U.S. Navy & Gas Measurement Trainings: Trends and Danger Signals

Abstract:

The U.S. Navy and Gas Measurement Business are both industries characterized by highly skilled teams whose expertise results from hundreds of hours of study and training necessary to perform their jobs safely and competently. The following examines training trends in both "industries" and looks at how those trends directly impact safety. The author posits that the experience of the U.S. Navy can and should be seen as a danger signal for the Gas Measurement Business and how we train our technicians.

Introduction:

As a member of the AGA and the natural gas business, it has been my experience that training Gas Measurement Technicians is a critical challenge facing the Transmission, Distribution, Production and Midstream communities. This, of course, isn't my own observation or even an unusual one. The natural gas business is well aware of the aging of our workforce and the need to train additional technicians. However, where undertaken and while well-intentioned, the new training reflects cost efficiencies that in the long run may prove to be short-sighted.

The U.S. Navy faced similar exigencies, i.e., the need to replace a highly trained workforce. To some extent, its response parallels our own, but by reviewing the results, the Navy "case history" may also provide an important caution for our community as we move forward.

Let's take a close look at the Navy and its training models. First, the results:

U.S. Navy Accident History

As you know, 2017 was a very eventful year for the U.S. Navy. In the last year, the following occurred:

- USS John McCain, August 2017 -- Collision with Liberian tanker. Ten sailors dead.
- USS Fitzgerald, June 2017 -- Collision with a Japanese merchant vessel. Seven sailors dead.
- USS Ronald Regan, November 2017 – C2 Greyhound Aircraft transport on route to USS Ronald Regan crashes into Philippine Sea.
- USS Benfold, November 2017 -- Tugboat loses propulsion and drifts into USS Benfold.
- USS Champlain, May 2017 – Collision with a South Korea fishing boat.
- USS Antietam, January 2017 – Runs aground while trying to anchor in Tokyo Bay.

The series of deadly accidents and collisions occurring in 2017 are all the more notable because such accidents heretofore have been extremely rare. "This is big news because it happens so rarely," said Bryan McGrath, a retired Navy commander whose last command was the USS Bulkeley, a destroyer similar to the Fitzgerald. As quoted in *USA Today*, McGrath said, "It happens rarely not because ship movements are so simple and straightforward — but because a high degree of professionalism is demanded from both military and commercial operators."[1]

[1] Bart Jensen, "Navy Collisions Rare but provide Lessons in their Wake," USA Today, June 18, 2017

In early years, even hitting a buoy could have serious consequences. *USA Today* journalist Bart Jensen reports that "A former chairman of the Joint Chiefs of Staff, Adm. Mike Mullen, described on David Letterman's program in June 2011 how he spent 11 years recovering from an early career setback when his ship hit a buoy in the channel during his first command.

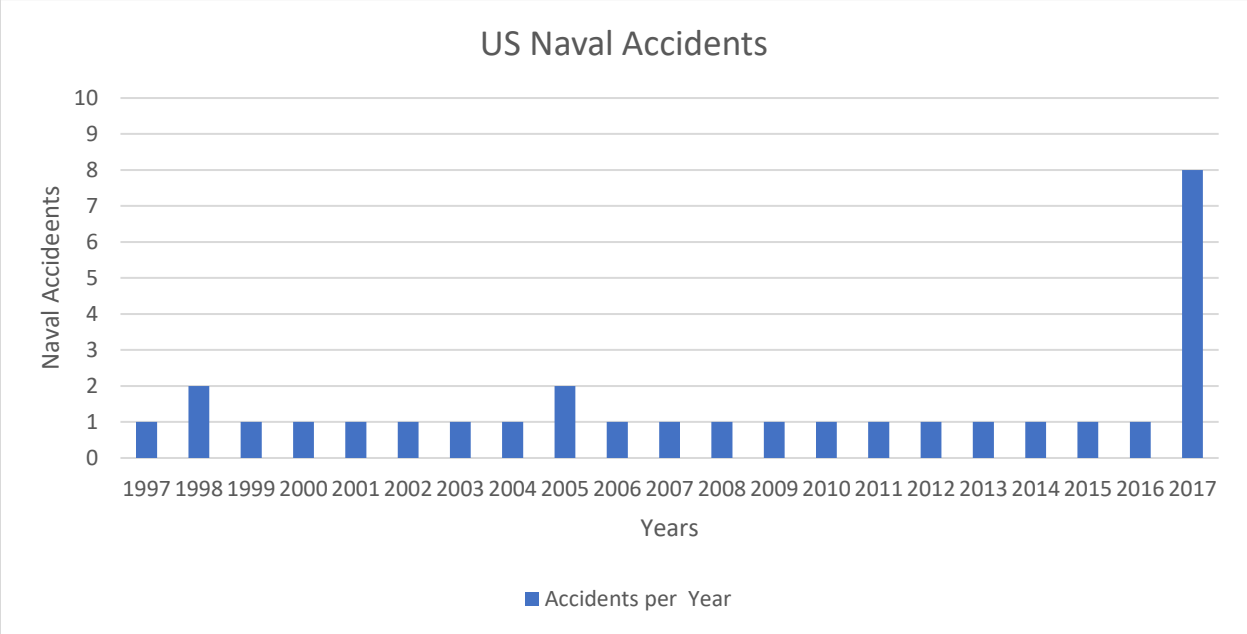
"It was a measure of getting up after those mistakes," Mullen said.[2]

