The PIPELINE

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Teamwork–The Key To Success

Brian Payne - Principal

After our last newsletter was published, we received a call from Dr. Hamid Rastegar, the President and Chairman of Aspen Environmental Group (Aspen). Hamid complimented our staff on the fine job they were doing with this newsletter. He had missed the regular updates during our long lapse between issues. Hamid also suggested a future newsletter topic – Teamwork.

Many of our clients have wondered how a regional firm such as ours can be involved with so many major projects. We would not have these opportunities without teaming with other firms. The last newsletter discussed the Chief Building Official oversight services we provide to the California Energy Commission (CEC). Our firm provides these services as a member of a large team, which is led by Aspen. The team is under contract to the CEC to provide engineering and environmental technical assistance to support electrical power plant licensing, among other things.

Our firm teams with a number of firms to provide a variety of professional services, including:

- Turnkey engineering, design, permitting, and construction (design/build) projects;
- Preparation of Environmental Impact Reports (EIR's) and other California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) documents;
- Environmental and technical permitting;
- Plan check and engineering design reviews;
- Construction inspection and monitoring; and
- Litigation support; etc.

Some of our teaming partners include: Aspen Environmental Group; URS Corporation; Padre Associates; ARB, Inc.; SSD, Inc.; SPEC Services; ESA Associates; Dudek; WorleyParsons; Michael Brandman Associates; Coates Field Services; Penfield & Smith; Cannon Associates; Golden State Aerial Surveys; RBF Consulting; Vertical Mapping Resources; Construction Materials Testing; and ConCeCo/MATCOR Engineering; etc.

We sincerely appreciate the diversity and expanded scope of projects we have been able to undertake with our colleagues. Whether working as a focused member of a large team, or leading the team ourselves, teamwork has definitely enhanced our professional lives and firm capabilities. Without our teaming partners, we would not be as successful in meeting our client needs.

Don't Stress Over Pipe Stress

We've recently been involved with a number of pipeline projects where some of the loading conditions had not been considered. Some of the consequences have included: the need to reduce the pipeline operating pressure and/or temperature, pipe replacement, re-purchase of uninstalled pipe materials, and pipe failure.

Title 49, Code of Federal Regulations, Parts 192 and 195 provide the regulations for gas and hazardous liquid pipelines respectively. These regulations provide specific equations for the determination of the required

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Pipe Stress

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wall thickness and pipe grade based on internal pressure or hoop stress (Reference 49 CFR § 192.105 and § 195.106). However, the regulations do not provide direct guidance for analyzing most external loads (e.g., earthquakes, thermal expansion and contraction, localized stresses, surcharge loads, fault crossings, etc.). A complete discussion of pipe stress analysis is beyond the scope of this newsletter. However, we have summarized some of the engineering analyses that should be considered during pipeline design.

Internal Pressure

The pipe grade and wall thickness must be selected to meet the hoop stress equations presented in the regulations and in ANSI B31.4 and B31.8, which are incorporated by reference into the regulations. For gas lines, and hazardous liquid lines in flat terrain, this is a fairly straightforward process, since the maximum internal design pressure is normally constant for the entire line segment. However, for liquid lines crossing hilly or mountainous terrain, the maximum internal design pressure can vary greatly along the pipeline depending on the pipe elevation. At higher elevations, the required pipe wall thickness may be significantly less than at lower elevations, due to the hydrostatic head of the fluid within the line.

We recommend the use of a pipeline profile drawing to aid in the analysis of liquid pipelines. The terrain profile, hydrostatic test pressure, internal design pressure, and other parameters can be shown on the profile drawing. All of the pressures can be converted to feet of head for the specific gravity of fluid being considered, thus enabling them to be plotted on the same vertical scale. Once this has been done, the limiting components and maximum allowable operating pressures can easily be identified.

Thermal Expansion and Contraction

For lines operated at temperatures different than during installation, expansion and contraction can cause significant pipe stresses and strains. For above grade pipelines, expansion loops, anchors, and other measures may be required to maintain pipe stresses within allowable limits. The primary concern associated with pipe movement at buried bends is the potential for fatigue damage due to repeated thermal cycling. For buried (restrained) pipe, additional pipe wall thickness, pipe grade, anchorage, bend radius, and/or depth of cover may be required.

We recommend the analysis of both above and below grade pipe subject to thermal loads using finite element modeling techniques. Some of the common engineering analysis tools include: CAESAR II (COADE Engineering Software), PIPLIN (SSD, Inc.), and AutoPIPE (Bentley Systems, Inc.).

Surge

The ANSI codes generally limit surge pressures to 110% of the internal design pressure. In order to evaluate this condition, a hydraulic analysis of the pipeline is required. Stoner Pipeline Simulator (Advantica) and AFT Impulse (Applied Flow Technology) are excellent transient modeling tools. Often, the surge pressure can be minimized by slowing the closure rate of block valves.

