FLUOR DANIEL
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Bruce Kerr Interlock Systems

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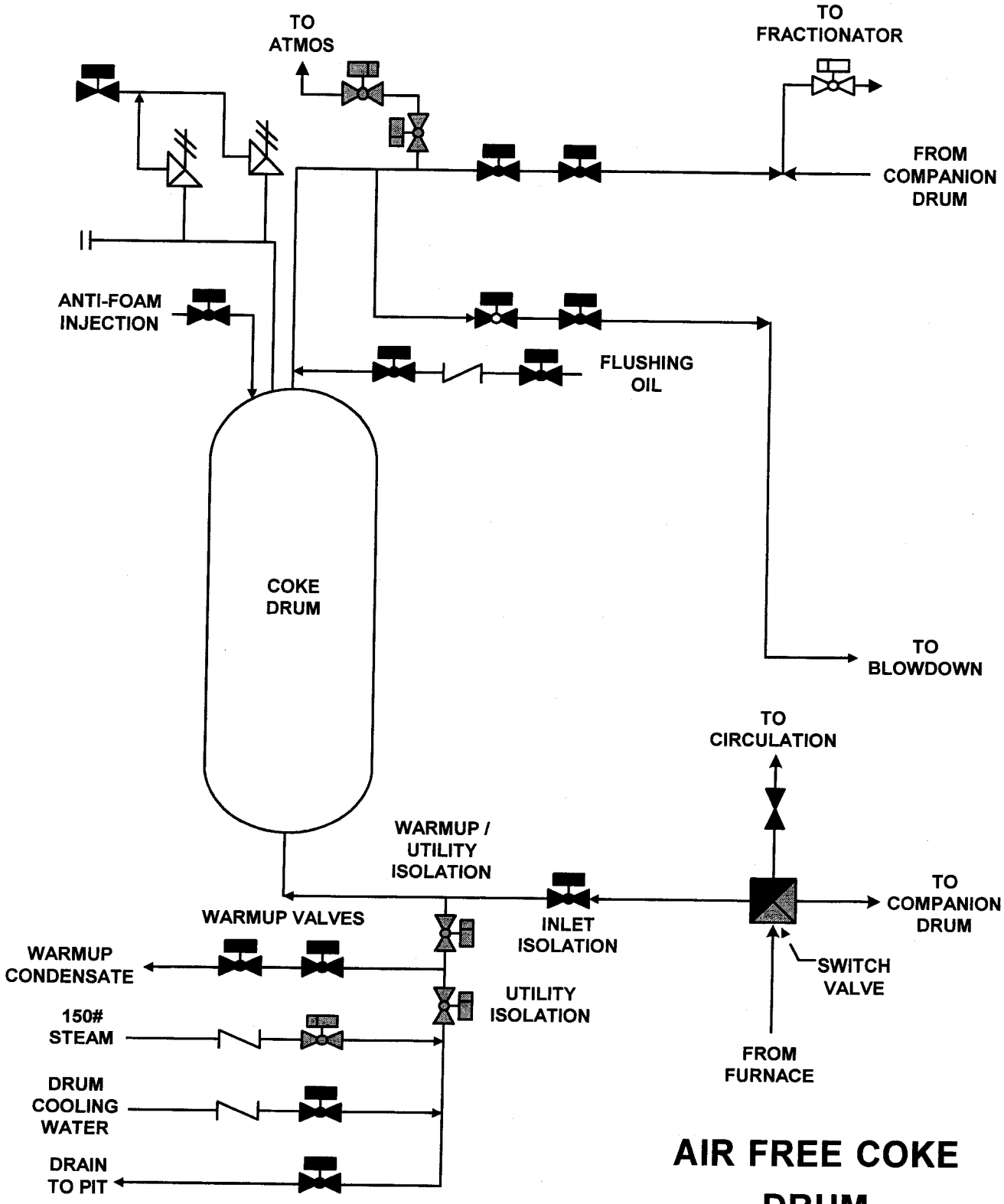

AIR FREE COKE DRUM

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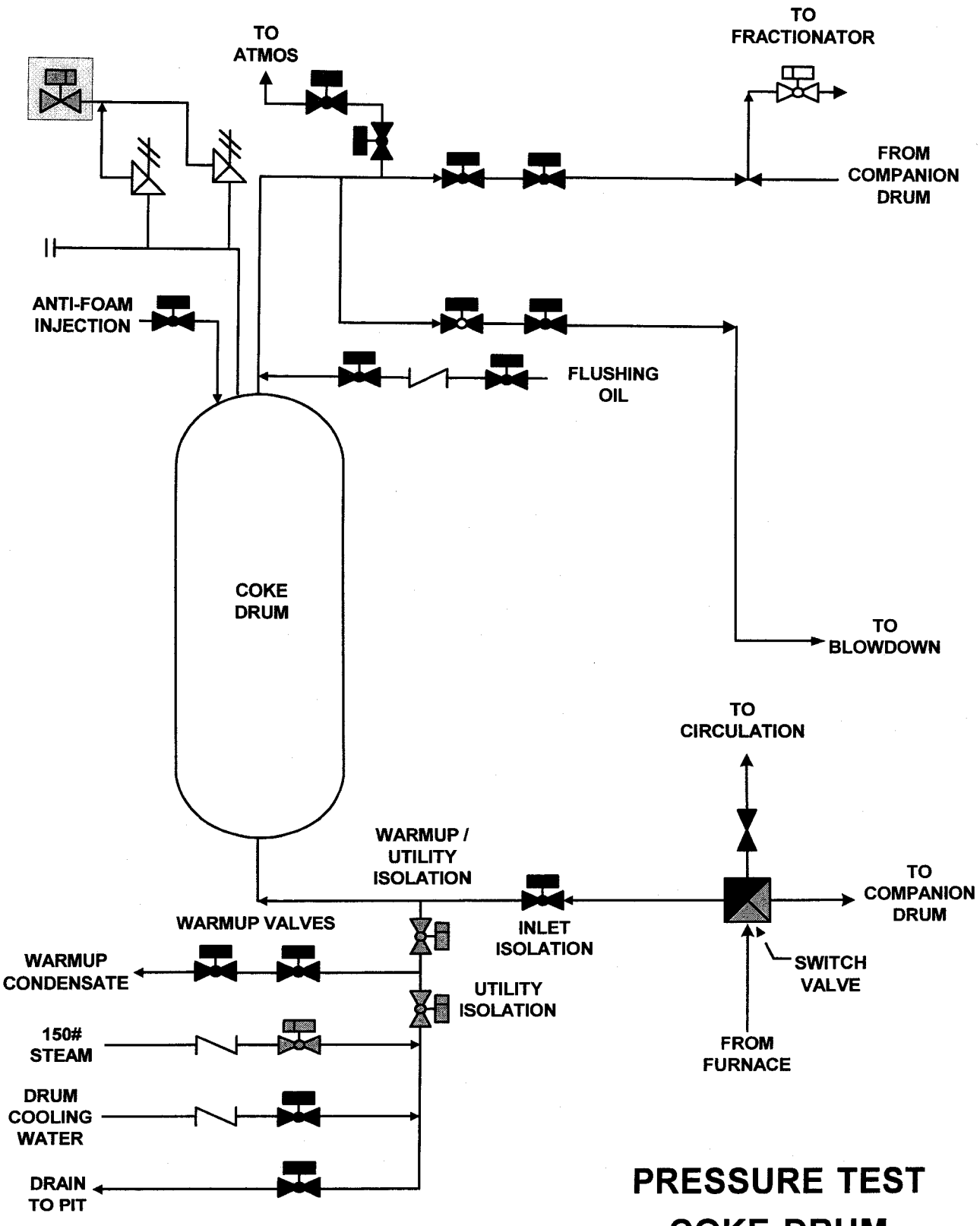

