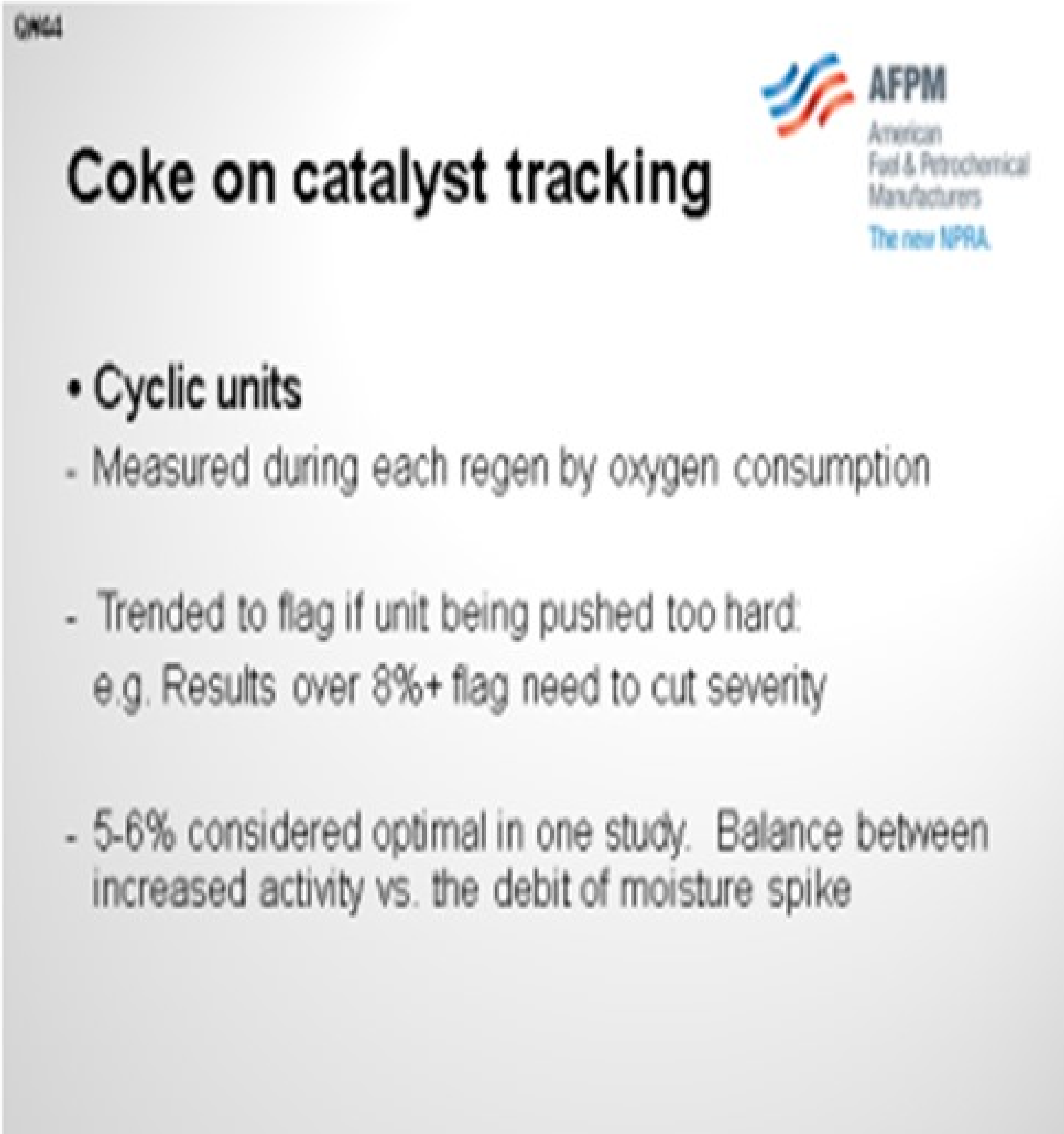
Question 44: How is coke on catalyst in fixed-bed and moving-bed reforming units tracked? How is this data used to adjust the reactor inlet temperatures in order to maintain constant product octane?

