TECHNICAL SERVICE AGREEMENTS
WORTH IT OR NOT

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ABSTRACT

There are a lot of older Sulfur Complexes in the industry worldwide, which were not designed to the most recent accepted industry standards and practices. A number of these plants have been operated at their limits for a long time without really understanding whether these plants are at risk of imminent failure. In addition, it is Comprimo's experience that the knowledge and experience of the people operating these units is declining with less and less understanding of what proper operation, start-ups and shutdowns for especially SRUs means.

In this paper, Comprimo would like to discuss some of their most recent experiences with performing Technical Audits as part of Technical Service Agreements (TSA) and how these TSAs can prove to be very beneficial for the operating facility long term. These reviews, for which the plant typically does not have time themselves, shine a light on practices and designs that may have been tolerated for extensive periods in the plants while resulting in poor performance, increased failure of the equipment as well as environmental and safety risks.

In addition, these reviews also flag a more prominent issue in our industry, which is the knowledge of the operators and how they can recover their units from operational issues that are caused by inadequate designs of the existing upstream systems that can cascade into much larger problems. In addition, the large period between turnarounds reduces the operators' ability to experience start up and shutdown practices.

Plant specific training is proving to be essential, which can easily be made part of the TSA process and Comprimo has a dynamic training module called IMMERSE that can mimic the operation of an SRU's control system.

1.0 INTRODUCTION

There are a lot of Sulfur Complexes in the industry that are starting to get a little long in the tooth, however, as is typically the case may be the forgotten units in a refinery as they are not the money makers. Only when these units become the limitation to processing the maximum capacity of the upstream profit centers such as the Fluid Catalytic Cracker (FCC), Coker and/or Hydrocracking units, tends there to be more focus on keeping the units in the sulfur complex up and running. This typically does not mean that necessary improvements are made to the facilities, just that maintenance on them becomes more urgent during these times.

In addition, the engineers and operators involved in the daily operation of these units are typically too busy with their day-to-day activities (including fighting fires) that there is little to no time to step back and do a thorough review of the design and identify operating flaws that may have become the norm for these units. Therefore, Worley Comprimo is of the opinion that there is more and more a necessity to take a more holistic view of the overall sulfur complex whereby design, operation, incidents, maintenance, start-up and shutdown practices as well as turnaround planning are considered.

2.0 THE NEED FOR EXTERNAL REVIEW

One of the options available to an operating company is to review the design, operation, incidents, maintenance practices as well as start-up and shutdown practices fully internally. This could be done in-house with people from the plant itself or with the assistance of people from other facilities that may have similar units in operation. Most operating companies will have a Subject Matter Expert (SME) available that oversees all of the facilities, who would typically have the best general knowledge of all the facilities that are in operation as well as their idiosyncrasies, problems and operating history.

Alternatively, it may be necessary to bring in external consultants to help with this review. External consultants may have substantial operating and troubleshooting experience as well as have been involved in the design of newer facilities that were more recently built and started up compared to the units in the facilities of the operating company. They may also be very familiar with any new industry standards like for example the new API 565 for thermal reactor designs or guidelines. In addition, by picking the right consultant(s), they may have substantial experience performing these types of reviews thereby being able to bring their knowledge and experience which may include “confidential” learnings from other facilities that could be useful to the facility under review.

Comprimo is of the opinion that a combination of the two options described above is the optimal solution for performing a technical audit. The SME of the operating company typically will have the most intimate knowledge of the company’s internal standards, which will likely be newer and more up to date than the facilities that are being reviewed. These company standards are regularly updated as new learnings may have become available from the industry which have been integrated into API and other industry standards and guidelines. Examples of this are for instance the recent development of the API 565 for Sulfur Recovery Thermal Reactors as well as updates to API 520 with respect to waste heat boiler tube failures.
It is also recommended to bring in someone from operations from another facility. This person can provide their learnings over time from inadequate designs and/or operations and be a useful resource for internal company learnings that may not have been communicated through the normal channels in the company. Not every company

has a Best Practices communication channel or is part of the Amine Best Practices Group (ABPG) where learnings can be shared anonymously between companies.