PRESSURE TEST COKE DRUM

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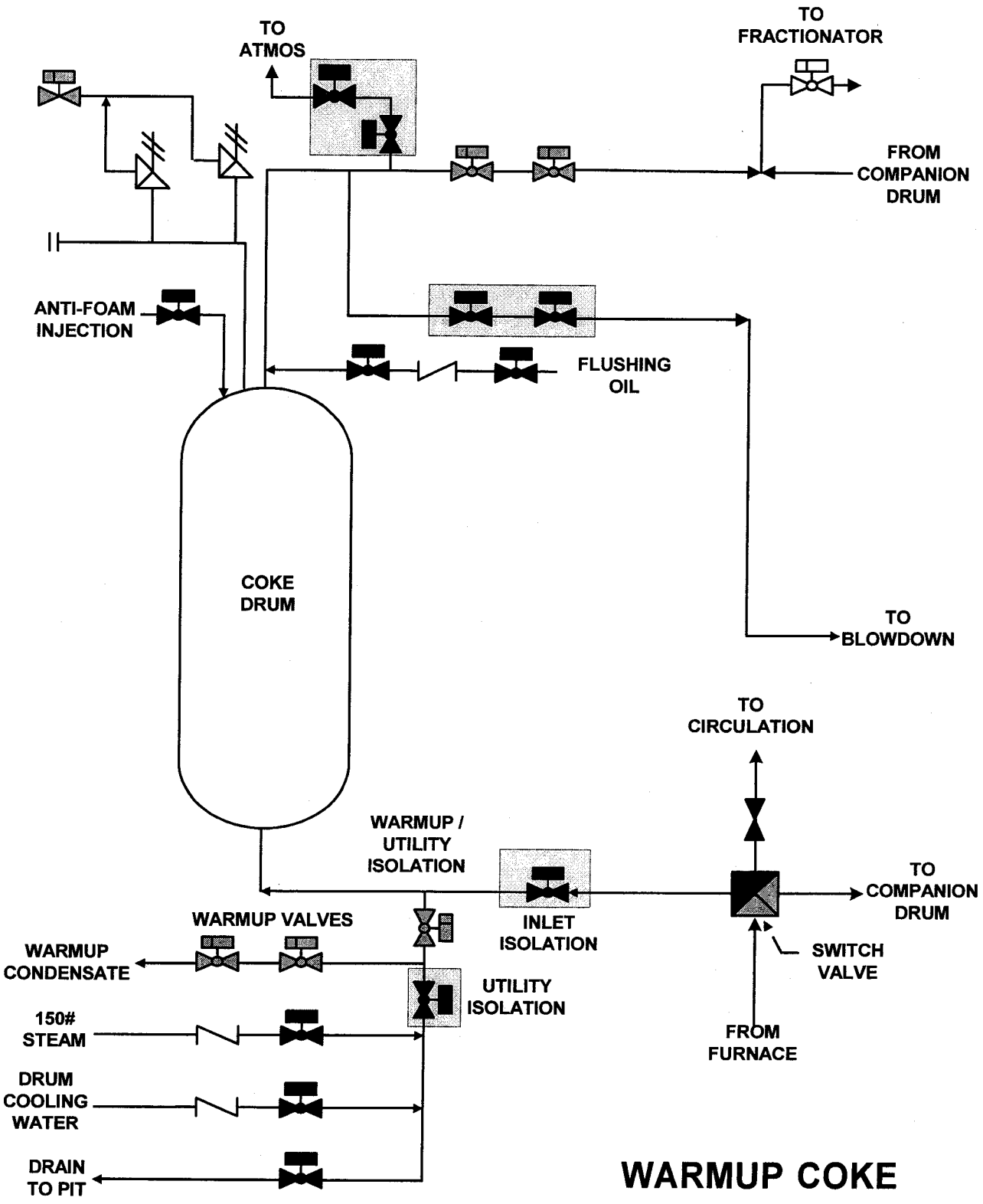

WARMUP COKE DRUM

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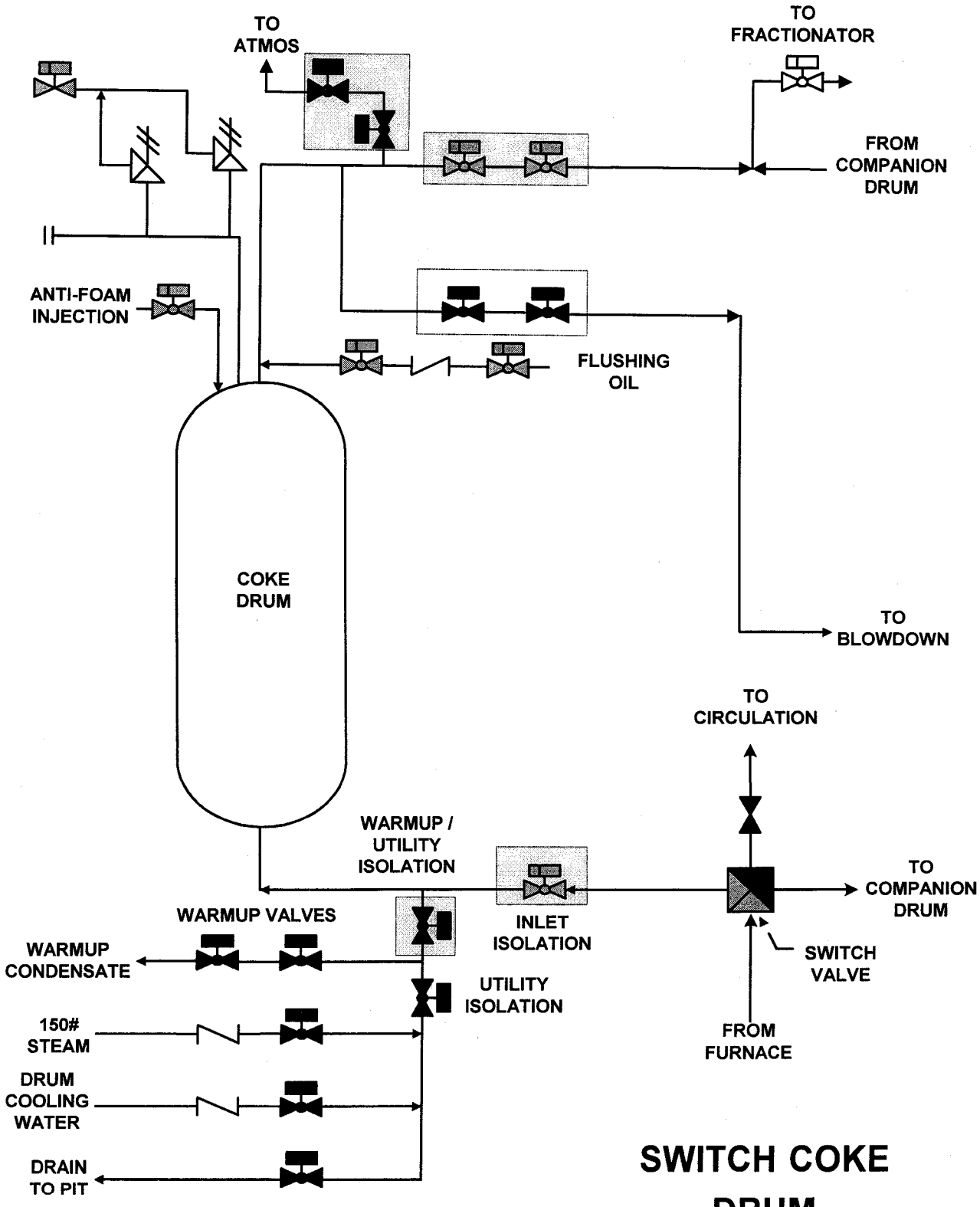

