Follow up on Rouging Query Raised at PUW & WFI System Design Lecture

By Hugh Hodkinson, 20th Dec 2011

There was a query at the lecture regarding what level of rouging is unacceptable in a PUW or WFI system and would necessitate that the system be repassivated. My recommendation was that all PUW or WFI systems should be inspected during annual shutdowns to check for rouge build up. If the level of rouging is judged to be excessive, the system should be passivated. It is common to passivate these systems every few years or more frequently if rouging is a particular issue.

In response to the query raised, my findings are that while excessive rouging is undesirable, there is no quantitative limit as to the maximum acceptable level of rouging. It is up to the engineering and quality representatives on each site to agree on whether the level of rouging in the system constitutes a risk and necessitates system repassivation.

Recap of what was stated at the lecture

- Rouging is a film of iron oxides and hydroxides
- Rouging is common in PUW, WFI and Pure Steam systems
- Rouging is acceptable in these systems, however it is recommended to monitor rouging, periodically remove it and minimise rouge levels passing into the product

There are three types of rouge:

Class 1: Caused by contamination from external sources, e.g. carbon steel particles getting into a PUW/ WFI/ PS (pure steam) system. This SHOULD never happen, as all good contractors are very stringent about separation of carbon steel stores from stainless steel stores, using separate tools for carbon steel and stainless steel, etc. If this type of contamination is in the PUW/ WFI/ PS system, I'd recommend shutting it down, draining, passivating, refilling and restarting. An investigation would have to be launched to determine how the contamination entered the system.

Class 2: Rouging in PUW/ WFI systems: These systems will always rouge, especially if they are > 60 °C. This does not affect the water quality, but it is good practice to periodically passivate these systems. The frequency depends on how much rouging occurs. Typically a facility would passivate these storage and distribution systems every few years.

Class 3: Rouging in Pure Steam systems: These systems will rouge quickly. This does not affect the PS quality, but it's worth considering putting the PS through a steel mesh before it reaches a critical process step. I'd recommend a 1 um mesh size.[1]

[1] Tverberg, J.C. and J.A. Ledden "Rouging of Stainless Steel in WFI and High Purity Water Systems", Proceedings of Tube 2000, Dusseldorf, 2000.

Answer to Query

Assuming the rouge in question is Class 2 or 3, studies have shown that rouge particles are typically about 1 µm in diameter[2]. This is acceptable by USP standards[3], which prescribe maximum quantities of particles greater than 10 µm and greater than 25 µm. Therefore 1 µm particles fall under the radar. However, there are at least three issues that must be considered:

1. Any form of contamination must be minimised in a PUW/ WFI system, pure steam system or pharmaceutical product, no matter how innocuous.
2. There is a concern that rouge particles could build up on a surface and release a cloud of fine particles into the PUW/ WFI system if there was a sudden pressure change or mechanical shock.
3. Parenteral products are normally filtered to 0.2 µm, if possible. Excessive rouge levels could inhibit the flow through a filter. More importantly, not all components of parenteral products are filtered (e.g. suspensions), so the rouge could carry over into the final product. What's more, any items which are cleaned with WFI after the final filter could see a build up of rouge, which would carry over into the product.

Based on the above, it is clear that there is no strict limit for the level of rouging in a system. However, Henkel produce an inline instrument which monitors rouge levels and produces a warning when rouge levels start to become excessive[4]. After reading the available paperwork (refer to their website for more details), it was not clear to me what the warning limit was based on. This is a question that a potential buyer should raise with with a rouge monitoring instrument vendor prior to purchase: what is the warning limit setpoint based on?

It is very important to note that rouge is composed of uncharged particles, so a conductivity sensor will not reveal the level of rouging in the water. It is a common misconception that conductivity sensors can detect all forms of contamination in compendial water systems, but that only applies to ionic contamination.

[2]Troels Mathiesen, Jan Elkjaer Frantsen, FORCE Technology, Rouging of Stainless Steel in WFI Systems – Examples and Present Understanding, Paper 07193, March 2007.
[3] United States Pharmacopoeia 788, Particulate Matter in Injections.
[4] www.henkel-epol.com

Methods for Minimisation of Rouging

The Force Technology paper referenced earlier gives a good summary of ways by which rouging can be minimised. These include the following:

- Electropolishing can reduce rouging in water systems, but can increase rouging in steam systems
- Surface treatment has a greater influence than the grade of stainless steel
- Reduce carbon dioxide levels in the PUW/ WFI
- Higher alloy stainless steels such as 1.4462 and 1.4539 do not lead to lower levels of rouging than the more standard 1.4435 (316L SS)
- High flow rates increase the rate of rouge formation

Rouge Removal

ASME BPE 2009 includes a lot of information on the efficacy of different chemical treatments for removal of the three different categories of rouge. The ASME guide provides information on the recommended concentration, temperature and contact time, as well as comments on unique aspects of each treatment. It is a useful starting point for anyone investigating how to remove rouge from a system.

Need for Research

The Force Technology paper finishes with a statement that more research is needed in this area. This is an issue which affects all pharmaceutical facilities which produce PUW, WFI or Pure Steam and it is a phenomenon which is not fully understood. Any potential masters or PhD students should consider this as a topic!