Using Hot Taps For In Service Pipeline Connections

Executive Summary

Natural gas transmission and distribution companies need to make new connections to pipelines many times a year to expand or modify their existing system. Historically, this has necessitated shutting down a portion of the system and purging the gas to the atmosphere to ensure a safe connection. This procedure, referred to as a shutdown interconnect, results in methane emissions, loss of product and sales, occasionally customer inconvenience, and costs associated with evacuating the existing piping system.

Hot tapping is an alternative procedure that makes a new pipeline connection while the pipeline remains in service, flowing natural gas under pressure. The hot tap procedure involves attaching a branch connection and valve on the outside of an operating pipeline, and then cutting out the pipe-line wall within the branch and removing the wall section through the valve. Hot tapping avoids product loss, methane emissions, and disruption of service to customers.

While hot tapping is not a new practice, recent design improvements have reduced the complications and uncertainty operators might have experienced in the past. Several Natural Gas STAR transmission and distribution Partners report using hot tap procedures routinely—small jobs are performed almost daily while larger taps (greater than 12 inches) are made two or three times per year.

By performing hot taps, Natural Gas Star Partners have achieved methane emissions reductions and increased revenues. Gas savings are generally sufficient to justify making all new connections to operating lines by hot tapping. The payback period for utilizing hot tapping is often immediate.

Technology Background

In natural gas transmission and distribution systems, it is frequently necessary to relocate or expand existing pipelines, install new valves or repair old ones, install new laterals, perform maintenance, or access lines during emergencies. Historically, it has been common practice to shut down the portion of the system during the alteration, vent the gas within the isolated segment, and purge the pipeline with inert gas to ensure a safe connection.

The procedure for performing the shutdown interconnect differs slightly depending on system pressure. In high-pressure systems, the surrounding valves are closed to isolate the pipeline segment and additional stoppels (inserted plugs) are placed next to the valves to prevent natural gas leakage and improve the safety conditions at the interconnection site. In a low-pressure system, the length of pipeline that is shutdown is typically much shorter. Rather than shutting the surrounding valves, stoppels are used to isolate the portion of the pipeline directly around the area of the tap. In both cases, the gas in the isolated pipeline segment is vented and the line is purged.

The impacts associated with performing a shutdown interconnect are both economic and environmental. Gas vented from the pipeline segment represents a loss of product and an increase in methane emissions. In

Economic and Environmental Benefits

Method for Reducing Natural Gas Losses	Volume of Natural Gas Savings (Mcf)	Value of Natural Gas Savings ($)			Other Savings ($)	Implementation Cost ($)	Other Costs ($)	Payback (Months)		
		$3 per Mcf	$5 per Mcf	$7 per Mcf				$3 per Mcf	$5 per Mcf	$7 per Mcf
Hot Tap Connection[a]	24,400 per year	$73,200 per year	$122,000 per year	$170,800 per year	$13,680 per year[b]	$47,409	$62,222 per year[c]	15	10	7

General Assumptions:
[a] Annual savings and costs are based on an average 320 hot taps (of various sizes) per year.
[b] Other savings shown are for inert gas.
[c] Other costs includes the O&M and contract services costs.

addition, removing a pipeline segment from service can occasionally cause gas service interruptions to customers. For example, a shutdown connection on a steel line can require one to three or more days of pipeline outage and possible interruption of natural gas shipments in addition to the release of methane to the atmosphere.

Hot tapping is an alternative technique that allows the connection to be made without shutting down the system and venting gas to the atmosphere. Hot tapping is also referred to as line tapping, pressure tapping, pressure cutting, and side cutting. The process involves attaching branch connections and cutting holes into the operating pipeline without interruption of gas flow, and with no release or loss of product. Hot taps permit new tie-ins to existing systems, the insertion of devices into the flow stream, permanent or temporary bypasses, and is the preparatory stage for line plugging with inflatable, temporary balloon plugs (stoppels).