Most shocking, of course, is the number of lost lives. A U.S. ship is damaged in a collision to my knowledge, only every couple of years," said McGrath, who is now managing director The FerryBridge Group, a national security consulting firm. "Loss of life, as we've had in this instance, is even rarer."[3]

The number of accidents and collisions in 2017 is in sharp contrast to previous *decades*. According to think tank Geopolitical Futures, "In the past 20 years, ships from the U.S. Navy have been involved in at least 24 collisions, according to open-source information, putting the average at just over one collision per year."[4]

Identifying Shortfalls

In 2009, Vice Admiral Phillip M. Balisle, USN-Ret. was directed to convene and lead a Fleet Review Panel to "assess surface force readiness across the man, train, equipment domain areas and provide recommended corrective actions."[5]



[2] Ibid.
[3] Ibid.
[4] "Evaluating the State of the US Navy," Geopolitical Futures, Dec 17, 2017
[5] Transmittal letter from Vice Admiral Phillip M. Balisle, USN-Ret. to Commander, US Fleet Forces Command and Commander, U.S. Pacific Fleet, February 26, 2010

That "Fleet Review Panel of Surface Force Readiness" was issued in February 2010. It was a systematic study of what the panel called the "Circle of Surface Force Readiness" and concluded that the "material readiness of the surface force is well below acceptable levels to support reliable, sustained operations at sea and preserve ships to their full service life expectancy."[6]

The Review looked closely at changes in training and concluded that "Significant changes in training have adversely affected the ability of the surface force to maintain readiness standards."[7] The report pointed to a number of decisions taken in the late 1990s that "drastically reduced the Professional Development and hands on training of our Sailors."[8]

Specifically, the report concluded:

- Sailors are not arriving on board ready to do what is needed of them; and
- Officers are not arriving on board with the correct baseline knowledge of surface warfare fundamentals;

The Panel pinpointed a variety of reasons for the lack of readiness. Most prominently however was the fact that the Navy essentially eliminated field training for a reliance on computer-based training. *"Over-the-shoulder training that was once the foundation of surface force training has vanished."* (My italics.)

Not only was the Panel was crystal clear in identifying the causes in readiness decline, it also predicted that "Officer qualifications, experience, and proficiency were negatively impacted (by training deficiencies) and may have reached a critical level that could affect a generation of Surface Warfare Officers and adversely affect the overall readiness of the future Navy."[9]

Predictions Fulfilled

It is no doubt extremely cold comfort to Balisle and the seven-member panel who created the report that by 2017, a series of deadly accidents highlighted Naval readiness and training inadequacies to the entire world.

For our purposes in identifying the similarities in training experienced by both the Navy and Gas Measurement Training businesses, it's instructive to take a closer look at two of the most highly publicized accidents.

On November 1, 2017, the Navy released its "Report on the Collision between USS Fitzgerald and Motor Vessel ACX Crystal" and "Report on the Collision between USS John S. McCain and Motor Vessel ALNIC MC."