Seismic

The stresses induced on a buried pipeline by seismic ground shaking are most often analyzed using the Newmark Equation. A useful reference has been published by the American Society of Civil Engineers, American Lifeline Alliance, entitled, *Guidelines for the Design of Buried Steel Pipe*, July 2001. In order to evaluate these stresses, the following data is required: maximum horizontal ground velocity in the direction of the seismic wave propagation (also referred to as the peak horizontal ground velocity) and the apparent seismic wave propagation speed. The consideration of these stresses is essential to pipeline design in regions prone to seismic ground shaking. Depending on the soil type and proximity to ground shaking, these stresses can be considerable.

Bending

Residual bending stresses can be induced during construction by a number of factors. Some of these include: curvature of the pipeline at horizontal directional drilled (HDD) installations; “roping” of the pipe to fit the ditch; above grade pipe spans; lateral loads induced by landslides, soil liquefaction, running water, etc. For gas lines, additional bending loads can be induced during hydrostatic testing or internal inspection pigging at above grade spans. These bending loads can normally be analyzed using routine structural engineering formulae.

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Survey SAYS

Thanks again to everyone who participated in our recent survey.

We asked – ***"What are your initial thoughts when you consider our firm for engineering projects?"***

Here are more responses from our clients:

"I have always believed that EDM Services adds value to my projects. EDM provides valuable advice to protect [the client's] interests. EDM has also worked on a wide variety of projects and has a work force with diverse experience."

"I know the great work and service that EDM provides. They have always been very customer focused and friendly."

"EDM has proven to be very customer and performance driven...I am also impressed with your attention to detail and respect for adherence to timeline issues and management."

"I have experienced excellent consultant performance from EDM Services."

"My initial thought regarding EDM Services is that EDM is probably the most qualified firm in the state to design oil and gas pipelines. EDM provides expertise for projects that are potentially controversial and technically challenging."

Pipe Stress

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Installation

During installation, the pipe can be stressed to the point of failure. Some situations where special structural analysis is warranted include:

- Horizontal Direction Drilling (HDD) – In some situations, the pipe wall thickness and/or pipe grade must be increased to accommodate the tensile loads to be encountered during pull back operations.
- Offshore Installations – When lines are being installed off a lay barge or vessel, the pipe string must be checked to ensure that it can be installed without buckling or tensile failure.

Surcharge

Surcharge loads can be imposed by highway traffic, trains, heavy equipment, etc. The American Society of Mechanical Engineers (ASME) Guide Material Appendix G-192-15 - *Design of Uncased Pipeline Crossings* and the American Petroleum Institute (API) Recommended Practice 1102 *Analysis of Pipelines Crossing Road and Railroads*, provide methodologies for analyzing most surcharge loads, including fatigue analysis.

Ground Faulting

Surface faulting can result in significant loads on a pipeline. As a result, fault crossings require careful consideration by the design engineer. The most significant factor is normally the fault crossing angle. Most faults can be safely designed, provided the pipeline alignment places the pipe in tension. The parameters affecting the performance of the pipe at a fault crossing include: diameter and wall thickness of the pipe; mechanical properties of the pipe steel; internal design pressure; transverse soil stiffness and strength (often a trapezoidal ditch is used with select backfill to reduce lateral stiffness); stiffness, strength and the longitudinal cohesion between the soil and the pipe; magnitude and direction of the fault displacement; width of the fault zone; the distribution of the fault displacement across this width; the angle at which the pipe crosses the fault; the three-dimensional alignment of the pipeline on either side of the fault zone; size of allowable weld defects within the fault zone; and the locations of girth welds within the fault zone.

We recommend that all fault crossings be analyzed using a three dimensional finite element analysis model using one of the tools cited earlier for thermal expansion and contraction.

Summary

In most cases, pipeline structural design is much more complicated than the simple consideration of hoop stress. The pipe wall thickness, pipe grade, pipeline geometry, and other parameters must be selected after considering a number of additional loads – some individually and many combined. In addition to internal pressure, a number of additional sustained and occasional loads must also be evaluated to ensure safe and reliable pipeline operation.

In The Spotlight

The Porutiu's - The firm's second husband and wife team help keep the family atmosphere alive

www.williamhardyphotography.com

Dana and Alex Porutiu were born and raised in Romania. Eight years ago, Dana won the U. S. State Department Visa lottery. Shortly after an interview at the American Embassy in Bucharest, the entire family boarded a plane and made their move to the United States. At the time, their children, then only 7 and 8 years old, knew only a few English words.

Dana initially became interested in American culture while attending middle school. A group of high school students from Hazleton, Pennsylvania and Hartford, Connecticut visited her home town in the Transylvania region of Romania. She was touched by the American songs and square dancing. Dana maintained a pen pal relationship with several of the Ambassadors for Friendship students for many years.

In their spare time, Dana and Alex are immersed in their family activities. Alexandra, a sophomore at Palos Verdes Peninsula High School, is an active choir member and has danced hip hop with Future Shock Los Angeles since 2004. Horea, a freshman, is on the high school varsity tennis team and also plays the drums; he has been ranked in the top 10 U.S. tennis doubles and top 100 tennis singles.

Dana joined the firm in March 2001; her husband Alex joined the firm last year. Dana and Alex are both electrical engineers. They are understandably proud of their children and work hard to contribute to EDM Services' success.

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