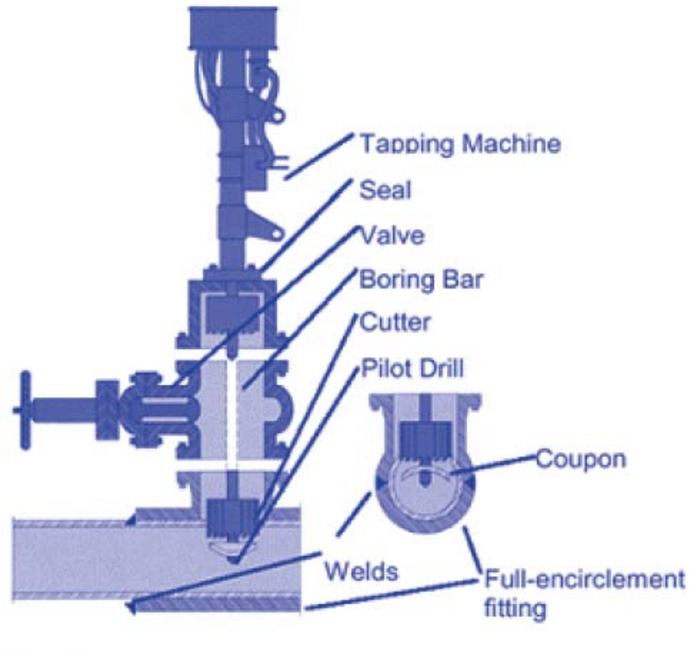
Hot tapping equipment is available for almost any pipeline size, pipe material, and pressure rating found in transmission and distribution systems. The primary equipment for a typical hot tap application includes a drilling machine, a branch fitting, and a valve. Hot tapping equipment is described below and shown in Exhibit 1.

- ★ **Drilling machine.** The drilling machine generally consists of a mechanically driven telescoping boring bar that controls a cutting tool. The cutting tool is used to bore a pilot hole into the pipeline wall in order to center a hole saw that cuts out the "coupon," or curved section of pipeline wall.

- ★ **Fitting.** Connection to the existing pipe is made within a fitting, which can be a simple welded nipple for small (e.g., one inch) connection to a larger pipeline, or a full-encirclement split-sleeve tee for extra support when the branch is the same size as the parent pipeline. The tee wraps completely around the pipeline, and when welded, provides mechanical reinforcement of the branch and carrier pipe.

- ★ **Valve.** The valve on a hot tap connection can be either a block valve or a control valve for the new connection, and must allow the coupon (section of pipeline wall cut out by the drilling machine) to be removed after the cutting operation. Suitable valves include a ball or gate valve, but not a plug or butterfly valve.

Exhibit 1: Schematic of Hot Tapping Machine with Profile



Source: IPSCO

Exhibit 2 provides a general schematic of a hot tapping procedure. The basic steps to perform a hot tap are:

1. Connect the fitting on the existing pipeline by welding (steel), bolting (cast iron), or bonding (plastic) and install the valve.

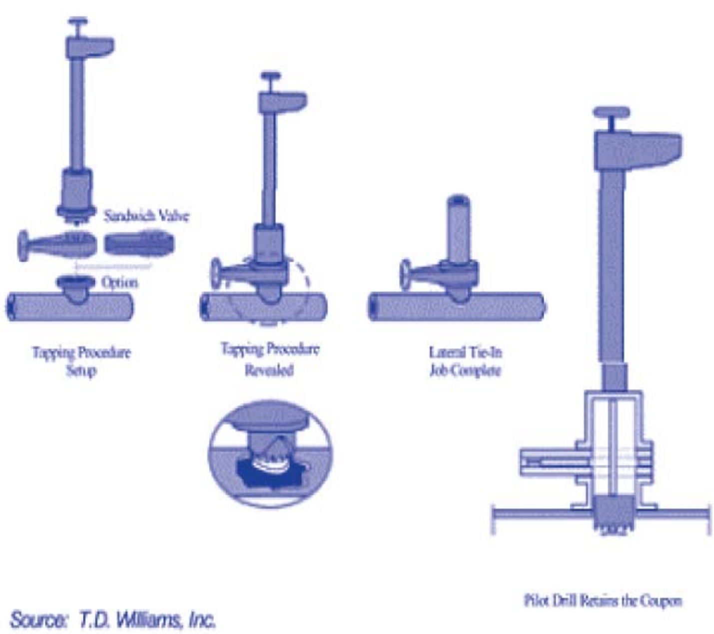
2. Install the hot tap machine through the permanent valve.

3. Perform the hot tap by cutting the coupon from the pipeline through the open valve. A special device retains the "coupon" for removal after the hot tap operation. Withdraw the coupon through the valve and close the valve.

4. Remove the tapping machine and add the branch pipeline. Purge oxygen, open the valve, and the new connection is put into service.

Hot taps can be vertical, horizontal, or at any angle around the pipe as long as there is sufficient room to install the valve, fitting, and tapping machine. Current technology allows for taps to be made on all types of pipelines, at all pressures, diameters, and compositions, even older pipes merging with new. New, lightweight tapping machines

Exhibit 2: Schematic of Hot Tapping Procedure



Source: T.D. Williams, Inc.

are also available that allow a hot tap to be performed by a single operator, without additional blocking or bracing.