SWITCH COKE DRUM

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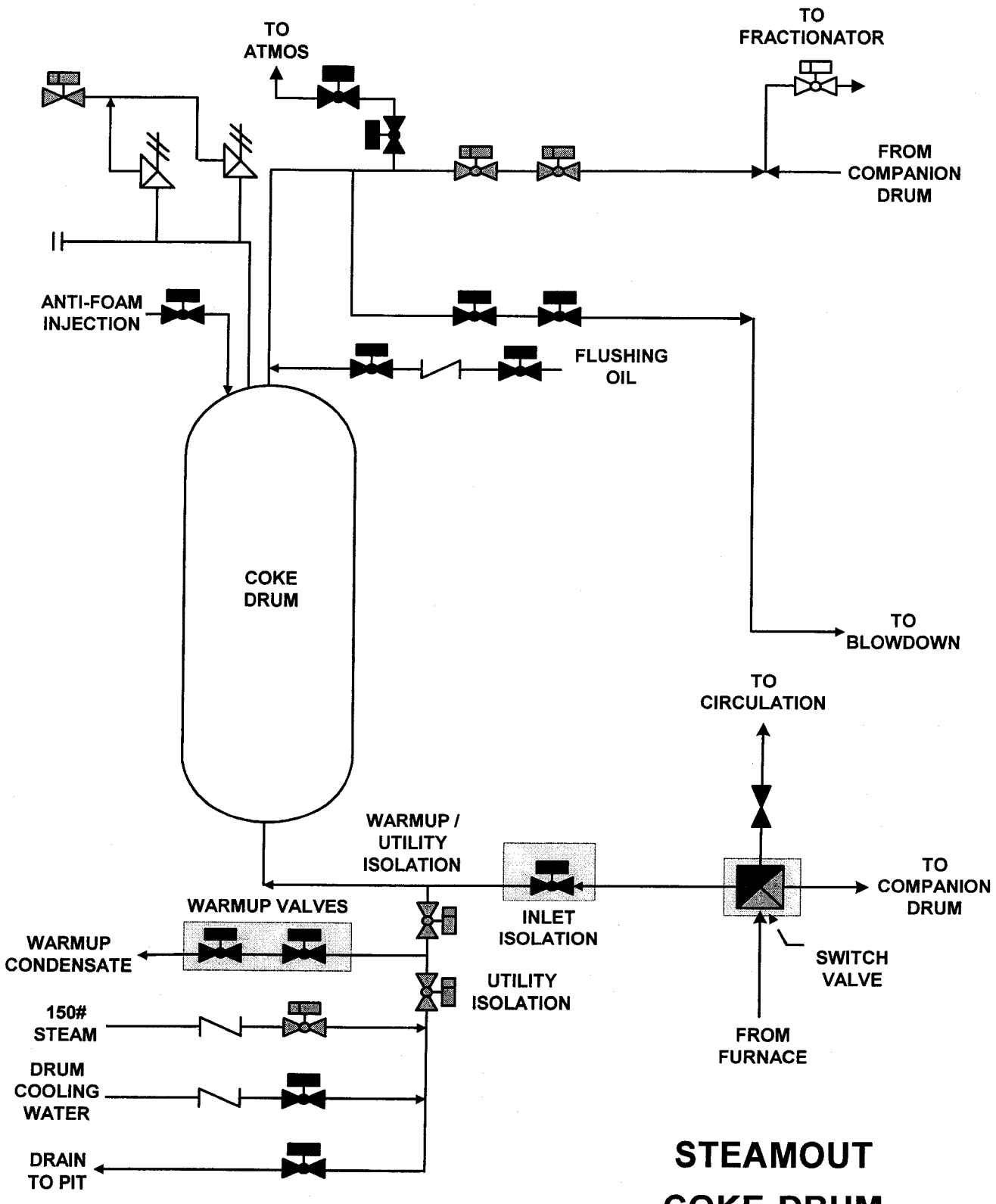

