes since Valve 45 is open to maintain equal pressure between the lift engager and reactor surge pot.

The sequence advances to the next step when:

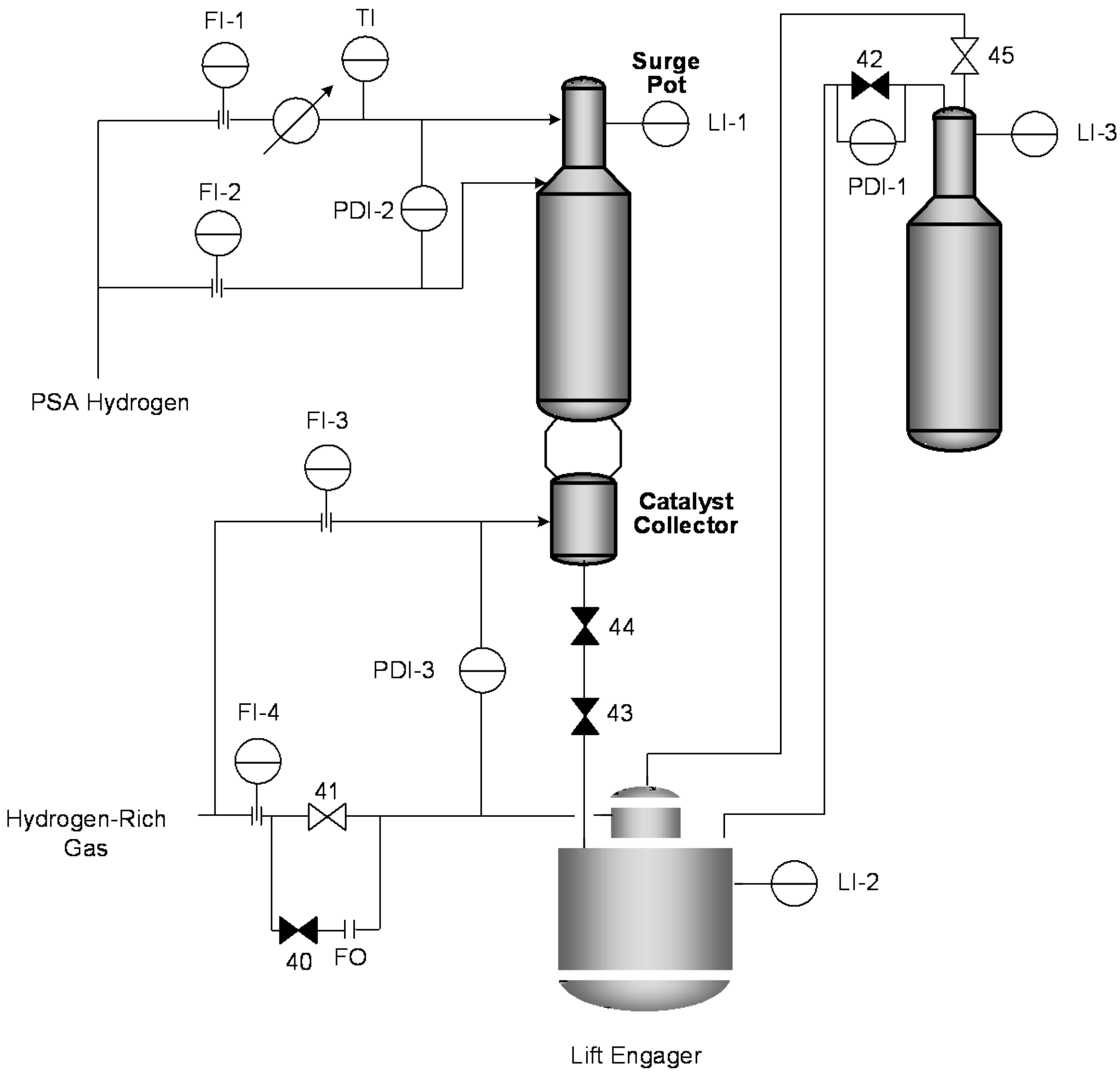
PDI-1 indicates equal pressure between the lift engager and the reactor surge pot.

Valve 42 is confirmed closed

AND

All Lift Engager Sequence valve positions are verified.

Step 10



If the Lift Engager Start/Stop Pushbutton indicator turns red during this step, the step completes before going to the Stop position. Advancing immediately to the Stopped position could close ball valve Valve 45 on catalyst, which could cause valve damage.

During this step, the low lift gas flow alarm activates if:

FI-4 indicates low lift gas flow

AND

Valve 41 is confirmed open for a minimum of five (adjustable) seconds

The low lift gas flow alarm clears at the end of this step, if activated.

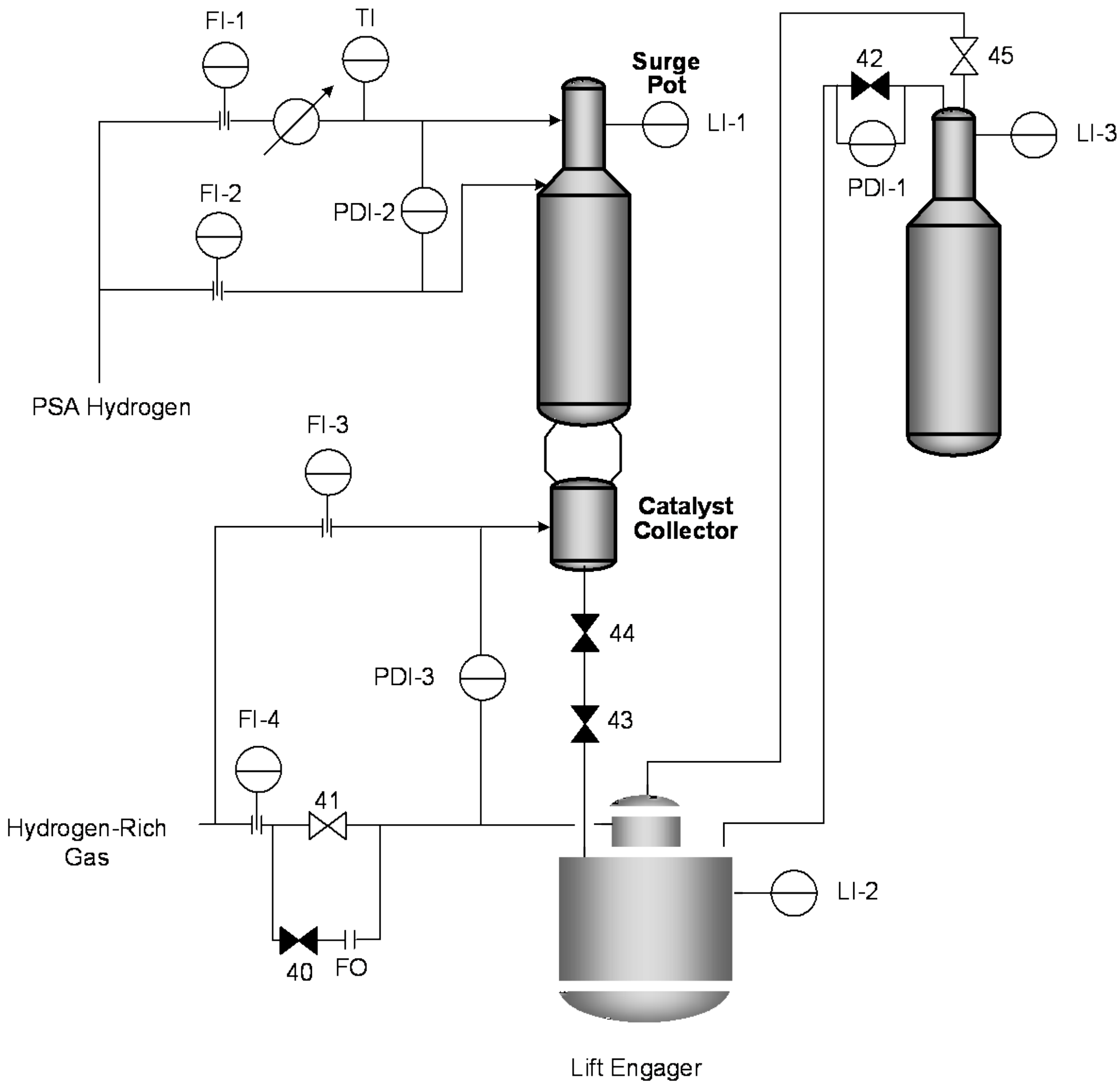
The Long Cycle Timer starts if entering this step directly from Step 0.

