Natural gas knowledge series : Laying Natural Gas Pipeline

Contents

History of Natural Gas Transmission

The record of first use of natural gas pipeline
shows that it was the Chinese who used bamboo cylinder as pipeline
before 900 BC

The emergence of using pipeline in the United States which was made of wood, took place in 1821 or 187 years ago. Today the pipeline network across the world covers a distance of one million kilometers; half of which is in the Northern United States and one fourth is in the Western Europe.

In Thailand, the pipeline was first commenced and commercialized in 1981 by PTT Public Company Limited (previously Petroleum Authority of Thailand) which was responsible for laying the pipeline from Erawan Gas Field to come ashore at Rayong and further along the main road to the customers e.g. Bangpakong Power Plant in Chachoengsao and South Bangkok Power Plant in Samutprakarn as well as several industries along the pipeline route. The diameter of the pipeline varied according to the volume of the gas sale.

Today (2008) the pipeline network of PTT across the country both onshore and offshore stretches over a distance of 3,100 kilometers. The network is transmitting over 3,500 million cubic feet per day (MMscfd) of natural gas to be used as fuel for the power plants, industries and as feedstock for the petrochemical industries.

PTT's Transmission gas pipeline

	Pipeline system	Length (kilometers)	Diameter (inch)	Deliverability (MMscfd)	Year of commencement
1.	**Offshore pipeline**				
	▪ Erawan-Rayong Gas Separation Plant (the first transmission gas pipeline)	415	34	860	1981
	▪ Plathong Field - The first pipeline	42	24	250	1984
	▪ Bongkot Field - Erawan Pipeline (the master pipeline)	171	32	635	1996
	▪ Erawan - Khanom Power plant	161	24	250	1996
	▪ Erawan - Rayong Gas Separation Plant (the second pipeline)	418	36	1,150	1996-1997
	▪ Tantawan Field - the second pipeline	54	24	300	1997
	▪ Benchamas Field - the second pipeline	55	18	100	1999
	▪ Pailin Field - Erawan Field	53	24	200	1999
	▪ N.Pailin to existing Pailin Pipeline	10	24	300	2001
	▪ Erawan-Rayong Gas Separation Plant (the thind transmission gas pipeline)	414	42	1,900	2007
	▪ Arthit Field to Arthit PLEM	18.5	42	700	2008
	▪ Arthit PLEM to Erawan	173	42	1,750	2008
2.	**Onshore pipeline**				
	▪ Rayong Gas Separation Plant - Bangpakong (the first pipeline)	104	28	540	1981
	▪ Bangpakong - South Bangkok Power Plant	57	28	-	1981
	▪ Bangplee - Saraburi	99	14	270	1983
	▪ Namphong Field - Namphong Power Plant	3.5	16	140	1990
	▪ Rayong Gas Separation Plant - Bangpakong (the second pipeline)	105	28	660	1996
	▪ Bangpakong - Wangnoi Power Plant	100	36	500	1996
	▪ Pipeline from Thai - Myanmar border - Rachburi Power Plant	238	42	1,265	1998
	▪ Ratchaburi - Wangnoi	154	30	400	2000
	▪ Rayong Gas Separation Plant - Bangpakong (the third pipeline)	110	36	350	2006
	▪ Wangnoi - Kaeng Khoi	73	36	520	2006
	▪ Sai Noi - South Bangkok Power Plant	66.5	30	470	2006
	▪ Phuhom field - Namphong Power Plant	0.25	30	160	2006
	▪ Trans Thai - Malaysia Gas Separation Plant - Chana Power Plant	7.6	20	290	2007

onshore natural gas pipeline

Generally, the steps of laying natural gas pipeline are as follows.

Site preparation

Around 12-23 meters is required for construction preparation area to facilitate the transportation of the pipes, ditchers and equipments depending on the condition of the location and pipeline size. The ground is leveled to be equally flat. The surface or the topsoil will be stripped and separated from the excavated subsoil and will be returned after the backfill in order to allow the plants to grow as normal.

Pipe transportation

Trailers are used to move pipes from stockpile sites to laying sites under the meticulous monitor and special care of specialists.

Ditching

A special excavator or specially designed excavator is used. The depth of a ditch depends on the pipe size and construction specifications which is normally one meter at the minimum. If the pipeline is laid along the highway area, 1.5 meter depth is required. The top soil will be separated and will be covered afterwards.