Safety manuals and procedural outlines are available from the American Petroleum Institute (API), American Society of Mechanical Engineers (ASME), and other organizations for welding on in-service pipelines for all sizes, flow rates, and locations. These manuals provide information on what to consider during welding, including burn-through prevention, flow in lines, metal thickness, fittings, post weld heat treatment, metal temperature, hot tap connection and welding design, and piping and equipment contents.

Vendor manuals and equipment catalogues are also good sources for determining which size and type of equipment is most appropriate. Several vendors have published comprehensive outlines and guides for performing hot tap procedures, including information on tapping on various materials, job-site evaluation and preparation, selection and installation of fittings and other equipment, and safety precautions. Most importantly, because this is a hazardous procedure, each potential hot tap must be evaluated on a case-by-case basis and a detailed, written procedure should be prepared or reviewed before starting each job to ensure that all steps are taken properly and safely.

Economic and Environmental Benefits

Key economic and environmental benefits of employing hot tapping procedures instead of shutdown connections include:

- Continuous system operation—shutdown and service interruptions are avoided.
- No gas released to the atmosphere.
- Avoided cutting, realignment and re-welding of pipeline sections.
- Reduction of costs associated with planning and coordination—meetings, schedules, paperwork, lost production, and direct manpower.
- Increased worker safety.
- Elimination of obligations to notify customers of gas outages.

By ensuring that best practices are followed when performing a hot tap, the time required for the procedure, as well as the potential for failure, is reduced.

Decision Process

Operators can assess the economics of performing a hot tap as an alternative to a shutdown connection by following the five steps below:

Step 1: Determine physical conditions of the existing line.

In preparation for a hot tap project, operators will need to determine the maximum operating pressure (during the hot tap), type of pipe material (steel, cast iron, plastic), and condition of the parent pipeline (internal/external corrosion, wall thickness) to assure a safe project. A hot tap connection can be made on a pipeline only where the parent pipe material is in good condition. Other conditions to evaluate include the location of nearby valves for emergency isolation in the event of an accident, the desired

Five Steps for Assessing Hot Tap Economics:
1. Determine physical conditions of the existing line.
2. Calculate cost of performing a shutdown interconnect.
3. Calculate the cost of a hot tap procedure.
4. Evaluate the gas savings benefits of hot tapping.
5. Compare the options and determine the economics of hot tapping.

Methane Content of Natural Gas

The average methane content of natural gas varies by natural gas industry sector. The Natural Gas STAR Program assumes the following methane content of natural gas when estimating methane savings for Partner Reported Opportunities.

Production	79 %
Processing	87 %
Transmission and Distribution	94 %

tap diameter, working space around the connection, location of other pipeline welds, and imperfections or obstructions. Operators should also determine if the line is "looped," as many gas transmission companies avoid operational disruptions by shifting the load to a parallel line. It is advisable to develop and follow a written plan to assure full and proper evaluation of a future connection.

Step 2: Calculate cost of performing a shutdown interconnect.

The cost of an actual project would include direct costs such as material and equipment, welding requirements, quality control, blowdown and purge costs, labor, and scheduling expenses. Additional indirect expenses or "hidden" costs might include the cost of shut-off valves, advertising if service is to be interrupted, relighting of customer services, and excavating for stopples and purge connections. Operators would be advised to reference historical data to determine these costs.

For the purposes of this scoping analysis, material and labor costs for cutting out the line section and welding in a tee connection in the shutdown method are assumed to be comparable to the cost of welding on the fitting and performing the hot tap when the branch connection is the same size as the pipeline. However, the costs of the gas lost through venting and inert gas purging are unique to the shutdown interconnect.

The formulas used to determine the cost of a shutdown interconnect are shown in Exhibit 3. For these calculations, low pressure is defined as less than 2 psig.

For comparative purposes, calculating the cost of a shutdown interconnect should take into consideration a multiple-project scenario. This multiple-project perspective allows for a more complete comparative cost analysis given the up-front capital costs of owning and operating a hot tap machine and the need to perform several interconnections throughout a given year. Exhibit 4 illustrates how the cost calculations in Exhibit 3 can be applied in a multiple connection scenario. The hypothetical situation presented includes several projects on pipelines of various sizes and pressures. Cost calculations, however, are only provided for the 4-inch pipeline scenario and only cover direct costs.