STEAMOUT COKE DRUM

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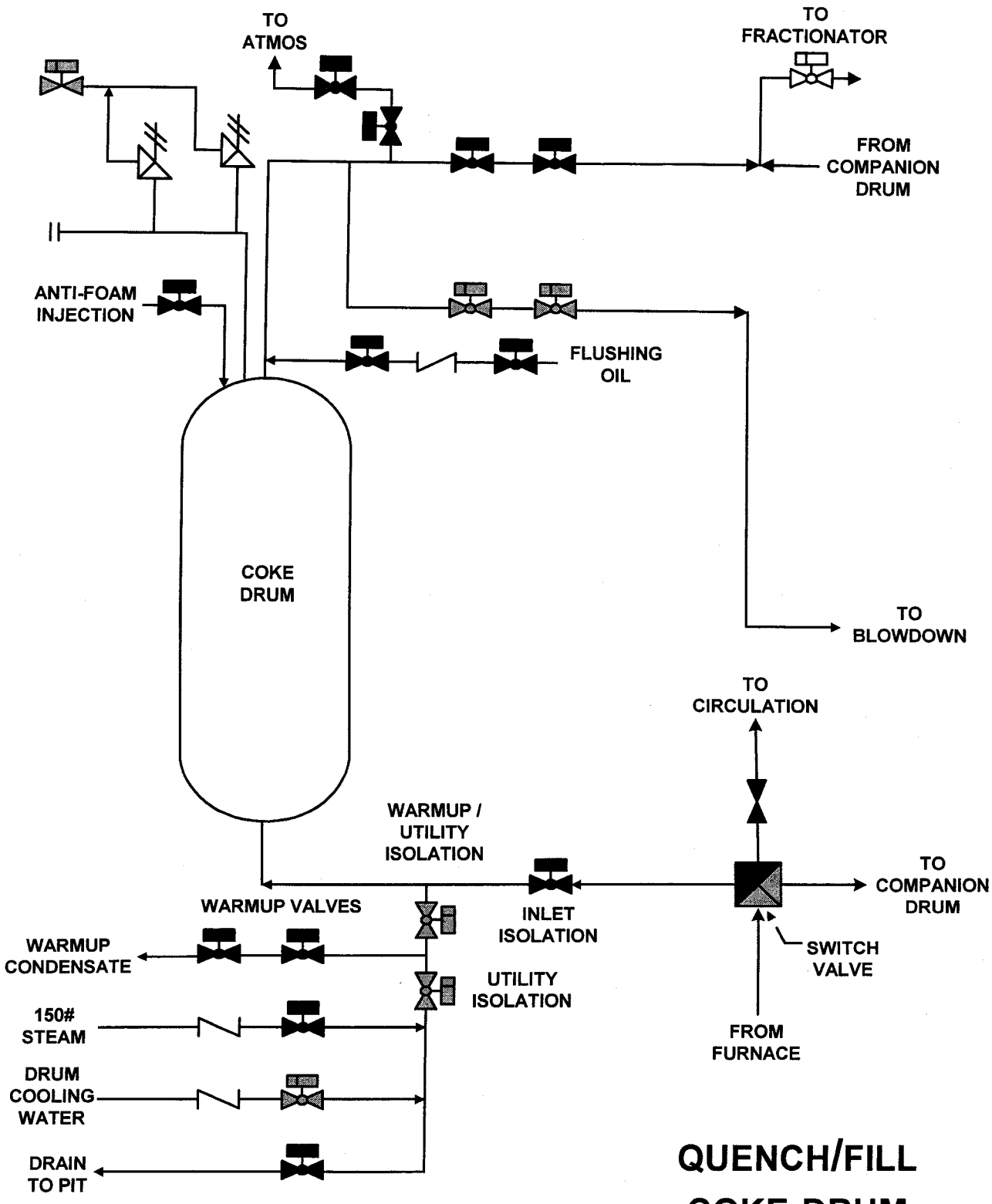

QUENCH/FILL COKE DRUM

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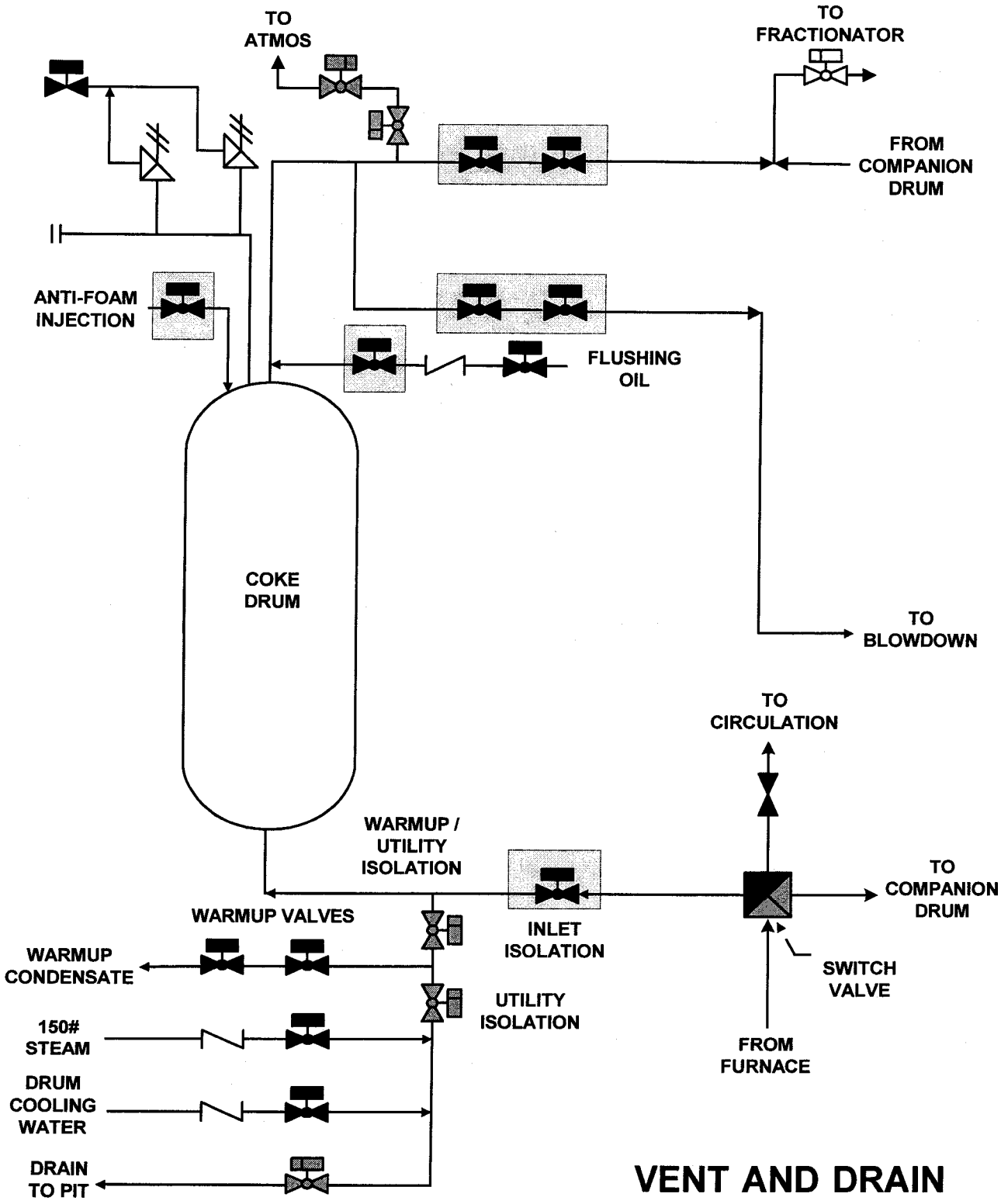