Pipe bending

As the pipeline route has to be curved according to the location and the elevation of the ditch, thus the pipe must be bent to follow the ditch and conform to the typography. Pipe bending by a specialize pipe-bending machine which makes minimum effect on coating, takes place along the trench or at pipeline sites.

Pipe welding and X-ray.

Normally, a pipe is 12 meter long for ease of transportation. During construction, welding joins each section of pipeline together into one continuous length. The welds are 100 percent x-ray checked and the pipe which does not pass the criteria will be cut and welded again.

External coating.

Typically, the external pipe coating to prevent corrosion is undertaken at the factory. There are a number of coating material and techniques according to ASBM B 31.8 standard such as coating of epoxy and high density polyethylene. After welding at the construction site, the pipes will be coated to prevent rust and rapture of the welding and checked before lowering into the ditch.

Lowering in

Tractors are used to lower the pipe into the trench. If there is rock, the bottom must be bedded with soil or sand prior to lowering-in to protect the pipe and coating from damage.

Backfilling

Backfilling is carried out in such a way that ensures sufficient padding and bedding to prevent damages from the pipes already coated. If there is rock, the bottom must be bedded with rough soil and sand and the excavated soil is put back to fill the trench and padded to the normal state. The topsoil is returned to allow the plant to grow.

Land restoration

After the backfill, the soil and environment of the pipeline will be restored to the original condition. Planting of big trees in the pipeline's proximity is avoided to prevent their roots from causing damages to the coating.

Onshore pipeline construction crossing waterways, road and railways

The construction can be performed by different methods.

Open drilling	▪ Sections of pipeline that cross water ways are coated with epoxy and concrete to increase additional weight which will prevent them from floating. ▪ Detour roads are built or iron sheets are laid over the construction sites in order not to cause traffic problems. ▪ Digging of ditch in the water ways will not be carried out before the pipeline is laid in the area in order to minimize sediment accumulation. ▪ Special methods to reduce sediment accumulation in the water ways resulting from the activities such as installing filters will be applied. ▪ Upon completion, grading the area and removing equipment from the construction site will be done as soon as possible. ▪ Placing sand bags or compounding the area in order to prevent collapse of the topsoil.
Drilling	▪ This method does not disturb the traffic flows. ▪ Initially, the pilot drill will be used to penetrate the pilot hole and followed with casing tubes. ▪ The actual pipeline in inserted and pulled out. ▪ Once the laying of pipeline is completed, the casing tubes will be removed.
Horizontal Directional drilling	▪ The exact entrance and exit of the pipeline must be specified before commencing drilling. ▪ In case the pipe must be laid in parallel with any other existing pipeline, sufficient space must be given to ensure safety. ▪ Soil, mud and chemicals must be contained and eliminated as required by the state agencies. ▪ For each directional drilling, the distance should not exceed two kilometers and the depth shall reach 30 metres.

In laying pipeline crossing waterways and canals

The company will take into account the feasibility and suitability of the methods. The selected methods can be opening drilling, drilling or horizontal directional drilling which does not affect the water flow but requires a substantial budget.

Laying pipeline underneath the roads

To construct the pipeline underneath concrete or asphalt roads which are the main roads and heavily congested, PTT prefers a directional drilling as it prevents traffic disturbance.

As for small roads with less traffic, a ditch can be dug with a detour road being built or that the trench is covered by iron sheets to allow vehicles to pass over.

Laying pipeline under rail roads

The sections of pipeline need to be buried at a depth of at least 1.5 meters under the railways. They must be protected by casing with closing at both ends and supported by spacers which are placed in a 3-meter interval according to the specification together with ventilation tubes at both ends of the pipeline.

Laying pipeline on unstable soil (marsh and swamp)

As for the unstable soil such as marsh and swamp, water must be drained first from the soil before laying pipe. In addition, a special technique called anchoring is applied in the area where ground water table is high so that the pipeline does not float. The contractor can also choose Push and Pull method by digging drainage ditch. The pipes are installed by welding at the end of the pipes (push pad) and they will be pushed and pulled through while floated (the ends are closed to prevent water).

