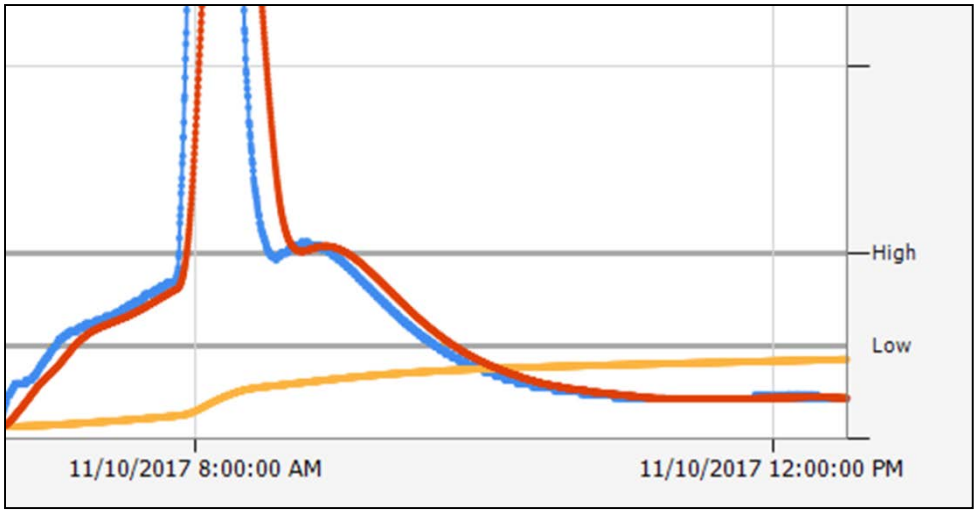
How Monitor Alarm Set Points Affect Real World Operator Level Behaviors



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Real World Behaviors

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Operational Problems with Direct Reading Monitors

- Monitors are typically used because they detect things we cannot *reliably* detect by ourselves

Operational Problems with Direct Reading Monitors

- Cross interferents can cause a false positive on a monitor—leading to confusion about what's "*really there.*"
- Not infrequently when monitors go into alarm the operator assumes there is something wrong with the *monitor*—"because we never have *that* problem"
- Some gas concentrations directly affect judgment
- Two or more monitors can give different readings. Operators will ~~*almost*~~ *always* believe the one that reads "clean".

Operational Problems with Direct Reading Monitors

- Causes of different readings:
  - The “clean” reading monitor may be defective
  - More typically differences are associated with one monitor drawing a remote sample and the other monitor being in diffusion. Differences can be caused by
    - Incorrect sample tubing
    - Incorrect wait to sample draw times
  - Another cause of different readings is a monitor being improperly zeroed in “Bad Air” either a contaminated environment or a residual chemical poisoning.

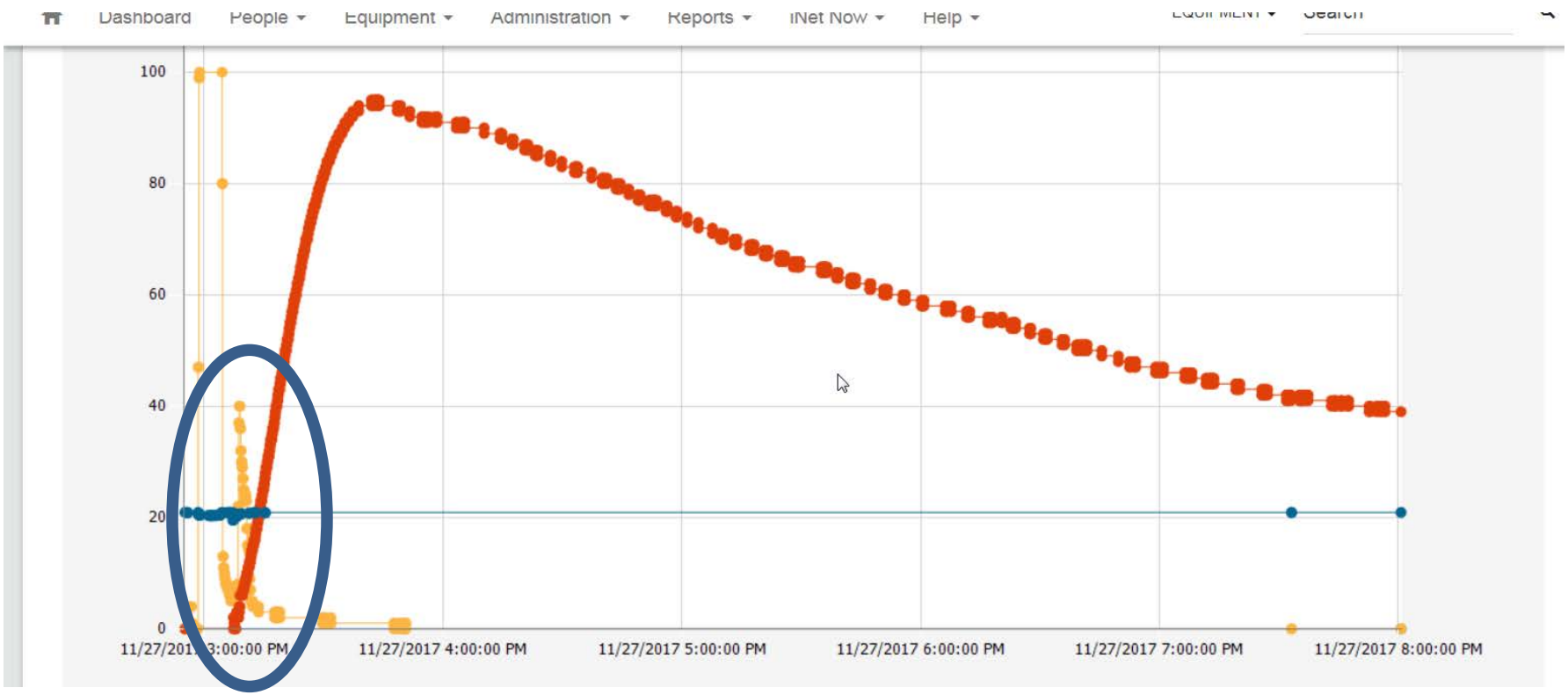
Operational Problems with Direct Reading Monitors

- Operators may also assume a monitor is giving a false positive when the monitor goes into alarm in a confined space but then *stays* in alarm in fresh air.

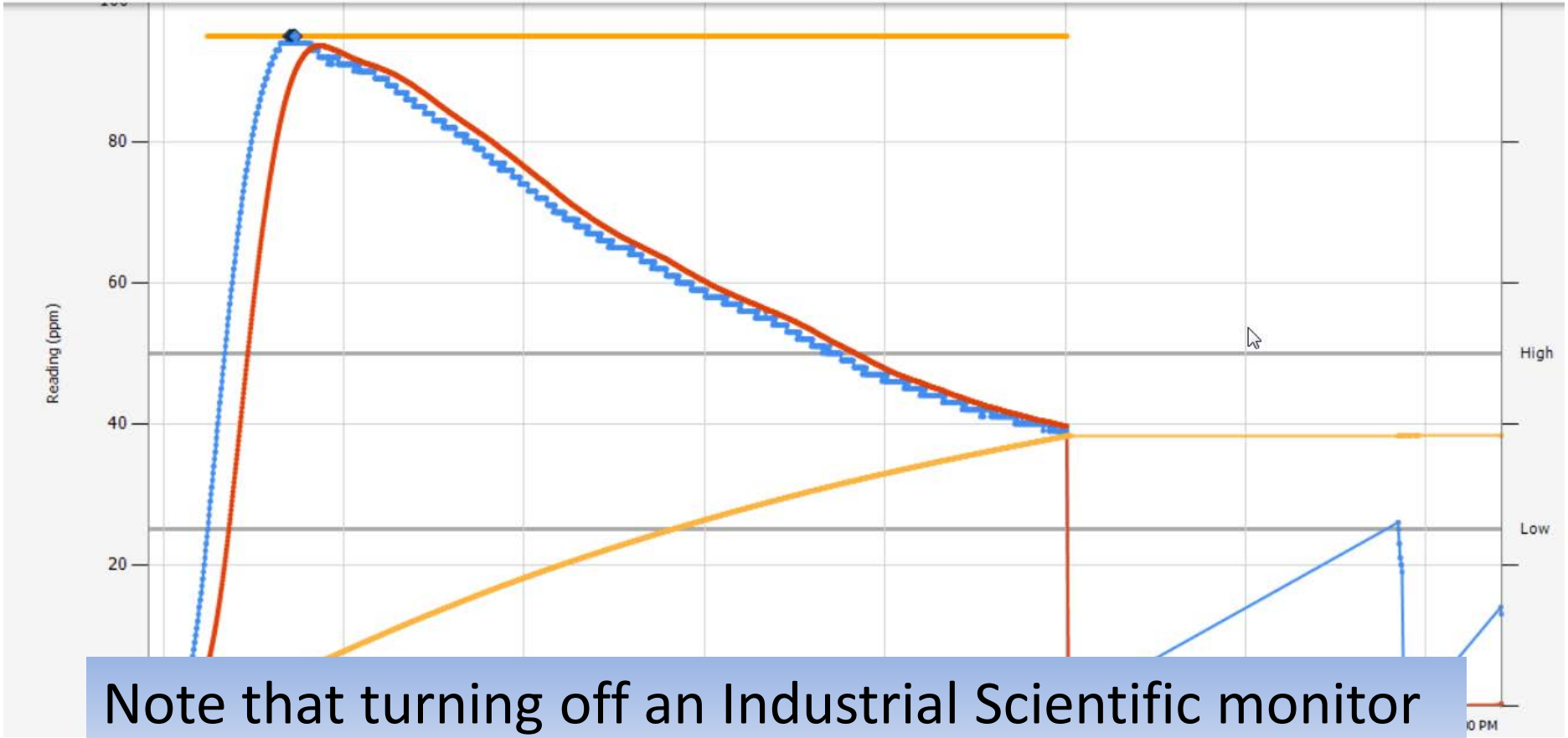
- The monitor may "*legitimately*" continue in alarm in fresh air for a number of reasons:
  - Chemical poisoning
  - Age of the sensor