VENT AND DRAIN
COKE DRUM

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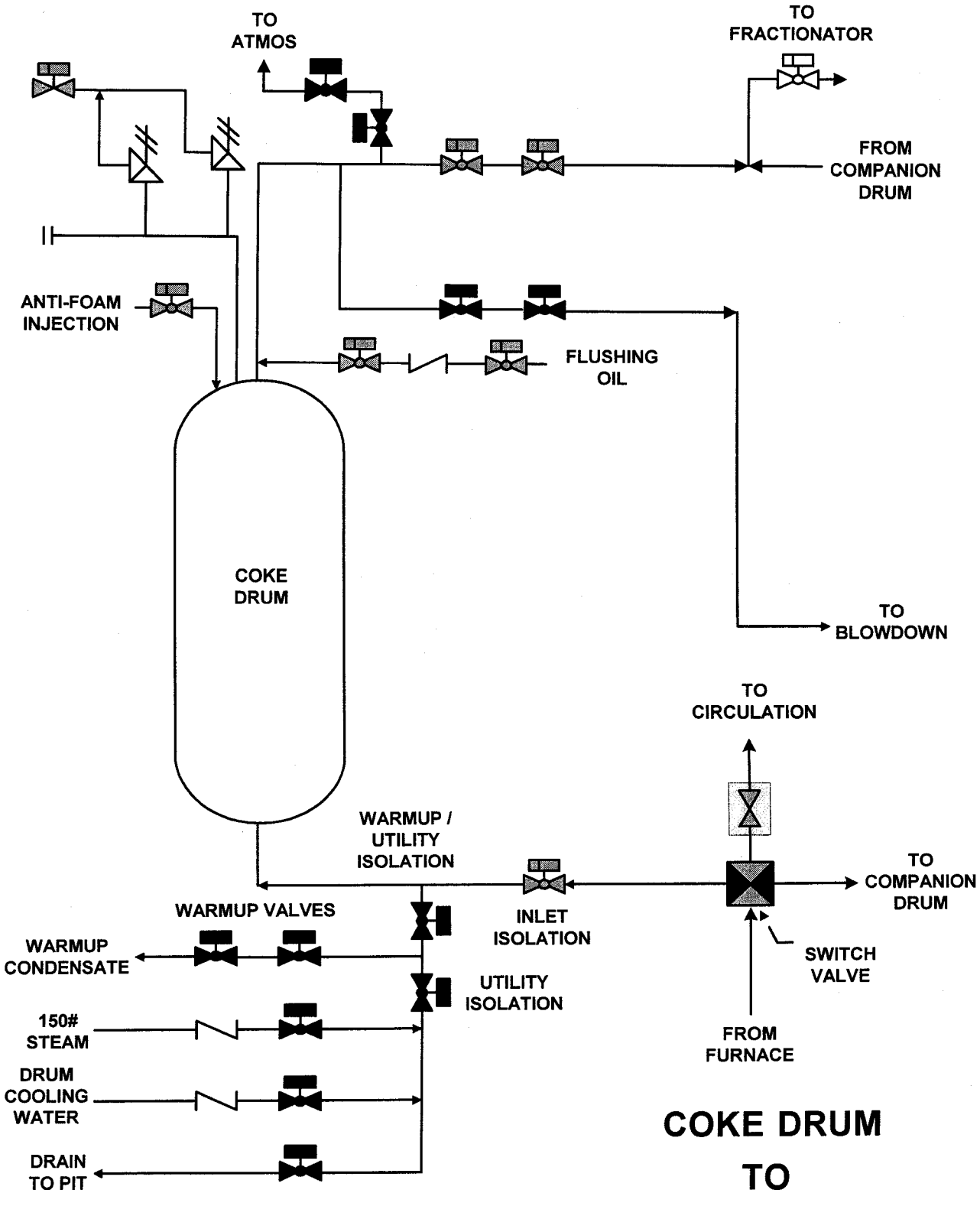

