

Interpretation of Event Monitor Agent Alarms

Introduction

The Event Monitor Trigger System contains data analysis algorithms that analyze the current water quality data once per minute. When the water quality data are benign, no alarm is given. During such times, the system builds a model of the expected water quality at the installation site. When the measured water quality parameters deviate from the expected water quality, the parameter deviations are analyzed for the magnitude of the change. If the magnitude is greater than a threshold, an alarm takes place. It is necessary to interpret the nature of an alarm so that a proper response can be made. This document provides information on how to qualify and interpret the data.

1. The Purpose of the Agent Analysis Algorithms

The analysis algorithms do four things:

- a) Trigger an alarm if the water quality deviations are excessive -
“Something unusual has happened.”
- b) Analyze the deviations to see if they match an agent fingerprint from the Agent Library, and report that match - presumptive classification found. The class or name of the agent, and a calculated probability of match are given.
- c) If an agent match is found, estimate the concentration of the agent in the water in terms of the percent of LD50 for that agent.
- d) If no agent match is found, the Plant Library is searched to see if there is a match with previously found fingerprints. If a match is found, it is reported, otherwise the fingerprint is named and stored in the Plant Library for future searches.

All of this is done for the purpose characterizing the event that has taken place and presenting that characterization to the people with responsibility for the system.

2. Commentary on the method

This method is interpretive. It does not depend on specific chemical sensors to find a given agent. The method is based on chemical responses across five fundamentally different water quality parameters. If the system reports cyanide in the water, it is not because a cyanide sensor has reported the presence of

cyanide. A cyanide report means only that a chemical's 5-dimensional response in water has a response very similar to that expected for cyanide. That is not proof that the chemical is present. The alarm should be considered tentative until a specific chemical analysis confirms or denies the presence of the reported agent.

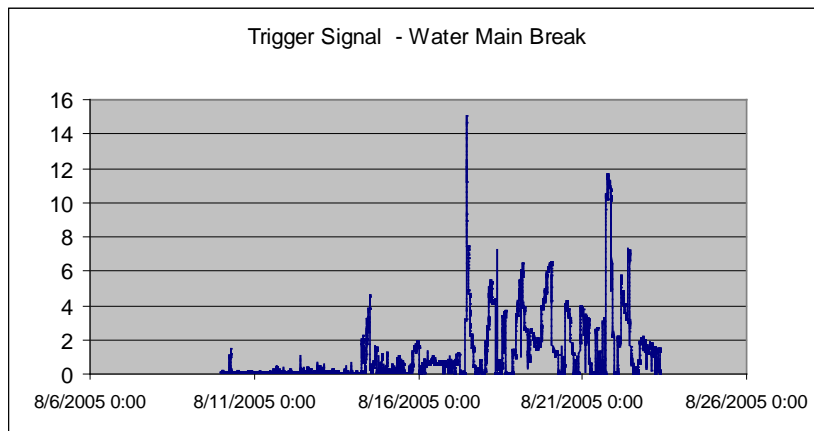
A corollary of the method is that multiple agents could be reported for one event because all of the reported agents have similar chemical fingerprints. When the agent(s) are reported, each name is associated with a probability of match. High probabilities suggest good match criteria, while low probabilities suggest weak match criteria.

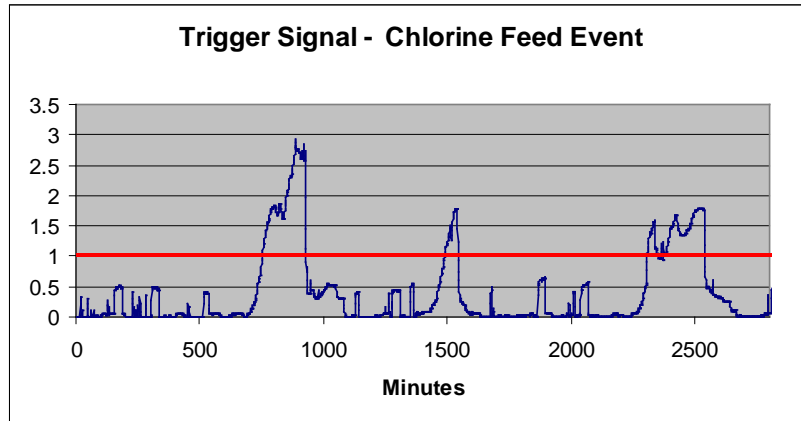
The chemistries of some highly toxic chemicals are very similar to those of some low-toxicity chemicals. The method does not directly or even indirectly measure toxicity, so additional testing would be necessary to assess the actual toxicity of the water.

