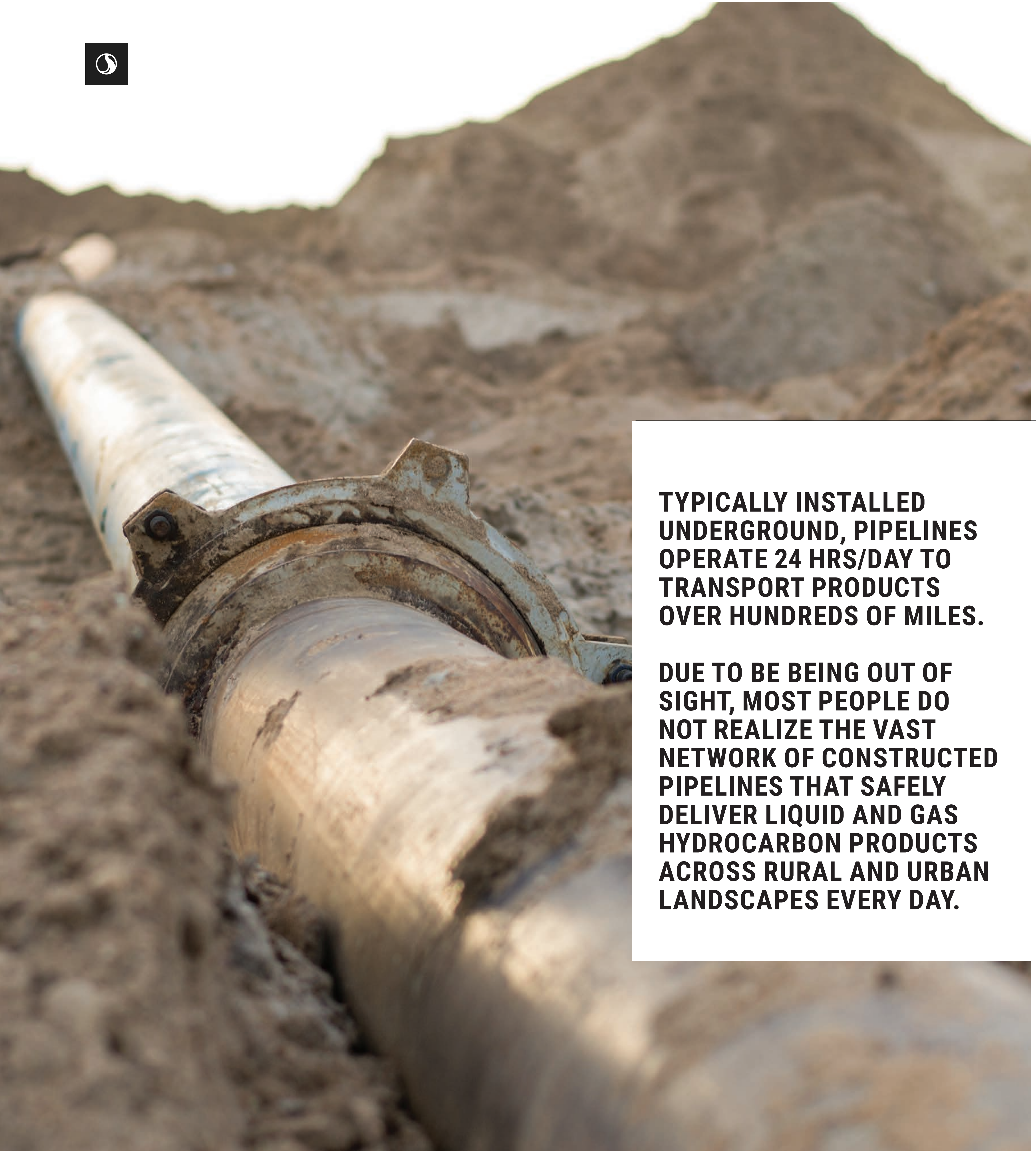


Data Management and Pipeline Integrity

TYPICALLY INSTALLED UNDERGROUND, PIPELINES OPERATE 24 HRS/DAY TO TRANSPORT PRODUCTS OVER HUNDREDS OF MILES.

