Cabot Corporation
Midland, MI Facility

(N6251)

Caustic Scrubber
Malfunction Abatement Plan (MAP)

July 2017

MALFUNCTION ABATEMENT PLAN
RENEWABLE OPERATING PERMIT

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1. General Description of the Caustic Scrubber Operation

Summary
All process gas that flows through vent EP-7 is scrubbed in the caustic scrubber, prior to release. This scrubbing will remove residual traces of hydrogen chloride and chlorine from the vent stream, as they react with the caustic solution to form salts. The salts are removed in the liquid phase and are sent to wastewater treatment. The exiting vent stream is continuously monitored, prior to venting through EP-7.

Detail

The caustic tower inlet fan, GB-10, compresses process gases containing carbon monoxide, carbon dioxide, hydrogen chloride, chlorine, chloromethanes, and air as they flow to the caustic tower, T-5. The process gases enter the bottom of the tower and flow up through the packed sections, making contact with the caustic. The caustic reacts with the process gas as follows:

$$Cl_2(g) + 2NaOH(aq) \rightarrow NaOCl(aq) + NaCl(aq) + H_2O$$

$$HCl + NaOH(aq) \rightarrow NaCl(aq) + H_2O$$

Liquid is collected in the bottom of the tower and pumped to the top of the column. Caustic is added to this recirculation loop at the suction of the recirculation pumps to control the pH of the recirculated liquid to the top of the column. Water is added in proportion to the caustic addition to allow for necessary dilution and quantity of solution to provide gas/liquid contact across the packing. A slipstream of recirculated liquid is removed to wastewater treatment to control the liquid level in the system. The residual gases at the top of the caustic tower are vented via the caustic tower stack, EP-7, to atmosphere.

Dual instruments measure the pH of the recirculation line being fed to the top of the tower. The operator selects which pH reading is to be used for control purposes. If there is a discrepancy between the pH meters, it will be determined which is more accurate and control off that instrument while the other is being re-calibrated.

The fresh caustic available for use in the scrubber is typically stored as a 20% solution. The pH of the recirculation loop will be maintained above 7.8. As makeup caustic is required to adjust the pH of the recirculation loop, water will be proportionately added to dilute the makeup to the desired strength.

There are two sources of water for makeup. Cooled, steam condensate is primarily used; however, industrial water will be automatically selected when there is a low level in the condensate tank. The operator can also manually select industrial water makeup.

As spent caustic leaves the caustic tower (based upon liquid level control in the tower) the fluid is pumped to the wastewater tank, D-6, and is then sent to wastewater treatment.

2. Caustic Scrubber Equipment Specifications

The major pieces of the Caustic Scrubber consist of the inlet fan, the tower, the recirculation pumps, the packing, and the stack. Specific design details of each of these pieces of equipment are presented in Table 2.1.

The inlet fan draws the reactor offgas from the process and compresses the stream into the packed tower. The tower contains 2 packed sections for enhanced contact of the acid gases with the caustic scrubbing solution. The reaction of the caustic with the acid gases will generally take place on the surface of the packing. The inert components of the gas stream will be vented through the top of the tower to the caustic tower stack. In this transfer line from the tower to the stack, control and process monitoring for carbon monoxide will take place.

The recirculation pumps transfer the caustic solution collected in the bottom of the tower back to the top of the tower, to provide continued scrubbing of the process gases. Makeup caustic (at a typical 4% strength) is added to the pump inlet to maintain the pH of the stream. A side stream off the discharge of the pumps is sent through dual pH monitors in order to adjust the caustic addition. The discharge from the monitors is returned back into the pump inlet. The recirculation pumps will also transfer spent caustic out of the system as the liquid level in the bottom of the tower increases.

There is an emergency generator installed to provide alternative power to both recirculation pumps and the inlet fan. This will ensure continued scrubbing of reactor offgas in case of unplanned events such as loss of power supply to the facility and the motor control center.