With respect to the collision between the John S. McCain and ALNIC, MC, the Navy wrote: "The collision between John S. McCain and Alnic MC was also avoidable and resulted primarily from

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[6] "Fleet Review Panel of Surface Force Readiness," Vice Admiral Phillip M. Balisle, USN-Ret., February 26, 2010, page 8,
[7] Ibid., page 14.
[8] Ibid., page 13.
[9] Ibid., page 15.

complacency, over-confidence and lack of procedural compliance. A major contributing factor to the collision was sub-standard level of knowledge regarding the operation of the ship control console. In particular, McCain's commanding officer disregarded recommendations from his executive officer, navigator and senior watch officer to set sea and anchor watch teams in a timely fashion to ensure the safe and effective operation of the ship. With regard to procedures, no one on the Bridge watch team, to include the commanding officer and executive officer, were properly trained on how to correctly operate the ship control console during a steering casualty."[10]

With respect to the collision between the US Fitzgerald and ACX Crystal, the Navy reported "The collision between Fitzgerald and Crystal was avoidable and resulted from an accumulation of smaller errors over time, ultimately resulting in a lack of adherence to sound navigational practices. Specifically, Fitzgerald's watch teams disregarded established norms of basic contact management and, more importantly, leadership failed to adhere to well-established protocols put in place to prevent collisions. In addition, the ship's triad was absent during an evolution where their experience, guidance and example would have greatly benefited the ship."[11]

Training Shortfalls

It's outside the scope of this paper to review training shortfalls in every skill set at every officer or seaman level. However, some examples should illustrate the shocking (there is no other word for it) nature of those shortfalls.

In 2017 testimony before the U.S. Senate Committee on Armed Services, John H. Pendleton, Director, Defense Force Structure and Readiness Issues, Government Accountability Office referenced and repeated an earlier warning on training. "In a 2015 report, we found that the ships based in Japan had such aggressive deployment schedules that they did not have dedicated training periods, like ships in the United States do. In fact, we were told that the overseas ships – overseas-based ships were so busy that they had to train on the margins. When I asked what that meant, it was explained to me that it meant that they had to squeeze in training when they could."[12] In other words, cruisers and destroyers ported in Japan set aside NO dedicated time for training.

Bryan McGrath, former commanding officer of the USS Bulkeley destroyer, now Assistant Director of the Hudson Institute's Center for American Seapower, has been outspoken about Navy training shortfalls.

In an interview with NPR, he notes he left college as a Navy Ensign in 1987. He spent more than a year learning to drive a warship. He attended classes, simulators, and spent time in water steering a patrol craft. Of the results of his training, McGrath said, "So, I showed up at that ship with an unbelievable amount of education about the basics of what my ship was doing, how to navigate it, how to maintain it and how to operate it."[13]

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[10] Navy Releases Collision Report for USS Fitzgerald and USS John S. McCain collisions, Navy Office of Information, Story Number: NNS171101-07, Release Date: 11/1/2017

[11] Ibid.

[12] John Pendleton, Testimony before the U.S. Senate Committee on Armed Services, Recent United States Navy Incidents at Sea, September 19, 2017

[13] "Navy Officials Examine Training Procedures after Ship Accidents," National Public Radio, September 7, 2017. Tom Bowman, reporter.

That was in 1987. Two decades later McGrath was in command of his own ship and witnessing the new ensigns coming aboard with no more months of classes under their belts. "They've been given a load of CDs. That's right - online learning. McGrath was stunned how their skills compared to what was expected when he first went to sea McGrath had a sense that these officers did not have a well-developed sense of their job, and what the blocking and tackling skills of a surface warrior were."[14]

Other Navy officers reflect his concerns. By 2003, the Navy was issuing training CDs to junior officers. This would meet two goals: the need to save money by doing away with months of classes and make sure crews got to their ships quickly. Kevin Eyer, a retired Navy Captain who has commanded three ships, explained they give you 21 CDs, send you to your ship and tell you will learn all you need while you are there in your first job.[15]