The Lift engager transfers catalyst with the following steps:

1) Opens Valve 41 to lift catalyst from the lift engager to the surge pot
2) Starts the Lift Initiation Timer (2 minutes)
3) Waits until PDI-1 indicates high lift engager-surge pot differential pressure. A high differential indicates that the catalyst is lifting properly.
4) Waits until PDI-1 ndicates equal pressure between lift engager and the reactor surge pot.. Equal pressures indicate that the catalyst transfer is complete.
5) Starts the Lift Delay Timer if conditions 3 and 4 are satisfied and Lift Initiation Timer has not expired.

Step 10 continues on the following page.

Step 10 (Continued)



The sequence advances to the next step when:

The Lift Engager Start/Stop Pushbutton indicator is in the Running (green) position

Valve 41 is confirmed open

Condition 3 has not been satisfied and the Lift Initiation Timer expires

AND

The Lift Delay Timer has expired

AND

All Lift Engager Sequence valve positions are verified.

The sequence advances to the Stop position when:

The Lift Engager Start/Stop Pushbutton Indicator is in the Stopped (red) position

The Lift Delay Timer expires

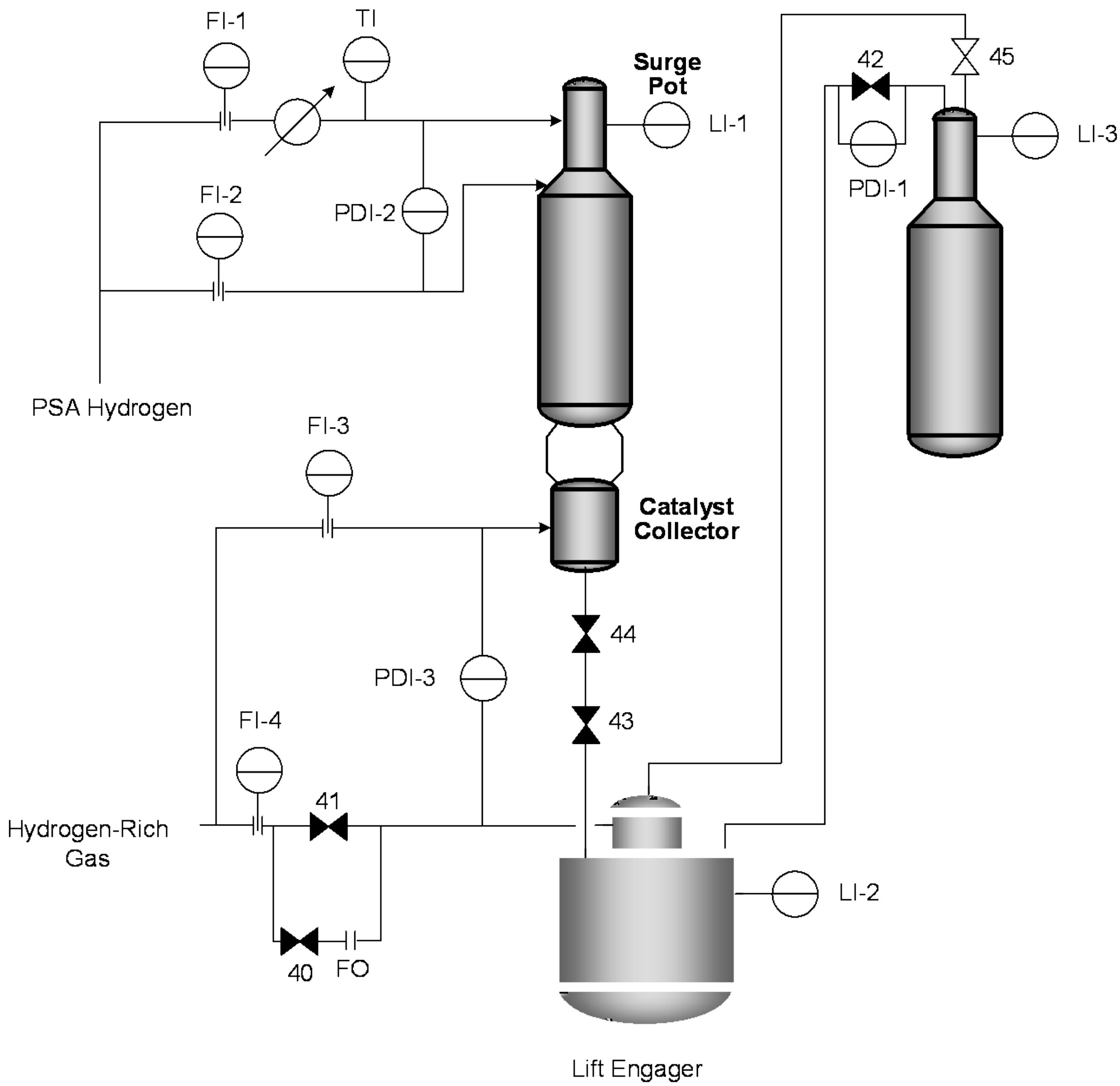
OR

Condition 3 has not been satisfied

AND

the Lift Initiation Timer expires. If the Lift Delay Timer expired, the Lift Engager Counter increments to count the number of catalyst loads sent to downstream Reactor.

Step 11



Valve 41 closes to stop lift gas flow to the lift engager.

The sequence returns to Step 0 when:

Valve 41 is confirmed closed

AND

All Lift Engager Sequence valve positions are verified.

IX. ANALYTICAL

A. Laboratory Test Schedule

Note: Refer to the UOP Engineering Project Specifications for the Test Methods and Sampling Schedule (934 Specification) for specific unit details.

Stream and Test Name	Test Method Number
Disengaging Hopper Product	
Size Distribution	UOP 333
Catalyst at Lower Burn Zone Outlet	
Carbon	UOP 703
Chloride	UOP 291
Loss on Ignition	UOP 954
Catalyst at Flow Control Hopper	
Carbon	UOP 703
Chloride	UOP 291
Loss on Ignition	UOP 954
Lift Gas Nitrogen	
Hydrogen	Online Analyzer
Regenerator Vent to Desuperheater	
HCl	Draeger
SO2	Draeger
Cl2	Draeger
CO2	Draeger
CO	Draeger
H2S	Draeger

Stream and Test Name	**Test Method Number**
NOx	Draeger
<u>Regenerator Vent Gas to Atmosphere</u>	
HCl	Draeger
SO2	Draeger
Cl2	Draeger
CO2	Draeger
CO	Draeger
H2S	Draeger
NOx	Draeger
<u>Circulating Caustic</u>	
%NaOH	UOP 209
pH	Online Analyzer
Total Dissolved Solids	APHA 2540-C
Total Suspended Solids	Online Analyzer
<u>Fines Drum</u>	
Size Distribution	UOP 333
<u>Catalyst from LE #1</u>	
Carbon	UOP 703
Chloride	UOP 291
<u>Catalyst from LE #2</u>	
Carbon	UOP 703
Chloride	UOP 291
<u>Catalyst from LE #3</u>	
Carbon	UOP 703

Stream and Test Name	**Test Method Number**
Chloride	UOP 291
<u>Catalyst from LE #4</u>	
Carbon	UOP 703
Chloride	UOP 291
Loss on Ignition	UOP 954
Size Distribution	UOP 333
<u>Reduction Zone Outlet Gas</u>	
Composition	UOP 539
HCl	Draeger
<u>Gas from Catalyst Collector below last Reactor</u>	
HCl	Draeger
<u>Lower Burn Zone Inlet Gas</u>	
Oxygen	Online Analyzer
<u>Upper Burn Zone Inlet Gas</u>	
Oxygen	Online Analyzer
<u>Chlorination Zone Vent Gas</u>	
Oxygen	Online Analyzer

B. Catalyst samples and Shipment to uop for analysis

While the above analyses are sufficient for normal operation of the CCR section, UOP offers additional catalyst analysis for troubleshooting catalyst-related issues and to provide an evaluation of the catalyst performance and estimate of remaining catalyst life. These analyses can be provided on an as-needed basis, or on a regularly scheduled basis. The analysis can include:

- Percent carbon on catalyst (spent or regenerated)
- Percent chloride on catalyst
- Percent sulfur on catalyst
- Loss on Ignition
- Trace metals content on catalyst
- Catalyst piece crush strength
- Platinum agglomeration by X-ray diffraction
- Catalyst attrition
- Surface area measurement
- Catalyst activity using combitorial chemistry
- Detailed structural analysis using scanning electron microscope

Please contact UOP for further information including price, terms and conditions.