TABLE 2.1
CAUSTIC SCRUBBER EQUIPMENT SPECIFICATIONS

Equipment	Item #	Description
Caustic Tower Inlet Fan	GB-10	Centrifugal fan with a capacity of 4183 SCFM at 20” WC
Recirculation Pumps	P-18 A&B	Spared, centrifugal pump with a capacity of 446 GPM at 115’ TDH
Emergency Generator	EG-001	Backup power supply to provide power to GB-10, P-18 A&B in case of motor control center power loss
Caustic Tower	T-5	FRP construction with Halar lining height of 60’-6” diameter of 5’-0” design pressure of +5/-3 psig design temperature of 150°F
Tower Packing		2-20’ packed beds 3.5” Rauchert Hi-Flow PVDF (or equivalent) design temperature of 200°F
Caustic Tower Stack	X-119	FRP construction Outlet elevation 135’ above grade height of 74’-0” diameter of outlet 24” design pressure of 25” WC design temperature of 150°F

Routine shutdowns of the process are intended every 12 – 18 months, to perform maintenance and upgrades of needed equipment. During these maintenance shutdowns, the caustic scrubber will also be shutdown and inspected. As part of this, the tower will be opened, to allow inspection of tower internals, such as the packing, packing supports, and liquid distributors.

It is anticipated that the tower packing will periodically need to be replaced. The inspections of the tower packing will be performed to better estimate the timing of the replacement. If it is determined that another packing is available that will better enhance the operation of the caustic scrubber, it will be used as a replacement.

The facility will maintain both recirculation pumps, so that there is generally an on-line spare available for immediate use. A pump taken out of service will receive timely repair, such that there will be little time when the plant is operating with only one pump. There will also be a spare replacement for the inlet fan maintained in inventory.

There will be weekly, visual inspections of the caustic scrubber system conducted. The visual inspection will include process equipment, piping, pumps, etc. The emergency generator will also be checked.

All maintenance and periodic inspections will be performed under the direct guidance of the Operations Manager for the facility. The Operations Manager reports to the Facility Manager, who will ensure that appropriate inspections and repairs are made in a timely manner.

3. Caustic Scrubber Process Control

The caustic scrubber will generally be automatically controlled, through the use of process monitoring instrumentation, computerized process logic and controllers. All operators will be trained in how to monitor and control the automatic operation of the facility, along with use of manual controls.

Table 3.1 itemizes the key process controls used for the caustic scrubber, with a description of operation and response that are part of the operating procedure. The operating procedure for the caustic scrubber indicates the intended operator responses to the pre-startup alarm or upset conditions, in addition to reflecting changes that will be due to operational experience with the plant, and so could be occasionally updated. The operating procedure will be made available for review, upon request.

TABLE 3.1
CAUSTIC SCRUBBER PROCESS CONTROL

Equipment	Description
pH Monitors	Will provide two active pH measurements of the caustic recirculation loop. Will be used to control the flow of 20% caustic to the recirculation pumps. The pH monitors are calibrated every 14 – 21 days, in accordance with manufacturer's recommendations. An alarm will be based on low pH, which corresponds to potential chlorine and hydrogen chloride emissions. Operator response to a confirmed low pH will be to add additional caustic to scrubber. An alarm will be based upon a deviation of greater than 0.3 pH units between the two pH probes. Operator response to alarm will be to check both probes to determine which is correct, and ensure that process will control off of the correctly reading probe. Instruments will receive timely repair, if warranted.
Independent High Tower Level Alarm	Probe (independent of analog tower level instrument) located on the tower that will sense high caustic inventory level in the bottom of T-5 tower. Triggering of this high level alarm will indicate that the analog level monitor on the tower may not be properly working. Operator responses similar to increasing tower level. Instrument will receive timely repair, if warranted.
Tower Level	Will provide indication of caustic inventory level in the bottom of T-5 tower. Will be used to automatically control the flow of spent caustic out of the tower. An alarm will be based upon high level in the tower. Operator response to increasing level will include increasing spent caustic discharge, consideration of flow restrictions to pumps, consideration of excessive makeup flow, and eventual process shutdown to ensure that packing does not get flooded. Instrument will receive timely repair, if warranted.
Recirculation Flow	Will provide flow measurement of the caustic recirculation loop. An alarm will be based upon low flow. Operator response to low flow will be to establish proper flow. This will include starting the spare pump, unplugging flow restriction, cleaning filter, etc. If proper flow cannot be established, the process will be shut down to locate and repair the source of the flow restriction. Instrument will receive timely repair, if warranted.