3. Consideration of Dynamic Profile

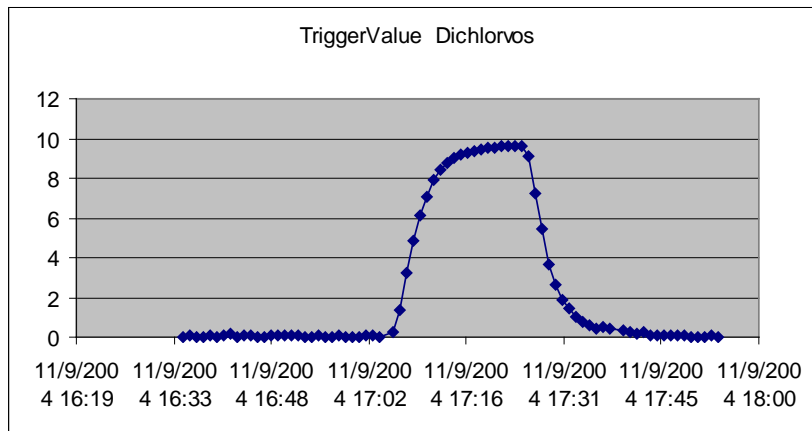
When the system alarms, one of the first questions will be “is it an agent attack, or just an operational problem?” This question can usually be resolved by looking at the graph of the Trigger Signal over time. Alarms that are “spikes” of a few minutes duration are of less concern in theory because deviations lasting only a few minutes suggest that only a small volume of water may be affected. On the other hand, a change that is continuous and persistent is of major concern because it probably represents a large volume of changed water. Alarms that are generated by such patterns should be investigated with urgency.

Operational problems usually present a “noisy” or erratic Trigger Signal graph. Sometimes the signal is just a relatively brief spike. See the two examples below.





An actual injection of a an agent will usually present a characteristic rise time and plateau of stabilization, then a drop-off when the contaminated water has passed the measuring point, and been replaced with uncontaminated water. See the example below.



Alarms that are associated with this kind of pattern should be taken seriously. Even if no agent is reported, it is possible that what is present is an agent which is not represented in the Agent Library.

It is possible that this kind of pattern will produce classification of different agents on the signal rise, plateau, and fall. This is caused by differences in sensor response times. Classifications on the rise and fall are not as reliable as those from the plateau of the response. This should be taken into account during the interpretation of the alarm.

Another characteristic of chemical injection is the magnitude of the Trigger Signal during the alarm period. Operational problems generally produce small changes that yield a Trigger Signal value less than 5. Injection of a chemical in serious concentration will normally produce Trigger Signal values greater than 10.

4. Qualification of System Operation

If a significant alarm condition occurs, the system should be inspected to verify that there are no operational problems with it.

Check the sampling system for compromising conditions:

1. blockages
2. leaks
3. tampering
4. shut off
5. air bubbles

Check the sensors for compromising conditions:

1. Out of reagents
2. loss of flow to the sensors - check the PSI graph
3. Improper maintenance
4. malfunctioning sensor - check sensor alarms

Check the sensor graphs for unusual or defective conditions prior to the alarm.

Check the Event Monitor for compromising conditions:

1. Loss of communication
2. Sensor alarms (Hi, Lo, Frozen)
3. Low pressure alarm from the TOC analyzer
4. Sensor diagnostic messages

If the system has been qualified, then the alarm is likely caused by real changes in water quality. A key question then becomes: is the cause attributable to known operations, or is it something unknown?

5. Qualification of input data (what could be happening?)

Data needs to be gathered regarding the operations upstream of the sampling point to see if there is any rational explanation for the change in water quality.

Here's a list of things to consider in root-cause analysis:

- Are there unusual weather conditions?
- Has work been done on or near water mains?

- Are there changes in plant operations?
- Are different treatment chemicals being used?
- Is there maintenance work on the plant or distribution system?
- Are there unusual water demands (major fire fighting, for example).
- Is there a water main break?
- Are control systems for pH or chlorine functioning normally?
- Who else has information?
- Why would this be happening now?
- Has the event happened elsewhere up-stream of the location?
- Has the event been seen downstream of the location?

If no obvious cause for the alarm can be found, then the question becomes: is this change in water quality harmful or not? Is it deliberate?

6. Sample Analysis



If a water sampler that samples in response to an alarm from the EMTS is included in the system, water samples can be analyzed for toxicity using rapid-response system like the Eclox Test Kit. The Utility should have adequate safety measures in place to handle samples that could be toxic or infectious by design.

7. Follow-up by naming Plant Events

The Event Monitor allows the Operator to associate a name and alarm priority with a Plant Event. The names and priorities cannot be logically assigned until the root cause of the event has been found. Once the root cause is known, Plant Events should be named so a recurrence can be identified quickly.