In order to comply with U.S. regulatory laws outlined by the Environmental Protection Agency (EPA) and United States Customs, UOP LLC must ensure that all chemical substances imported into the United States adhere to the prescribed procedures. Please contact UOP Technical Services for the current forms and procedures for shipment of catalyst samples to UOP for analysis.

X. TROUBLESHOOTING

This section covers problems with the logic control systems, analyzers, and ball valve leakage.

A. Abnormal Load Alarm

There are two timers that monitor if catalyst is being loaded into the Lift Engager/Lock Hopper within a specified time, the Abnormal Load Minimum Timer and the Abnormal Range Timer.

The Abnormal Load Minimum Timer starts when the Vee Port valve above the Lock Hopper/Lift Engager opens and catalyst starts to flow. The Abnormal Load Minimum Timer is set during commissioning so that it will time out before the Lock Hopper/Lift Engager catalyst level is satisfied. A typical timer setting for the minimum range timer is ~30 seconds before the Lock Hopper/Lift Engager catalyst level is satisfied. If the catalyst level in the Lock Hopper/Lift Engager is satisfied before the Abnormal Load Minimum Timer times out, the Abnormal Load Alarm will sound. This would be an indication that the Lock Hopper/Lift Engager is being loaded with catalyst too quickly. The operator should monitor the next time the Lock Hopper/Lift Engager is loaded to ensure the following:

1. Normally the catalyst loads by gravity flow only. If there is a co-current gas flow downward, due to a leaking valve, catalyst flow into the Lock Hopper/Lift Engager will be faster than normal.

2. If the PDI between the Catalyst Collector and the Lock Hopper/Lift Engager is not calibrated properly, a pressure differential between the Catalyst Collector and Lock Hopper No. 1 could exist, causing fast catalyst loading.

3. Confirm that the detector switching point is operating properly. The level should show when 2/3 of the diameter at the point of the nuclear detector

and source is filled with catalyst. When the vessel is empty the detector can be calibrated using the catalyst equivalent mass in lead plates.

4. Confirm that the level detector and source are both set at the same elevation, corresponding to the desired load size.

5. Confirm that the Lock Hopper/Lift Engager is being completely unloaded during each cycle. If some catalyst remains in the vessel from the previous cycle, the time required to partially refill the vessel is reduced.

After the Abnormal Load Minimum Timer times out, the Abnormal Range Timer begins. A typical timer setting for the Abnormal Range Timer is set during commissioning and should be set for 60 seconds. If the Lock Hopper/Lift Engager catalyst level is satisfied before the Abnormal Range Timer times out, no alarm sounds. However, if the Abnormal Range Timer times out before the catalyst level is satisfied in the Lock Hopper/Lift Engager, the Abnormal Load Alarm will sound. This would be an indication that the Lock Hopper/Lift Engager is being loaded with catalyst too slowly. The operator should monitor the next time the Lock Hopper/Lift Engager is loaded to ensure the following:

1. If there is countercurrent gas flow upward, the catalyst will load slowly. The primary causes of slow catalyst loading is a leak through the Lift Engager pressure-up valve. On Lock Hopper 2, the slow loading could be caused by a low Surge Hopper nitrogen purge flow.

2. If the level detector calibration has been changed or the Abnormal Load Minimum Timer has been readjusted, the Abnormal Load alarm may sound while a normal volume of catalyst has been transferred.

3. Confirm that all of the valves above the Lock Hopper/Lift Engager are opening completely during the Load step and there is no foreign material that may prevent catalyst from flowing into the Lock Hopper/Lift Engager.

B. Lift Engager Lift Rate

There is a direct relationship between the axial “gap” of the two concentric lift pipes in the Lift Engagers and the catalyst transport rate. Due to the geometry of the two lift pipes, a certain amount of gap is required before the inner pipe is nearly immersed in the catalyst below the outer pipe. No catalyst is lifted until the inner pipe is nearly immersed in the catalyst. The amount of gap above this minimum requirement is directly proportional to the catalyst transport rate.

Since the angle of repose of the catalyst is nearly 30 degrees, the minimum gap to just start lifting the catalyst is equal to one-fourth of the difference in inside diameters of the two lift pipes. With one gap setting, its corresponding transport rate and the minimum gap requirement, a new gap setting to achieve the desired transport rate is found by linear interpolation. An approximate slope of catalyst transport rate per increment in gap is 3600 lb/hr-in2 per inch of gap increase, based on the inner pipe inside cross-sectional area (10 kg/hr-cm2 per mm of gap increase).

The desired lift rate of the last reactor Lift Engager is such that there will be a 15 lb/hr-in2 catalyst flux in the elutriator tube, based on the tube inside cross-sectional area.

The desired lift rate of the Regeneration Section Lift Engager is such that the transport rate should be no less than 120% of the design circulation rate of the unit and no more than 600 lb/hr-in2, based on the inside cross-sectional area of the lift pipe.

The desired lift rate of the inter-reactor Lift Engagers is such that the transport rate should be no less than 120% of the design circulation rate of the unit and no more than 600 lb/hr-in2, based on the inside cross-sectional area of the lift pipe.

C. Logic Controllers

Problems with the logic control systems can be found and isolated by using a logical systematic approach. A detailed write-up describing the operation of the Lock Hopper

Control System is contained in the Equipment Instructions and Data Book supplied by UOP for the Lock Hopper Control System.

D. Hazardous Gas Mixtures

Two hydrogen-hydrocarbon analyzers are provided with the Regeneration Section to detect hazardous gas mixtures. One analyzer monitors the nitrogen lift gas and the other is for the Surge Hopper nitrogen gas blanket.

a. For the lift gas system, the possible contamination problems, causes, and solutions are as follows:

i. A high hydrogen content indicates leaking catalyst load ball valves, catalyst unload ball valves or insufficient purging of Lock Hopper 1. If the hydrogen content increases above 0.5 mol%, check the ball valves for leakage and/or increase the number of purges (i.e., increase the setting on the Purge Selector Switch for Lock Hopper No. 1 Controller).

ii. High hydrocarbon content indicates insufficient or improper Catalyst Collector purging and/or nitrogen purging of the spent catalyst in Lock Hopper 1. If the hydrocarbon content temporarily goes high, usually when initiating catalyst flow from the Catalyst Collector after a prolonged shutdown, a small bleed of lift gas at the blower discharge will purge the circulating nitrogen stream.

Care must be exercised when establishing this small bleed to avoid losing the Disengaging Hopper/Regeneration Tower differential pressure and shutting down the Regenerator Tower. If the hydrogen/hydrocarbon content remains higher than 0.5% check to be sure that the proper purge rates are established at the Catalyst Collector and Lock Hopper 1.

Normally the nitrogen lift gas should contain only trace quantities of either hydrogen or hydrocarbon. Do not allow any appreciable quantities of hydrogen or hydrocarbon to collect in the lift gas since it will consume oxygen in the Regenerator. The obvious danger of contacting excess quantities of hydrogen or hydrocarbon with hot oxygen must be avoided.

b. For the Surge Hopper nitrogen blanket gas, the possible contamination problems, causes, and solutions are as follows:

i. A high hydrogen content indicates leaking load ball valves and/or a plugged load bleed line. Since the high hydrogen content in the Surge Hopper will cause the master controller to shut down, the source of the problem should be corrected as soon as possible.

ii. High hydrocarbon content in the Surge Hopper can only occur when spent catalyst with excessive hydrocarbon content is added to the Surge Hopper. The possibility of this occurrence is rare; but if it is necessary to add spent catalyst to the Surge Hopper, be sure to first purge any hydrocarbon from the catalyst. If a high hydrocarbon level ever exists in the Surge Hopper, increase the nitrogen purge flow to maximum to purge the hydrocarbon from the system as quickly as possible.

Note: A high rate of nitrogen purge to the Surge Hopper may prevent normal loading of Lock Hopper 2. To avoid this problem, it is advisable to discontinue Lock Hopper 2 operations temporarily while carrying out this rapid Surge Hopper purging.