Again, individual operators will need to reference company records to determine the exact procedures and factors to use when performing shutdown interconnects. The procedures described above are general guidelines for preliminary economic assessment and can differ from company to company. Additional factors that are company specific include gas leakage past the pipeline valves on both ends of the shutdown, number of stoppers, tap holes for venting and purging, and type of purge gas. Leakage is particularly important as large pipeline block valves can leak significant volumes of gas because they are used infrequently and the valve seat can accumulate debris that inhibits a tight seal. The volume of leakage is highly variable, dependent on valve type, age, pipeline pressure and service (dry gas causes much less corrosion and accumulation of debris than wet gas). If a Partner's individual evaluation following this *Lessons Learned* results in marginal economic justification, then company experience on pipeline valve leakage should be factored in to improve the economics.

Step 3: Calculate the cost of a hot tap procedure.

When comparing the up-front costs of hot tapping with shutdown interconnects the only significant difference is the cost of the hot tap equipment. The tee fitting or full encirclement sleeve, and the valve have nearly the same cost for either method when the branch is essentially the

Nelson Price Indexes

In order to account for inflation in equipment and operating & maintenance costs, Nelson-Farrar Quarterly Cost Indexes (available in the first issue of each quarter in the *Oil and Gas Journal*) are used to update costs in the Lessons Learned documents.

The "Refinery Operation Index" is used to revise operating costs while the "Machinery: Oilfield Itemized Refining Cost Index" is used to update equipment costs.

To use these indexes in the future, simply look up the most current Nelson-Farrar index number, divide by the February 2006 Nelson-Farrar index number, and, finally multiply by the appropriate costs in the Lessons Learned.

Exhibit 3: Calculating the Cost of Shutdown Interconnect

Given:

D = diameter of pipeline (inches)

T = taphole diameter (inches) - for low pressure shutdown with tapholes for stoppers

L = length of pipeline between tapholes (feet) - for high pressure shutdown

P = line pressure (psia for low pressure, psig for high pressure)

P_{pgas} = current purge gas market price ($/Mcf) - assumed $8/Mcf

P_g = current gas market price ($/Mcf) - assumed $7/Mcf

C_e = cost of extra excavation, use company records ($)

C_p = cost of purge connections and excavation

C_s = cost of hidden shutdown expenditures, see Appendix ($)

C_f = cost of fittings, see Appendix ($)

Time Taphole is open = from prior experience (minutes)

Calculate Direct Costs:

1. Calculate A = area of pipeline (ft^2) = $\frac{3.14 * D^2}{4 * 144}\left(\frac{ft^2}{in^2}\right) = \frac{D^2}{183}$
2. Calculate V_p = volume of pipeline (Mcf) = $\frac{A * L}{1{,}000}\left(\frac{Mcf}{ft^3}\right)$
3. Calculate V_{pgas} = volume of purge gas = V_P * 2.2 (shutdown + restore + 20% wasted)
4. Calculate C_{pgas} = cost of nitrogen purge gas = $V_{pgas} * P_{pgas}$
5. Calculate V_g = volume of gas lost in high pressure systems: V_g (Mcf) = $\frac{D^2 * P * \left(\frac{L}{1{,}000}\right) * 0.372}{1{,}000}$

   V_g = volume of gas lost in low pressure systems: V_g (Mcf) = $\frac{T^2 * P * No.of\ Tapholes * Time\ taphole\ is\ open}{60}\left(\frac{hr}{min}\right)$
6. Calculate C_g = cost of gas lost ($) = $V_g * P_g$

Calculate Indirect Costs:

1. Calculate C_e = cost of extra excavation for tie-in ($)
2. Calculate C_p = cost of purge connections ($)
3. Calculate C_s = cost of hidden shutdown expenditures ($)
4. Calculate C_f = cost of fittings ($)
5. Calculate C_i = indirect costs ($) = $C_e + C_p + C_s + C_f$

Calculate Total Costs:

Calculate C_{total} = total cost ($) = $C_g + C_{pgas} + C_i$

Source: Pipeline Rules of Thumb, p. 270 and p. 278

Exhibit 4: Hypothetical Scenario and Example Calculation of Lost Gas and Purge Gas Costs for a Shutdown Interconnect

Given:

A pipeline company requires numerous shutdown or hot tap connections as follows:

Pipeline Diameters, inches	4	8	10	18
Pipeline Pressures, psig	350	100	1,000	200
Pipeline Lengths[a], miles[b]	2	1	3	2
Annual Taps[c], number	250	30	25	15