3.0 THE PROCESS

There are a number of steps involved in the process of a technical audit.

3.1 GATHERING OF INFORMATION

Step one of a technical audit is the gather the pertinent information of the plant that is being reviewed. Depending on the overall scope of the investigation, the amount of information to be reviewed can become quite substantial.

As a minimum Comprimo recommends that the following items are provided by the customer:

- Process Flow Diagrams and Heat and Material Balances
- As-built Piping and Instrumentation Diagrams
- Datasheets for all of the equipment including General Arrangement drawings and vendor drawings
- Start up and Shutdown guidelines
- Operating Guidelines
- Control Narratives
- Logic Narrative
- Event log and root cause analysis of the events
- Most recent performance tests done on the facility

3.2 INITIAL REVIEW OF AVAILABLE DESIGN INFORMATION

The initial review of the available data should focus on getting a better understanding of the plants that are there. What is the age of the plants, what specific design features stand out for the plants?

This review will typically already point out a number of design features that may not be up to the latest standards for the design of these units. There may be features in the design that were included due to cost savings which typically will not provide the same operating stability found in more robustly designed units. One such example is the use of stab-in-type condensers in sour water strippers or the use of common equipment without proper ability to isolate the equipment for safe switch over with minimal impact to operation or the environment.

3.3 IN-PERSON MEETING

There are several methodologies possible for the performance of the technical audit. One of the options that Comprimo has used is to arrange individual meetings with the different groups that are responsible for the maintenance, operations, turnaround planning, etcetera. However, the most efficient way has proven to be the methodology where a central team comes together and other interested parties are brought in on an as needed basis.

By having the team work together to develop an agenda that clearly defines who will be needed at what time during the review, it will ensure that the right people are available for the correct sections of the review. For the first meeting, it is essential to lay out the purpose of the evaluation as well as lay some ground rules for how the review will be done. The first step is to define what the expectations are from the review and once this has been established, a quasi-PFD review can be done for everyone to understand the design that is currently in place. Very often during this review, a substantial number of issues will already be brought up by the plant as they know where the shortcomings and design flaws of the unit can be found.

3.4 SITE WALK

Feet on the ground is absolutely essential during a technical audit. The site walk should include one of the more experienced field operators and the plant engineer, as they are the ones most aware of the problems that have been experienced in the field. In addition, there are installation details that will likely not be observed from just studying the PFDs, P&IDs and datasheets. Field installation details are very important to compare to the original design intent of a plant.

As an example, the installation details of a weathershield on a thermal reactor in a sulfur recovery unit is essential to prevent either sulfuric acid attack on the shell or high temperature sulfidation. Insufficient coverage of the thermal reactor shell with a weathershield can lead to potential cold spots on the shell and thereby potential condensation of sulfuric acid behind the refractory resulting in increased corrosion rates. On the other side, not installing a vent on the weathershield can lead to potential high temperature areas (in particular in the middle top of the thermal reactor) where the shell temperature can exceed high temperature sulfidation conditions and thereby create again potential for high corrosion.

Figure 1 - Thermal Reactor Weathershield without vent

As another example, during one of such visits to a plant, it would not have been easy to determine from the P&IDs or vendor drawings that the location of the sulfur pit vent gas piping nozzle into the main burner resulted in the slow formation of a sulfur stalactite in front of one of the two flame scanners which led to spurious trips.

Things such as improper installation of jacketing, tracing and insulation cannot be determined by looking at P&IDs. These issues can typically only be found through a proper site walk.

Figure 2 – Tracing and Insulation for sulfur pit vent gas

Long-term experience with problematic designs provides the clues that the technical auditor can use to provide guidance to the plant to improve the operation long-term.

3.5 DISCUSSIONS WITH OPERATORS

One of the key components of a Technical Audit are the discussions with the operators. In general, this can be both the field and board operators, however the primary focus should really be on the board operators as they monitor the day-in day-out operation of the facility. They are also the ones that have to handle any upset situations that may arise during operation, which can be due to the following reasons:

- Feed instability
- Instrumentation failure
- Equipment failure
- Weather events
- Miscommunication
- DCS or SIS issues
- Power failures

It is important to understand the resources that the operators have available to them to properly manage any situation that may arise during operations.