Operational Problems –Chemical Poisoning

- Typical curve of a monitor poisoned by exposure to an unsaturated hydrocarbon such as a monitor that was cleaned with a solvent or exposed to an air freshener spray.



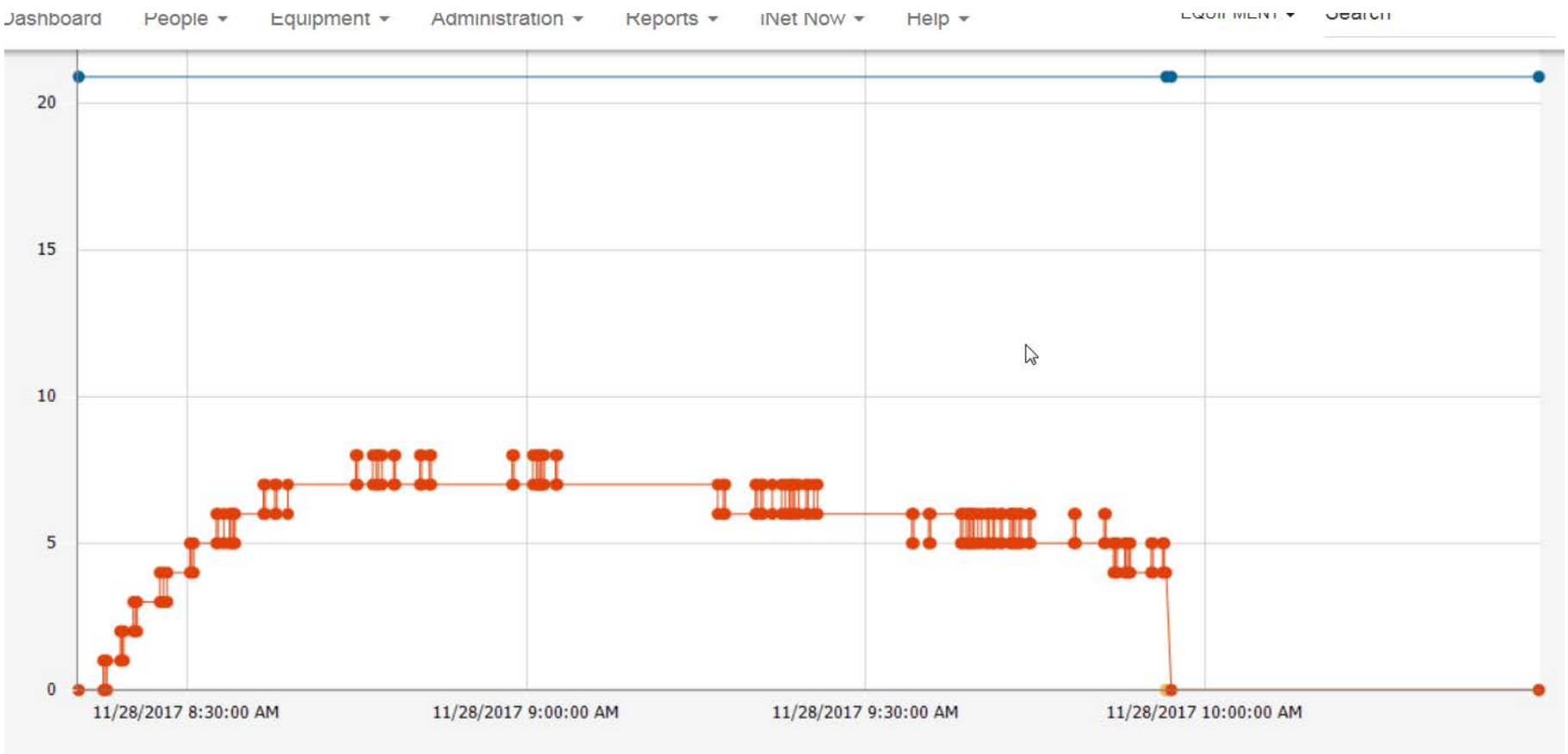
Operational Problems –Chemical Poisoning



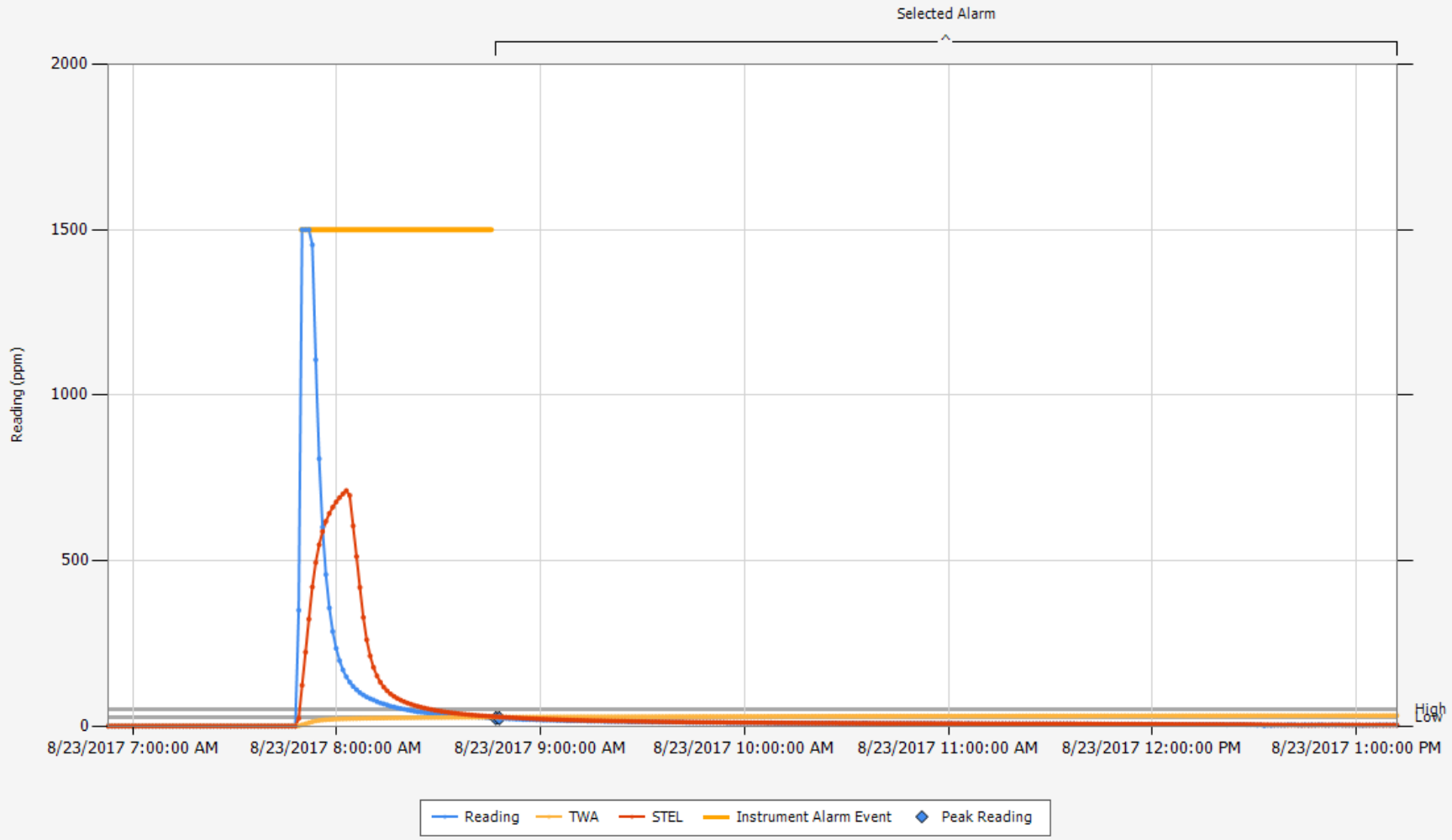
Note that turning off an Industrial Scientific monitor and turning it back on does not re-set the TWA