Equipment	Description
Low Flow Switch	Will sense low analyzer loop flow. An alarm will be based upon triggering of this low flow switch. The alarm condition will indicate that the pH monitors may not be receiving a representative sample. Operator response will be to ensure that the probes are getting a good sample flow, by increasing sample flow or flushing/unplugging the sample line. If it is confirmed that the analyzers are not receiving proper flow for measurement purposes, the process will be shutdown to locate and repair the flow restriction. Instrument will receive timely repair, if warranted.
Pressure Relief	Provides T-5 with a pressure relief device that will pass exhaust gases to the atmosphere if the pressure exceeds 5 psig. In this event, the process will be shutdown, which halts the reaction. The only source of gas generation is the actual reaction, and very little gas is actually in residence within the process, as it is continually being scrubbed. Within seconds, any residual gas within the system would be vented. It is anticipated that much less than one pound of chlorine and hydrogen chloride would be vented in such a case. The cause of overpressuring of the system would be investigated and corrected appropriately. Startup of the process would not occur until the source was determined and corrected. This vacuum/pressure protection for T-5 is checked during the maintenance turnarounds.

4. Caustic Scrubber Instrumentation Specifications

The instrumentation critical to the operation of the caustic scrubber was described in Section 3. The process monitors employ analog instrumentation, used to control the variables during normal operation, and many of the key process parameters will also have digital switches to be used as redundant indications of control. An example of this is a variable tower liquid level, plus a high level switch.

The following Table 4.1 lists the process controls referred to in Section 3 and further identifies the pre-startup design criteria. The alarm setpoints indicated for analog instrument signals will generally be defined through use of control logic software, and may be subject to change, so as to improve process reliability. The specifications for the instruments may change over time, as the plant gains additional operational experience, and enhances the design of the control scheme. Any changes will be identified in the operating procedures, and available for review, upon request.

The parameters listed in Table 4.1 will be monitored in the control room, and recorded on computer. The data being monitored will, at a minimum, be extracted once every 15 minutes and averaged to calculate an hourly average for the parameter. The hourly averages will be recorded on computer for a period of not less than 5 years from the date of generation and made readily available to AQD staff upon request.

TABLE 4.1
CAUSTIC SCRUBBER INSTRUMENTATION SPECIFICATIONS

Process Parameter	**Instrument Equipment Number**	**Instrument Range**	**Setpoint or Normal Operating Range**	**Alarm Setpoint**
pH	AE-4412 A&B	0 – 14 pH	Minimum 7.8 pH	*Low* 8.3
Tower Level	LT-4419	0 – 100%	25 – 55%	*Low* 17% *High* 60%
Independent High Tower Level Alarm	LSH-4417	Switch location on tower corresponds with 81% of LT-4419 span	Off	*High* On
Recirculation Flow	FT-4405 or FT-4452	0 – 600 gpm (140000 kg/hr)	50,000 Kg/hr	*Low* 50,000 Kg/hr *High* 140,000 kg/hr
Analyzer Low Flow Switch	FSL-4426	1.04 – 10.4 gpm (240-2400 kg/hr)	3 – 8 gpm (700-1800 kg/hr)	*Low* 5 gpm (1100 kg/hr)

5. General Description of the Product Vent Filter Operation

Summary

In the final stages of fumed silica production, process gasses flow through a particulate bag filter (TF-13), which is used to control particulate emissions during the secondary separation of fumed silica from conveyance air.

Detail

Following a combustion reaction and many meters of cooling tubes to lower temperature hot gases are introduced into a Main Unit Filter (MUF). At the MUF, the fumed silica is separated from the off gas and conveyed to a cyclone (JC-7) where it is then separated from the air and fed into a rotary calciner (HD-1). In the calciner, steam or sweep gas is used to remove residual HCl. Following calcination the fumed silica is conveyed to another cyclone (JC-8). Off gas from JC-8 is directed through the product vent filter (TF-13) and discharged through ROP Stack ID SV-2A.

6. Product Vent Filter Equipment Specifications

The major pieces of the product vent filter consist of the inlet/outlet fan, product filter vent, filter bags and vent stack. Specific design details of each of these pieces of equipment are presented in Table 6.1.

The inlet/outlet fan draws particulate-laden air into the product filter vent and through the filter bags. Particulate recovered from this process is reintroduced into the product conveying line and conveyed to JC-8 and off gas is discharged to the atmosphere through SV-2A.