(1) Calculate: V_s = Volume of Natural Gas Lost

$$V_g\ (\text{Mcf}) = \frac{\left(D^2 * P * \left(\frac{L}{1{,}000}\right) * 0.372\right)}{1{,}000}$$

$$V_g = \frac{\left(4^2 * 350 * \left(\frac{2 * 5{,}280}{1{,}000}\right) * 0.372\right)}{1{,}000}$$

V_g = 22 Mcf

(2) Calculate V_{pgas} = Volume of Purge Gas[d]

$$V_{pgas}\ (\text{Mcf}) = \frac{\left(\frac{D^2 * L}{183}\right)}{1{,}000} * 2.2$$

$$V_{pgas} = \frac{\left(\frac{4^2 * 2 * 5{,}280}{183}\right)}{1{,}000} * 2.2$$

V_{pgas} = 2 Mcf

(3) Calculate: Value of Gas Lost by Shutdown Interconnects (Including Purge Gas)

Cost = $C_g + C_{pgas} = V_g * P_g + V_{pgas} * P_{pgas}$

Cost = (22 Mcf * \$7/Mcf) + (2 Mcf * \$8/Mcf)

Cost = \$170 for each of the 4-inch pipeline shutdown interconnects

[a] Isolation length between block valves or stoppers.
[b] Formula requires length in feet (1 mile = 5,280 feet).
[c] Scenario is based on Partner and vendor information.
[d] Inert gas assumed to be nitrogen.

same size as the pipeline (information on fitting types and costs is shown in the Appendix). The cost of welding a full encirclement sleeve is nearly the same as the cost of welding a tee fitting in a line. Labor cost for cold cutting the pipeline and hot tap cutting out a coupon are sufficiently close for this type of feasibility evaluation. Maintenance costs apply only to hot tap equipment, such as drill sharpening and other equipment care and replacement.

Tapping machines come in several sizes, and a single machine can perform hot taps from 3 to 12 inches. Less expensive machines can be purchased to perform small (e.g., 1 to 3 inch) taps. In general, capital costs for purchasing the hot tap machines typically used by gas companies for the most common sized connections range from $17,287 to $30,122.

Equipment cost is normally a one-time capital expenditure and can be depreciated over the life of the equipment, typically 15 to 20 years. Each company, however, should calculate the depreciation in the same manner used for other equipment purchases (e.g., amortized, over a fixed period of time). This should be considered in conjunction with how often the machine will be used in the future. To make this determination, operators should look at company records to determine the number of times similar connections have been performed.

Typically, a company that performs several hot taps a year will find it economical to own the equipment, especially in sizes up to 12 inches, and to maintain trained personnel to perform the service. These jobs are usually simpler and require less specialized training than larger hot tap jobs. For larger and less frequent hot taps a company might consider it more cost effective to hire a contractor who will supply the equipment and trained personnel. Most hot tap vendors will supply all necessary tapping equipment, including the drilling machine, fittings, valves, cutters, and repair services. The majority of vendors also offer contract services for larger or infrequent jobs, or will rent out the tapping equipment. Supplying support services, such as excavation, welding, and cranes, can reduce the costs of using an outside contractor.

Other factors, such as the line material and thickness, system pressure, and temperature, should also be considered when determining the alternatives of purchasing hot tapping equipment or hiring contractors. A company should evaluate how often the tapping equipment would be used and if they would realize savings by owning and maintaining the equipment and training operators.

Exhibit 5: Hot Tap Expenses

Connection Size	Capital Cost ($)		Contracting Service Cost ($)	Equipment O&M Cost ($/yr)
	Machine[a]	Material		
Small Taps (<12")	17,287 - 30,122	-	-	724 - 7,235
Large Taps (>12")	130,963 - 261,927[b]	2,619 - 11,944[b]	1,447 - 5,788	-

[a] Hot tap machines can last from 5 to 40 years. A company can perform as may as 400 small taps per year.
[b] Most companies will find it more economical to contract out large hot tapping jobs, and would not therefore incur these costs.
Note: Cost information provided by Hot Tap manufacturers and contractors. Prices are only provided for the most economic options.

Exhibit 5 presents ranges of hot tapping costs for both equipment purchase and contracted services. The cost ranges shown include all materials; additional expenses will result from labor and maintenance expenditures, as discussed above. Vendors state that the operations and maintenance (O&M) costs can vary greatly, depending on the number of taps performed and equipment and procedural care.

