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**Question 2: Which type of valve technology or design is typically utilized in units with high catalyst withdrawal rates? Do you continuously withdraw catalyst? From a reliability and safety perspective, what type of hardware are you using for control? What is the best withdrawal line design?**

THOMPSON (Chevron)

Valve selection for FCC catalyst withdrawal services is dictated by temperature and erosion considerations. FCC catalyst is very erosive and when withdrawn from the regenerator is typically in the 1200°F range. These considerations, coupled with high velocities when purge or carrier air is added, lead to very severe conditions with lots of erosion. We have developed a Best Practice for catalyst handling systems and the information that I will be presenting generally follows those guidelines. We have experience with four types of valves in catalyst withdrawal service. They are a conventional gate valve with or without hard facing; the Tapco Mini Slide; the Everlasting rotating disc valve; and high performance ball valves. Generally, the gate valves have been poor performers, even with hard facing, giving one to three years' life. Both the Tapco Mini Slide and the Everlasting rotating disc valve have given good performance, typically lasting multiple runs. We have limited experience with the high performance ball valves. Continuous catalyst withdrawal from the regenerator has been suggested as a way to even out the swings in level and catalyst activity that occur when catalyst is withdrawn. We have no experience with that sort of a system, but we have several units that have been interested in perhaps trying it. For units that have power recovery turbines, we do use a form of continuous catalyst withdraw off the third-stage hoppers, which has its own specialized design. For intermittent and semi-batch operation, the valve types described earlier are used for throttling. Block valves are most commonly low chrome gate valves with hard-faced seats. Temperature monitoring of the withdrawal lines is recommended because if the withdrawal rate is very high, then the line may exceed the design temperature. We have a few units that have added fins as a way of cooling the catalyst when it is withdrawn. Carrier air is a big help in cooling the catalyst. Catalyst withdrawal lines are subject to leaks at the erosion points. We have looked at using boronizing and other similar sorts of coatings as a way to mitigate the erosion, but these have not been widely applied. The erosion generally occurs at turns; and so for those, we have used cushioned tees. That is the preferred method for preventing the erosion. Also, we found that air purging of the blocked valves can create localized erosion, particularly if the air is left on when the valve is sitting in a closed position. We had an experience a year or two ago where we actually eroded through the side of a valve body under those circumstances. So the recommendation is to use the air purge strictly when the valve is being moved, either opened or closed, and to leave the air purge off otherwise.

ASDOURIAN (Sunoco Inc.)

Sunoco FCCUs typically use manual gate valves with either stainless steel or chrome bodies on catalyst

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withdrawal lines. We have air purges on the seat and the stem. Recently, we began installing Nitronic 50 coatings on the stem for added protection against erosion. Along with the gate valves, one of our units uses plug valves; and yet another has a ball valve installed downstream of the gate valve. Several other valve designs have been used to try to improve or speed shutoff and extend valve life. High performance ball valves were installed on one unit for two runs. These valves were much more expensive than gate valves, but the thought was that a quarter-turn design with upgraded seat and design material would give better and quicker shutoff. However, we did not realize a drastic improvement. One unit has tried knife gates, since this type of valve is used extensively on ESPs to the dump catalyst. However, on the hotter surface of the regenerator, the knife gate design did not perform well and experienced many mechanical issues. It has been removed from service. One unit also used the ball valve in one installation; and again, there was no noted improvement in shutoff or service life. One unit uses quarter-turn plug valves; and again, they have seen no major service improvements or drawbacks associated with the plug versus the knife gate. Thus, there have been several attempts to use higher performance valves, but none has worked any better than gate valves. We continue to examine valve options for improved reliability in this service. Regarding continuous withdrawal and control, all of our installations are on units that dump catalysts intermittently. All catalyst dumps are manually controlled based on instrument readings either at the bed level or the online temperature readings, depending on the limitation. The challenge on all these installations is the same: achieving tight shutoff after a dump of very hot and erosive material. The catalyst withdrawal valves are typically reworked and often replaced at each turnaround. Sunoco FCCU catalyst download lines are primarily carbon steel. Some installations use double plates in areas where we expect high erosion, such as elbows. Carbon steel lines have been used with varying degrees of success. Some units have had no issues over extremely long service lives, and others have experienced minor holes that can be managed with patches during a run. On major projects, some alloy has been installed on catalyst unloading lines. Current industry standards regarding design temperatures would dictate using alloy material when replacing unload lines. The use of alloy creates installation and future maintenance challenges. Industry material standards and negative experiences at some facilities would most likely drive Sunoco towards using alloy materials for future catalyst unloading line replacements, even with the challenges of installing and repairing these type of lines.

## WALKER (UOP)

UOP recommends continuous catalyst withdrawal for high catalyst users, maybe five or more tons per day. Continuous catalyst withdrawal, in combination with continuous makeup, allows you to minimize the catalyst level and inventory. This results in better activity maintenance and lower particulate emissions, as well as reducing manpower requirements. We recommend Everlasting rotating disc valves to control the flow of the catalyst. Cooling fins are used on the withdrawal line to cool the catalyst before entering the hopper. The alloy metallurgy is used to accommodate the high temperatures associated with the catalyst withdrawal. Carrying air is used to cool the catalyst and maintain the line below allowable temperature limits. Flow controllers are used to adjust the carrying air and skin TIs are used to monitor the temperature. Everything is controlled by the DCS and runs with very little operator intervention. The system is essentially a regenerator-level controller with a very slow reset. The withdrawal valves are normally closed, then opened periodically for a short time, and then closed again. We do keep a gate valve adjacent the regenerator for isolation.