TABLE 6.1
PRODUCT VENT FILTER EQUIPMENT SPECIFICATIONS

Equipment	Item #	Description
Inlet/Outlet Fan	GB-15	Centrifugal fan Aluminum Construction Capacity = 60,000 SCFH Pressure in = -15" WC Pressure out = 3" WC Horse Power = 10
Product Filter Vent	TF-13	Aluminum construction Design temperature = 200F Design pressure = +/- 40" WC Capacity = 60,000 SCFH
Filter Bags	Not Applicable	PTFE felt construction (102", 22 oz/yd^2) Design temperature. = Cont. 500F; Surge 525F Design pressure = 400 psi burst pressure Filtration efficiency >99.5% at 0.3 microns Differential Pressure (dirty) = 6 in H2O
Product Filter Vent Stack	SV-2A	FRP construction Outlet elevation above grade = 47' Diameter of outlet (internal) = 8.04" Design pressure = 150 psig Design temperature = 200 F Capacity = 60,000 SCFH

It is anticipated that the bags will periodically need to be replaced. Inspections of the bags are performed during maintenance shutdowns to better estimate the timing of the replacement. If it is determined that another bag is available that will better enhance process operation it will be used as a replacement. The facility has developed and implemented a comprehensive preventative maintenance program for GB-15 and also maintains a 'drop-in' spare. All maintenance and periodic inspections will be performed under the direct guidance of the Operations Manager for the facility. The Operations Manager, who reports to the Facility Manager, will ensure that appropriate inspections and repairs are made in a timely manner.

7. Product Vent Filter Process Control

The product vent filter will generally be automatically controlled through the use of process monitoring instrumentation, computerized process logic and controllers. All operators will be trained in how to monitor and control the automatic operation of the facility, along with use of manual controls.

Table 7.1 itemizes the key process controls used for the product filter vent, with a description of operation and response that are part of the operating procedure. The operating procedure for the product filter vent indicates the intended operator responses to presupposed alarm or upset conditions. The operating procedure will be made available for review, upon request.

TABLE 7.1
PRODUCT VENT FILTER PROCESS CONTROL

Equipment	Description
Differential Pressure	Will provide active differential pressure measurements across the product filter vent to determine differential pressure. An alarm will be based on high differential pressure, which corresponds to potential filter plugging. Operator response to a high differential pressure is detailed in Work Instruction JWAZ-Denser, which is available upon request. Instruments will receive timely repair, if warranted.

8. Product Vent Filter Instrumentation Specifications

The instrumentation critical to the operation of the product vent filter was described in Section 7. The process monitors employ analog instrumentation, used to control the variables during normal operation.

The following Table 8.1 lists the process controls referred to in Section 7 and further identifies the pre-startup design criteria. The alarm setpoints indicated for analog instrument signals will generally be defined through use of control logic software, and may be subject to change, so as to improve process reliability. The specifications for the instruments may change over time, as the plant gains additional operational experience, and enhances the design of the control scheme. Any changes will be identified in the operating procedures, and available for review, upon request.

The parameters listed in Table 8.1 will be monitored in the control room, and recorded electronically. The data being monitored will, at a minimum, be extracted once every 15 minutes and averaged to calculate an hourly average for the parameter. The hourly averages will be recorded electronically for a period of not less than 5 years from the date of generation and made readily available to AQD staff upon request.

TABLE 8.1
PRODUCT VENT FILTER INSTRUMENTATION SPECIFICATIONS

Process Parameter	Instrument Equipment Number	Instrument Range	Setpoint or Normal Operating Range	Alarm Setpoint
Differential Pressure	DPT 3027	0 to 24.88 mbar	*Maximum* 15 mbar	*High* = 12 mbar

9. Historical Changes to the Malfunction Abatement Plan

Cabot submitted the original Operating and Preventive Maintenance Plan (O&PM Plan) on July 1, 1999. This plan will be referred to as "O&PM7199."

MDEQ (both Lansing and Saginaw Bay District staff personnel) reviewed O&PM7199 and sent an email listing 12 issues that needed to be resolved prior to approval.

Cabot submitted an amended O&PM Plan on July 30, 1999 that addressed each of the 12 issues raised by MDEQ-AQD staff. This plan will be referred to as "O&PM73099."

Saginaw Bay District staff verbally told Cabot that O&PM73099 was considered approved if Cabot resolved the issues that resulted from the review by MDEQ.

