Statistical Data Trending Analysis for Professional Engineers: Converting Alphabetical Data to Numerical Data

An Online Continuing Education Course for Engineers

Course Number: F-3009

Credit: 3 Hours / 3 PDH / 3 CPD

Introduction to Data Trending Objectives

Jeffrey S. Caudill, P.E.

“Putting that Word Database to Work for Your Company”

What is Data Trending? Why do one?

The costliest learning events are often caused by our inability to learn from past failures. This is not the ideal learning platform. However, we cannot ignore the value in unlocking the hidden potential in what our data is telling us. Further, small, incremental failures left unchanged can contribute to a behavior called normalization of deviance.

What is normalization of deviance or NOD?

- Definition 1: A long-term phenomenon in which a lower standard of safety is accepted until that lower standard becomes accepted as the norm.
- Definition 2: Accepting small, incremental deviations from a work process that seem harmless at their time of occurrence, but their cumulative effects result in a significantly negative outcome.
    - It is human behavior based,
    - The deviation repeatedly occurs overtime,
    - The deviation does not cause an immediate incident or a noticed process effect until a later time when confidence is built, and tolerance-complacency is normalized.

Why should we care?

- Normalized deviance is what leads to significant incidents and catastrophic failures.
    - People can be injured; fatalities and life-altering injuries can occur
    - The community will lose trust in your company
    - The environment can be adversely impacted
    - If you are not producing; you are losing money
    - Legal issues can result, hampering our ability to operate, obtain permits and financially weaken the company
    - License to operate can be suspended, revoked or not renewed

Let’s review a maintenance reliability example that will demonstrate this point further. Most companies have an incident investigation database. They will most likely have maintenance records or even a reliability database on failures of piping, equipment, and other maintenance-related issues. Additionally, if this is a process plant, there will be near-miss reports and operator reporting on maintenance related issues. Lastly, process hazard reviews and auditing data can be reviewed to support the overall findings.

The result was that the foaming system failed to activate on an open floating roof hydrocarbon tank. Further, fire monitors close to the tank were compromised and could not provide the full water flow as one of the monitors was tagged out of service. This is a fictional example and is not intended to be representative of any real-life events. However, scenarios like this example happen far too often.

A fire occurred on the tank, and the automatic foaming system failed to activate on-demand as it was designed. A temporary pump caught fire, removing product from the tank. The fire traveled back through the rubber deinventory hose, igniting a small leak at the flange to the tank. The flames traveled up the side of the tank as more product escaped from the flange due to the heat from the fire, causing the flange to expand further separating it. This eventually ignited vapors around a seal leak on the floating roof, the original purpose for the maintenance project. The roof seals were scheduled to be replaced as hydrocarbon vapors were causing intermittent environmental releases and process safety issues by this point.

There were three fire monitors strategically located around the tank that not only serviced this tank for additional fire protection but could be manually maneuvered to service adjacent tanks. The tank's direct foaming system, when activated, is designed to dump foam onto the floating roof at a rate sufficient enough to smother any fire. This system was not functioning at the time of the event as it, too, was a part of the maintenance activities. So, by now, you are wondering how a Deep Dive trending analysis could catch something like this before it occurs.

This method will not repair insufficient business practices or poor safety culture. If these things exist, then you will most likely not even be supported in conducting a Deep Dive.

You begin with a starting point and develop a plan. It is not practical to monitor and trend everything. You must also choose a platform to begin pulling data from. For this incident, it begins with the reliability incident reporting system. A report is to be made anytime the foaming system or its components fail a system check. This particular tank, and several others in the tank farm, had increasing reports of the foaming system routine preventative maintenance checks failing.

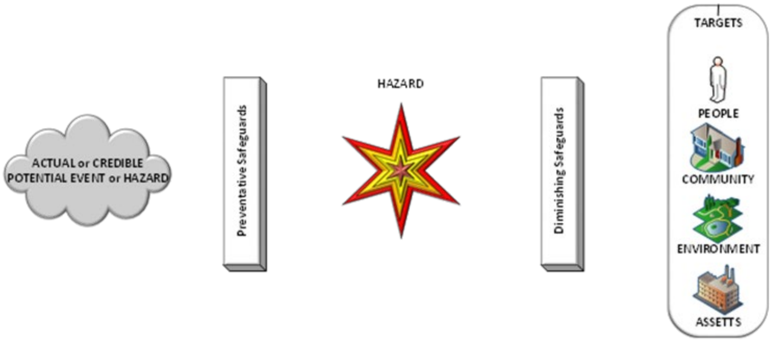
These increased failures not only caught the attention of maintenance supervision but the plant leadership. However, they seemed minor, even routine in nature: part of doing business. Due to budget concerns and maintenance limitations associated with the budget, these types of projects were harder to justify and bring to the forefront. The system would be limped along until the next ten-year tank turnaround cycle.