- How were they trained on the console?
- What is the chain of command?
- Do they have authority to make decisions on their own?
- Have they had any external training both theoretical as well as any dynamic modelling of their particular plant?
- How many experienced operators are there per shift?

- What is the average experience of a board operator?
- How do they interact with the field operators as well as the plant engineers?
- Are the plant engineers experienced with the units that they are in charge of?
- Are there thorough and easy to navigate operator manuals and procedures readily available?

There are several ways of managing the interaction with the operators. It is possible to have one on one discussions with the different operator crews as well as bringing the field operators along during the site walks (which one should do anyway due to typical rules in plants that consultants cannot venture out on their own in the plants). An alternative methodology is to prepare a customized questionnaire for the operators (and engineers) to get a better overview of their understanding of the plant. These questionnaires can be made as customized as necessary. In one case, Comprimo developed a questionnaire which dealt mostly with general knowledge of the units that were under review. In another scenario, where there were very specific upset situations that the plant had experienced, the questionnaire was much more focused on the details of the upset situations to get a better understanding of whether the operators understood the control system installed as well as the tools that were at their disposal to manage the upset situations that had occurred.

4.0 THE RESULTS

Comprimo has used two methodologies for the communication of the recommendations made to the plant to improve the design, operability and reliability. We recommend producing the recommendations as individual worksheets which are attached to the report or they can be provided in a separate chapter in the final report. Comprimo's preference is to use worksheets, as these can easily be part of a (construction) work package that then can be implemented in the field.

It is important to provide information such as expected installed cost of the proposed modifications, benefits and drawbacks, any risks associated with the proposed modifications.

It is not the intent of the technical auditor to do the engineering required to make the modification in the plant to improve the operation, reliability or performance. It is intended that the technical auditor flags any gaps in design, operation, maintenance or training that they have observed and recommend steps forward to improve these gaps.

5.0 OPERATOR TRAINING

One of the key items that appears to be found every time that Comprimo is part of a Technical Audit is the need for operator training. There are a number of industry training courses available to the industry, however it is Comprimo's opinion, that these training courses are very general in nature, with little time spent on the actual configuration and problems that the engineers and operators experience in their facilities. There are a number of advanced courses available as well, which dive into more details than the general courses which can be very useful to provide a general basis for the engineers and operators. These training courses are not always customized for the particular configuration, control system, start up and shutdown logic, etcetera that is present in the plant for which the operators and engineers are responsible.

Operating practices in a plant are typically handed down by experienced operators to new operators and it appears that these practices are not always rooted in optimized operation of the facilities. Very often, there may have been an issue in the facility that may have led to an operating practice just to prevent an upset. One example that Comprimo experienced for this was a plant where there was a strict instruction to maintain the overhead temperature of a sour water stripper at 100°C (212°F). This instruction originated in a sour water stripper with a non-standard overhead condensing system and due to past upsets in the unit with the control system for the overhead temperature, this higher than recommended operating temperature had become the norm for operation. This of course came with a number of issues with the sour water acid gas to the sulfur recovery unit, such as a water content of 50% instead of 33%, which in part led to lower thermal reactor temperatures, which led to a requirement to co-fire natural gas continuously to meet the minimum required temperature for ammonia destruction.

Another indication of "learnt" behavior was seen at several refineries where, due to the installation of venturi flow meters on the combustion air, the operators depended on a differential pressure reading across the control valves to determine potential back flow from the thermal reactor to the suction of the combustion air blowers. As a result of several trips caused by this differential pressure measurement, the operators in these facilities started to ensure that sufficient margin was maintained between the low differential pressure setpoint and the actual differential pressure. In either case, we found that the operators had been taught to maintain the back pressure of the thermal reactor of the SRUs at least 3 psi below the combustion air pressure, which in one case meant that the maximum back pressure on the SRU was about 3 psig. In both cases, the plants were looking for additional capacity to be processed in the SRUs and wanted to find "low-hanging fruit" options for the units. The additional capacity was found without requiring substantial investment cost by changing the approach to this large safety margin between the trip setpoint and the actual operating point. In addition, it was found that by changing the venturi air flow meters to balanced orifice flow meters, it would be possible to eliminate the differential trip altogether and use a low low flow trip again.