Cabot submitted an amended O&PM Plan on May 25, 2000 based upon the request of Saginaw Bay staff. This plan will be referred to as "O&PM52500." The reasoning of MDEQ for the revision was to remove information related to stack monitoring to a monitoring plan, and to make the O&PM plan fit the framework of a malfunction abatement plan under Rule 911.

Saginaw Bay District staff began review of O&PM52500, and issued an email on August 9, 2000 listing 7 issues that needed to be resolved prior to approval of O&PM52500 as a malfunction abatement plan.

On August 16, 2000 Saginaw Bay District staff were reassigned, and submission of the amended O&PM52500 was on hold.

On August 9, 2000 e-mail from J. Stark to K. Burley raising questions and comments on the O&PM Plan.

On November 28, 2000 and March 19, 2001 Saginaw Bay District staff met with Cabot to discuss several air permitting issues, including the status of the O&PM Plan.

On May 4, 2001 the amended O&PM52500was submitted to resolve staff issues raised upon review of O&PM52500. This submission was referred to as version "O&PM50401."

On June 26, 2001 e-mail from K. Burley to C. Cottick with written answers to questions 1 and 5 of J. Stark's e-mail (Aug 9, 2000).

On August 20, 2001 letter from M. Reed to P.Fraser approving the Malfunction Abatement Plan (MAP) (formerly the Operating and Preventive Maintenance Plan).

On August 24, 2001 Minor revisions to MAP, referenced as MAP082401, submitted to C.Cottick.

On May 8, 2006 Cabot added FT-4452 to Table 4.1 as a redundant means by which to measure recirculation flow. Verbal approval given by Mike Gruber II and documented change submitted to M. Reid for official approval.

On December 11, 2006 Cabot added the Product Vent Filter to the MAP per the request of Mike Gruber II.

On Feb. 28, 2007 Cabot removed the low differential pressure alarm and all references to it. Also, verbiage was added to 7.1 in support of this change.

In May 2017, Cabot updated the MAP to reflect current controls and maintenance strategies.
Section 1: Caustic Tower pH probe selection is updated. Grab samples are taken when a discrepancy occurs between the pH monitors.
Section 1: The upper limit for Caustic Tower pH is eliminated since there is no negative environmental consequence of high pH operation. The lower limit is maintained.
Section 2: The term “emergency generator” replaces the term “standby generator” throughout the MAP.
Section 2: Routine plant maintenance shutdown frequency is updated from “annual” to “12 – 18 months” throughout the MAP, based on operating history and reliability. The Caustic Tower packing replacement expected frequency of 3 years is removed.
Section 3, Table 3.1: Routine calibration checks of the pH monitors are conducted bi-weekly during plant operation. The DCS alarm setting for deviation between the pH probe readings is reduced from 0.5 to 0.3 pH units.
Section 3, Table 3.1: Tower Temperature is removed from the Process Controls as it varies with ambient conditions, and does not impact emissions at any anticipated process temperatures.
Section 3, Table 3.1: Pressure Relief device inspection frequency is updated to align with the maintenance shutdown schedule.
Section 4, Table 4.1: Normal operating ranges and alarm setpoints for pH and Tower Level are updated based on current operating practices. Tower Temperature is removed from the table.
Section 6, Table 6.1: Product Filter Vent and Filter Bag descriptions are updated for the current bags, including material of construction, and temperature, pressure, and differential pressure ratings.
Section 6, Table 6.1: Product Filter Vent Stack exit temperature and exit flow are removed as they vary with ambient conditions and normal operations and are not impactful to emissions.
Section 6: The Product Filter internal inspection frequency is aligned to the plant maintenance shutdown frequency. The filter bag replacement expected frequency of 3 years is removed.
Section 7, Table 7.1: The Differential Pressure description is updated to reflect current process understanding that bag failure is unlikely to cause high DP. Work instruction references in this table are updated.
Section 7, Table 7.1: Inlet Temperature and Inlet Pressure are removed from the Process Controls table as there is no expected impact on particulate removal efficiency at all anticipated process temperatures/pressures.
Section 8, Table 8.1: The Differential Pressure normal operating range and alarm setpoints are updated for the current filter bags.
Section 8, Table 8.1: The Inlet Temperature and Pressure instruments are removed from the table.