DUE TO BE BEING OUT OF SIGHT, MOST PEOPLE DO NOT REALIZE THE VAST NETWORK OF CONSTRUCTED PIPELINES THAT SAFELY DELIVER LIQUID AND GAS HYDROCARBON PRODUCTS ACROSS RURAL AND URBAN LANDSCAPES EVERY DAY.

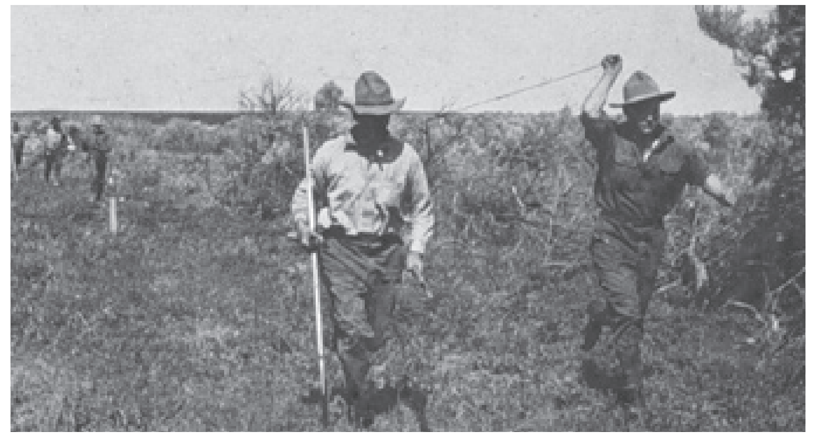
Locating Pipe

The underground installation of pipelines is the origin of some unique challenges for managing and maintaining the inventory of individual pipes (pipe joints). The first challenge is how to locate, for examination or repair, any given pipe in the inventory. Although it is impossible to 'lose' a pipe, finding a specific pipe in the pipeline can be difficult without exposing a large section for visual identification. Once a total of 88 to 132 pipes are joined, lowered into a trench then backfilled to make 1 mile of pipeline, locating a specific pipe in the line of pipes is most easily resolved by utilizing geomatics data principles.

To estimate the location of a pipe, surveyors used to use metal survey tape to physically 'chain' up to 2 miles along the pipeline right-of-way. Photo 1 predates modern pipelines but illustrates the technique:

Potential sources of error, besides the survey itself, include angled pipes that do not follow the contour of the ground. A typical surveyed location obtained using this method can be off by more than the length of one pipe (40-60 ft). Digital GIS-based referencing has replaced the physical work of chaining however major sources of error remain.

It may be assumed that a 4-mile geomatics survey span is bounded by endpoints where one or more specific pipes can be visually identified, such as at valve risers. However, with typical pipeline valve spacing of up to



↑ Photo 1: Historical Survey Tape Measurement
Credit: Hodgson[1]

15 miles, surveyors rely on a series of temporary marker devices to log when an in-line pipe-wall inspection tool passes underneath. Combined with the recorded time each join between pipes is navigated by the in-line inspection (ILI) tool, the markers provide a virtual pipe reference that can be used to shorten the maximum distance that needs to be 'chained' to locate a pipe-wall anomaly (usually 2 miles

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or less). While helping reduce the 'chaining' error, the temporary markers are themselves a source of error. Unless accurate sketches and/or photos clearly record the marker location (and deployment), the reproduced position of a marker can be off target by the width of a road allowance (65 ft) or more.