E. Lock Hopper Valve Leakage

Flow instruments with high flow alarms are installed in the bleed headers for each Lock Hopper. Although in most cases catalyst transfer can continue until the leaks become excessive, leaking ball valves should be repaired when possible to avoid catalyst loss or damage and possible hazardous situations.

F. Expert System

UOP has available the "Oleflex CCR Catalyst Circulation Expert System". This tool is a computer-based diagnostic tool that simulate the interactions an operator might have with UOP Technical Service specialists for Oleflex when trying to troubleshoot particular problems within the catalyst circulation portion of the CCR section of the unit. The system "asks" the user a series of questions about the problem and then provides possible causes and suggested solutions. Please contact UOP for more information regarding this system.

XI. NORMAL SHUTDOWN

MANUAL REGENERATION SECTION SHUTDOWN PROCEDURES

The operator may employ the following procedures to accomplish a normal planned shutdown of the CCR Regenerator Section. The procedures are also applicable for shutdowns caused by one of the following occurrences:

1. A sudden rise in the Regeneration Tower bed temperatures, the top of the Transition Zone thermocouple or Regeneration Zone outlet.

2. Contamination of the nitrogen lift gas system with greater than 0.5% hydrogen contamination or greater than 7.5% hydrocarbon contamination as indicated by the on-stream analyzer.

3. Loss of the electrical heaters within the Regeneration Tower system.

4. Sustained loss of the nitrogen or hydrogen lift gas systems.

5. Loss of the Surge Hopper catalyst level.

6. Cooling water failure.

7. Oleflex Reactor Section shutdown.

The situations listed above do not cover all possibilities, but most other failures result in an automatic shutdown sequence. Information regarding instrument air failure, serious leaks, etc. is given in the Emergency Procedures later in this section.

1. Hot Shutdown Procedure

If the shutdown is only going to be for a short duration (no more than 36 hours), maintain the Regenerator heat input and proceed as follows:

a. Stop catalyst flow by depressing the Catalyst Flow Stop Button.

b. Start a nitrogen purge to the tower by depressing the Nitrogen Button.

c. Stop Chlorine addition by depressing the Chlorine Button.

d. Stop air addition to the tower by depressing the both the Lower and Upper Air Button.

e. Set the Flow Control Hopper timer to zero seconds to prevent the carbon profile in the Regeneration Zone of the tower from being accidentally disturbed during the shutdown.

f. Close the Upper Burn Zone and Lower Burn Zone Air Flow Control Valves.

g. Set the nitrogen flow through the Air Heater at design rate.

h. Depress the Lock Hopper 1 Run-Hold Button once the Disengaging Hopper level is established.

i. Depress the Lift Engager Pushbuttons once the various levels at the tops of the reactors are satisfied (if possible).

j. Depress Lock Hopper 2 to once the level in the Reduction Zone is satisfied.

2. Cold Shutdown Procedure

If the Regeneration Unit shutdown is to last for a period longer than 36 hours (or if vessels or lines are to be opened) proceed as follows:

a. Press the Regenerator Stop Button.

b. Set the Flow Control Hopper Timer to zero seconds to prevent the carbon profile in the regeneration zone of the tower from being accidentally disturbed during the shutdown.

c. Set the Upper Regeneration Heater, Lower Regeneration Heater and Air Heater temperature controllers to manual at zero output.

NOTE: The zero output for the Regeneration Heater is 50% of the output scale since this controller is split range with the Cooling Blower butterfly valve. The butterfly valve is to remain closed.

d. Close the Upper Burn Zone Air Flow Control Valve and the Lower Burn Zone Air Control Valve.

e. Set the nitrogen flow through the Air Heater at design rate.

f. Stop Chlorine addition by depressing the Chlorine Button.

g. Allow Lock Hopper 2 to continue in operation at all times to maintain the Reactor 1 catalyst level.

h. If the Regeneration Tower is going to be entered, requiring the Disengaging Hopper and the tower to be emptied, Lock Hopper 1 should be placed in the hold position to ensure catalyst is not transferred to the Regeneration Section.

i. Continue to cool the tower until all temperatures are down to 205°C (400°F) (or as low as the blowers will allow). Adjust blower speeds on the Upper Regeneration Blower and Lower Regeneration Blowers following vendor recommendations. If the blowers have two speed settings, switch to the lower speed and continue to cool the tower as low as possible. Then shut down the blowers.

j. Continue the design nitrogen purge rate through the Air Heater until all temperatures are down to 95°C (200°F) or lower.

k. Stop the nitrogen purge through the Air Heater. Maintain the Surge Hopper purge rate at design flow. Maintain the design delta P between the Disengaging Hopper and Regeneration Tower. These purges will keep the tower air free.

l. Should it be necessary to open the Regeneration Tower, dump all catalyst into the Surge Hopper by cycling the Flow Control Hopper valves. To prevent a Regeneration Tower shutdown, the low-low differential pressure shutdown will need to be bypassed to allow the Flow Control Hopper to continue operating. Alternatively, both valves can be opened simultaneously manually.

XII. EMERGENCY PROCEDURES

The following situations necessitate immediate shutdown of the Regeneration Section as described below.

1. Instrument Air Failure

Upon instrument air failure, all Masoneilan G-valves in the regeneration system will move to the fail safe positions. However, the ball valves associated with Lock Hoppers 1 and 2 will not move to safe positions. The Upper Burn Zone, Lower Burn Zone and Lower Air control valves will close and the nitrogen valve will open, establishing a nitrogen purge through the Regeneration Tower.

A hot shutdown should be initiated immediately. Complete the shutdown of the Regeneration Section according to the Hot Shutdown Procedure as covered in the Normal Shutdown Chapter of this Manual.

2. Explosion, Fire, Line Rupture, or Serious Leak

Do the following if possible:

a. Turn the “Emergency Stop” switch to the “Off” position. This will immediately close all Vee-port and B-ball valves between the catalyst collectors and lift engagers in the reactor section, between Lock Hopper No1 and the lift engager beneath it, around the Flow Control Hopper and between Lock Hopper No 2 and the lift engager beneath it.

NOTE: Use of the Emergency Stop switch may result in the B-ball valves being closed on catalyst and may result in damage to the valves. Use the “RUN” – “STOP” button to close the Vee-port and B-ball valves with a time-delay between the closing of the Vee-port and B-ball valves to avoid damaging the valves if possible.

b. Isolate the affected area of the unit. Block in high pressure hydrogen service as required.

Note: To avoid coking catalyst in the reduction zone, maintain either the reduction gas or hydrogen lift gas flow to the reduction zone. This flow should continue as long as possible.

c. Complete the shutdown of the Regeneration Section according to the Cold Shutdown Procedure in the Normal Shutdown Chapter of this Manual.

3. Cooling Water Failure

a. Loss of cooling water to the Surge Hopper cooling panels can result in hot catalyst damaging the B-ball valves between the Surge Hopper and Lock Hopper 2. Also, prolonged exposure of hot catalyst to nitrogen may result in nitrogen reduction of the platinum on the catalyst, resulting in a temporary loss of catalyst activity.

b. Loss of cooling water to the Lift Gas Blower Spillback cooler can cause the blower to overheat.

c. The Vent Gas Treatment System may automatically shutdown to prevent high temperatures from damaging the FRP material used in the System. A shutdown of the System will automatically divert the vent gas from the Regeneration Tower from the System to atmosphere.

In case of loss of cooling water, follow the Cold Shutdown Procedure as per the Normal Shutdown Chapter in this Manual.

4. Loss of Chlorine Injection

If chlorine injection into the Chlorination Zone is stopped, the platinum on the oxidized catalyst in the Chlorination Zone will become agglomerated, meaning that the platinum will be in clusters or clumps within the catalyst pill rather than being uniformly dispersed throughout the catalyst pill. Catalyst activity will decrease, resulting in a lower conversion of paraffin to olefin in the reactors.

In the event of loss of chlorine injection, it is recommended that catalyst circulation be stopped until chlorine injection is restored. The reactor inlet temperatures should be reduced as per the Reactor and Fractionation Section emergency procedures for loss of catalyst circulation.

5. Automatic CCR Regenerator Section Shutdown

The Lock Hopper Control System will immediately shut down the Regeneration Section in case of an emergency or unsafe condition. There are two types of shutdowns.