PIZZINI (Phillips 66)

In our cyclic units, just based on the air consumption, we can measure the coke each time a reactor comes out for a regen. We are not grabbing samples. Our experience with the cyclics is that if you get up around 8% coke on catalyst, the unit will be pushed a little too hard. You will then need to think about backing it down on feed rate octane, finding a better-quality feed, or possibly increasing the hydrogen/oil ratio.

In one of our studies, we found that 5% to 6% coke on catalyst for a cyclic was just about optimal between the activity and the effect on yields. Every time we switch in a new reactor, we have a bump in moisture, resulting in more C4- until the unit dries out.



Where we could regen faster, we discovered that the optimum cycle was to allow 5% or 6% coke on catalyst. Some of our semi-regen vessels do have catalyst sampling options, but we actually discourage taking those samples frequently. The concern, of course, with a radial reactor is that you never want to uncover the top part because it could allow gases to bypass into the center downpipe.
The octane control on a semi-regen is just a matter of sending samples to the lab and tracking the octane. The purposes of the other components are to figure out the length of your run and manage feed

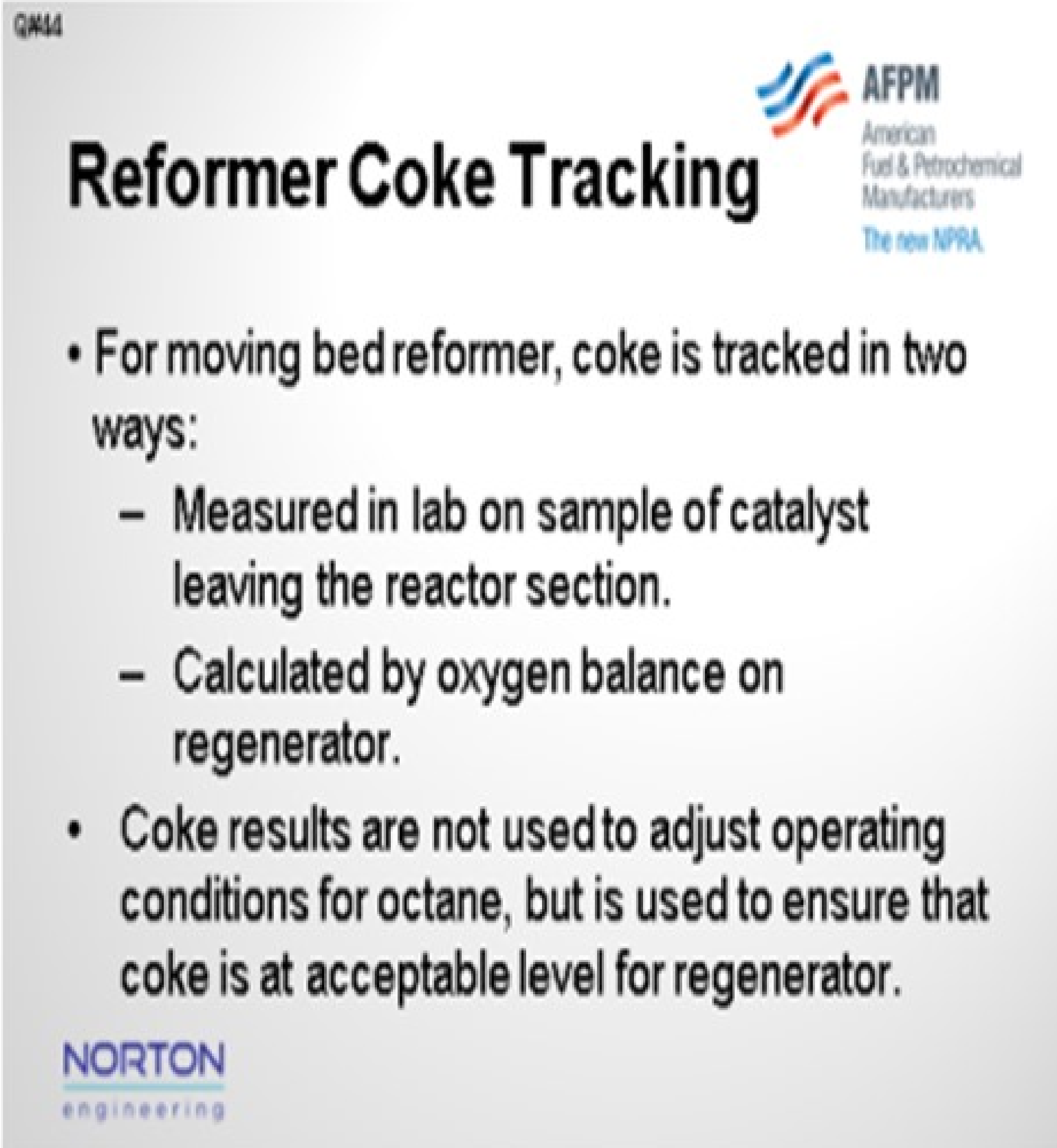
rate and severity to make the run.