Vice Admiral Peter Daly said that was a problem because more seasoned officers didn't have time to teach those ensigns the basics. "This presumption that the ships can make up for people who are untrained and just do it on the job is flawed," he explains.[16]

The decision to rely upon CDs and haphazard on-ship training even has a name. "In contrast, the high operational tempo of ships homeported overseas had resulted in what Navy personnel called a "**train on the margins**" (my emphasis) approach, a shorthand way to say there was no dedicated training time set aside for the ships, so crews trained while underway or in the limited time between underway periods. We found that, at the time of our 2015 review, there were no dedicated training periods built into the operational schedules of the cruisers, destroyers, and amphibious ships homeported in Yokosuka and Sasebo, Japan. As a result, these crews did not have all their needed training and certifications."[17]

Take-aways

A simple review of the consequences of reduced training of Naval personnel would lead any reasonable person to conclude that:

- The consequences can be catastrophic;
- Correcting training deficiencies can take years;
- Half-measures are ineffective.

So now let's review trends in our own industry.

Gas Measurement Training: The Background

An analysis entitled "Communication between the Office and Field," by Duane A. Harris, Vice President Sales and Support, Flow-Cal, Inc., succinctly described the broad changes impacting the gas measurement business. "Previously, all major companies staffed their own measurement training facility. A company would provide the training at regularly scheduled intervals throughout the year. The training would often take place at a live gas facility and might include videos, classroom training sessions, and hands-on field training. Each organization had their own set of Standard Operating Procedures (SOP) and the appropriate

[14] Ibid.
[15] Ibid.
[16] Ibid
[17] "Navy Readiness – Actions Needed to Address Persistent Maintenance, Training and Other Challenges Facing the Fleet," Statement of John H. Pendleton, Director Defense Capabilities and Management, United States Government Accountability Office, Thursday, September 7, 2017.

AGA, API, and GPA documents. The procedures in each document were taught, demonstrated, and executed by all measurement technicians. Each SOP had a standard form which outlined the procedure on how to successfully document the gas measurement data. Every measurement technician was cycled through multi-level training classes. Upon completion of each measurement level, the technician received a certificate and sign-off.

"By the mid to late 90s, FERC636, deregulation, and major corporate organizational changes resulted in the discontinuation of the majority of the company-staffed measurement training facilities. Many companies experienced major SOP modifications and consolidations. During that time period, consolidation forced the 'retirement' of a significant portion of the industry's gas measurement professionals and their associated experience. Fortunately, the prior training investment was able to sustain the industry's needs for several years.

"Presently, new measurement technicians being hired do not have the benefit of the training and understanding their predecessors received. The bar has been raised as new measurement technicians require computer skills and operations knowledge for the never-ending list of new equipment. In addition, the Operator Qualification program has made a significant impact on required documentation and sign-off for new and existing measurement personnel."[18]

Impact of Sarbanes Oxley

The passage of Sarbanes-Oxley in 2002 in response to the Enron scandals had major impacts on the pipeline industry. Sarbanes-Oxley seeks total transparency by eliminating any executive vagueness about company operations and financial statements. According to Tim Nesler, Chairman and CEO, EMS Pipeline Services, "Heightened public demand for corporate accountability and increased regulatory scrutiny of the accuracy and integrity of financial data have prompted many energy companies to tighten financial controls, strengthen external reporting and review corporate governance structures. They have discovered that practices related to measurement of production volume, gas quality and delivery transactions play a crucial role in accurately recording revenue and reporting financial results.

"In fact, experience has shown that the natural gas measurement function serves as the foundation for Sarbanes-Oxley compliance."[19] (My italics.)

So, at the same time the industry was grappling with reduced numbers of technicians and the need to replace them and the challenges of new technology, it was confronted with the need to comply with tightened government scrutiny.

Industry Response

Unlike the Navy, the pipeline business is not monolithic, and companies responded to the increased pressures in their operating environment in a variety of ways. (It's also important to notice that the Navy has the ability to conduct cross-service research while some of the following is necessarily anecdotal.)