Exhibit 6 shows the equipment, O&M, and contractor services cost to perform the 320 taps per year in the hypothetical scenario first described in Exhibit 4. The assumption is made that the 4", 8", and 10" taps (a total of 305 taps) would be performed by the company. Because few taps equal to or larger than 18 inches are performed

Exhibit 6: Estimated Annual Hot Taps Costs for the Hypothetical Scenario

Given:

Equipment cost per machine = $23,704[a]

Operations and maintenance (O&M) cost per machine = $3,979[a]

Contract services cost per tap = $3,618[a]

Number of hot tap machines = 2

Number of contracted taps = 15 (all taps 12 inches and larger)

Calculate:

Total equipment cost = $23,704 * 2 = $47,409

Total O&M cost = $3,979 * 2 = $7,959

Contract services cost = $3,618 * 15 = $54,263

[a] Average costs from ranges in Exhibit 5.

each year, these taps (a total of 15 taps) would be contracted to vendors. The equipment cost includes the purchase cost of two small (<12") tap machines. For the purpose of this *Lessons Learned*, the average value of the purchase, O&M, and contracting service costs listed in Exhibit 5 are used to complete the cost analysis for the hypothetical scenario. Based on these assumptions the total equipment cost is calculated at $47,409, the O&M cost at $7,959 and the contract services cost at $54,263.

Step 4: Evaluate the gas savings benefits of hot tapping.

Exhibit 7 presents the natural gas and purge gas savings associated with hot tapping on small and large diameter high-pressure pipelines in the hypothetical scenario of 320 taps per year. The values are calculated using the equations in Exhibit 3, multiplied by the number of annual connections. Gas losses associated with shutdown interconnects are the primary savings when these connections are made by hot tapping.

Step 5: Compare the options and determine the economics of hot tapping.

The economic analysis shown in Exhibit 8 compares the significant cost and benefit differences between hot tapping and shutdown interconnections for the hypothetical scenario of 320 taps per year. The significant costs are the purchase, operation and maintenance of hot tapping equipment and/or contracting for hot tapping services. In this scenario, both costs are included: the purchase of two hot tapping machines for $47,409 for the smaller sizes and contracting the 15 large taps at $54,263 per year. The purchased hot tap machines are operated and maintained at $7,959 per year. All these costs are

Exhibit 7: Estimated Annual Gas Savings for the Hypothetical Scenario

Tap Scenario 1 Pipelines[a]	Annual Taps Number	Natural Gas Savings		Purge Gas Savings[b]		Total Gas Savings[c]
		Per Tap Mcf	Annual Mcf	Per Tap Mcf	Annual Mcf	$
4" pipeline 350 psig, 2 mile line	250	22	5,500	2	500	42,500
8" pipeline 100 psig, 1 mile line	30	13	390	4	120	3,690
10" pipeline 1,000 psig, 3 mile line	25	589	14,725	19	475	106,875
18" pipeline 200 psig, 2 mile line	15	255	3,825	41	615	31,695
Total Annual	320		24,440		1,710	184,760

[a] The sizes and number of taps from scenario given in Exhibit 4.
[b] Example for 4-inch pipe interconnect shown in Exhibit 4.
[c] Natural gas valued as $7 per Mcf, inert gas (nitrogen) valued at $8 per Mcf.

Exhibit 8: Economic Analysis of Hot Tap Versus Shutdown

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Capital Cost ($)	(47,409)	0	0	0	0	0
Contract Service Cost ($)	0	(54,263)	(54,263)	(54,263)	(54,263)	(54,263)
O&M Cost ($)	0	(7,959)	(7,959)	(7,959)	(7,959)	(7,959)
Total Cost ($)	(47,409)	(62,222)	(62,222)	(62,222)	(62,222)	(62,222)
Natural Gas Savings ($)		171,080	171,080	171,080	171,080	171,080
Inert Gas Savings ($)		13,680	13,680	13,680	13,680	13,680
Net Benefit ($)	(47,409)	122,538	122,538	122,538	122,538	122,538
					Payback (months)	**5**
					IRR	**258%**
					NPV[a]	**$417,107**

[a] Net Present Value (NPV) based on 10% discount rate for 5 years.

calculated in Exhibit 6. Many expenses, including the cost of fittings, valves and basic labor, are assumed to be similar in both hot tap and shutdown procedures, and therefore can be excluded in the comparative analysis. A more complete analysis can be done by evaluating and including the company specific "hidden" costs per Exhibit 3.