COKE DRUM TO CIRCULATION

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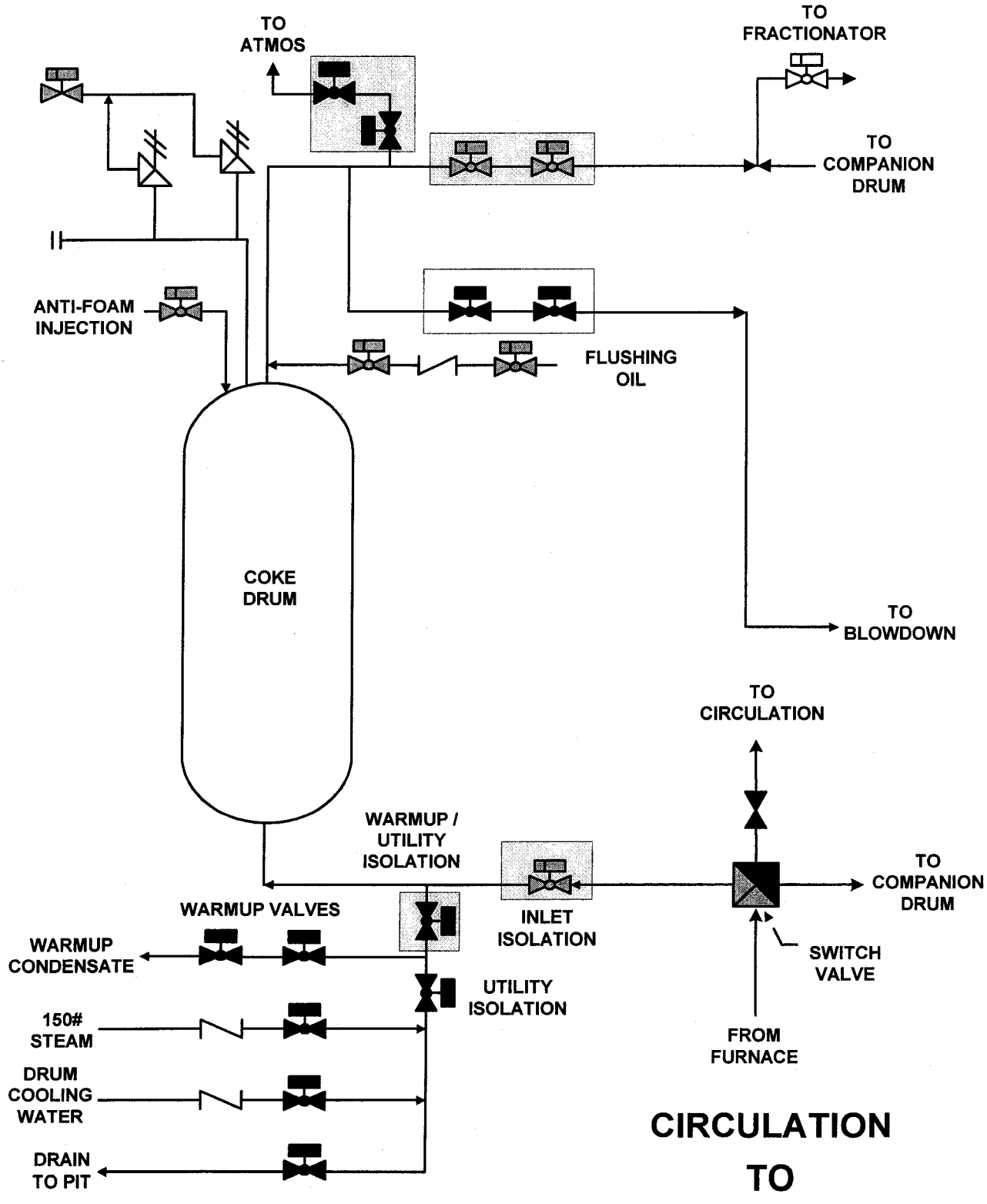
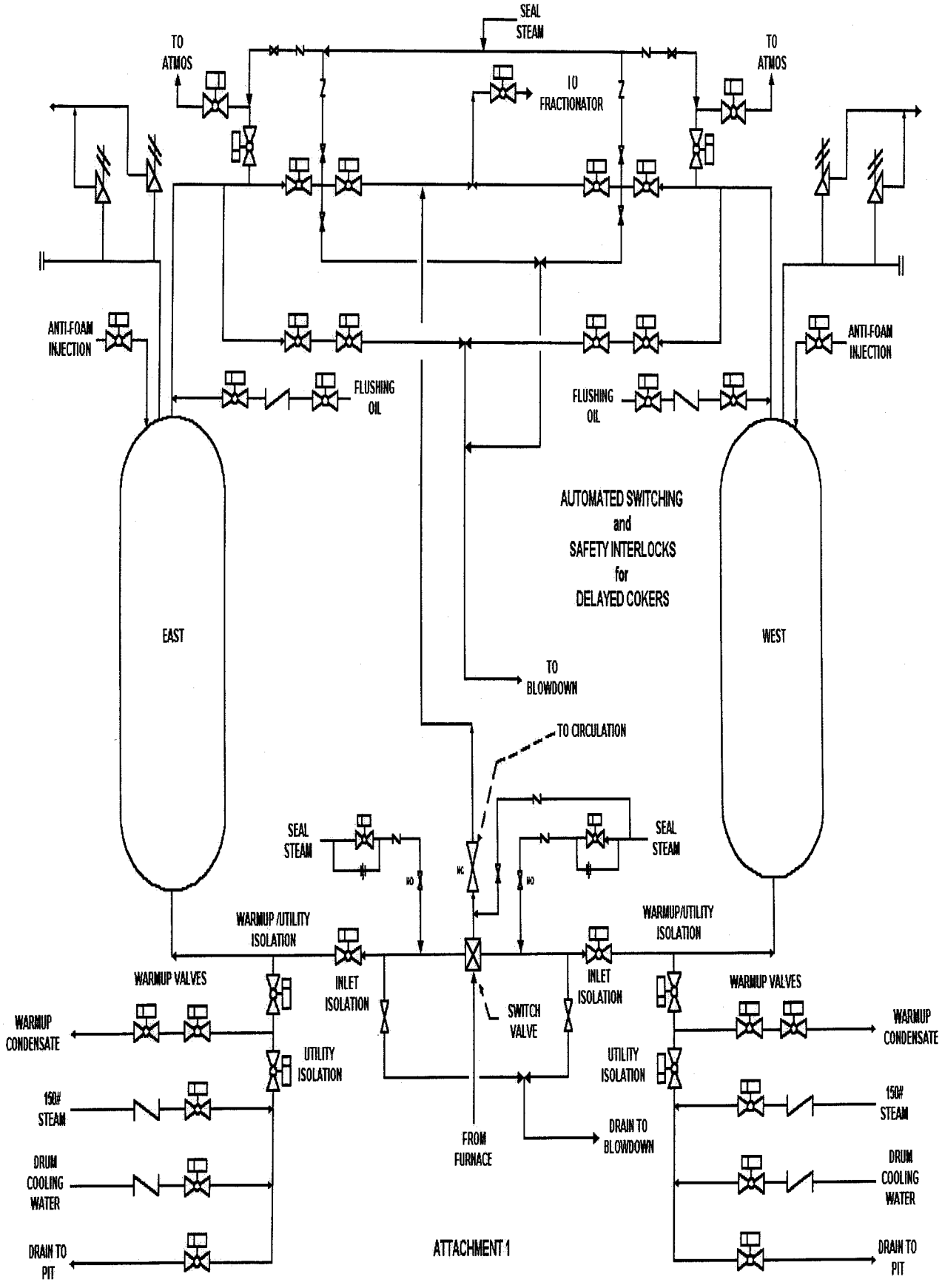


CIRCULATION TO COKE DRUM



ATTACHMENT 1

by Bruce Kerr

Attachment 1

DELAYED COKING
Automated Coke Drum Switching
and
Safety Interlocks

by Bruce Kerr
Fluor Daniel

Introduction

Why are refiners today installing safety interlocks and even fully automating the coke drum switch?

Delayed Cokers are very manpower intensive units that require a great deal of operator attention. Through the years refiners, that have Delayed Cokers, have seen and/or have read many incident reports where operators have inadvertently opened valves creating serious safety problems. Results from these incidents can be and have been devastating, not only to equipment loss and unit downtime but moreover serious injury to personnel and even death.

Operating Philosophy's Differ

Operations personnel differ in as far as operating philosophy throughout the Delayed Coking industry. One refiner may want a fully automated system, this system would use the DCS to initiate valve movements for the drum switch. Sequencing programs can be installed in the DCS to allow for the drum switch from the air free step through the switch itself without outside operators doing the switch. This system could also have a complete Safety Interlock in place that would not only prevent catastrophic hot oil losses to the atmosphere but also prevent operational upsets. Another philosophy may have the outside operator monitoring valve movements from a safe location, on the switch deck, and setting steam seals between valve sequencing during the drum switch. Some refiners may prefer to have a basic interlock system that will prevent erroneous valve movements, which may cause catastrophic oil losses or blocked process flow to the coker heater. This type system could be operated by manual valves with proximity switches mounted to the valve or operated locally from a panel or push button station at either an air, electric, or hydraulic operated valve with no valve movements initiated from the DCS.

Many refiners are installing this technology in their facilities, whether it be retrofitted to an existing unit or on a grass roots unit. Installing simplified systems to the fully automated DCS control scheme and variations stages of automation in-between.