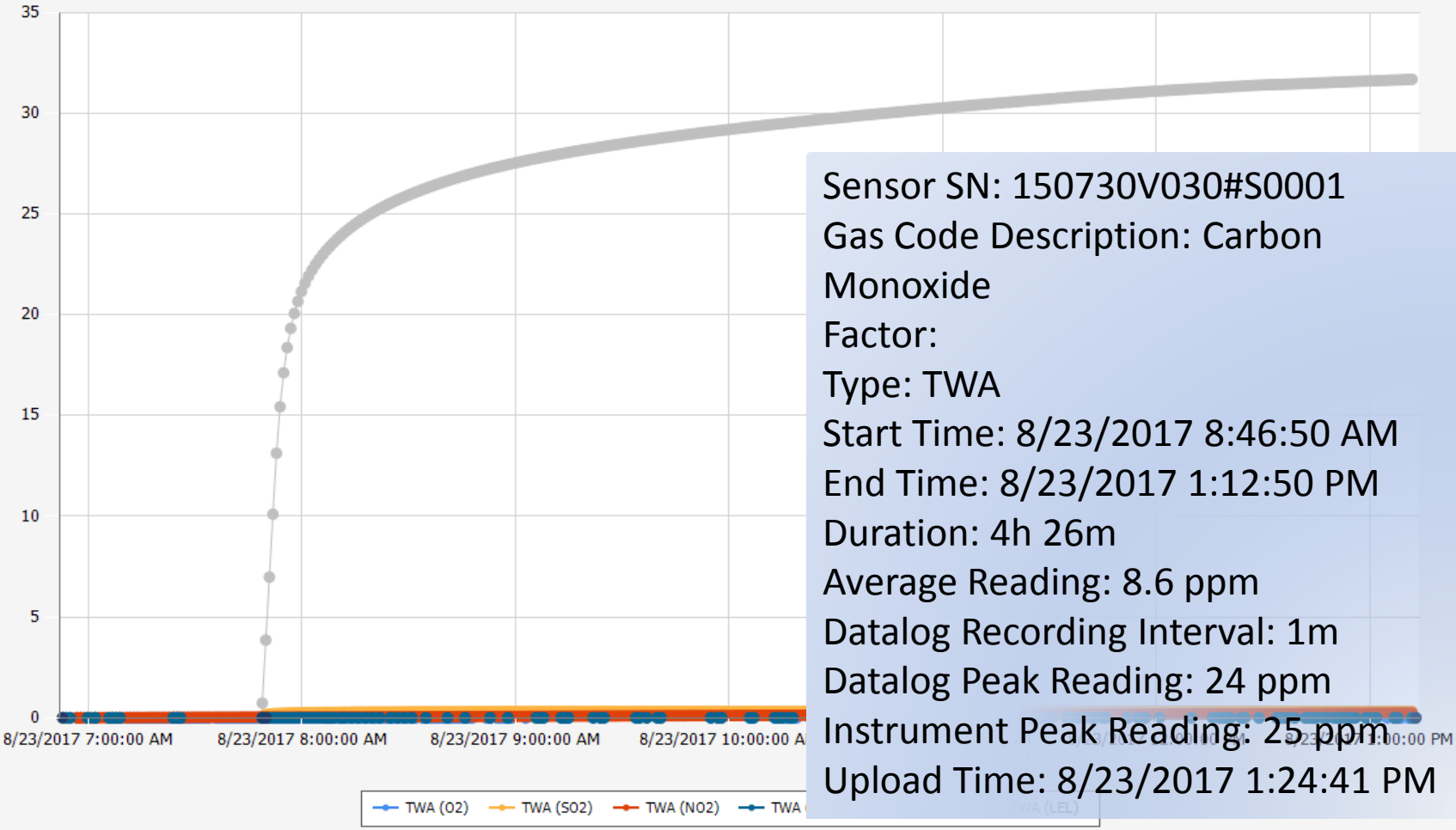
Operational Problems –Chemical Poisoning

- The datalog curve of the same monitor the next day



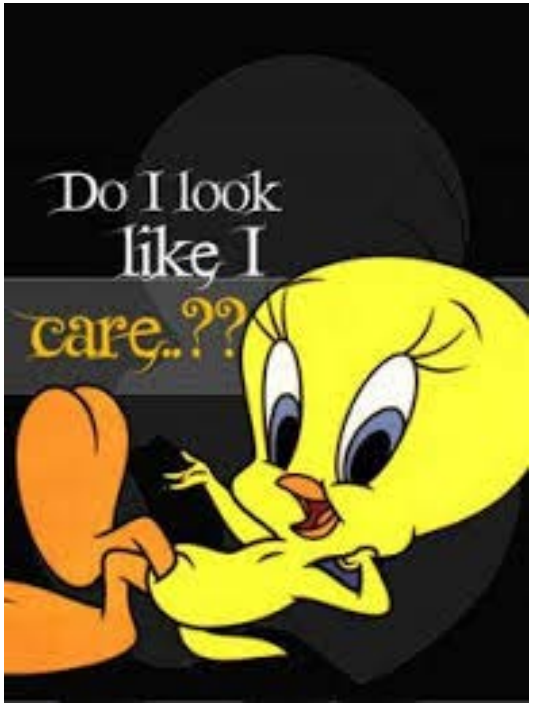
- Typical curve of an actual CO exposure. Note the rapid recovery of the sensor. This exposure did result in a TWA alarm




35
30
25
20
15
10
5
0
8/23/2017 7:00:00 AM
8/23/2017 8:00:00 AM
8/23/2017 9:00:00 AM
8/23/2017 10:00:00 A
TWA (O2)
TWA (SO2)
TWA (NO2)
Sensor SN: 150730V030#S0001
Gas Code Description: Carbon Monoxide
Factor:
Type: TWA
Start Time: 8/23/2017 8:46:50 AM
End Time: 8/23/2017 1:12:50 PM
Duration: 4h 26m
Average Reading: 8.6 ppm
Datalog Recording Interval: 1m
Datalog Peak Reading: 24 ppm
Instrument Peak Reading: 25 ppm
Upload Time: 8/23/2017 1:24:41 PM

Operational Problems –Chemical Poisoning

- So how much does the typical operator want to know about alarms due to chemical poisoning?



Operational Problems with Direct Reading Monitors

- Other factors leading to “False Alarms”
- The monitor may also be in alarm for other reasons not understood by the operator
  - TWA or STEL alarm (more typically TWA)
  - Latched LEL alarm
  - Over ranged LEL alarm
  - Sensor is in Failed condition
- Operators may prefer to think the monitor is bad rather than that they need more training.