The significant benefit differences are the reduction in natural gas loss by eliminating venting and the inert purge gas used in the shutdown interconnect procedure. As summarized in Exhibit 7, annual natural gas savings total 24,440 Mcf for the hypothetical hot tapping scenario, worth $171,080 per year at $7 per Mcf gas price. The annual inert gas savings of 1,710 Mcf is worth $13,680 per year at $8 per Mcf of nitrogen, for a total annual benefit of $184,760. Additional benefits from avoiding gas leakage through pipeline block valves during shutdown interconnect would further improve the hot tapping economics.

When assessing options for making new pipeline connections, natural gas price may influence the decision making process. Exhibit 9 shows an economic analysis of the 320 new connections using hot taps scenario at different natural gas prices.

Exhibit 9: Gas Price Impact on Economic Analysis

	$3/Mcf	$5/Mcf	$7/Mcf	$8/Mcf	$10/Mcf
Value of Gas Saved	$73,320	$122,200	$171,080	$195,520	$244,400
Payback (months)	23	8	5	4	3
Internal Rate of Return (IRR)	44%	154%	258%	310%	413%
Net Present Value (i=10%)	$46,520	$231,814	$417,107	$509,755	$695,048

In conclusion, hot tapping has been found to be more cost effective than shutdown interconnects. Even when the system must be taken out of service, hot tapping presents opportunities for both time and cost savings. While hot tapping is a practice that has historically been performed by companies for reasons other than the gas savings, consideration of the methane reduction benefits can often serve to justify hot tapping over the shutdown interconnect procedure in a variety of circumstances.

Case Study: One Vendor's Experience

A vendor reports that, for a gas transmission client, one day of gas service in a 36" natural gas pipeline operating at 1,000 psig is worth $365,000 in gross revenue. It would take approximately 4 days to perform a shut down connection at a cost of $1.5 million, not including the cost of venting the pipeline contents in order to perform the tie-in with shutdown. A hot tap connection would eliminate this loss of revenue by enabling uninterrupted service.

Lessons Learned

Pipelines typically undergo several transformations each year. Performing hot taps to make these connections and installations can reduce methane emissions from pipelines and increase savings and efficiency. The following are several lessons learned offered by Partners and hot tap vendors:

★ Hot tapping has been performed by transmission and distribution companies for decades. By evaluating the gas savings associated with this practice, hot tapping can be used in many situations where it would not ordinarily have been used.

★ The site for the branch weld must be free of general corrosion, stress corrosion cracking, and laminations.

★ Hot tap should not be performed immediately upstream of rotating equipment or automatic control valves, unless such equipment is protected from the cuttings by filters or traps.

★ For tapping on steel pipes, fittings generally consist of a welded branch connection. However, when tapping into cast iron, asbestos cement, or concrete, the fitting cannot be welded onto the existing header. Alternative fitting attachment techniques, such as a split cast iron compression sleeve or a mechanical joint saddle, must be employed.

★ For plastic systems, the operator should ensure that the hot tapping fittings are compatible with the type of plastic pipe in the system and appropriate joining methods are used. Vendors can supply suitable fittings and tools for almost every kind of plastic system.

★ If hot tapping has not been performed in the past, a hot tapping procedure should be developed and personnel trained. Be sure to include instructions concerning possible burn through or hydrogen cracking during welding.

★ All equipment must meet minimum industry and federal standards for pressure, temperature, and operating requirements.

★ If conditions of temperature, pressure, pipe composition, or tap diameter are encountered that are unusual for your system, be sure to consult the manufacturer of the tapping equipment or fittings.

★ Industry and federal codes and standards should be consulted for more specific specifications (e.g., ASME B31.8, API 2201, API 1104, API D12750, 49 CFR 192).

★ Record emissions reductions associated with using hot taps and submit them with your Natural Gas STAR Annual Report.

References

American Petroleum Institute. *Procedures for Welding or Hot Tapping on Equipment in Service*. API Recommended Practice 2201, Third and Fourth Editions, October 1985 and September 1995.

American Petroleum Institute. *Welding of Pipelines and Related Facilities*, Publication No. 1104, 19th Edition, September 1999.

American Society of Mechanical Engineers (ASME). ASME Code for Pressure Piping, B3I, ASME B31.8-1995 Edition.

Bruce, William A. Edison Welding Institute. Personal contact.

Burns, David. TransCanada Hot Taps. Personal contact.

Chaput, James. Michigan Gas. Personal contact.

Chila, Vern. International Piping Services Company. Personal contact.

Davaney, Tom. Con Edison. Personal contact.