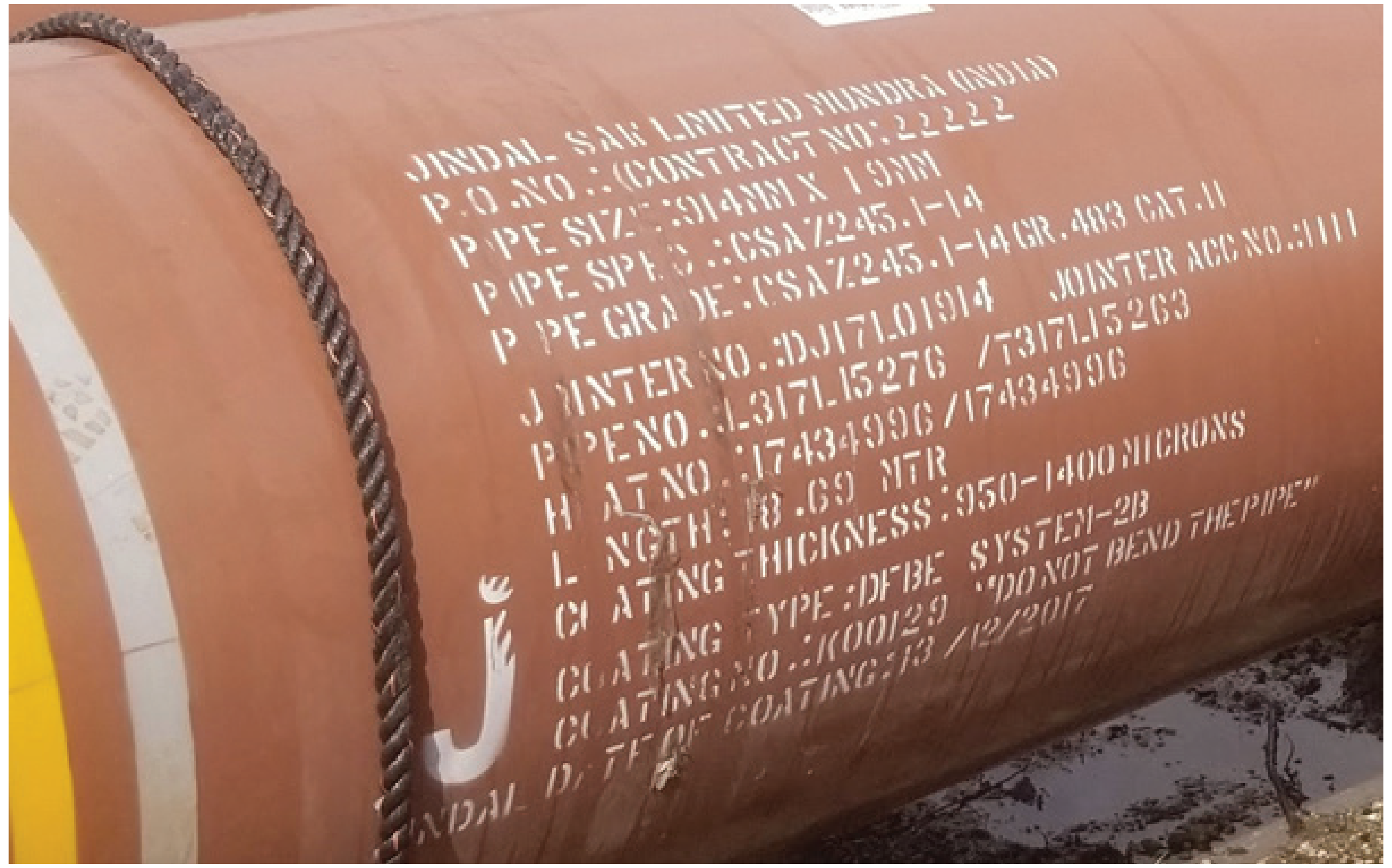
Over the past 15 years, the addition of inertial mapping units (IMU) to in-line inspection (ILI) tools has replaced the requirement to 'chain' the location of a given pipe. This technique can make locating a pipe either easier and more difficult, depending on the how well the sources of errors are controlled in the integration of the survey and inertial datasets. For current construction, the most definitive as-built pipeline survey is done using sub-cm GPS to record the position of each pipe, prior to backfilling.

Tracking pipe properties

After a pipe has been located, the second challenge with inventory management is authenticating the origin, vintage and grade of the pipe installed without physical markings. Understanding that original construction Quality Assurance (QA) records for a vintage pipeline would not meet current standards, records that were retained likely went through a series of storage transfers as ownership of the pipeline and records management systems changed over time. Each transition, if not well managed, can mean that some of the records may have been degraded through reproduction, lost or discarded. Assuming 10-years between transitions in records management systems for typical pipeline as-builts, one may encounter difficulty in authenticating pipe that has been in the ground for 50-70 years.

