Question 56: Startup, shutdown, and upset conditions can result in abnormal pressure conditions in process equipment and connected utilities. What are the panel's experiences with reverse flow of hydrocarbon into the connected steam systems? What designs and practices are employed to prevent this?

CLIFFORD (Motiva Enterprises LLC)

In terms of hydrocarbon reversing to steam systems, there are several ways to go about it. The best and most effective approach is design. Check valves may be employed in steam service; however, they can be somewhat unreliable. Another design option is to use pressure controllers to hold the pressure well above the operating conditions. Generally speaking, the steam supply is external to unit operations so that an upset in unit operation will not affect the supply pressure of the steam to the unit.

Procedurally, we are going to block in our steam controllers and manually block the steam at the entrance to the vessel, essentially not relying on the check valves. We then exercise care whenever we are draining or venting steam knowing that there is a risk that we had a reverse flow event.

There are conditions that increase the chance of this occurrence. We use those opportunities to heighten the awareness of the operating personnel. Instrument error or failure can lead valves to their failure positions. You can also have malfunctions which cause valves to go to fail positions or to fail in the opposite direction. If you have a steam coil that super-heats the steam, you may have a failure in the steam, too, which would cause local low-pressure conditions that allow for reverse flow. Externally sourcing the steam can result in loss of steam supply, which would result in low pressure. In the case where the relieving pressure of a vessel is higher than the steam supply, you may be concerned about reverse flow.

DION (GE Water & Process Technologies)'

One refinery had a leak in its condensate system, which fouled the deaerator trays. They repaired the leak, cleaned the system, and installed turbidity meters in the system. The turbidity meters give them an early warning indicator of potential leaks. GE’s Custom Clean* products were employed to assist in cleaning out oil residue from the condensate system. The chemicals in these products increase the affinity of hydrocarbons for entering the water phase and expedite the flushing of residual hydrocarbons from the system.

LEE (BP North America)

I have one interesting anecdote to share about getting oil into a steam system. We had a vacuum furnace with one of the passes plugged. This furnace had coil injection steam, and it was medium pressure steam. One of the coils plugged to the point where it actually backed atmosphere resid into the steam system. That was an interesting incident.

VILAS LONAKADI (Foster Wheeler USA Corporation)

One of our refineries has two different headers. One is called oil-contaminated low pressure (LP) and the other: low pressure steam. The oil-contaminated LP steam line is connected to all of the heat exchangers that use LP steam for the process to avoid hydrocarbon backing up into the LP steam line.

CLIFFORD (Motiva Enterprises LLC)

I have heard of that at other refineries, but I do not have any personal experience of it.

KEVIN PROOPS (Solomon Associates)

Panel operating companies, have you employed layers of protection or safety instrumented systems to prevent reverse flow similar to what was discussed yesterday with hydroprocessing, for instance? Do you have automated low flow trips on the steam meters or other systems, besides a check valve, to prevent backflow?

CLIFFORD (Motiva Enterprises LLC)

I do not have any personal experience with automated trip valves.

LEE (BP North America)

We have had a couple of installations where a valve will trip on high pressure on the tower or low steam flow, but it is not very typical. It is a special case type of application. For the most part, we just rely on a single check valve and regulatory control.

KEVIN PROOPS (Solomon Associates)

So, does that imply that you do not consider the consequence of backflow to be as extreme as some of the other cases where backflow is a bigger deal?

LEE (BP North America)

Yes, I would say that is the case. We do differentiate safety issues from commercial issues. It will be a commercial issue with oil in the steam system, but there is a process safety scenario where you should think about getting a significant amount of hydrocarbon into your steam system. Consider the relieving capacity for that system because hydrocarbon backflow might be a scenario that was not considered.

CLIFFORD (Motiva Enterprises LLC)

Convent uses a mix of design and procedural mitigations to prevent reverse flow of hydrocarbon into steam systems; however, it has occurred at this site. On a design side, check valves are installed on steam connections to the process. The pressure of steam systems which supply stripping steam is held well above the operating pressure of the associated vessels. Steam is supplied by plant utilities and not produced by the unit. So, unit shutdowns and upsets, generally do not impact the pressure of the steam to the columns. However, the site does have superheat coils in process heaters, so upsets which affect the integrity of the superheat coils can result in localized low pressure of the steam.

Procedurally, steam is blocked in both via the flow controller, and the manual valve located at the column to which it is being injected as part of the shutdown procedure.

The site’s experience stems from a complete plant shutdown associated with a hurricane. During this shutdown, utilities including instrument air and steam were lost. This caused the steam headers to

depressure and valves went to their failure positions. It is possible for valves to fail open and allow natural gas to reverse flow into the steam headers. Knowing the risk associated with this scenario, positive isolation is recommended.

DION (GE Water & Process Technologies)

One refinery incurred a hydrocarbon leak into the condensate system which fouled the deaerator trays. The leak was repaired, the system was cleaned, and turbidity meters installed on major condensate return lines. The turbidity meters, in some instances, can also detect iron, a corrosion byproduct, providing an early warning indicator of potential leaks before they occur.

If warranted, specialty chemical companies, like GE Water & Process Technologies, have products to add to a water or steam flush to assist in stripping hydrocarbons off vessel and pipe walls. These chemicals increase the hydrocarbon's affinity to enter water droplets in the steam aerosol mist and subsequent bulk condensate.

BASHAM (Marathon Petroleum Corporation)

At one former Marathon Petroleum Company (MPC) refinery's FCC (fluid catalytic cracking) unit, there was atomizing steam connected to the feed header. Due to feed nozzle plugging the back pressure of the feed header would overcome the 150 psig steam header pressure (normally 120 psig), and gas oil would migrate through the steam system. This event happened several times. The MPC standard is a block, bleed, check, bleed, block for all utility connections. The block, bleed and check are rated for the hydrocarbon contaminants.

LEE (BP Products North America)

We typically rely on a single check valve. In a couple of isolated cases, there were high backpressure and low steam flow automated shutoffs. Of particular concern is whether or not the utility system can handle the relieving load from such a hydrocarbon flow reversal. We have had a high vacuum tower pressure and subsequent high-level excursion result in vacuum resid into a stripping steam header. We have also had atmospheric resid back pressure into a coil steam header when one of the tube passes in a vacuum furnace got plugged and saw a high pressure drop. On a coker furnace, we had medium pressure steam used to purge hydrocarbons from the heater coil on unit shutdown. The normal operating pressure of the hydrocarbon stream was higher than the medium pressure steam header. If the steam was opened before the pressure was lower than the steam pressure, hydrocarbon would flow backwards into the steam header. This is even though check valves were in place to prevent the reverse flow. The hydrocarbon stream was heavy enough that the flapper on the check valve was stuck in the open position. Heat tracing the check valve has helped to mitigate this particular hazard.

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