A hot shutdown of the Regeneration Tower will:

- Stop catalyst circulation via the Flow Control Hopper
- Stop flow of air to the Upper Burn Zone, Lower Burn Zone and Chlorination Zone
- Stop chlorine injection to the Chlorination Zone
- Start nitrogen flow to the Chlorination Zone

The following items will cause the Regenerator to go into a hot shutdown

- High temperature Circulating gas from Regeneration Tower
- High temperature in any one of the temperature indicators in the Upper Burn Zone or Lower Burn Zone of the Regeneration Tower
- Low circulating regeneration gas across the Regeneration Heater
- Low gas flow to the Air Heater

- Low nitrogen purge flow to the Surge Hopper
- Low differential pressure between the Disengaging Hopper and the Regeneration Tower
- Shutdown of Regeneration Blower
- Upper Burn Zone oxygen analyzer trouble

A cold shutdown of the Regeneration Tower will do the same as a hot shutdown; and in addition will:

- Stop power to the Upper Regeneration Heater
- Stop power to the Lower Regeneration Heater
- Stop power to the Air Heater

The following items will cause the Regenerator to go into a cold shutdown:

- High H2/HCBN reading in the Surge Hopper
- Shutdown of the Vent Gas Treating System
- High temperature – circulating gas from Regeneration Tower
- High temperature – any one of the temperature indicators in the Upper Burn Zone or in the Lower Burn Zone
- High temperature – Transition Zone
- High temperature Chlorination Zone
- High differential temperature between Chlorination Zone and the Air Heater outlet

XIII. SPECIAL PROCEDURES

A. Trickle Mode and Low Firing Mode

UOP designs the Oleflex reactor internals such that they can accommodate certain transient temperature changes during normal operations as well as during startups and shutdowns. However, due to the fact that it is possible to exceed the limits of this design, operations personnel must have a thorough understanding of these limits and how to avoid exceeding them. Following any trip of the Reactor Effluent Compressor (REC), the Oleflex fired heaters will shut down. By their nature, the fired heaters cool down at a faster rate than do the Oleflex reactor internals and catalyst bed.

Upon commissioning of the REC, the colder gas present in the heater coils causes the inner screen to shrink slightly, increasing the volume of the catalyst annulus into which catalyst from above flows. As time passes following the compressor restart, the reactor outer basket and catalyst bed cool down as well. The net effect of this cycle is to open the catalyst annulus volume, fill it with catalyst from above, and then attempt to reduce the volume to its original level. During the last step of this cycle, the screen compresses the catalyst, which in turn applies radial force back to the screens. If this force (hoop stress) is severe enough, radial buckling of the inner screen will result. To preclude this excessive hoop stress on the screen during restart of the REC, UOP has developed a procedure termed low-firing mode. This procedure is described in detail within the Oleflex Reactor Section General Operating Manual and must be adhered to in order to prevent reactor internals failure.

The Trickle Mode of operation is the second major procedural event designed to preclude any damage to the reactor internals. Trickle Mode is performed after the REC is restarted and is designed to relieve the catalyst bed pressure (hoop stress) generated during the REC restart. Although the inner screen can tolerate the hoop stress generated by the maximum allowable heater/reactor delta T during REC restart, the axial stress which would be created during heat up of the reactor can cause axial failure of the inner screen if the catalyst bed pressure is not removed prior to the heat up. This is the purpose of Trickle Mode. Following the REC restart, catalyst is removed from the Oleflex reactors in very small increments to ensure a uniform decrease in catalyst bed density within the reactor annulus. Thus, after completing Trickle Mode, any catalyst bed pressures above normal are removed, thereby eliminating the possibility of excessive axial stress developing during reactor heat up. With this accomplished reactor section heat up then commences. The Trickle Load function is accomplished using the existing catalyst transfer equipment and a sub-routine within the Lock Hopper Control System.

During normal operation, the combustible gases vented from Lock Hopper 1 are vented to the Charge Heater via the vent and vent drum system instead of to the relief header; this is done to avoid the potential of hydrogen or hydrocarbon gas in the relief header from being pressured into Lock Hopper 1. During Trickle Mode however, the Oleflex fired heaters are not in operation, except for low firing mode. Accordingly, the combustible gases are routed to the relief header, which is normally at a higher pressure. To ensure proper depressuring of the Lock Hopper 1 during Trickle Mode, the set point of Lock Hopper 1 pressure switch is changed within the Lock Hopper Control System and the number of purges performed on Lock Hopper 1 will be automatically increase by one.

The proper sequence of events following a compressor trip is described below:

1. Reactor Effluent Compressor shuts down. REC restart permissive is disabled until supervisory switch is activated later in the restart procedure, indicating that conditions which could lead to reactor internals failure do not exist.

2. Oleflex fired heaters trip on low recycle gas flow, or low net reactor effluent flow to the separation system.

3. The Trickle Load indicator lights turn on at the LHCS control panel. At this time, the Oleflex fired heater enable signal is removed. The Lock Hopper 1 vent system is automatically routed to the relief header. Although the Lock Hopper systems have shut down, continue to operate the Regeneration Tower in white burn mode by cycling the FCH. Continue this operation until the volume of catalyst to be trickle loaded out of the last Reactor into Lock Hopper 1 has been removed from the Disengaging

Hopper. Then perform a hot shutdown of the Regeneration Tower. This operation will ensure that the Disengaging Hopper catalyst level remains low during the entire Trickle Mode such that Lock Hopper 1 can operate without restarting the Regeneration Tower.

4. As detailed in the Oleflex Reactor Section General Operating Manual, low-firing mode is performed as necessary to prevent excessive hoop stress from developing on the reactor internals during REC restart. Following low-firing mode, the supervisory permissive for REC restart is activated, and the REC is restarted.

5. Following line out of the REC operation and upon pressing the Lock Hopper 1 pushbutton, Lock Hopper 1 will automatically start in the Trickle Mode of catalyst transfer, and upon pressing the Lift Engager Button, the Lift Engager will automatically start in the Trickle Mode of catalyst transfer. If low-firing mode was used before and during REC restart, then the heat input to each heater MUST be maintained at the same level during the entire Trickle Mode proceedings. This will ensure no excessive axial stresses develop on the inner screen before all abnormal catalyst bed pressure is removed via Trickle Mode.

Normally the cycle begins with Lock Hopper 1 partially or completely filled with spent catalyst under pressure in a hydrogen rich atmosphere. The following tabulation outlines Loch Hopper 1 sequence of operation.

Basic Step	Operation
Ready	Lock Hopper 1, full of catalyst and under hydrogen pressure, waits for a signal to start the cycle.
Purge	Lock Hopper 1 is depressured and purged with nitrogen. All vent gases are routed to the relief header. Number of purges is increased by one.
Unload	Catalyst is unloaded to the Lift Engager and transferred to the Regeneration Section.

Pressure	Lock Hopper 1 is pressured with nitrogen.
Load	Catalyst is loaded from the Catalyst Collector to the Lock Hopper 1 by cycling the V-ball valve below the Catalyst Collector.

At the end of the Load step, the Lock Hopper 1 returns to the "READY" condition. Trickle Mode of operation continues until the specified number of cycles is completed. When Lock Hopper 1 and the inter-reactor Lift Engagers have all satisfied this requirement, the Oleflex fired heaters permissive start relay is activated (this refers to the main fuel gas permissive – low firing mode fuel header is already in service). Heat up of the Oleflex reactor section may begin at this time.

Note that previous operating procedures refer to a REC restart timer, typically set at 15-30 minutes, which dictated the amount of time allowed for REC restart. The timing out of this timer disabled the REC restart permissive such that a supervisory override was necessary to restart the REC, and it also activated Trickle Mode. UOP strongly recommends performing Trickle Mode after every REC trip or trip of the fired heaters even if the REC remains in operation. Thus, it is recommended that existing REC restart timers be set to a very short timer setting (10 seconds) to ensure that Trickle Mode will be automatically activated after every REC trip. The need to reset the REC startup permissive is still referred to in Step 4 above.

With respect to operation of the Lift Engager in the inter-reactor circulation section, normally the cycle begins with the Lift Engager empty and under pressure in a hydrogen rich atmosphere. Within the Trickle Mode however, consideration must be given to the possibility that the Lift Engager contained catalyst prior to the REC shutdown. Accordingly, the Lift Engager is first emptied. This ensures that all of the loads taken out of the reactors during the Trickle Mode are full loads. The following tabulation outlines the lift engager sequence of operation.