[18] Duane A. Harris, Vice President Sales and Support, Flow-Cal, Inc., "Communication Between the Office and Field," http://flocal.com

[19] Tim Nesler, Chairman & CEO, EMS Pipeline Services, "Gas Measurement has Key Role in Sarbanes-Oxley Law Compliance," Pipeline & Gas Journal, September 2005

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More companies are relying on computer-based training (CBT) for gas measurement over classroom training where real knowledge of field experiences can be shared. Companies prefer on-the-job training, but face challenges in this effort: Companies may or may not have formal training programs set aside for gas measurement technicians. For example, Pipelines like Spectra Energy (Enbridge) have formalized programs taking advantage of classroom and onsite training for their measurement technicians.

Companies like Atmos Energy (Charles Vaughn Training Center) and Northwest Natural Gas (Sherwood Training Center) have formalized training programs AND training centers for their measurement technicians. In the case of Distribution Companies, gas measurement skills are being taught to distribution meter technicians in controlled environments like Vaughan Training Center in Plano Texas (Atmos Energy) and Sherwood Training Center in Oregon for Northwest Natural Gas. Various pipelines have implemented formal gas measurement programs like Spectra Energy (Enbridge) while others have chosen to train in-house curriculums taught by available talent within their organization.

Each training type (CBT, on-the-job and formal in-house training programs) has its own set of challenges including:

- To provide training, companies must take essential, knowledgeable measurement professionals out of the field. A good rule of thumb for management is that a week of content creation must be set aside for each day of training. This represents a significant and cost commitment.
- Each company needs to train to their set of practices and procedures. This results in dedicating time and personnel to developing company-specific programs, a costly and time-consuming process.
- Companies have Gas Measurement Standard Operating Procedures (SOP)'s that they may or may not train to. The difficulty in training to SOPs is keeping them up-to-date with latest list of standards released. In 2017, these are some of the Standards released in gas measurement:
    - AGA Measurement Manual Part 4
    - AGA Report 9
    - AGA Report No 3 Part 2
    - AGA Report No 8 Part 1
    - API MPMS 19.4 -A2
    - API MPMS 19.6.1
    - API MPMS 14.12
    - API MPMS 7.1
    - API MPMS 13.3
    - API MPMS 14.1 A1
    - API MPMS 19.1
    - API MPMS 20.1 (R2016)
    - API MPMS 22.2
    - API MPMS 14.4 or GPA 8173-17
    - API MPMS 8.4
    - API Technical Report 2578
    - GPA 2140
    - GPA 2166-17
    - GPA 8186-17
    - Odorization Manual (Rv April 2017)
    - Onshore Order 3170, 3173, 3714, 3175

- Companies that have no scheduled, formalized training set aside during the work week or work year have moved to a model of "Big Bubba Training" where Big Bubba Trains Little Bubba with his existing knowledge. The training is obviously haphazard and critical procedures and processes for gas measurement are not necessarily communicated to the technician resulting in errors and measurement uncertainty.

The 2010 Balisle Report noted that "Over-the-shoulder training that was once the foundation of surface force training has vanished." While the gas measurement industry has not reached that point, the trends toward a reliance on CBT and in-classroom training are troubling.

American Gas Association

At about the same time that Phillip Balisle issued his panel's report on surface force readiness, the AGA Transmission Measurement Committee recognized the need for comprehensive and transparent gas measurement training guidelines

Its goal was to "define a comprehensive list of tasks including the minimum knowledge, skill and time requirements to develop necessary competence for measurement field personnel."[20] The White Paper issued in 2010 detailed the necessary skill sets (and hours of training) for gas measurement technicians whether they were in transmission, distribution, midstream or production roles and provided provided a "road map" for individual management teams to review and properly allocate resources (both financial and internal) to ensure that their measurement professionals could obtain a level of competency in a time range of 1-3 years depending on their job descriptions.

NGMT Guidelines and Tasks

The Natural Gas Measurement Training and Development Guidelines are intended to define a comprehensive list of tasks including the minimum knowledge, skill and time requirements to develop necessary competence for measurement field personnel. The scope of the 2010 white paper includes: "Development programs, which include aptitude recognition, knowledge, and skill progression, should be structured to improve the retention of existing and newly hired technicians. These programs need to provide for expeditious and comprehensive qualification of technicians."[21] So, not only did the AGA recognize the retention and retirement issues facing the pipeline community, it also recognized the aptitudes necessary for technician success. These issues are outside the scope of this paper, but worth noting within its context.