As a tragic illustration of the impact that unknown pipe properties, according to the NTSB[2], a contributing cause of the 2010 San Bruno gas pipeline rupture and fire was replacement sections that "… did not conform to any known specification for pipe" and was found after testing to not meet the minimum requirement for strength according to the original construction specification.

Pipe inventory information can be rebuilt through a systematic search of historical construction and inspection records. With time, expertise and a proven approach, much of a pipeline's original construction specifications can be recovered. Depending on the complexity of the pipeline's history, it may be necessary to reconstruct the timeline of changes to establish a link between pipe that is currently in operation to historical materials records.



← Photo 2: Example of Pipe Manufacturer's Barcode and Information Stencil

Current pipe manufacturers provide traceability using bar codes and stenciling on each joint of pipe (Photo 2). While these markings will likely degrade after the pipeline is backfilled, as part of leading construction QA practices, materials and joining information can be scanned directly from each pipe to record the mill and heat numbers before lowering into the trench.

Modern pipeline spatial integration databases, such as ones based on the Pipeline Open Data Standards [3] (PODS) 6.0 Spatial, retain materials and Construction QA data in relationship with coordinate (location) data for each pipe. In accordance with the latest data management standards (e.g. API 1178), traceability to original records is managed as part the commissioned database.

There are over 3 million miles of pipeline infrastructure in North America.

Attributing safety criterion

Ultimately, having found and validated the material properties for each pipe, a third element of the pipe inventory needs to be managed: maximum pipe stress criteria applicable to safe operation. Several factors can make this criterion different for each pipe, including hydrotest pressure and land use along the pipeline right-of-way (ROW). It is also possible that different standards apply for similar land use due to the effective date of regulatory changes. Spatial (location) integration for data representing pipe material, hydrotest and maximum stress criteria is needed for maintenance and safe operation of the pipeline.

In summary, lines of underground pipes, joined end-to-end, transport energy products to meet the needs of consumers. Safe operation of a pipeline requires a system for locating individual pipes as well as for authenticating materials and operating limits that vary along the line. Without accurate as-built survey prior to backfilling the pipeline, optimized geomatics workflows are necessary to pin-point the location of individual pipe years or decades after installation. Pipe inventory and Construction QA records benefit from historical archiving suitable for retaining the authenticity of material records. Finally, regulated maximum stress criteria needs to be matched with land use at the location of each pipe to establish safe operating limits.

QUALITY MANAGEMENT IS KEY TO CREATING AN EFFECTIVE AND TRUSTWORTHY PIPELINE DATABASE.

JAMES FERGUSON
MANAGER, INTEGRITY BUSINESS DEVELOPMENT & TECHNOLOGY

Spatial data integration is used to manage multiple generations of pipe, spanning vintage to new construction. Quality management in commissioning the pipeline database will result in an overlay of datasets that can be trusted to safely operate the pipeline over its life.

FOR AN OVERVIEW OF HOW A PIPELINE DATABASE IS COMMISSIONED, MY NEXT ARTICLE WILL OUTLINE BEST PRACTICES AS DEFINED IN CURRENT STANDARDS FOR DATA INTEGRATION.

Stantec

CONTACT US

To learn more about our pipeline integrity services contact:

James Ferguson

Data sources:

[1] Hodgson, C. V. Measuring base with invar tape. Tape underway. Base line and astro party, ca. 1916. NOAA Historical Photo Collection (2004). Retrieved on April 20, 2006, from http://www.photolib.noaa.gov/.

[2] Pacific Gas and Electric Company Natural Gas Transmission Pipeline Rupture and Fire San Bruno, California September 9, 2010, NTSB Accident Report; NTSB/PAR-11/01; PB2011-916501 https://www.aga.org/sites/default/files/legacy-assets/our-issues/safety/pipleinesafety/Technicalreports/Documents/Final%20Report%20of%20NTSB%20San%20Bruno%20Accident%20Investigation.pdf

[3] https://www.pods.org/

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