Not every trend or Deep Dive will prevent a major incident like this one. Sometimes they even confirm that you have very robust management systems in place. But each system component failure is a safeguard that may not be available when it's needed, as was the case for this incident. The fire protection systems for this tank should have been in operations until it is fully deinventoried. Alternately, a backup system provided, such as on-site fire and rescue foam trucks awaiting in standby, would be a sufficient supplement.

Now, let’s rewind to determine how Deep Dive trending works. No one has a crystal ball. In addition, people make mistakes, and equipment will break unexpectedly, even with the best of care, maintenance, and process design. To clarify this point, we need to understand that those that claim zero failures and zero incidents and events are fooling themselves. You may not agree, but the goal of zero is to operate in a fault-tolerant zone where events (incidents, near misses equipment issues) do not injure people, damage equipment beyond repair or harm the environment.

How is this zero-fault tolerant world achieved? By having robust systems with multiple layers and safeguards. To learn more about safeguards, you can review “Incident Investigation Principles & Techniques 101.” All failures and incidents can identify at least one safeguard that is either less than adequate, missing, misapplied, or has incrementally been deviated from over time until they are no longer effective.

A safeguard for the purposes of this course is a barrier or control that protects the targets. A hazard is something that you do not want to happen that harms the targets. Preventative safeguards do just that: in the simple terms, they protect the event from growing to a state at which they are a hazard. A diminishing safeguard is one that can diminish the impacts of the hazard. For the tank example, the fire scenario has alarms, automatic foaming, manually operated fire monitors equipped with foam totes, operator rounds, cameras run to a monitoring control room, remotely activated isolation valves, manually activated isolation valves, and a trained fire response team. If these fail, the result is a broken preventative safeguard.



The purpose of this diversion is to ensure you understand what you are looking for in the Deep Dive trending analysis you will be performing. The individual leading the Deep Dive trending exercise must have a starting point, unfortunately. This will usually be a noticeable change in your operations, process, safety, or reliability reporting over a short time period.

The tank example demonstrates that the automatic foaming system had been failing system checks on similar tanks while performing monthly preventative maintenance. The system checks verified signals to the foaming system to ensure automatic deployment when needed. This system also has a manual backup that must be activated by a board operator.

The system activates by sensors that detect either heat or high hydrocarbon LEL (lower explosive limit) levels for the stored material composition. These sensors began failing calibration over the last two quarters. The automatic foam system had been in operation for about eight years and was installed on over twenty similar tanks. These calibration failures coupled with two separate events of inadvertent activation in which the foam system for no apparent reason deployed made everyone’s radar. The maintenance, operations, and ES&S managers were particularly concerned.

A foam activation is not only expensive; it is expensive and a disruption to business to clean up. The investigation performed concentrated on the activations or consequences at the individual tanks in which they occurred. No one looked at the overall automatic foam systems within the entire facility. Sensors were upgraded on the failures as they occurred.

The number of sensor calibration had diminished to a tolerable level for management as a budget was needed for other more pressing projects. Because there was no justification to replace sensors or look at the other tanks were no failures had occurred, a false sense of security had prevailed that the storm had been weathered.

This is a good Deep Dive opportunity. The problem has presented itself. A similar example is an increase in loss of primary containment (LOPC) events on chemical treatment systems or at injection quills causing minor environmental or process safety events. It could be rigging and lifting near misses, dropped and falling objects, equipment collision incidents. Catching these minor incidents that are repeating are where to look.

Revisiting our tank incident, the maintenance manager assigned a control's reliability engineer with an Electrical Engineering discipline background to perform a Deep Dive. Still better, the Electrical Engineer in the controls group asked to perform a Deep Dive trending.

This is where your story will begin. A Deep Dive trend will begin with at least one data system, and it may expand to multiple systems. For this tank example, a review of all past reliability failures and incidents set up the justification to go deeper. Over a five-year period on the twenty systems that were installed at the plant, there had been 37 failed calibrations, three inadvertent activations, and more serious than all these was one failure to activate on-demand that fortunately did not result in any serious consequence.

Each one of these failures was reviewed to find cause, sensor life, sensor type, environmental conditions, and many other categories to make sense of the issue. Further, the company that designed the system was brought into the Deep Dive. The Deep Dive was expanded to include past work orders, process hazard review recommendations, audit findings, operator round logs, and other similar maintenance reports.

After a full and complete analysis, it was determined that the sensors were not a one size fits all. Different sensors and modes of operations were required for different storage situations. Further, it was determined the sensors shelf life for service was not as long as the manufacturer had claimed. So, changes were made to replace them every five years, no matter their condition.