Operational Problems with Direct Reading Monitors

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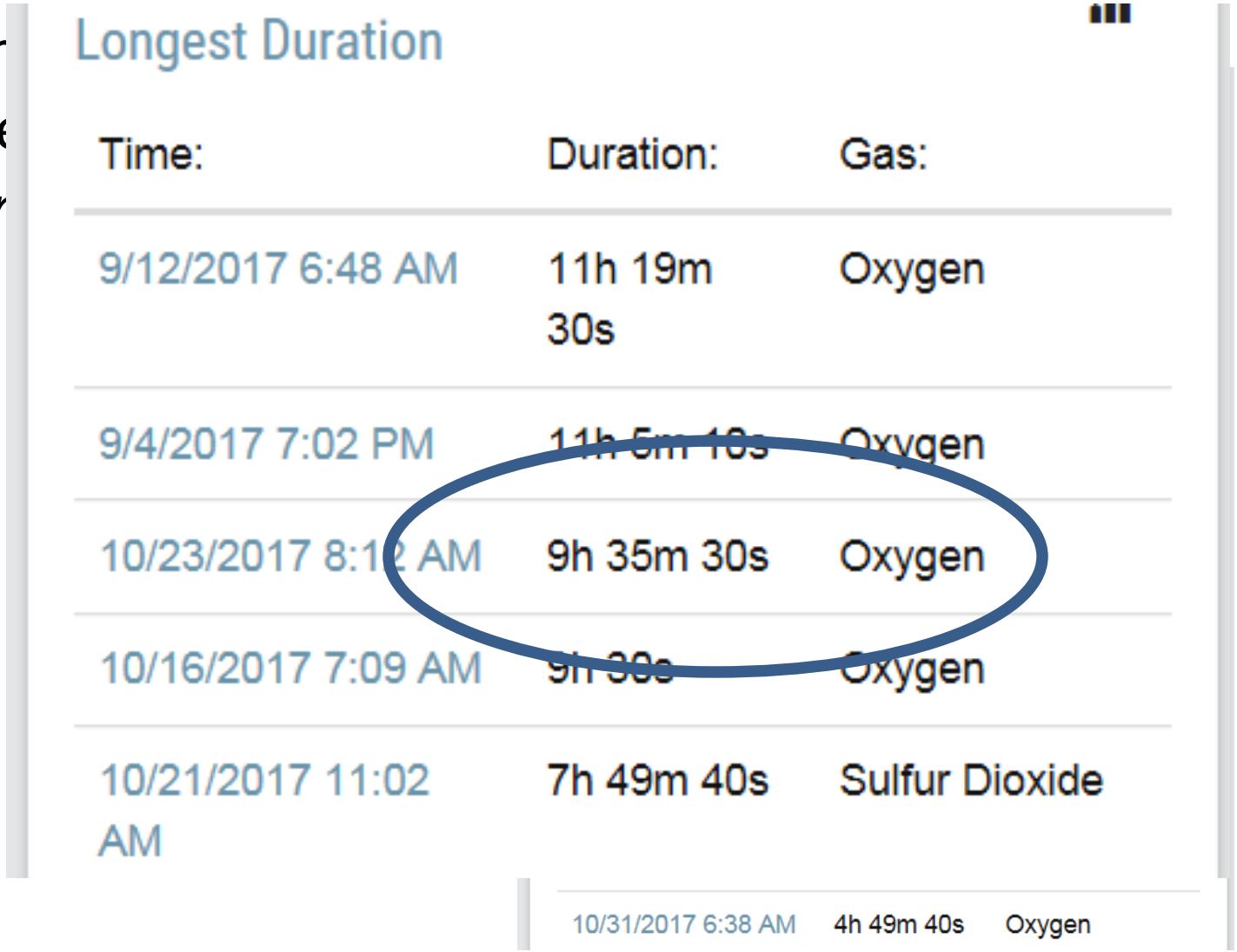
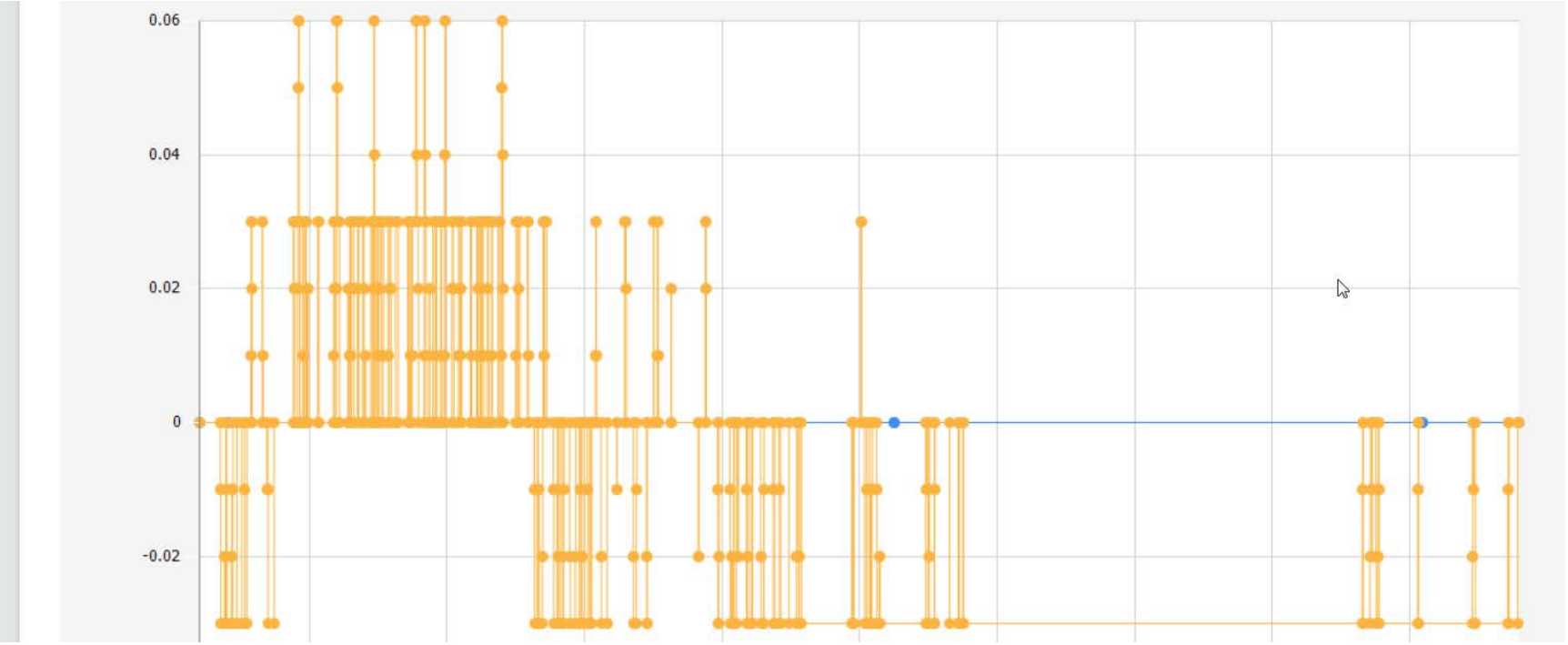


Longest Duration

Time:	Duration:	Gas:
9/12/2017 6:48 AM	11h 19m 30s	Oxygen
9/4/2017 7:02 PM	11h 5m 16s	Oxygen
10/23/2017 8:12 AM	9h 35m 30s	Oxygen
10/16/2017 7:09 AM	9h 30s	Oxygen
10/21/2017 11:02 AM	7h 49m 40s	Sulfur Dioxide
10/31/2017 6:38 AM	4h 49m 40s	Oxygen

Operational Problems with Direct Reading Monitors

This is the actual datalog of the O2 reading showing no O2 in the environment—remember that the monitor was continuously in alarm on 10/23 for over 9 hours