In its broad comments on training, the Guidelines said, "It is desired that a new technician be exposed to a set of basic skill sets and the experiences that fulfill development objectives at a satisfactory pace and meet the requirements of the position." It went on to say, "A balanced program that incorporates computer based, classroom, formalized hands-on, and on-the-job training may be utilized. Gas property and measurement technology training is better suited for computer-based modules and classroom instruction. *However, skill development through exposure to actual field experiences cannot be simulated in classroom or computer-based training.* For example, reacting to pressure control requirements of a

[20] "Natural Gas Measurement Technician Training and Development Guidelines," AGA Transmission Measurement Committee, 2010, page 1.
[21] Ibid., page 1.

specific pipeline system cannot be taught, except at a field location. Confidence and proficiency should be gained through both classroom and real life experiences."[22]

According to the Natural Gas Measurement Technician Training and Development Guidelines, a gas measurement technician needs 456 minimum hours of training in basic gas measurement skills and a maximum of 810 hours to be proficient.

MEASUREMENT TASKS Basic Level (Continuation from previous page)	**Level B = Base A = Advanced**	**Recommended Minimum Training Hours**	**Estimated Maximum Training Hours**	**Recommended Minimum Skill Development Hours**	**Estimated Maximum Skill Development Hours**
OPERATE, TEST & MAINTAIN VALVE ACTUATOR	B	8	16	8	16
PERFORM ODOROMETER TESTS	B	2	4	8	12
REVIEW & EDIT VOLUME DATA	B	8	12	8	12
REVIEW METER STATION DESIGN & CONSTRUCTION DRAWINGS	B	8	12	8	12
TEST & MAINTAIN TRANSMITTERS	B	8	16	8	16
TEST CONTROL VALVE	B	8	16	16	24
TEST METER OR WITNESS METER TEST	B	8	12	8	16
TEST PRESSURE REGULATOR (Worker Device)	B	8	16	16	24
TEST RELIEF DEVICES	B	8	16	16	24
TEST & MAINTAIN CHART RECORDERS	B	8	12	16	32
TRANSFER PROVE FIELD METERS	B	8	12	8	12
TUNE & ADJUST CONTROLLERS & POSITIONERS	B	12	24	12	16
Basic Level Total Hours:		456	810	550	984

While the objective of this paper is not to review gas measurement technician skill sets in detail, it is worth a look at those skill sets and the settings where they can be most effectively taught, specifically asking which portions of those skill sets lend itself most easily to CBT Training.

- **Gas Measurement Fundamentals**: Gas Measurement Fundamentals is the basic core of understanding all gas measurement concepts. All standards from API, GPA and AGA determine how gas measurement is performed, and require the student to understand the concepts behind the standards and how non-compliance can produce measurement uncertainty. CBT training and classroom training.
- **Fundamentals of Code and Safety Requirements:** CBT training.
- **Calculate and Report Unmetered Gas Usage:** CBT training
- **Collect a Gas Sample:** Field on Site Training to Company SOPS
- **Change, Inspect and Size Orifice Plates:** Field on Site Training to Company SOPS
- **Install and Test Chromatograph:** Field on Site Training to Company SOPS

[22] Ibid., page 2.

Much of skill sets in the Guidelines require field hands on training, which cannot be accomplished by CBT training.

As an industry, we are comfortable teaching basic safety skills on CBT, but companies like Atmos and Northwest provide training exercises in their "gas cities" on detecting and repairing natural gas leaks.

Instrumentation Classroom training will always need to take place before handling equipment from Electronic Gas Measurement (EFM's), Chromatographs, Ultrasonic, Coriolis, Gas Sampling Systems, Composite Sampling Systems, Odorization Systems and many more. Hands on Field Training for proper installation, Initial Verification, Commissioning and Calibration as per API 21.1 or other standards will require more formal training in the field.

The point is that while portions of fundamental skill sets can be appropriately assigned to CBT training, critical elements in those skill sets must be acquired via on-site training.