The board operators typically do not get any opportunities outside of the normal operation of the units to "play" with the parameters of the control system or even practice on how to manage upsets in the unit. In one facility, Comprimo was brought in because there had been a number of substantial SO_2 emission excursion events over the past two years. Initially, the customer thought that these emission events had been caused by a recent change in DCS system or issues with the Logic Programming handling all the start-ups and shutdowns. Upon review though, it was found that the board operators had taken no action whatsoever during these events to resolve the problem and fully depended on only the DCS actions (i.e., tail gas analyzer controller) to solve the problems for them. The issues could be traced to several control issues such as introduction of air into a hot sulfur plant for an extended period, incorrect air to acid gas ratios resulting in over response of the combustion air controls, as well as incorrect tuning of the tail gas analyzer control.

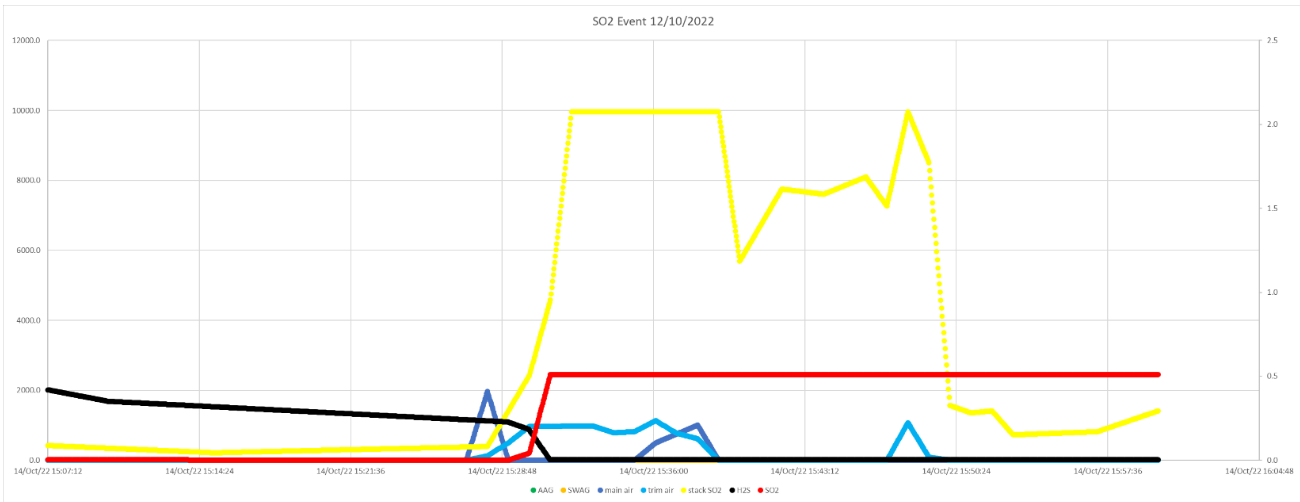

Figure 3 - SO_2 emissions event

5.1 OPERATOR TRAINING USING DYNAMIC SIMULATORS

A number of technology providers have developed tools that are able to mimic the operation of their technologies in a virtual environment. These are most common for technologies where optimization of the operation of the unit can lead to higher profit margins. For sulfur recovery units, Worley Comprimo has developed a dynamic training tool which can mimic the operation of a sulfur recovery unit including all the logic that is programmed into the DCS and SIS. This tool, which is called IMMERSE, can be fully customized to the customer's needs, from fully matching the customer's DCS screen layout to matching only the process control and startup and shutdown logic implemented in the DCS using generic screens.
With IMMERSE, the operators can practice controlling the SRU during start-ups, shutdowns and upset situations before these events happen in real life. Thus, it provides a unique learning experience that is typically not possible in a live environment.