Operational Problems with Direct Reading Monitors

In terms of Operator error you might think this monitor was not bump tested

Equipment Category	Time		Result	Reason	Activity	Duration
Instrument	11/11/2017 5:05 AM		Failed	Scheduled	Bump Test	61
Instrument	11/4/2017 6:16 AM		Passed	Forced	Bump Test	148
Instrument	11/4/2017 6:08 AM		Failed	Forced	Bump Test	181
Instrument	11/4/2017 6:02 AM		Failed	Forced	Bump Test	76
Instrument	11/4/2017 5:42 AM		Failed	Forced	Bump Test	63
Instrument	10/18/2017 4:28 AM		Failed	Forced	Bump Test	69
Instrument	10/8/2017 5:35 AM		Failed	Forced	Bump Test	65
Instrument	10/7/2017 5:24 AM		Failed	Scheduled	Bump Test	184
Instrument	9/20/2017 10:55 AM		Passed	Scheduled	Bump Test	63
Instrument	9/20/2017 10:42 AM		Passed	Scheduled	Bump Test	112
Instrument	9/19/2017 7:54 AM		Passed	Scheduled	Bump Test	121
Instrument	9/9/2017 4:52 AM		Passed	Scheduled	Bump Test	74

Remember that the monitor was used on 10/23

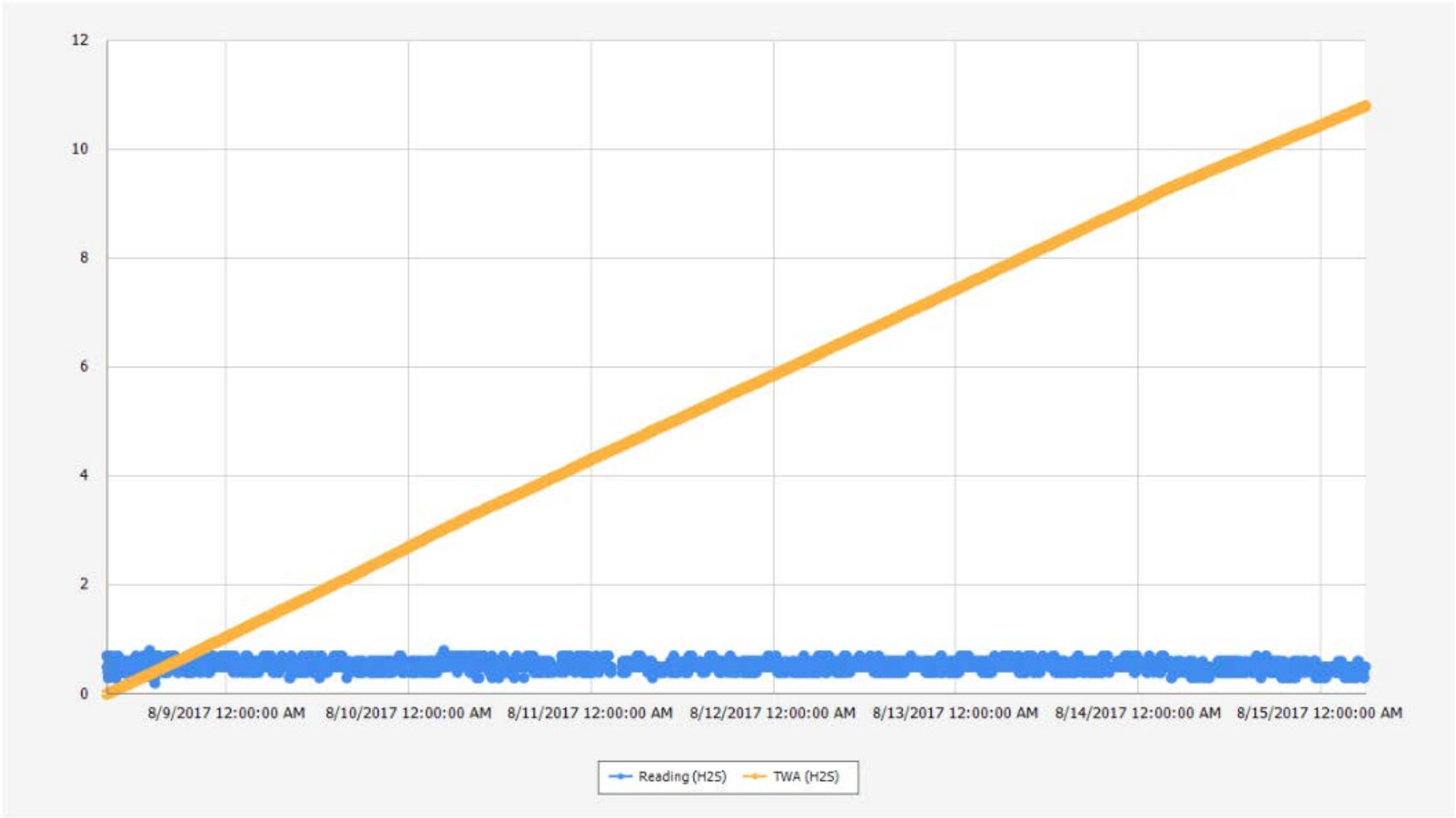
Operational Problems with Direct Reading Monitors

So in this first case we saw a monitor left in alarm due to a (defective) worn out sensor. Did the operator carry the monitor with him continuously in alarm—or did he leave it in his truck?

What can we do to keep operators safe when they are working in environments hazardous enough to require monitoring but not hazardous enough for them to care?

Operational Problems with Direct Reading Monitors

Monitors may also be driven into a TWA alarm if the Datalogs are not cleared and re-set.



Operational Problems with Direct Reading Monitors

In this case the monitor was actually in TWA alarm for 13 hours and 37 minutes but the monitor “read” 0.

Alarm

Sensor SN:	VIRTUAL#17032WL170#17032WL173#S0002
Gas Code Description:	Hydrogen Sulfide
Factor:	
Type:	TWA
Start Time:	8/14/2017 4:17:01 PM
End Time:	8/15/2017 5:54:01 AM
Duration:	13h 37m
Average Reading:	0.5 ppm
Datalog Recording Interval:	10s
Datalog Peak Reading:	0.7 ppm
Instrument Peak Reading:	0 ppm
Upload Time:	8/15/2017 5:56:28 AM

Operational Problems with Direct Reading Monitors

- So a number of errors can cause the operator to "loose confidence in the monitor."
- Monitors are typically used because they detect things that cannot *reliably* be detect without them.
- Operators want them to just be like hard hats.
- What are some of the behaviors by the operators
  - Turning the monitor off while in alarm
  - Leaving the monitor on but in the truck
  - Push buttons on the monitor until it stops making noise (re-zeroing the monitor-inadvertently clear TWA)

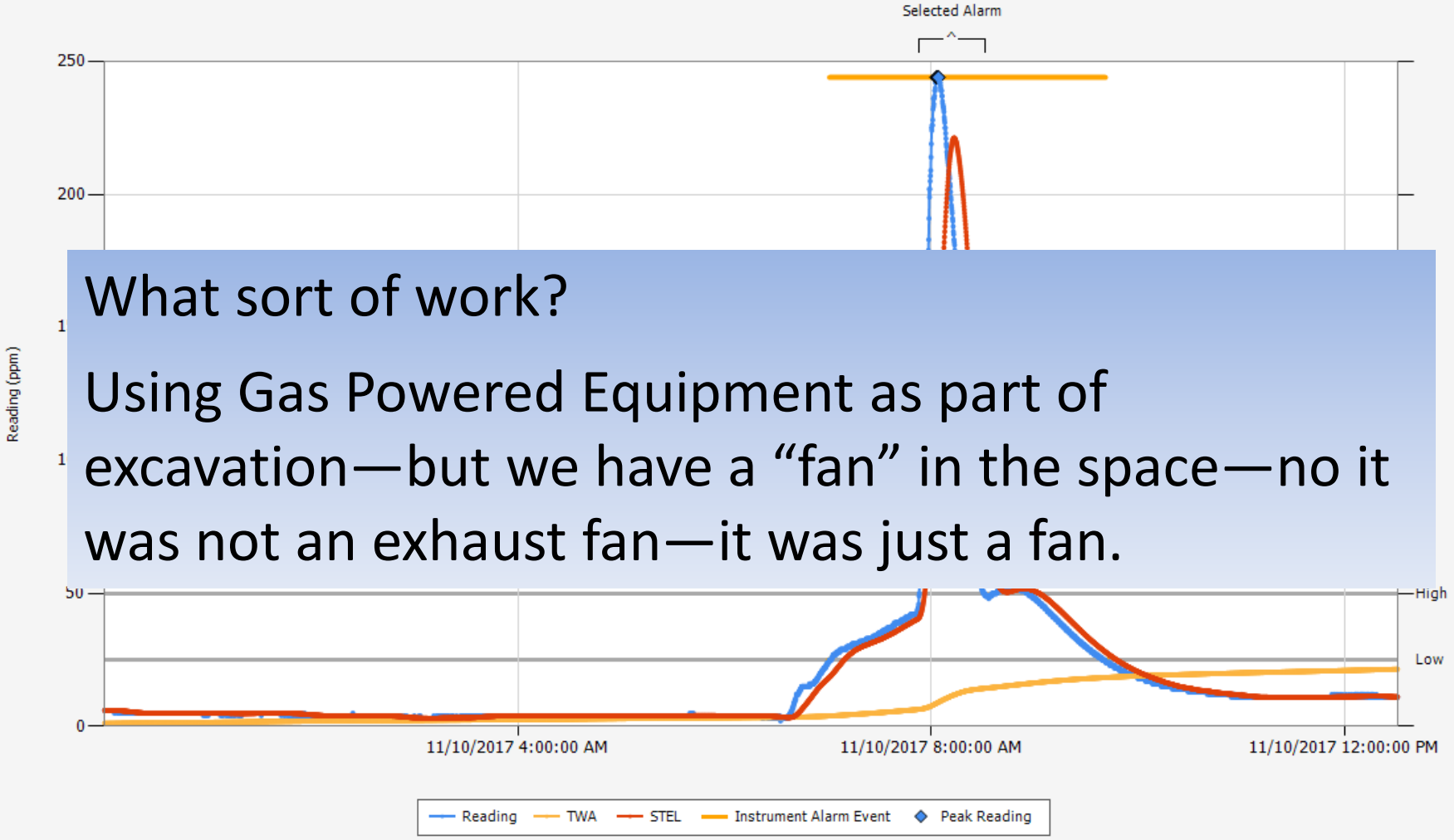
Operational Problems with Direct Reading Monitors