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WARDINSKY (ConocoPhillips)

We typically rely on a series of two to three gate valves to withdraw catalysts from the regenerator. Some of these valves have actuators on them. The valve internals are metallurgically enhanced to reduce erosion; and for high temperature service, we plan on replacing the valves at each turnaround. With the exception of third-stage separator underflow, we do not continuously withdraw catalysts from our regenerators.

HAZLE (NPRA)

I want to remind you that your Answer Book includes some of the panelists' responses as well as responses from other people that submitted them before the conference. I encourage you to open that and follow along and keep track.

KEVIN PROOPS (Solomon Associates)

Aram, when you were talking about valves, you mentioned that you have or have considered stainless steel. You also mentioned that you are considering alloying the line. I believe, Pat, you used the word alloy. I believe we have brought up, in the past at these sessions, concern about polythionic stress corrosion cracking in this service, and I would like to confirm or clarify whether we are talking about the 300 series stainless or something else. My experience would be that if you are having problems with erosion on the line and you are considering alloy, then I think, economically, you might do better to have a larger pipe or go with the cushioned tee-type installation and not go to alloy because I have experience with these lines lasting a very long time in carbon steel service or low chrome. I would like to hear comments on metallurgy from both Aram and Pat.

ASDOURIAN (Sunoco Inc.)

You bring up a very good question. We do have folks that we pay to take care of this type of alloying questions. Unfortunately, I am not one of them, but I can query those personnel and put my response in the Answer Book.

WALKER (UOP)

I agree with the polythionic stress corrosion cracking comment. When I refer to alloy, I mean 5-chrome or similar.

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THOMPSON (Chevron)

I would agree with that. We typically have 5-chrome. We have a few places that have selectively used just 1¼-chrome, but usually it is 5-chrome. We stay away from 300 series stainless for the reason you mentioned: that PSCC is a known risk and there is really no need for it at that location.

PHILLIP NICCUM (KBR)

I would like to just agree and reinforce that in catalyst withdrawal service, we would definitely recommend staying away from a stainless steel, such as 304-type stainless steel. We have seen instances where it had been used and the lines would break due to polythionic acid cracking.

MASHUD MARTLE (KBR)

In the past, we have used stainless steel 321-X for catalyst withdrawal lines and kept avoiding the polythionic corrosion. We kept nitrogen purge so that keeps a continuous flow into the regenerator to the flue gas, which does not condense, and it keeps the nitrogen as a blanketing. We used 321 stainless steel and it worked very well in a few instances.

ZIAD JAWAD (Shaw Stone & Webster)

Mike, you mentioned the flue gas fines collection systems. In those systems with the fourth-stage underflow, do you utilize gravity drain down into the fine topper? Has anyone seen corrosion in the fine topper if it is pressured up in that service?

WARDINSKY (ConocoPhillips)

I am not aware of any corrosion problems in those lines. I have not heard any reports of that. We do have, I believe, some fourth-stage separators with gravity drainage to a hopper where the catalyst is then cooled and offloaded later.

WALKER (UOP)

I have heard of corrosion in that area. The catalyst accumulates down there. It can insulate and you can trap corrosive materials. We insulate and heat-trace that area.

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ZIAD JAWAD (Shaw Stone & Webster)

In those services, do you have metering block valves or different types of block valves? Do you have corrosion in those lines as they meter the catalyst down to the fine hopper?

WALKER (UOP)

Those hoppers are usually on a timer and they are periodically unloaded to maintain the level. I am not sure if that answers your question.

WARDINSKY (ConocoPhillips)

Yes. The hoppers are typically unloaded at least once a shift in that service. I am not aware of any corrosion issues associated with the valves.

REZA SADEGHBEIGI (RMS Engineering)

Besides temperature that Ralph mentioned, one of the key criteria in designing those valves is the pressure drop. You know, the regenerator pressure can run anywhere from 15 pounds to as high as 50 pounds. So when you look at designing that valve, you are taking a lot of pressure drop if you are running a 40-pound regenerator and you want to go down to zero, basically, or one- or two-pound. So that is the one you have to look at. It is similar to designing a slide valve. You may need to have a two- or even a three-valve system to allow you to take reasonable pressure drop across the valve. Otherwise, it is not going to last very long, especially if you have to withdraw very often. The other thing that I have seen happen is that erosion in the piping that you were talking about downstream: Most cat crackers do not pay attention to how much purge air rate they have going through there. They just open the valve. They have no idea whether it is too much or too little. I would recommend putting some sort of a restriction orifice or a flow meter and target about 30 fps velocity. That will ensure that your catalyst is moving and that you do not have erosion, especially around the elbows. Thanks.

DOC KIRCHGESSNER (W.R. Grace Refining Technologies)

Pat, I would like to ask you, in particular, a question. You commented about the simple regenerator-level control scheme. Would you care to comment how prevalent this is in actual practice? About how many people do you know who are actually, continuously, adding and withdrawing catalysts from the FCC regenerator?

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WALKER (UOP)

I am not sure how many continuous withdraw systems we have operating. I am intimately familiar with one that is working very well in the Middle East, and I believe we have a handful of other ones that are also working without any problems; again, using the Everlasting valves. Prior to that and since the beginning of cat cracking, it was done periodically maybe once a day or once every three days, depending on the unit, and that still works fine. It is still the most common industry practice.

WARDINSKY (ConocoPhillips)

I am a little skeptical of the continuous withdraw system because within our system, we see a lot of units struggle to maintain a continuous addition to minimize swings in the unit operations. One of the first things we do when we go out is to try to get people to look at loading systems that are reliable and that maintain a continuous addition to the regenerator. We still seem to experience a lot of problems with loading systems and reliability of those systems.

WALKER (UOP)

I have just one more comment on what Mike said about addition systems. It seems that the most reliable, repeatable systems are those based on day hoppers on weigh scales.

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