Attachment 1

DELAYED COKING
Automated Coke Drum Switching
and
Safety Interlocks

Design Considerations and Installation

There are several issues to consider when deciding to install Coke Drum Switching Automation and Safety Interlocks. When it comes to safety interlock systems refiners differ in their philosophy with respect to what type of voting logic to install. Many refiners use 1 out of 2 voting logic where some refiners use 2 out of 3, the later being more reliable. The 2 out of 3 voting logic means that losing one switch will not stop the permissive, but an alarm will let the operator know that there is a switch malfunction. On the other hand, the 1 out of 2 voting logic, if one switch fails means the permissive will need to be bypassed to continue the drum switch.

One issue is deciding whether to retrofit existing valves with switches. If these valves are manual type valves, installing switches external to the valve are not as reliable, due to the environment the switches are exposed to verses enclosing the switches on a automated valve. Many refiners install pneumatic and electric actuators to the valves incorporated in the drum switch. One consideration could be to install hydraulic actuators especially if the unit has a hydraulic unheading system. These units are very compact and can be retrofitted to the hydraulic skid for the unheading device.

While trying to decide the magnitude of the automation and interlock system, consider the type of unit that is being interlocked. A four drum unit verses a two drum unit will impact that decision. The reason being is a four drum unit has inherently more risks for operator error than a two drum unit. The four drum unit has two pair of drums operating and what happens is an operator moves the right valves on the wrong pair of coke drums.

Many refiners are installing ball valves for isolation around the coke drum. Some refiners prefer these valves for ease of installation of the safety interlock switches and automating the coke drum switch. There are some valves that are fitted with throttling capability for ease of depressuring coke drums and warming of the coke drum prior to switching. The ball valve makes it easier for this type of operation. This is not to say that these switches cannot be installed on wedge plug valves, they can. There is a refiner on the West coast that has a system with all hydraulic operated wedge plug valves and this system operates well.

Attachment 1

DELAYED COKING
Automated Coke Drum Switching
and
Safety Interlocks

How the System Works

Attached is a drawing of a pair of coke drums and piping systems with automated valves. This drawing can be used, throughout this section, as a reference **(see attachment 1)**.

Once the decision has been made to automate and interlock the drum switch, the designer needs to follow the existing coke drum switch procedure as close as possible when building the interlock matrix. The reason for this is to keep changes, to what the operators have been doing for years, to a minimum. When reading through this procedure, remember that some valve movements have probably occurred simultaneously. These valves must be opened and closed in a sequence if they are incorporated into the interlock system. In an interlock system, certain conditions must be met for an interlocked valve to be opened or closed.

Most refiners keep a log of near miss reports or incident reports that have occurred during coke drum switching activities. This is a good starting point for deciding what type of incidents the interlock will prevent from occurring and the magnitude of automation and interlock to be installed.

Basically, to build an interlock matrix, one must walk through the coke drum switch sequence. Starting with the air free of the coke drum, pressure test, warm-up, switch, steamout, drum cooling, to the coke drum vent and drain. Each valve movement through the switch sequence should be looked at as far as a "what can happen" scenario.

Going through the sequence for a typical drum switch starting with air freeing the coke drum, the first valve to open is the steam to the drum at the utility manifold. Normally there are no conditions that need to be met to make this valve movement.

The next step would be to pressure test the drum. The coke drum vent valve must be closed to do this step. If the coke drum has some type of eductor system, for top head removal, it would be necessary for the interlock to verify that the valve to the eductor has been closed to prevent pulling a vacuum on the coke drum. Some refiners block the coke drum safety valve on the discharge when the drum is taken out of service for decoking. If this is the case then the system needs to verify that this valve is opened to prevent over pressuring the coke drum during the pressure test and to ensure that the safety is lined up when the drum is switched into.

The next sequence is the coke drum warm-up. The warm-up/utility isolation valve and the warm-up valves will be opened along with the coke drum overhead vapor valves. When

the warm-up/utility and warm-up valves are opened the system needs to verify that the coke drum inlet isolation valve is closed to ensure isolation from the hot feed, and the utility isolation valve is closed to ensure isolation from the condensate generated from the warm-up step. To complete the valve movements for the warm-up step, the coke overhead vapor valves must be opened. The system needs to verify that the coke drum atmospheric vent valve is closed to prevent the release of hydrocarbon vapor to the atmosphere. The coke drum blowdown valves can be interlocked closed at this point to prevent depressuring the fractionator to the blowdown system. This particular interlock will prevent operational upsets. The blowdown valves are already in the interlock system for another situation, so the system can act as a monitor of valve positions associated in the interlock system to prevent not only safety incidents but also operational upsets.

Prior to switching the coke drum many refiners dryout the steam at the utility manifold, of the full drum, in anticipation of the switch. Several valve movements occur with the coke drum switch that are included in the interlock. The first valve is opening the inlet isolation valve on the empty drum or drum being switched into. The warm-up/utility isolation valve should be closed. This step ensures isolation of the hot feed from the warm-up and utility systems. Move the switch valve from the full coke drum to the empty coke drum. The system verifies that the inlet isolation valve on the empty drum is open to prevent blockage of process flow through the heater. The system also verifies that the coke drum overhead vapor valves are open to ensure a pathway and to prevent the coke drum safeties from lifting. Again the system can act as a watch-dog by verifying that the warm-up/utility isolation is closed and the coke drum atmospheric vent valve is closed to prevent the release of hydrocarbons to the atmosphere.

The next step in the sequence is to inject steam into the full coke drum or the drum that was switched out of. For this step to occur, the utility isolation valve and warm-up utility isolation valve must be opened. When the utility isolation valve is opened the system verifies that the warm-up valve is closed to ensure isolation from that system. The warm-up/utility isolation valve will be opened next to allow steam to enter the full coke drum. Again the system verifies the warm-up valve is in the closed position. At this point the system verifies the position of the switch valve making sure that the valve is set filling the opposite coke drum. The next valve to close is the feed inlet isolation valve on the drum that has just come off-line or is steaming.

The next step in the sequence is to put the off-line coke drum overhead vapors into the blowdown system. The valve movements in this sequence is opening the blowdown valves and closing the overhead vapor valves. At this point one of the blowdown valves

can be a ball valve with throttling capability along with one of the overhead vapor valves. Installing throttling capability will try and minimize the fractionator upsets when

swinging the overhead vapors from the fractionator to the blowdown system. When the blowdown valve is opened the system verifies that the feed inlet isolation valve is closed to ensure the coke drum is off-line. When the overhead vapor valves are closed the system verifies the position of the switch valve being into the opposite drum or in the circulation position. This will prevent process flow blockage through the heater.

Once the on-line drum overhead vapors have reached operating temperature then the coke drum overhead line flushing oil is opened to the on-line drum. The flushing oil is injected to minimize coking in the coke drum overhead vapor system. The interlock system will again verify that the overhead vapor valves are open ensuring this drum is on-line and hot flushing oil is not opened up into an off-line drum.