Basic Step **Operation**

Depressure	The Lift Engager is depressured to the downstream reactor pressure.
Lift	Catalyst is lifted to the downstream reactor.
Ready	Lift Engager is empty and under positive hydrogen pressure.
Pressure	The Lift Engager is pressured with hydrogen to the same pressure as the reactor above.
Load	The catalyst is loaded into the Lift Engager by cycling the V-ball valve above the Lift Engager.

At the end of the Load step, the Lift Engager returns to the Depressure step. Trickle Load Mode of operation continues until the required number of cycles is completed. When Lock Hopper 1 and the inter-reactor Lift Engagers have all satisfied this requirement, the Oleflex fired heaters permissive start relay is activated (main fuel gas header permissive - low-firing mode fuel header was already in service). Heat up of the Oleflex reactor section may begin at this time.

During Trickle Mode, catalyst is not moved from the Surge Hopper to the reduction zone on top of Reactor No 1, thus there are no special steps for Trickle Mode for Lock Hopper 2. To prevent the possibility of transferring non-reduced (or partially reduced) catalyst to Reactor 1 from the Reduction Zone, the controller will not allow more than the specified number of Trickle Mode loads of catalyst to be removed from Reactor 1.

B. Catalyst Fines Survey

A suggested catalyst fines survey procedure is outlined below:

1. Prior to the survey:

a. Thoroughly blow down the Dust Collector.

b. Install an empty tared 55 gallon drum beneath the Dust Collector to collect fines.

c. Set the elutriation gas flow at the desired rate. Set the nitrogen lift gas flow at design rate based on lifting catalyst.

d. Record the Lock Hopper 1 and Lock Hopper 2 transfer counters.

2. During the survey:

a. Hold lift and elutriation gas flows steady to provide constant elutriator velocity.

b. Collect a 500 cc composite sample of catalyst from the Disengaging Hopper.

3. At the conclusion of the survey:

a. Thoroughly blow down the Dust Collector.

b. Determine the net weight of fines collected during the survey.

c. Collect a 500 cc sample of the fines drum material.

d. Record the Lock Hopper 1 and Lock Hopper 2 transfer counters.

e. Determine the size distribution of the Disengaging Hopper product catalyst and fines drum material using the UOP specified test method.

f. Calculate the percent removal of the various particle sizes as follows:

   i. Based on Lock Hopper 1 transfer counts, determine the total weight of catalyst fed to the elutriator during the survey.

   ii. Determine the total weight of Disengaging Hopper product by subtracting the total fines weight from the total feed weight.

   iii. Calculate the weight of the various size ranges making up the Disengaging Hopper product and fines streams by multiplying the size distribution results by the respective total stream weights.

   iv. Calculate the weight of the various size ranges making up the Disengaging Hopper feed by adding the weight breakdowns on the Disengaging Hopper product and fines streams.

   v. Determine removal of the various size ranges by dividing the weights of each size range contained in the fines stream by the corresponding weights contained in the feed stream. Convert fractions to percent.

   vi. On five cycle semi-log graph paper, plot percent removal on the log scale versus average particle size on the linear scale.

An example of typical fines survey calculations is presented below:

FINES SURVEY CALCULATION EXAMPLE

Given the following plant data:

L.H. 1 transfers during fines survey	21
L.H. 1 load size	52.164 kg
Total fines collected during fines survey	870.91 g.

Fines and D.H. sample size breakdown as follows:

	Size Breakdown	
Size (U.S. Sieve No.)	**Fines** (wt%)	**D.H. Product** (wt%)
14	6.02	99.7471
16	49.69	0.2370
18	23.01	0.0150
20	11.72	0.0009
30	3.19	0.00002
Pan	6.37	0.0000

The fines removal efficiency during the survey is calculated by the following steps:

a. Total catalyst circulated during survey period (MT)
MT = (21)*(52.164) = 1095.444 kg

b. Total D.H. Product (MD)
MD = 1095.444 -0.87091 = 1094.573 kg

c. Calculated spent catalyst size breakdown
For each size range:
Fines + D.H. Product = Spent Catalyst
i.e., for 14 mesh
(6.02)(0.01)(870.91) + (99.7471)(0.01)(1094573) = 1091856.89 etc.

	Size Breakdown by Analysis				Cat. Size Breakdown
Size (U.S. Sieve #)	**Fines (Wt%)**	**(Grams)**	**D.H. Product (Wt%)**	**(Grams)**	**Spent Catalyst (Grams)**
14	6.02	52.429	9.7471	109184.47	91856.89
16	49.69	432.79	0.2370	2593.71	3026.50
18	23.01	200.42	0.0150	163.98	364.40
20	11.72	102.03	0.0009	10.09	112.12
30	3.19	27.75	0.00002	0.28	28.03
PAN	6.37	55.50	0.00005	0.56	56.06
(SUM)		870.91		1094573.09	1095444.00

d. Fines removal efficiency for each size range

$$\frac{\text{Fines}}{\text{Spent Catalyst}} \times 100 = \text{wt\% removal}$$

i.e., For 14 mesh

$$\frac{52.429}{1091856.89} \times 100 = 0.0048\%$$

Size (U.S. Sieve No.)	**Avg. Particle Size (In.)**	**Wt% Removed**
14	0.055	0.0048
16	0.0505	14.3
18	0.0425	55.0
20	0.036	71.0
30	0.028	99.0
PAN	0.023	99.0

C. Adding Fresh Catalyst

Fresh catalyst is periodically added to the Surge Hopper to replenish catalyst which has been removed as fines via the Dust Collector. The fresh catalyst is added via the Catalyst Additional Funnel and Catalyst Addition Lock Hopper, which are located above the Surge Hopper. The Funnel and Hopper are sized to hold approximately one drum of catalyst.

B- type ball valves, controlled by the Lock Hopper Control System (LHCS), are located above and below the Catalyst Addition Lock Hopper and are provided to isolate the Catalyst Addition Lock Hopper and the Surge Hopper from the Catalyst Addition Funnel. A manual switch, located at the Funnel is provided to allow the operator to signal the Lock Hopper Control System when the upper valve is to be opened for loading the Catalyst Addition Lock Hopper, and when the lower valve is to be opened for unloading the Catalyst Addition Lock Hopper.

D. Cleaning Regeneration Tower Inner Screen

Periodically, the Regeneration Tower inner screen will require cleaning, to remove catalyst dust and chips from the screen. If not removed, gas flow distribution through the Upper Burn Zone and Lower Burn Zone may be impacted.

In order to clean the screen, the following steps should be taken:

- Reduce the reactor inlet temperatures to 600 C, in order to minimize coke on catalyst while catalyst circulation is stopped.

- Place Lock Hopper 1 in the STOP position. This will prevent catalyst from being circulated into the Disengaging Hopper.

- Once the level in the Disengaging Hopper is low, stop all air flow to the Regeneration Tower, stop chlorine injection and start nitrogen flow to the Chlorination Zone.

- Stop the Upper Regeneration Heater, Lower Regeneration Heater and Air Heater. Maintain nitrogen flow to the Chlorination Zone. Shut down the Vent Gas Treatment System per vendor recommendations.

- Shutdown the Regeneration Blower, the Lift Gas Blower and (if provided) the Fines Removal Blower.

- Bypass the low–low differential pressure shutdown signal between the Disengaging Hopper and the Regeneration Tower. Increase catalyst circulation to design rate and continue circulating catalyst via the Flow Control Hopper until all catalyst in the Disengaging Hopper and Regeneration Tower has been transferred into the Surge Hopper.

- Stop nitrogen flow to the Chlorination Zone and to the chlorine stripping zone.

- Disconnect the catalyst transfer pipes from the Disengaging Hopper to the Regeneration Tower. Remove the circulating regeneration gas outlet elbow from the top of the Regeneration Tower. Disconnect the vent line from the Chlorination Zone. Unbolt the Regeneration Tower top head. Disconnect the multi-point catalyst bed thermocouple assemblies from the junction boxes.

- Using the trolley supplied with the structure, or a crane, lift the top head and the inner screen up until the bottom of the inner screen is clean of the top head flange. Move the inner screen away from the Regeneration Tower and lower it to the deck, providing sufficient protection beneath the screen from damage.

- Using stainless steel wire brushes, clean the screen of all catalyst fines and dust. Inspect the profile wire of the screen for any damage. Screen slot size should be compared against the dimensions specified in the UOP Engineering Project Specifications, and should be repaired if the slot size exceeds the specified dimension.