- Another problem associated with Operator error is assuming the monitor is wrong so what it is reporting is not what is there at all—is must be something else

- *"We were in clean air the whole time—we couldn't have any CO exposure so what caused these readings?"*
  - *(they were outside but they were standing between two gas generators powering welding equipment)*

Operational Problems with Direct Reading Monitors

- We're working in a confined space that was open at the top so what is causing these CO readings?

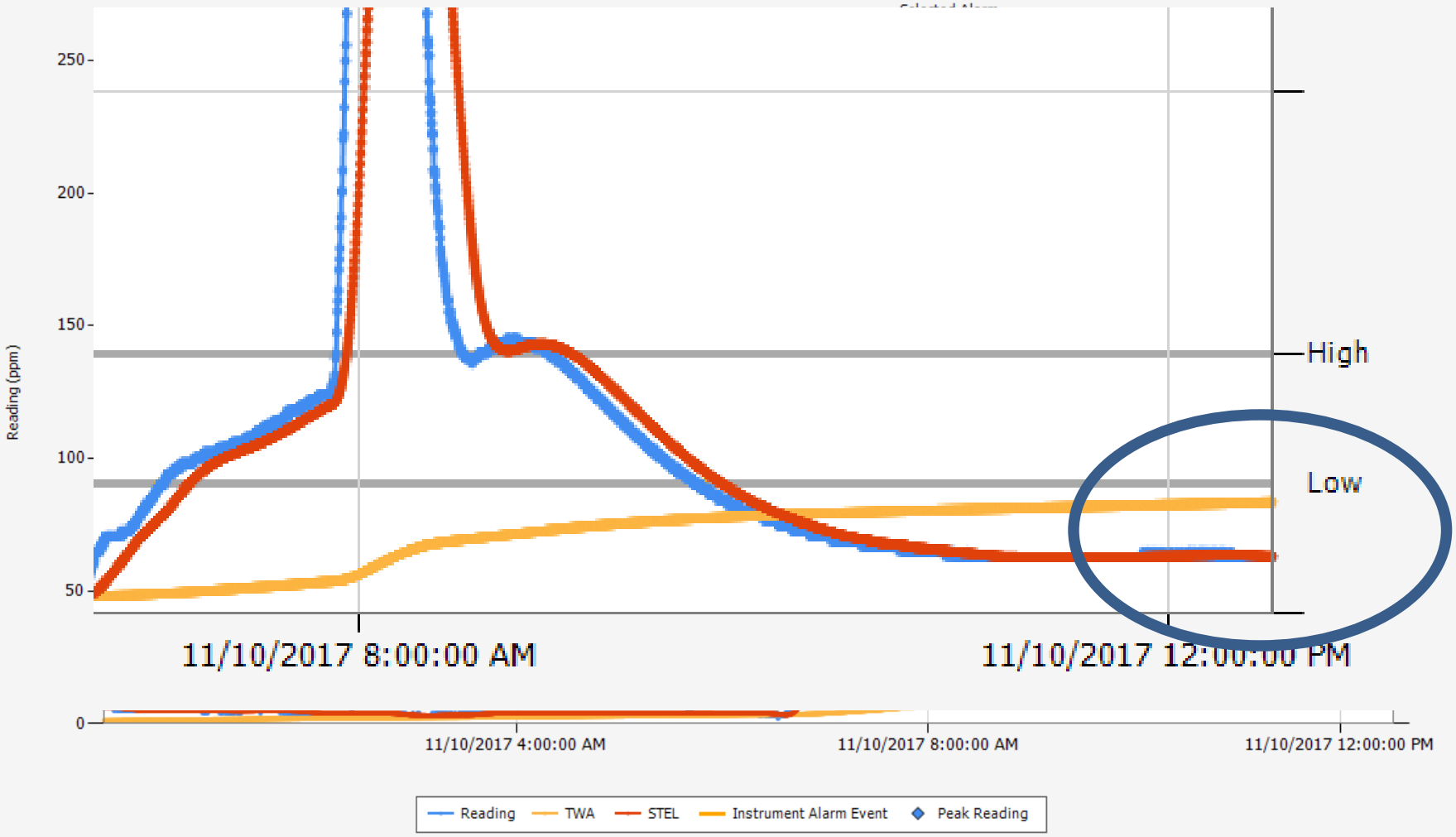


What sort of work?

Using Gas Powered Equipment as part of excavation—but we have a "fan" in the space—no it was not an exhaust fan—it was just a fan.

Operational Problems with Direct Reading Monitors

- This did result in a TWA reading but note that the TWA is below the alarm threshold



Alarm
Sensor SN: 16041K2040#S0001
Gas Code Description: Carbon Monoxide
Factor:
Type: High
Start Time: 11/10/2017 7:53:06 AM
End Time: 11/10/2017 8:31:16 AM
Duration: 38m 10s
Average Reading: 148.9 ppm
Datalog Recording Interval: 10s
Datalog Peak Reading: 244 ppm
Instrument Peak Reading: 0 ppm
Upload Time: 11/10/2017 1:19:38 PM

Concerns resulting from Operational Problems

- Operators may become desensitized to alarm conditions—*normalization of deviation*
  - They may believe that monitors are too sensitive and that the alarms are just nuisances
  - If they get alarms and no one does anything about them, they may assume the alarms are not really all that important
  - Ignoring one aspect of safeguards increases the level of comfort for disregarding other safeguards

Concerns resulting from Operational Problems

- Operators may follow procedures but not be able to get any work done
- Or following the procedures takes too long and is too expensive
  - Too time consuming
  - Monitor maintenance is too expensive
    - Requires additional training
    - Requires calibration gas and spare parts

Mitigating Operational Problems

- Some problems are found more frequently in different industries. Water treatment operating environments are not the same as refining, or mining; however similar operational problems occur everywhere.
- Remember the bases of the problem:

Operational Problems with Direct Reading Monitors

- Monitors are typically used because they detect things we cannot *reliably* detect by ourselves
- Cross interferents can cause a false positive on a monitor
- Not infrequently when monitors go into alarm the operator assumes there is something wrong with the *monitor*—because we never have *that* problem
- Some gas concentrations directly affect judgment
- When two or more monitors are giving different readings Operators will believe the one that reads “clean”.