Laying pipeline along high - voltage transmission lines

A parallel distance of 25 meters between the pipeline and the power lines must be maintained. The trench will be 5 meters away from the centerline and the outer side of power lines routes and the pipe must be at buried at least 1.5 meters depth under soil cover.

Laying offshore pipeline

Survey

Before a pipeline is laid, a route survey must be carried out to discover geophysical and geotechnical data for instance, bathymetryl and seabed condition. In addition, soil samples will be collected to test the properties.

The survey will help identify problems along the pipeline route e.g. existing construction, the use of area by third party, and installation at the area near ashore, and etc.

Typically, there are three techniques of laying offshore pipeline

1. Pipe laying by lay barge.
2. Pipe laying by reel barge.
3. Pipe laying by towing.

This article will describe the method of laying the pipes by lay barge only as it is applied in Thailand at present.

Lay barge pipe laying

In this method, the pipes will be assembled and welded end to end on the barge and leave at the rear of the barge. There are also two types of techniques according to the curve of the pipes lowering into the sea.

1. **S lay**: This method is used for laying offshore pipelines in relatively shallow water of around 100-200 meter deep. The pipeline construction in the Gulf of Thailand has applied this method because the sea is only 50-70 meters deep.
2. **J Lay**: This method is used for laying offshore pipeline in deep water or more than 200 meters depth.

Welding

Before welding, the pipe ends will be bevelded and the pipes will be further sent to the firing line. Fit up of pipes will be done by the internal clamp.

The welding will be performed at four stations. Two highly trained welders and two assistants are assigned at each station. The first, second and third stations will apply Gas Metal Arc Welding technique and the last station applies Flux - Cored Arc Welding technique. These techniques use mixtures of Carbondioxide ($CO_{2)}$ and Argon (Ar) in order to prevent air from disturbing filler wire.

In order to comply with WPS standard, several procedures need to be undertaken. The welders require to ensure the quality of all processes i.e. beveling, preheating, the electricity current and voltage in melting filler wire, the rate of travel speed, the ratio of gas mixture as well as the quality of filler wire which must be kept clean and free from dirt and dampness.

With the use of pulse echo technique, an Automatic Ultrasonic Test (AUT), a non-destructive testing, will be performed to detect defects of welded joint. Namely the flaw of welded joints can be observed from the deviant of echo. If found, the welding needs to be repeated and fixed.

Field joint coating.

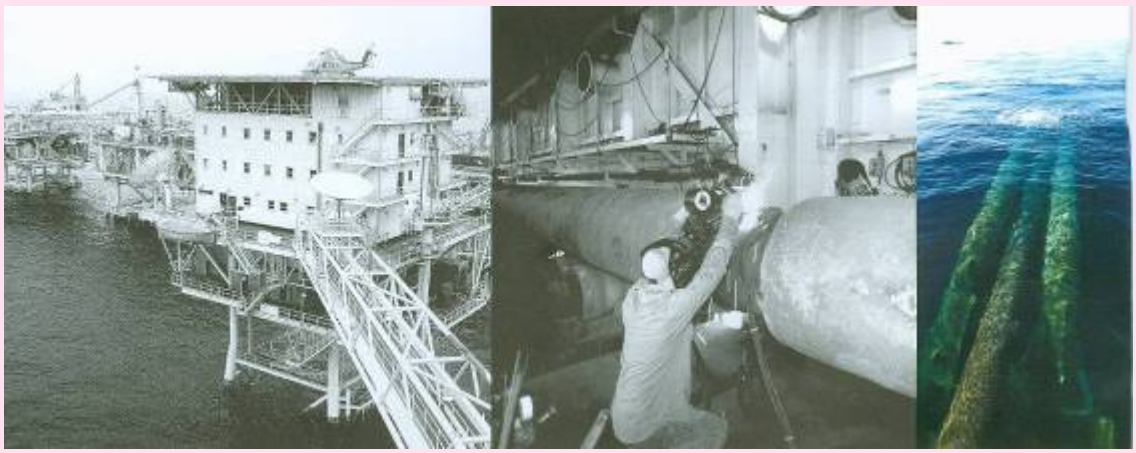
After AUT, the pipes will be preceded to a field joint coating station using HDPE Shrink Sleeve (HSS). HSS will be preheated and firmly pressed on the welded joints while vacuum must be prevented. A holiday detector releasing 12 kv current is used to detect the condition of HSS. If the sleeves are torn or damaged, they need to be repaired before sending the pipes to the next station.