Pipeline Incident Trends

Gas Measurement professionals are aware of the danger to their lives and the lives of others during their processes and procedures. According to the Pipeline and Hazardous Materials Safety Administration, the impact of poorly trained gas measurement professionals can be seen in some of the following accidents:

- On February 10, 2017 a Phillips 66 natural gas liquids pipeline (TENDS pipeline Sorrento system) near the Williams-Discovery natural gas plant on US Route 90 near Paradis, Louisiana exploded while being cleaned, killing one worker, and sending another worker to a burn unit. Traffic on US 90 and La 631 was shut down and residents in the area evacuated.[23]
- On December 2, 2016 equipment failure in a Denbury Resources source water pipeline led to a leak of approximately 84,000 gallons of source water into Skull Creek, in Bowman County, North Dakota.[24]
- On November 15, work was being performed on a flow control valve, on a Sunoco 10 inch crude oil pipeline, in Wortham, Texas, when the valve failed, injuring five workers, and spilling crude oil. It was later determined that the valve was under 400 psi of nitrogen pressure when it was being worked on.[25]
- On November 18, 2013 a gas pipeline burst near Ranger, Texas causing a fire in a field, with flames reaching 100 feet high. Some houses nearby were evacuated for a time. The owner of the pipeline, Hanlon Gas, had been installing a new compressor station, and they believe a malfunction led to the rupture and fire. There were no injuries reported.[26]
- On October 11, 2010 equipment failure on Centurion Pipeline caused it to fail in Levelland, Texas releasing about 428,000 gallons of crude oil.[27]

[23] Heather Miller, WGNO-ABC, (February 9, 2017). "One missing, two injured in Paradis pipeline explosion".
[24] "Leak causes approximately 2,000 barrels of source water to flow into Skull Creek in Bowman County". North Dakota Department of Health. December 2, 2016.

[25] Administration, Department of Transportation's Pipeline and Hazardous Materials Safety. "PHMSA – Briefing Room"

[26] "Gas Pipeline Rupture Send Flames 100 Feet into Air". Big Country Homepage. Associated Press.
[27]."PHMSA: Stakeholder Communications - Operator Information". primis.phmsa.dot.gov.

- On July 20, 2011 a six-month-old, 30-inch natural gas pipeline exploded near Gillette, Wyoming, creating a 60-foot (18 m) crater. There was no fire, nor any injuries. Construction or installation issues caused the failure.[28]
- On May 2, 2000, at Greenville, Mississipppi, six workers were injured during a turbine construction project at the Williams Gas Pipeline-Southcentral natural gas compressor station. A flash fire occurred when contractor employees were beginning to install an isolation cap on a 26-inch diameter natural gas line. The fire extinguished itself. Evidence available has not allowed determination of cause. [29]

U.S. Navy & Gas Measurement Training: Parallels & Differences

At this point, the broad parallels between the experiences of the Navy and the natural gas measurement community are clear:

- Similar challenges, including reduced numbers of available personnel and cost efficiencies, have resulted in an overall reduction in time, amount and type of training, especially field training, and in a reliance upon CBT training;
- This, in turn, has resulted in failures, sometimes catastrophic, for both the Navy and the natural gas pipeline community.
- The conclusions of various studies conducted by the Navy and key natural gas measurement industry groups is that programs can succeed or fail based on scheduled, formalized training time in the field. (The U.S. Navy has identified other significant contributors to its recent series of accidents.)

While the majority of this paper addresses the similarities in these experiences, moving forward, it is important to acknowledge differences, particularly differences in operating environments. The Navy is, for example, fundamentally a monolithic organization. Our community is composed of individual companies. We answer to different "masters" – shareholders on one hand and SecNav (the Secretary of the Navy) and, ultimately, the president on the other. And, so on. The point here is that while it's vital to learn from the experience of a similarly critical "industry" (the U.S. Navy), it's equally vital that we be clear-eyed about specific challenges facing our community and the individual companies within it. This recognition, most importantly, has obvious implications for the way in which we gather and share information.

Conclusions

At the risk of some, hopefully minor, repetition of points already made and recognizing the (necessary) limitations of this white paper, here are some conclusions which might suggest a path forward:

- At a minimum, a gas measurement technician needs 456 minimum hours of training in basic gas measurement skills and a maximum of 810 hours to be proficient. The time must be allocated and allocated appropriately, that is, technicians must have the field training they need for proficiency.