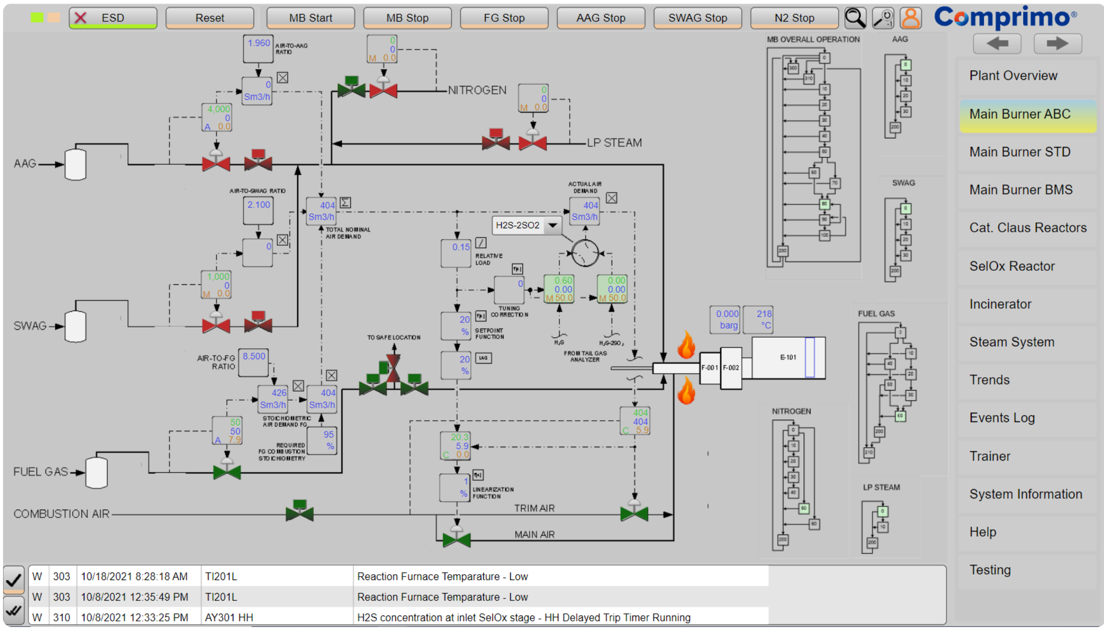

Figure 4 - Main Burner ABC Interface

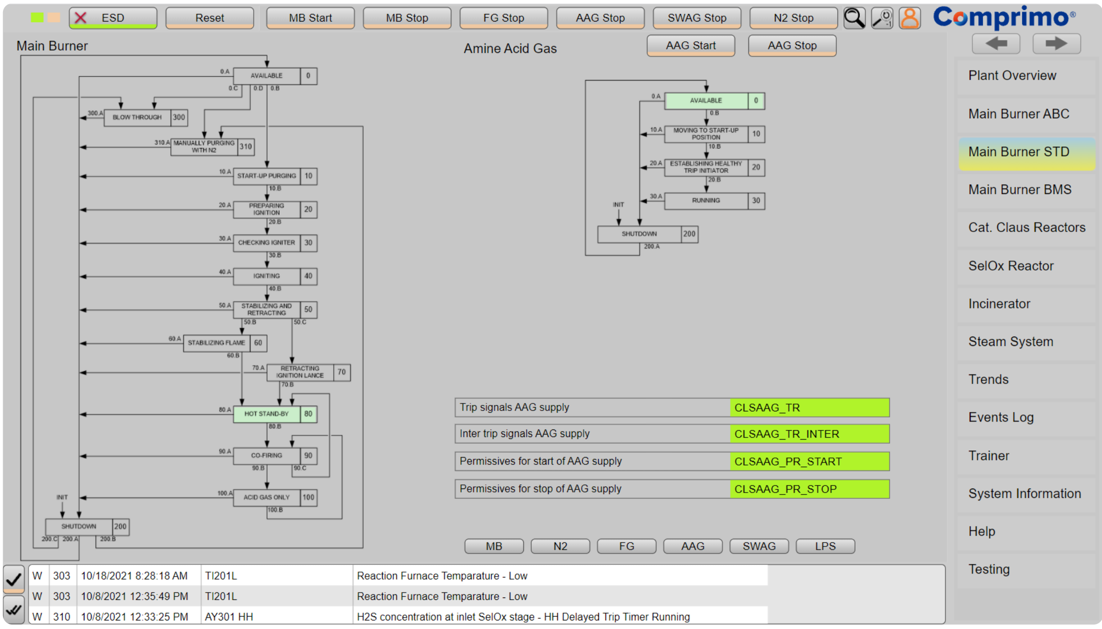

Figure 5 - Main Burner State Transition Diagram Interface

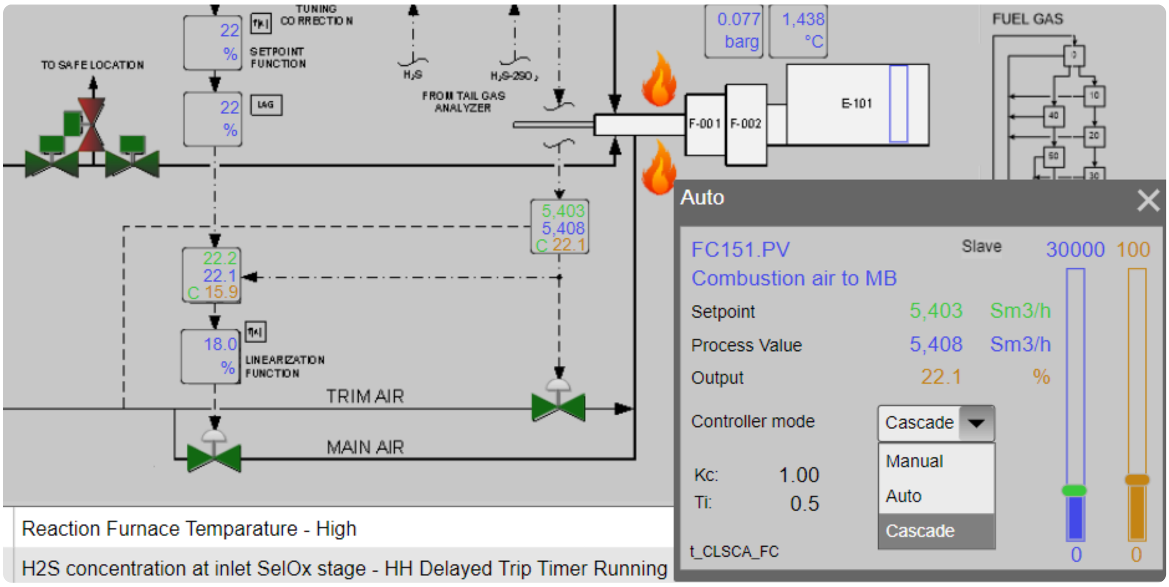

Figure 6 - Controller Face Plate

The tool provides options to the trainer to demonstrate the start-up and shutdown procedures, which for a number of plants may only occur every five years. In addition, upset situations such as hydrocarbon carryovers, failure of tail gas analyzers can be introduced during the training to allow the operators and engineers to observe the consequences of these events on the operation and performance of the SRU. One example that Comprimo has observed in operations is for instance using incorrect air to acid gas ratios in a refinery SRU, where this can lead to substantial upsets during weather events leading to large swings in acid gas flows.

6.0 CONCLUSIONS

Comprimo is observing more and more need for in depth reviews of existing sulfur complexes to assist operating companies in coming up with investment plans as well as training plans to reduce the number of unplanned outages. Comprimo uses a structured process to assist the client with this evaluation which can be limited to only the initial review but might eventually extend to supporting the facility during shutdowns, start-up, equipment inspection and so forth. In addition, Comprimo can develop a custom training program for the operators (and engineers) to get a better understanding of the triggers that they have available to manage plant upsets and optimize the operation of the plant.