The last station is marine mastic station where the welded pipe joint is coated with hot marine mastic at a temperature of 200 + 10^0 C. The marine mastic will be fully poured into the mold which is wrapped around the pipe joints. Then the mold will be sealed and water cured.

Each station takes 12-15 minutes per each pipe lowering into the sea. Therefore, around 1-1.5 kilometers of pipe will be lowered into the sea if work is done 24 hours a day.

Lowering the pipe into the sea

While the barge is moving forward, the pipe is lowered into the sea by deploying 6 anchors at the head of pipe laying barge (2 anchors in the middle and 2 anchors at the rear). The pipes are lowered into the sea at the rear end of the barge.



The pipes laid into the sea which forms S curve or S lay is designed to withstand both overbend and sagband stress.

Overstress prevention can be done by three equipments: a tensioner, a stinger and a buckle detector.

The tensioner is located between AUT and HSS; it is used to hold the pipe to create a tension in the front so that the pipe will not be lowered into the sea with too much angle.

The stinger supports that portion of the pipeline leaving the barge. Everyday a diver will check the condition of the stinger twice a day. The tension from the tensioner as well as the depth of the stinger depends on the sea depth, size of pipe and concrete coat.

The buckle detector is a device made from two circle-shaped steel plates. The size of a detector is 96% of pipe diameter. There are also core and wheels between the two plates.

The buckle detector will be inserted in the pipeline at 50-60 meters after the touchdown point. The buckle detector will be pulled forward every time the pipe is lowered into the sea. If the buckle exists in the pipe, the buckle detector will be pulled harder and that portion of the pipeline will thus have to be repaired.

In addition, a Remote Operated Vehicle (ROV) is also used to check the general condition of the pipe from stinger end to the touchdown point twice a day.

The survey after pipe construction

After construction, the survey will be conducted again to inspect if the pipe is well laid on the seabed or if it lies with free span over the sea or a part of the pipe where the pipe has no support on the seabed. If free spans are reported, the supporter has to be built or the seabed has to be leveled.

Safety standard

Gas pipe: Material and specification

- The gas pipe is made of high-tension steel. Its strength varies in accordance with the pressure and site condition. API 5L-X65 means a pipe has a yield strength of 65,000 psi.
- The pipes are produced by international standard factories and tested prior to the delivery.
- The diameter of pipeline is determined by the maximum gas flow.
- The thickness is dictated by several factors e.g. maximum pressure of the gas, tension during the pipe laying, external pressure which may damage the pipe.
- The thickness of the pipe as well as the bottom of the pipeline trench conform to the international standard. On the hill/non community area, the pipe will be buried at a depth of 1-1.5 meters. For the pipe laying underneath the road, three meters from the soil to the upper surface of the pipe is required according to the Highway Department standard.
- Design of pipeline conforms to the ASME B31.8 Gas Transmission and Distribution Piping systems established by the American Society of Mechanical Engineers (ASME).

Corrosion Protection

- Pipe coating; Pipes are externally coated to prevent external corrosion. For submarine pipelines, there are two types of coating - corrosion coating and concrete coating to increase weight and enable them to lie on the seabed. The latter also prevents the pipeline from the impacts created by fishery and marine activities.
- Cathodic Protection is designed for 40-year service. In replace of steel, a corrosion cell is constructed by feeding a negative direct current to the pipe and a positive direct current to impressed current anodes designed to be erode instead of the pipe which are buried along the pipeline. The interval and size of anodes depend on the environment as well as gas qualification.
- Hydrostatic testing is applied to identify if the pipeline can withstand a maximum designed pressure. For inland pipeline, the test pressure is set at 1.25 to 1.4 times over the designed pressure, and 1.25 times for offshore pipeline. The test is conducted prior to the real gas transportation.