On CCRs, we do sample the spent catalyst directly for coke on catalyst. That number is compared with the calculated coke number, which is determined based on the air demand. Again, that number is used to track whether or not we are pushing the unit too hard. If it will be necessary to make less coke, then you could reduce the octane feed or increase the hydrogen-oil ratio. The goal is to maintain a maximum circulation of catalyst.

STEVES (Norton Engineering Consultants, Inc.)

My experience and comments are about a moving-bed reformer or CCR. We track coke in two ways. As Paul mentioned, we take a sample of the catalyst and measure the coke in the lab. We also then calculate, by oxygen balance, the coke in the regenerator that is being combusted. We do not use the coke results to adjust the operating conditions for octane, but we do use it to ensure that the amount of coke entering is within the coke burning capability of that regenerator.

I have seen coke prediction spreadsheets used to estimate the coke being made on the catalyst when the regenerator section is taken out of service for maintenance or screen cleaning. With that spreadsheet tool, we evaluate multiple cases to determine the impact of feed rate octane and feed quality on the coke levels to ensure that the coke stays below the maximum target levels before the regenerator is returned to service.



PATRICK BULLEN (UOP, A Honeywell Company)

For CCRs, we recommend that you do weekly sampling of the coke in your unit's local lab to make sure that you are at the right point for your calculations and that you then make adjustments as needed.

PIZZINI (Phillips 66)

On fixed-bed cyclic units, the coke on catalyst is quantified on each reactor when it cycles out for regeneration. This information is mainly used to identify if the unit is being pushed too hard with respect to rates, octane, and H2/oil ratio. Experience has shown that coke on catalyst greater than 8% may indicate a coke-imbalance which will require a rate cut to hold constant octane. A study on one of our cyclic reformers showed that a regeneration frequency that averaged 5% to 6% coke on catalyst provided the optimal yields and activity. For that unit, regenerating too often caused a drop in average C5+ and H2 yields due to the moisture spike that results when each reactor comes back into the process from regeneration. Otherwise, RITS are adjusted “as needed”, based on daily octane results.

On one of our CCRs, we measure actual coke on spent catalyst to validate the air-demand coke calculation. Both readings are used to adjust reactor operation if necessary to make less coke (e.g., feed quality, severity, feed rate, H2/oil ratio) with a goal of maintaining maximum catalyst circulation. Catalyst samples are also used for chloride adjustment.

On our semi-regeneration reformers, we discourage frequent catalyst samples to test for coke content because over time the loss of catalyst increases slump and causes bypassing at the top of the reactor. This can affect reactor performance and lead to catalyst fluidization and attrition.

SUBHASH SINGHAL (Kuwait National Petroleum Company)

In CCR units, the coke in spent catalyst is analyzed, and regenerator conditions are adjusted to achieve the target coke level in the regenerated catalyst. Constant octane is maintained by adjusting reactor temperature, preferably flat profile.

Tags

Catalysts

Feed Quality

Octane

Operations

Process

Reactor Vessel

Reforming

Regenerator