- Inspect the multi-point thermocouple assemblies for any signs of damage or mis-alignment.

- Inspect the outer screen, which will remain inside the Regeneration Tower. Typically, the outer screen will not require cleaning. Care should be taken not to drop any tools, debris etc into the bottom of the Regeneration Tower.

- Once the inspection and cleaning is completed, carefully replace the inner screen into the Regeneration Tower. A new gasket should be used for the top head flange and all other flanges which have been opened. Reattach the Upper Burn Zone outlet elbow, Lower Burn Zone outlet elbow, and the catalyst transfer pipes from the Disengaging Hopper. Reattach the multi-point thermocouple assemblies.

- Once the Regeneration Tower and Disengaging Hopper have been reassembled, reload the catalyst in the same order it was taken out through the top of the Disengaging Hopper.

- Start nitrogen flow to the Chlorination Zone and to the chlorine stripping zone. Sample the nitrogen from the Regeneration Tower using the sample connection on the catalyst transfer line from the Disengaging Hopper, to ensure that the oxygen concentration is less than 0.5 mole %.

- Disengaging the low-low differential pressure shutdown signal bypass for the Disengaging Hopper and the Regeneration Tower.

- Restart Lock Hopper 1 and Lock Hopper 2. This will allow catalyst to circulate from the reactors back into the Disengaging Hopper and into the Regeneration Tower.

- Once the level switch on the Disengaging Hopper indicates that there is a catalyst level in the Disengaging Hopper, follow the Normal Start Up Procedure (Chapter VII) to restart the Regeneration Tower.

Once White Burn conditions have been established in the Regeneration Tower, gradually increase the reactor inlet temperature to their pre-shutdown values.

The expected time for cleaning the inner screen is approximately 24 to 48 hours, excluding preparation time and time for repair of any damage found to the inner screen.

E. On the Fly Catalyst Change Out

This procedure summarizes the activities required to change out the Oleflex catalyst inventory while the reactor section remains in operation. This allows any deactivated catalyst to be removed whenever necessary, regardless of turnaround or shutdown scheduling. However, an on-the-fly change out should not be considered as a replacement for periodic scheduled reactor section turnarounds when reactor disassembly is necessary.

Preparation

1. Transport the drums of fresh catalyst to be loaded to a convenient location at the bottom of the CCR structure. The full drums will be hoisted to the catalyst loading hopper platform within the CCR structure during the loading. Record the lot and drum number of each drum of catalyst. Transport as many fresh catalyst drums as possible to the Loading Hopper platform while still allowing for some working area on the platform.

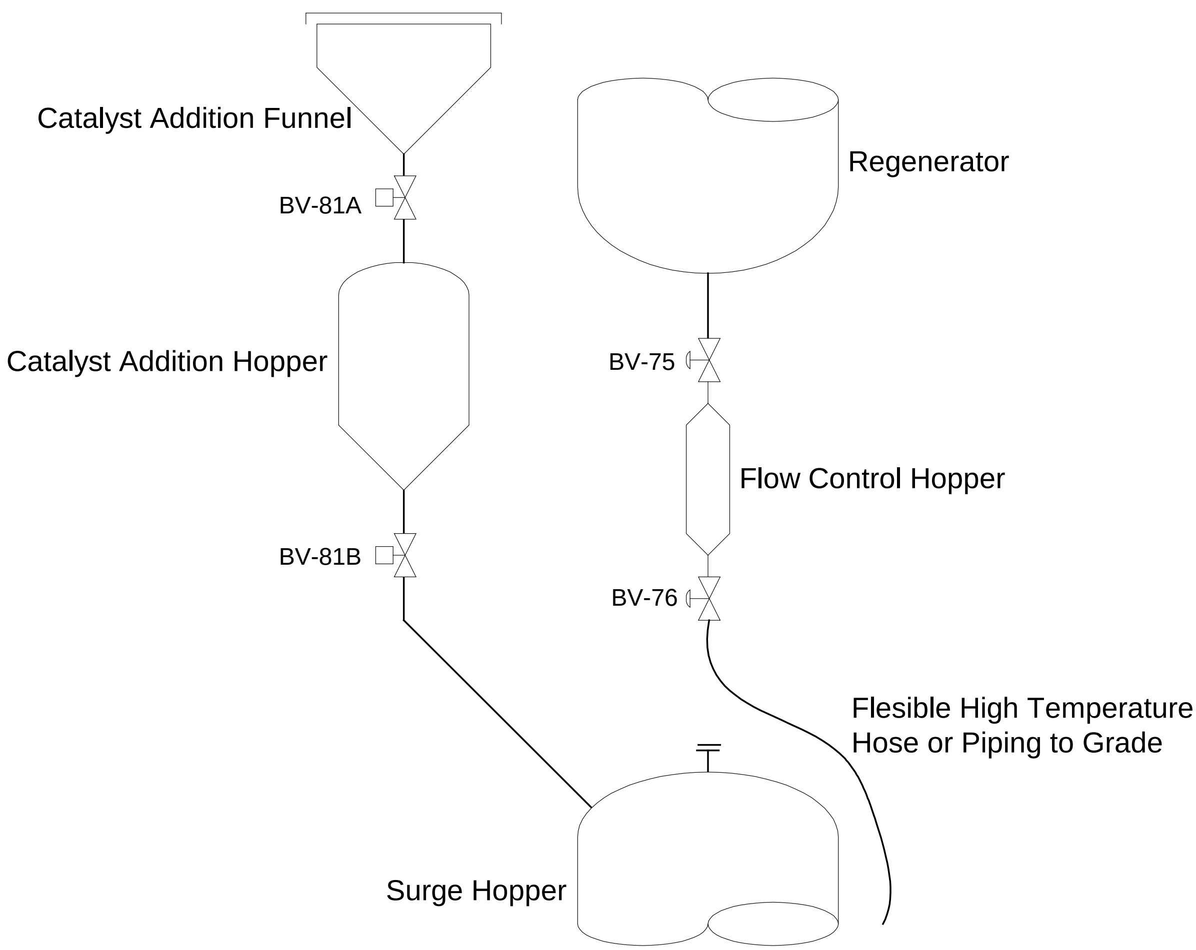
2. Collect enough clean, empty Oleflex catalyst drums to allow for unloading the catalyst to be replaced. The number of empty drums required will be about the same as the number of fresh catalyst drums to be loaded. Pallets and a forklift will be needed to move the drums away as catalyst is unloaded. Keep the empty drums and drums full of fresh catalyst clearly separated so that the drums filled with the used catalyst during the unloading are not mixed or confused with the fresh catalyst drums. An alternate approach is to use large unloading bins. A typical size holds approximately 3000 pounds (1300 kg) of catalyst.

3. Rig up a flexible, high-temperature, hose from the Flow Control Hopper platform down the CCR structure to grade. This hose will direct the used catalyst being unloaded into drums. The hose should run to grade at a steep angle so that catalyst will flow through it (at least 45 degrees if possible). The top end of the hose should be fabricated to allow for a connection to the V-valve below the Flow Control Hopper. The bottom end of the hose should be directed to the area at grade where the empty drums and pallets are located. See Figure XIII-1.

4. Connect a flexible hose from the Surge Hopper unloading nozzle and direct it to grade where the empty drums and pallets are located. This hose will provide a means of unloading the used catalyst from the Surge Hopper.

FIGURE XIII-1

ON-THE-FLY CATALYST CHANGEOUT



Catalyst Loading and Unloading

1. Stop catalyst circulation and put the Regeneration Tower into a hot shutdown condition. If catalyst circulation is shutdown, immediately reduce any RIT above 640°C to 640°C. Also if Reactor #4 is operating above 620°C, reduce to 620°C. Continue to reduce reactor section severity as outlined in the Emergency Procedures (Section XII) Loss of Catalyst Circulation.

2. Shut down the Air Heater. Maintain normal Regeneration Heater and Chlorination Heater outlet temperatures. The Regeneration and Chlorination Blowers should remain in operation, and design nitrogen flow should be maintained to the Drying Zone.

3. Remove the expansion bellows from the catalyst transfer line between the Flow Control Hopper and Surge Hopper. Connect the unloading hose assembly to the bottom of the valve below the Flow Control Hopper. Cover up the top nozzle on the Surge Hopper.