Once the steaming is complete, water is opened to the drum for cooling. This step doesn't require an interlock. When drum reaches a satisfactory water level, usually the top level detector, and overhead temperature and pressure is low enough, the coke drum vent and drain can be opened. The interlock will verify that the feed inlet isolation valve is closed to ensure the drum is off-line. Also the system will verify that the overhead vapor, blowdown, flushing oil, and antifoam injection valves are closed to prevent a release of hydrocarbons to the atmosphere.

The interlock system can be as complex as what refiners want to make it. Whatever decision is made and the complexity of the system, this technology exists and refiners are using it. Refiners must commit to maintaining the system, as is for any new technology or equipment installed in their plants.

ATTACHMENT 2

SAFETY INTERLOCK SYSTEM DOCUMENTATION

by Bruce Kerr

PRESSURE TEST/WARM-UP

1. CLOSE "WEST" VENT

If there is an eductor system associated with the drum, for evacuating steam away when unheading, the ***eductor isolation valve*** should be interlocked closed to prevent pulling a vacuum on the coke drum. Also if the PSV outlet header block valve was closed, due to the drum being out of service, then this valve must be opened prior to closing the vent to prevent a possible coke drum overpressure situation.

2. OPEN "WEST" WARM-UP/UTILITY ISOLATION AND WARM-UP CONDENSATE VALVES

This step is required to drain warm-up condensate from the coke drum inlet during drum warm-up. The ***West inlet isolation*** valve must be closed to insure isolation from the hot resid. The ***West atmos vent*** valve must be closed to prevent loss of hydrocarbon to the atmosphere. The ***West utility isolation*** valve must be closed to ensure warm-up condensate isolation from the utility manifold. The ***West blowdown valves*** must be closed to prevent depressuring the fractionator tower to the blowdown scrubber.

3. OPEN "WEST" OVERHEADS VAPOR VALVES

This step permits the introduction of "EAST" drum vapors to initiate "WEST" drum warm-up. The ***West atmos vent*** valve must be closed to prevent loss of hydrocarbon vapor to the atmosphere. The ***West utility isolation*** valve must be closed to ensure warm-up condensate isolation from the utility manifold.

SWITCH

4. OPEN "EAST" DRAIN TO THE COKE PIT (FOR STEAM DRYOUT)

This step permits drying out of the steam through the drum drain prior to adding steam to the coke drum inlet following the feed switch.

5. OPEN "WEST" DRUM INLET ISOLATION VALVE

This step is required in preparation for feed switch to the "WEST" drum. The ***West warm-up/utility isolation*** valve must be closed to ensure isolation from the utility manifold and the warm-up condensate system as well as to prevent resid plugging of the warm-up/utility isolation valve, utility isolation valve, and the warm-up condensate valve cavity. The ***West OH vapor*** valves must be open to ensure vapor outlet when drum is ready for hydrocarbon service.

6. MOVE SWITCH VALVE FROM "EAST" TO "WEST"

This step permits the introduction of feed to "WEST" drum and removes feed from "EAST" drum. The ***West inlet isolation*** and ***West OH vapor*** valves must be open to ensure an open flow path. The ***West warm-up/utility isolation*** valve must be closed to ensure isolation of the utility manifold and warm-up condensate systems. The ***West atmos vent*** valves must be closed to prevent release of hydrocarbon to the atmosphere.

7. OPEN "EAST" DRUM UTILITY ISOLATION VALVE

This step permits the introduction of steam up to the ***East warm-up/utility isolation*** valve in anticipation of a feed switch out of "EAST" drum. The ***East warm-up valves*** must be closed to ensure isolation from the warm-up condensate system. This interlock also prevents opening of the ***East utility isolation*** valve during warm-up. The ***East warm-up/utility isolation*** valve must be closed to prevent the possible introduction of water to a hot hydrocarbon system.

8. OPEN "EAST" DRUM WARM-UP/UTILITY ISOLATION VALVE

This step permits the introduction of steam to the "EAST" drum inlet line following the switch of feed out of "EAST" drum. The ***East warm-up valves*** must be closed to ensure isolation from the warm-up condensate system. The ***Switch*** valve must be turned to "WEST" drum or circulation position to ensure that hot resid feed is isolated away from the "EAST" drum prior to steam introduction.

9. CLOSE "EAST" DRUM INLET ISOLATION VALVE

This step permits positive isolation of resid feed from the "EAST" drum. The Switch valve must be turned to "WEST" drum or the ***Circulation valve*** open to prevent resid flow blockage.

LINE UP TO THE BLOWDOWN SYSTEM

10. OPEN "EAST" BLOWDOWN VALVES

This step permits routing coke drum steamout vapors to the blowdown scrubber system. The ***East inlet isolation*** valve must be closed to ensure the coke drum is "off oil". The ***East vent*** valve must be closed to prevent possible loss of hydrocarbon vapors to the atmosphere.

11. CLOSE "EAST" DRUM OH VAPOR VALVES

This step is required to isolate coke drum steamout vapors from the bubble tower prior to quench/fill. The ***Switch*** valve must be turned to the "WEST" drum or ***Circulation valve*** open to ensure the drum is "off oil" and a flow blockage will not occur.

12. OPEN "WEST" DRUM QUENCH OIL VALVE

This step puts hot quench oil into the coke drum overhead vapor line to mitigate coke formation. The ***West OH vapor*** valves must be open to ensure that the drum is "on oil", and hot quench oil is not introduced to an open drum.

QUENCH AND FILL

13. OPEN "EAST" DRUM UTILITY WATER VALVE (QUENCH/FILL VALVE)
NA

VENT AND DRAIN

14. OPEN "EAST" DRUM ATMOS VENT
This step permits final depressuring of the coke drum and precludes pulling a vacuum on the coke drum during draining. The ***East inlet isolation*** valve must be closed to ensure the coke drum is "off oil". The ***East OH vapor*** valves, ***East blowdown valves***, ***East anti-foam injection*** valve, and ***East quench oil*** valve must be closed to prevent possible loss of hot hydrocarbon to the atmosphere.

15. OPEN "EAST" DRUM DRAIN VALVE TO THE COKE PIT (FOR DRUM DRAIN BACK)
NA

CIRCULATE

16. MOVE SWITCH VALVE FROM THE "EAST" DRUM TO CIRCULATE
This step permits removal of resid from "EAST" drum when it is full and the "WEST" drum is not ready to receive feed. The ***Circulation*** block valve must be open to ensure an open path and prevent flow blockage.

RETURN FROM CIRCULATION

17. MOVE SWITCH VALVE FROM THE CIRCULATE POSITION TO THE "WEST" DRUM
This step permits removal of resid feed from the circulate line and introduction to the "WEST" drum when it is ready to receive feed. The ***West inlet isolation valve*** and ***WestOH vapor*** valves must be open to ensure an open flow path. The ***West warm-up/utility isolation*** valve must be closed to ensure isolation from the utility manifold and the warm-up condensate system. The ***West atmos vent*** valve must be closed to prevent the loss of hot coke drum vapors to the atmosphere.