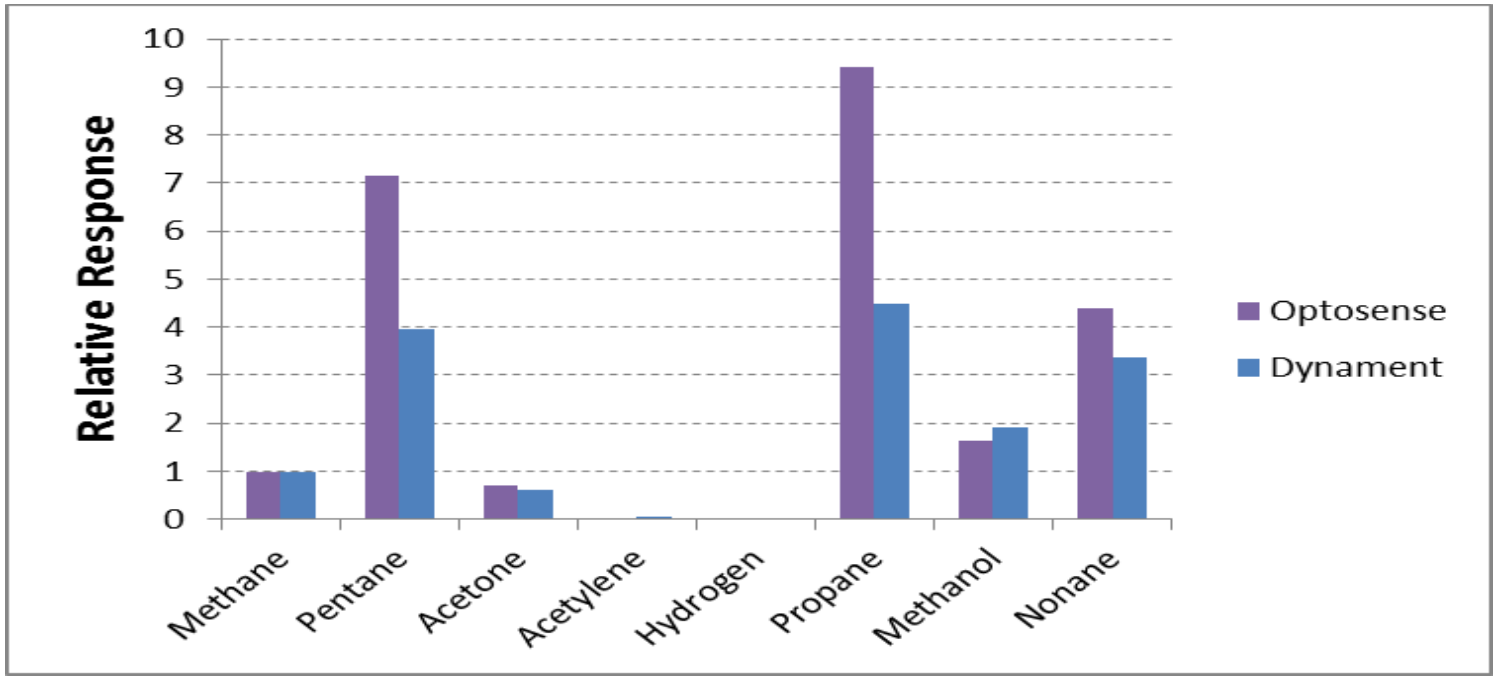
Operational Problems with Direct Reading Monitors

- “I can’t detect it without the monitor so I have no way if knowing if its *really* a problem.”
- “Safety tells me that I have to have this but production is telling me to get my job done.”
- This monitor is in my way
  - Which is easier:
    - Getting rid of the gas hazard?
    - Getting rid of the monitor?

Mitigating Operational Problems

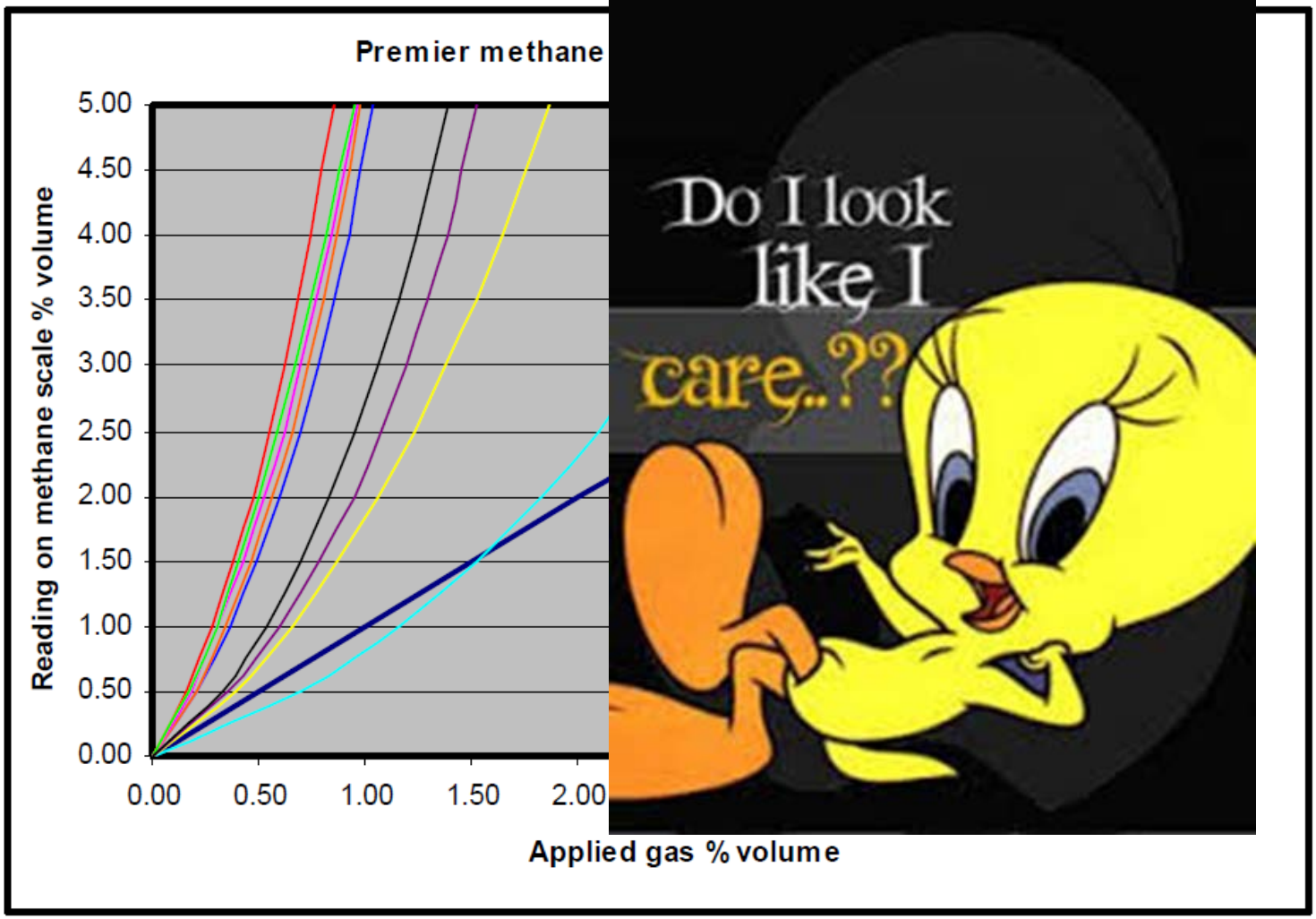
Solutions?

- Buy monitors that don't go into alarm (?)
  - Driven by Operator Selection
  - Driven by incorrect application of technology



IR sensors are inherently non-linear

Technology can be complicated



Mitigating Operational Problems

Solutions?

- Simpler automation (Bad Ideas)
  - Sensor Response Gain Escalators
  - No real time fault indicators
  - Turn off Calibration and Bump Test Reminders
  - Clearing TWA on Monitor Re-Start or clearing peak readings
  - Utilize Rolling TWA calculations rather than true Time Weighted Averages

Mitigating Operational Problems

Solutions?

- Better accountability for field level alarms
- Better, more solutions oriented training
- Utilize the TWA alarms
  - Most agencies simply set the low alarm set point to the TWA
  - ***If Cal OSHA passes the new TWA of 1 ppm H2S then Operational Problems associated with how the monitor handles TWA this is going to become more important***

Mitigating Operational Problems

Solutions?