[28] "Wyoming nat gas pipeline out of commission". UPI. Archived from the original on February 3, 2016.
[29] PHMSA Pipeline Safety-Flagged Incidents (1986-2001), link on the Pipeline Incident Flagged Files page at www.phmsa.dot.govdata-and-statisticspipelinepipeline-incident-flagged-files.

(CBT training is a marvelous component of overall training, but it cannot take the place of field or Instrumentation Classroom training.)

- The training of gas measurement technicians should be "triaged." In private industry, gas measurement technicians can wear multiple hats, such as having telemetry or compressor plant responsibilities. This reduces available training time while simultaneously increasing the need for training in what could be considered his primary own skill sets.
- The gas measurement industry faces a major challenge in training to the most recent SOPs. In 2017, the number of standards released could be counted in the double digits. The success of individual teams is defined by the ability of senior measurement staff to instruct and communicate SOPs and processes in a real-world environment, not in a classroom, not on a CBT, but in the field where it counts.
- Implied, but not explicitly stated, is the need for what could be called a renewed commitment to training by top management. And, it should be noted that this can also involve a capital commitment. Natural Gas companies like Peoples Gas and North Shore Gas are building new facilities to replace their 30-year-old aging facility for training to their measurement professionals.

While the training focus is necessarily a company-specific challenge, there are some "big picture" steps which could be helpful for the community as a whole. These research efforts could be undertaken by appropriate industry groups and shared within the gas measurement communities. Specifically:

- There is no confirmed data from transmission or gatherers or production companies on the amount of time they dedicate to on-the-job training outside of regular technician's duties.
- For this white paper, I did not pull data from SGA, Spectra Energy (Enbridge), Atmos Energy Field Skills work program, or other programs for their data for how they judge the success of their gas measurement training program. A comprehensive look at these programs might be helpful going forward.
- While we've discussed the need for training, we've not discussed the need for testing. Thorough testing and certification should be required for technicians.
- It might also be instructive to learn the proportion of gas measurement technicians within the community who wear multiple hats and the amount of time and resources dedicated to their training.

The safety track record of the U.S. Navy has been well-publicized and the reasons for the accidents studied and understood. It is presently implementing a program to increase the percentage of time allocated to training in U.S. Navy Cruisers and Destroyers Homeported in Japan and the U.S. and is studying other ways to increase training[30]. In recognition of the need for increased and appropriate gas measure training, specific companies within our community are taking steps to address that need, however, the response has been far from community-wide. Like the Navy, ours is a demanding, critical profession and it's our responsibility to ensure our members are up to the task.

[30] "Navy Officials Examine Training Procedures after Ship Accidents," National Public Radio, September 7, 2017. Tom Bowman, reporter.

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Ardis Bartle founded APEX Measurement and Controls in 2004. As president, she has more than 30 years of experience in gas measurement, including development, business strategy and selling PGAS, one of the leading gas measurement software systems in the gas measurement market. Many of the leading producers, distribution and transmission companies have sought her technology expertise in gas measurement solutions, ranging from gas measurement systems to electronic meter tests. Ardis works closely with the leading gas measurement school, Gas Certification Institute (GCI), to assist with curriculum development and attendee generation for its gas measurement training program. She also provides technical writing support and works with GCI to write and implement Sarbanes-Oxley compliant gas measurement standard operating procedures (SOP).

Ardis is an active participant in numerous trade associations, including acting as the District Vice President Section 7 and Past President for ISA Houston and serving on the American Gas Association (AGA) Transmission Measurement Committee (TMC) and Distribution Measurement Committee (DMC). Currently she is a member of the committee reviewing ANSI B109 Standard, AGA 4A and AGA 5. Her white papers include AGA DMC Technical Note on Turbine Meters. In addition to serving as a director on West Harris County MUD 6, she also provides community service, such as the Houston Livestock Show & Rodeo Season Ticket Sales committee, Art on the Avenue Raffle Chair, as well as community recreational boards. She received a Masters in Business (MBA) from Southwest Texas State University in 1979.