This was a broad-based high-level explanation of what Deep Dive data trending is and why you would want to perform one. With that in mind, there are many details and steps that were not clearly defined. In the next few sections, we will explore potential options for data mining and known limitations. Then we will learn the Deep Dive data trending methodology. Lastly, we will learn how to transform Deep Dive data trending into real-time trending to monitor data as it comes in. This final technique can only be accomplished once you know your data system common causes. Clear definitions of causation can be found in "Incident Investigation Principles & Techniques 101" training module.

Understand Data Trending Options

When most people hear data trending or similar buzz words, they imagine Pareto Diagrams or process control graphics for pressure, temperature, or level. Paretos are a good data trending tool; however, what we are discussing is taking word or descriptor data, and trending user-developed keywords. These keywords are meaningful to the user and the user's organization. This is not a numerical trending training module in the classical sense.

The options for Deep Dive data trending, as described in this training module, are limited to word-based databases. Here is a good example of the difference. Corrosion on exterior pipe walls. There
are two items that can be trended here. The traditional numeric would be on the
wall thickness along the length of the line only. This type
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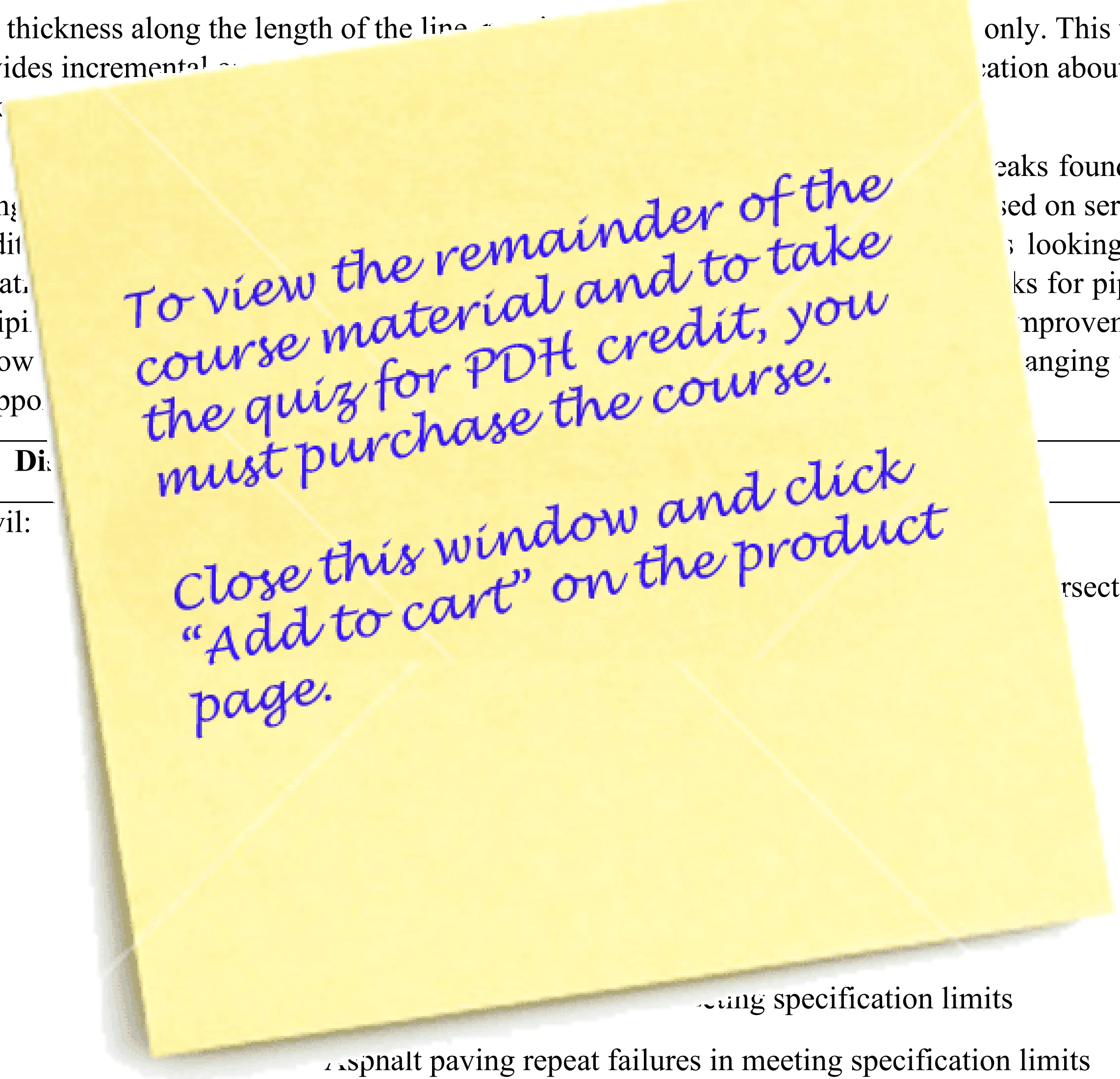

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