- Better accountability for field level alarms

People ▾ Equipment ▾ Administration ▾ Reports ▾ iNet Now ▾ Help ▾

Instrument SN	Gas Code Description	Alarm Time	Alarm Types	Duration (seconds)
16043BG-001	Carbon Monoxide	9/7/2017 9:23:11 AM	Low	1
16043BG-001	Carbon Monoxide	9/7/2017 10:34:10 AM	Low	1
16043BG-001	Carbon Monoxide	9/7/2017 10:34:13 AM	Low	1
16043BG-001	Carbon Monoxide	9/7/2017 11:20:01 AM	Low	1
15102H5-005	Oxygen	9/7/2017 2:10:55 PM	Low	1
15090ZV-003	Oxygen	9/14/2017 12:16:34 PM	Low	1
11111H9-001	Combustible Gas	9/15/2017 11:42:38 AM		1
131121W-001	Oxygen	9/20/2017 1:58:54 PM	Low	1
1609340-021	Carbon Monoxide	10/17/2017 11:04:30 AM	Low	1
13034QD-003	Carbon Monoxide	11/29/2017 8:17:29 AM	Low	1
13034QD-003	Carbon Monoxide	11/29/2017 8:18:11 AM	Low	1
13034QD-003	Carbon Monoxide	11/29/2017 8:20:24 AM	Low	1

Mitigating Operational Problems

Solutions?

- Better accountability for field lever alarms

Instrument SN	Gas Code Description	Alarm Time	Alarm Types	Duration (seconds)
				60
140832Q-007	Hydrogen Sulfide	9/1/2017 8:23:21 AM	High	60
170245R-002	Oxygen	9/5/2017 9:16:43 AM	Low	60
16043BG-001	Oxygen	9/7/2017 7:26:21 AM	Low	60
14030RN-001	Hydrogen Sulfide	9/7/2017 7:37:33 AM	High	60
14030RN-001	Oxygen	9/7/2017 7:37:33 AM	Low	60
14030RN-001	Combustible Gas	9/7/2017 7:37:33 AM	Critical	60
16043BG-001	Carbon Monoxide	9/7/2017 11:20:06 AM	Low	60
15092SZ-001	Oxygen	10/25/2017 1:49:18 PM	Low	60
17102V2-001	Combustible Gas	11/27/2017 1:13:11 PM	High	60
17102V2-001	Combustible Gas	11/27/2017 1:15:47 PM	High	60
15081YM-001	Combustible Gas	11/27/2017 1:49:32 PM	Critical	60
16043BG-001	Oxygen	9/7/2017 9:22:27 AM	Low	70

Mitigating Operational Problems

Solutions?

- Better accountability for field lever alarms

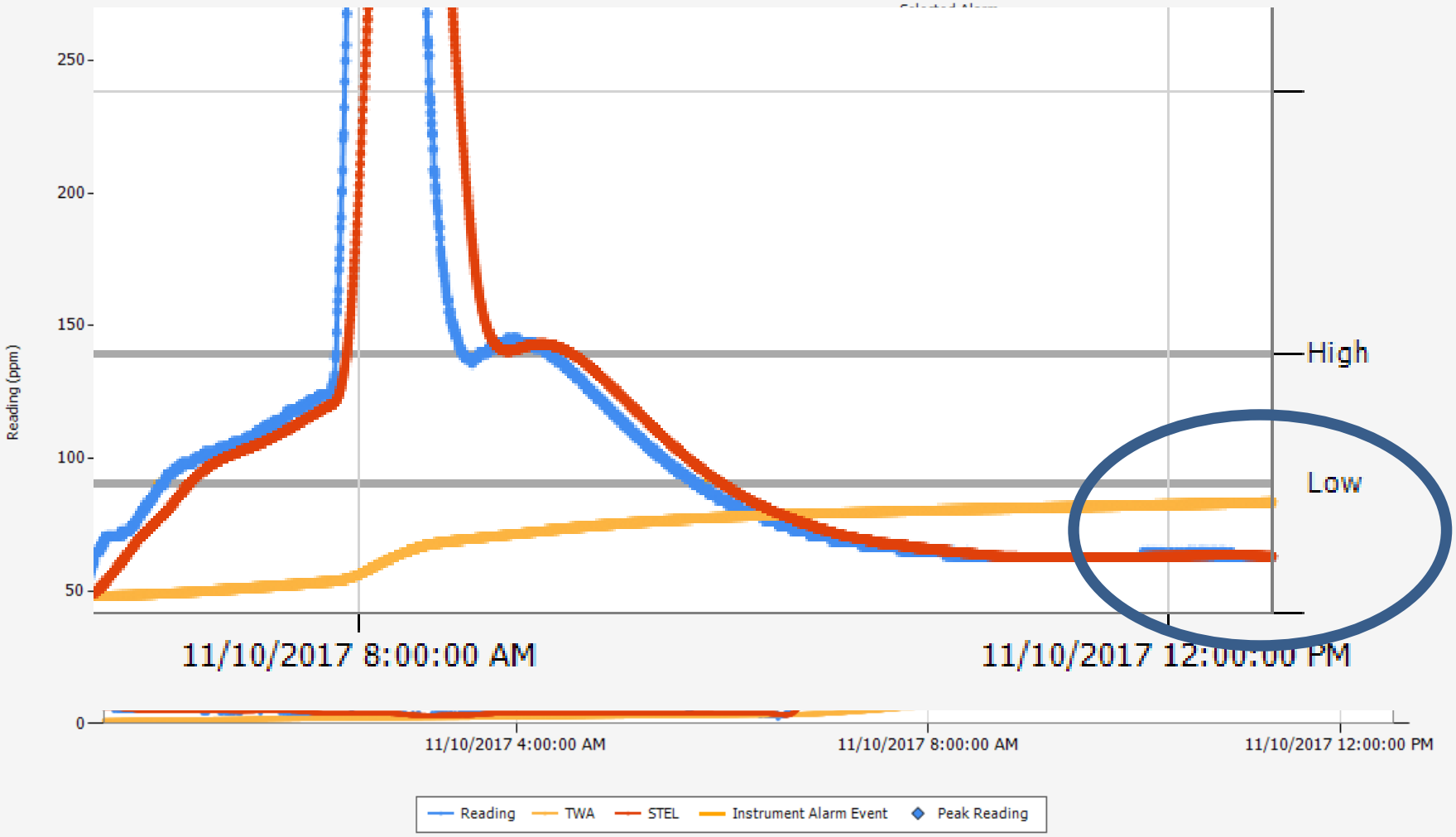
Dashboard People Equipment Administration Reports iNet Now Help

a column header here to group by that column

View Graph	Instrument SN	Gas Code Description	Alarm Time	Alarm Types	Duration (seconds)
				Critical	60
View Graph	14030RN-001	Combustible Gas	9/7/2017 7:37:33 AM	Critical	60
View Graph	15081YM-001	Combustible Gas	11/27/2017 1:49:32 PM	Critical	60
View Graph	140701B-001	Oxygen	11/7/2017 7:50:19 PM	Critical	80
View Graph	14030RN-001	Combustible Gas	9/19/2017 1:45:59 PM	Critical	90
View Graph	1604277-001	Oxygen	11/1/2017 2:00:41 PM	Critical	100
View Graph	17100YQ-001	Combustible Gas	11/29/2017 7:00:04 AM	Critical	100
View Graph	17100YQ-001	Combustible Gas	11/29/2017 7:02:23 AM	Critical	150
View Graph	161117M-034	Oxygen	11/1/2017 1:50:56 PM	Critical	170
View Graph	13034QD-003	Carbon Monoxide	11/28/2017 1:02:02 PM	Critical, TWA	310
View Graph	13034QD-003	Carbon Monoxide	11/28/2017 9:27:42 AM	Critical, STEL	440
View Graph	13034QD-003	Carbon Monoxide	11/28/2017 9:19:02 AM	Critical, STEL	520
View Graph	131121W-001	Oxygen	9/6/2017 7:37:26 AM	Critical	19660

Operational Problems with Direct Reading Monitors

- This does result in a TWA but note that the TWA is below the alarm threshold



Mitigating Operational Problems

Solutions

- Set appropriate Instantaneous and TWA alarms
- Review Utilization and Alarm Data
- Reduce the number of Exposure Alarms
  - Start with the longest duration and greatest risk
- Reduce the number of *false* positives
  - Have the correct monitor for the correct application (H2 Null sensors in H2 areas)
  - Have targeted rather than general training
  - Involve your Gas Monitor Representatives early and often