4. Ensure that personnel required to load and/or move catalyst drums are ready to start work and are properly equipped to safely handle the hot, 100-300°C (200-500°F) drums containing the used catalyst from the Flow Control Hopper.

5. If catalyst drums are to be used for unloading, place 4 drums on a pallet. Place another pallet with 4 drums next to this one. Position the unloading hose so it can be moved easily from drum to drum. A forklift truck can then move the empty and full pallets around without interrupting unloading.

6. Unload all used catalyst from the Surge Hopper to drums at grade.

7. Clean the Surge Hopper, if necessary. UOP recommends that the Surge Hopper be cleaned nominally once a year as dust and fines tend to accumulate on the bottom of the Surge Hopper. If dislodged, these materials can cause problems in Lock Hopper No. 2, Lift Engager No. 4 or 5, the Reduction Zone and Reactor No. 1. In addition, clean out the catalyst transfer pipe (Y-spool piece) beneath the

Surge Hopper. Dust and fines could settle in this line when unloading catalyst from the Surge Hopper.

Note: Properly isolate and air purge the Surge Hopper prior to entry for cleaning follow confined space procedures.

8. Following cleaning, close the Surge Hopper manway and establish an N_2 atmosphere in Surge Hopper. Maintain normal N_2 purge flow.

9. Have an instrument technician open both of the catalyst loading valves above and below the Catalyst Loading Hopper. Make sure the Surge Hopper nitrogen purge is set at its design value. A small N_2 purge should be flowing out at the Loading Hopper.

10. Load fresh catalyst into the Surge Hopper. During the entire on-the-fly loading procedure, maintain the Surge Hopper catalyst level 1-2 feet above the panel coils. The catalyst level can be determined using the manual tape gauge at the top of the Surge Hopper.

11. After at least 1 hour has elapsed since the Air Heater was shutdown and after all previous steps in this procedure have been completed, begin black burn operations and restart catalyst circulation a design rate. Adjust upper air injection rate to control the desired O_2 level at the burn zone inlet. As catalyst circulation proceeds, one Flow Control Hopper load of catalyst will flow down through the unloading hose to grade with each cycle of the Flow Control Hopper. The catalyst will be <u>Hot</u>, so take necessary precautions.

12. Fill up the empty drums with catalyst from the Flow Control Hopper. As the Flow Control Hopper cycles, small loads of catalyst will flow into the drums or bins approximately every 60 seconds. Place a nitrogen hose (with a small flow of nitrogen coming from it) into each drum as the catalyst is unloaded into the drum. After each drum is filled up, remove the nitrogen hose and seal the drum immediately. As a drum fills, it is an easy task to move the catalyst unloading hose between drums. However, if it is desired to give some control to the workers at

grade, a temporary instrument air line can be hooked up to BV-76. (Figure XIII-5). The worker can then shut off air flow to BV-76. Since the Regeneration Tower is in black burn operations, the boardman should be notified whenever the outside workers close BV-76.

13. It is recommended that the individual Oleflex reactor inlet temperatures be reduced one at a time, as the leading edge of the new catalyst enters each respective reactor. Normally the temperature is limited to between 595 to 600°C (868 to 873°F) for the first catalyst cycle when fresh catalyst enters the reactor. This should minimize the propensity for generating any high coke on the new catalyst during its first pass through the reactors and will serve as a good base case from which operating conditions can be further adjusted to achieve desired production targets. Contact UOP for specific reactor inlet temperature targets.

14. Continue loading catalyst to the Surge Hopper and unloading catalyst from the Flow Control Hopper until the target amount of catalyst has been replaced. The final Surge Hopper level should be approximately 6-12 inches above the panel coils. During on the fly catalyst change out it is recommended to load at least 103% of original inventory in order to verify that all the old catalyst has been removed or diluted in the system.

15. When the catalyst change out is completed, stop catalyst circulation and discontinue upper air injection to the burn zone. Restart the Air Heater, and raise the heater outlet temperatures to 538°C (1000°F). If catalyst circulation is shutdown, immediately reduce any RIT above 640°C to 640°C. Also if Reactor #4 is operating above 620°C, reduce to 620°C. Continue to reduce reactor section severity as outlined in the Emergency Procedures (Section XII) Loss of Catalyst Circulation.

16. Remove the unloading hose below the Flow Control Hopper and immediately reinstall the expansion bellows.

17. Have an instrument technician return the Catalyst Loading Hopper valves to their normal, closed position.

18. When design temperatures are reached in the Regeneration Tower, proceed with a black burn catalyst CCR startup and resume catalyst circulation. Switch to white burn operations once the tower has established a satisfactory carbon profile with regenerated catalyst carbon levels of less than 0.1 wt%. Begin Cl_2 injection in accordance with normal operating guidelines.

19. Maintain reactor inlet temperatures for all reactors between 600°C and 620°C during the first three regeneration cycles. Fresh catalyst tends to produce more coke on catalyst until ~3 regeneration cycles have been completed. Reactor operating conditions should be adjusted so as to keep the spent catalyst level at the typical 3-4 wt % range.

XIV. SAFETY

Abstract

The process unit and its operation may present hazardous to the operators and the environment. This section outlines some of the proper controls expected to be implemented. Since the use of UOP products by others is beyond UOP control, no guarantee, expressed or implied, is made and no responsibility assumed for the use of this material or the results obtained there from. Moreover, the recommendations contained in this manual are not to be construed as a license to operate under, or a requirement to infringe, any existing patents, nor should they be confused with state, municipal or insurance requirements, or with national safety codes.

The owner is responsible for establishing and following all pertinent safety procedures for the start up, shut down, operation and maintenance of this process unit. As UOP does not perform the final design work for the unit, it is expected that the owner will perform a process hazard analysis or similar investigation of the final process design.

A. UOP provided information:

This process unit may contain hazardous due to chemicals and materials including flammable hydrocarbons, hydrogen and other materials. A listing of the chemicals and materials present and recommended safety equipment can be found in the UOP Engineering Project Specification 903, “Safety Equipment” issued for this process unit.

Material Safety Data Sheets (MSDS). MSDS for UOP supplied catalysts and adsorbents may be obtained by UOP at www.uop.com. For the MSDS of all other catalysts and chemicals used in this process, contact the vendor.

The General Operating Manual provided by UOP is not considered sufficient operational guidance and the owner must develop operating instructions for the plant.

B. General elements of process safety management

The owner is expected to develop and establish policy and procedures for the following:

a. Operating procedures
b. Employee training related to the process and its operation
c. Contractors
d. Mechanical integrity of equipment

e. Preparing equipment or piping for introduction of hazardous materials
f. Removal of hazardous materials from equipment or piping in preparation for inspection or maintenance of said equipment or piping.
g. Line Breaking Procedures
h. Confined Space Entry
i. Energy control (Lock-out and Tag-out of Equipment)
j. Fall Protection for Personnel.
k. Hot Work Procedures

Operating procedures presented in this manual are general in nature. The steps required to start up, operate, and shut down the unit will broadly apply to units for which this manual applies. Stepwise procedures that identify specific equipment are to be developed by the owner. Operating procedures may be reviewed with the UOP representative present for start up and vendor representatives present for commissioning of specific equipment. The owner of the unit may also implement procedures and policies that govern the modification of or deviations from the normal operating procedures.

The owner will manage the training of the personnel and contractors who enter and operate the plant.

A regular plan of inspection and testing will be required to maintain the physical integrity of the equipment of the unit. Process equipment has an expected design life which can be altered by process and other environmental conditions. Procedures and practices should monitor the process equipment to determine if it is fit for service.

Many materials can be considered toxic or hazardous. Procedures and policy must be implemented to insure the safe handling of the materials used in the plant.

Confined spaces are a recognized hazard in most process units. Procedures for access control, entry, and work in confined spaces are implemented by the owner to protect personnel from hazardous encountered in confined spaces.

Energized equipment is also a recognized hazard in most operating units as unexpected operation of equipment may cause injury. The control of equipment and sources of other energy will need to be managed for the purposes of maintenance and inspection.

Falls constitute a hazard in most units when work is performed outside of the normal platforms and walk ways designed to be occupied by workers. Policy to reduce injuries as a result of falls is normally a part of the safety management system of the unit.

As most units contain flammable materials, a system to reduce accidental ignition of flammable materials is implemented. Such systems are commonly referred to as "hot work” systems to protect against ignition of flammable materials by open flames and other ignition sources.