Doig, Deanna. TransCanada Alberta System, TransCanada Pipelines. Personal contact.

Hranicka, Anthony. Con Edison. Personal contact.

Hydra-Stop, Inc. A Pressure Installation Primer: Basic Information and Procedures for Line Tapping and Linestopping.

LaShoto, Paul. Bay State Gas. Personal contact.

McAllister, E.W. Editor. *Pipeline Rules of Thumb Handbook*. Fourth Edition, Gulf Publishing Company.

McElligott, John A., John Delanty, and Burke Delanty, "Use of Hot Taps for Gas Pipelines Can be Expanded," Oil and Gas Journal, 11/30/98.

McMicken, Mike and Brian Boucher. Team Industrial Services, Inc. Personal contact.

Petolick, Don and Gary Vanderhye. Hydra-Stop, Inc. Personal contact.

Rodgers, Erick. Topaz Inc. Personal contact.

Smith, Sharlye. Mueller Co. Personal contact.

Vandervort, Dal and T.D. Williamson. Inc. Personal contact.

Venugopal, Shrikanth. TransCanada Transmission. Personal contact.

Tingley, Kevin. EPA Natural Gas STAR Program. Personal contact.

U.S. Code of Federal Regulations. Title 49, Part 192 (49 CFR 192), Subpart D, "Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards; Design of Pipeline Components".

Appendix: Supplemental Information

Valves. Valves used in hot tapping are typically full opening ball or wedge gate valves. Pipe suppliers can usually supply prices for valves and fittings, if provided with the scenario information including pipe size, outlet size, and line content, pressure, and material.

Tees/Fittings. There are several different types of mechanical and welded fittings applicable to hot tapping including weldolet, threadolet, scarfed nipple, tapping tee, or full encirclement saddle. The most common tapping fitting is a split cast iron sleeve. Fittings are typically priced by size, flange (ANSI/pressure) rating, and any special characteristics. Typical vendor fitting costs are presented below.

TD Williamson - Full Split Tee Costs ($)

Size (pipeline x outlet)	
16" x 16"	$2,000
18" x 18"	$3,000
20" x 20"	$5,000
24" x 24"	$6,000
30" x 30"	$9,000
40" x 16"	$2,500
60" x 16"	$2,500

Price estimates are for a 300# rating.
Fittings are also available for 150#, 400#, 600#, 900#, and 1,500# flange ratings and sizes 1" x 1" to 96" x 96".

Topaz - Tapping Tee Costs ($)

Size (pipeline x outlet)	150# Flange Rating	300# Flange Rating	600# Flange Rating
2" x 2"	$386	$399	$443
4" x 4"	$407	$428	$481
12" x 12"	$1,394	$1,484	$1,624
20" x 20"	$3,645	$3,857	$4,290
12" x 4"	$1,248	$1,251	$1,347
20" x 8"	$1,428	$1,468	$1,521

Fittings are available for other sizes.

Topaz - Full Encirclement Saddle Costs ($)

Size (pipeline x outlet)	Part 1	Part 2
2" x 2"	$227	$189
4" x 4"	$227	$189
12" x 12"	$645	$539
20" x 20"	N/A	$1,306
12" x 4"	$594	$495
20" x 8"	$1,303	$1,076
40" x 16"	N/A	$3,493

Fittings are available for other sizes.

One of the possible hidden costs of a shutdown connection, if gas cannot be supplied from alternate sources, can be the cost of relighting customers. This process would require two visits, one to shut down and the second to turn on and relight. Typically, a visit to a residential customer would take 15 to 30 minutes, and a visit to a commercial or industrial customer would take approximately 1 hour. According to the Bureau of Labor Statistics, an employee would be paid approximately $9.75 per hour for this work.

Cost of Relighting = [(No. of residential customers) * (0.38 hrs)] + [(No. of commercial/industrial customers) * (1 hr)] * $9.75/hr

It might not be possible to perform a shutdown connection during optimal hours. Scheduling and additional planning might have to be completed to arrange the construction and additional excavation necessary to shut down the line, pay employees overtime, and advertise the shutdown to customers. These costs are variable and will depend on the company and internal factors.

Other additional costs exist, such as scheduling, labor, overtime, and advertising, but are unique to each company, and beyond the scope of this study. These costs can be estimated based on past shutdown experience. An operator should examine past records to determine what, if any, costs are being avoided by performing a hot tap versus a shutdown connection.

United States
Environmental Protection Agency
Air and Radiation (6202J)
1200 Pennsylvania Ave., NW
Washington, DC 20460

October 2006