Control and communications

- The Flow of the gas is controlled and assessed through Supervisory Control And Data Acquisition system or SCADA which is centrally controlled by Chonburi Operation Center. PTT's personnel are assigned to control the flow of the gas around the clock.
- The block valve stations are located to inspect the pressure, velocity, temperature, density of the gas throughout the line.
- In compliance with international safety standard, the block valve stations are constructed at a minimum of 7.5 meters away from the pipeline for safety practice. The wall is also built for a block valve station having high traffic.
- Under abnormal circumstance, the valves will be directly commanded by the Operations Center. They can be turned on or shut down by automatic system of Chonburi Operations Center.
- The main communication system includes microwave, optic fiber and other efficient system which are all integrated 24 hours. Satellite is used as a back up system.
- The communication system for each area:
    - Microwave is the main communication system for Chonburi Operation Center and Region II and III Operation centers.
    - Buried along pipeline, the optic fiber cable is designated as main communication tools for the western pipeline network and under processing of expanding the system to cover all areas.
    - Satellite Telecommunication is a back up system used when main network fail.
    - Ultra high frequency (UHF) and Very high frequency (VHF) cover the entire network.
    - PTT in-house telephone system and external service provider.
    - All system is advanced and up to date technology to ensure highest efficiency and reliability.

Inspection

- In general area: Along the pipeline route, the inspection is performed by car and walk inspection. Aerial inspection or aircraft is also used to identify the changing environment such as the change of grass color above the pipeline.
- In the forest area: A walk through or personnel inspection is performed as planned.
- Internal inspection is done by the use of a pipeline inspection gauge (PIG) which is inserted and run through the pipeline. The data collected from the PIG can be analyzed and identify the potential location of damage to be fixed beforehand. The inspection will be carried out every 5 years. The PIG can:
    - Identify the thickness of the pipe
    - Identify the dent of the pipe
    - Identify the shift of the pipe
    - Locate the damage of the pipe
    - Identify the information on both internal and external corrosion
    - No gas disruption during inspection or PIG running
    - Undertaken by leading international oil and gas companies
    - Use a global positional system technology to locate the area

- After the backfilling, the marker sign will be placed along the pipeline to indicate the location of the pipeline as well as PTT’s telephone numbers for reporting accident.
- TIS 18000 standard and Pipeline Integrity Management System are applied in the project to minimize and prevent the pipeline from accidents.

Odorant

- Prior to gas delivery to the customer, an odorant - Mercaptan is added to natural gas to make it easier to detect in case of a leak. Mercaptan is also used as an odorant for LPG in containers.
- Mercaptan injector apparatus is disclosed; mercaptan is injected into the gas flow to mix with the gas.

Environment impact minimization standard

Typically, the ASME B31.8 standard applied in natural gas pipeline construction also concerns the minimization of impact on environment and community. In practice, in Thailand, all the petroleum transmission projects are required to conduct Environmental Impact Assessment (EIA) study under the stipulations of the Office of Environmental Policy and Planning, Ministry of Science, Technology and Environment. The study includes measures to minimize environmental impacts before, during and after the construction. The project owner must integrate measures with engineering of the projects and strictly comply with them by supervising the work of the contractor to follow the measure as planned. The action will thus ensure that the project will least affect the community, environment and well - being of surrounding public.

Nevertheless, during the construction, the project may temporarily affect the environment for a period of 3-4 months. After the backfill, the environment can be restored to resume original condition. Namely, the site construction can be done by planting cover crop to prevent topsoil erosion. As for cultivated and living areas, the people can do the farming as usual. However, perennial plants are not allowed to plant and buildings are not constructed in the stipulated parameter of the pipeline either. In addition, the contractor must offer a one-year construction warranty; while PTT will closely monitor environmental impact and continuously look after the environmental impact and the site.

Conclusion

The natural gas pipeline system is a vital infrastructure of natural gas business and has been well accepted as one of the most important efficient and safe systems. As the system has been unceasingly developed, the gas pipeline is aimed to deliver a substantial amount of natural gas which is ready to use and generates a saving of transportation. Both road and waterway traffic problems as well as accidents can be lessened. Most of all, the project can help alleviate the air pollution. In the long term, the natural gas pipeline will be the most efficient gas transmission system and more cost-effective than other modes of mass transportation system. In addition, the project causes no environmental effect during gas transmission.

To operate, it is necessary to gain cooperation from the public and community to comply with the safety measure in addition to the sacrifice in allowing PTT or the project owner to use the land to construct the pipeline. PTT will form a sub committee of price reconciliation and compensation of assets located along every petroleum pipeline project. To ensure maximum confidence of the public, PTT offers insurance for individual person and assets that covers damage from the pipeline operation.

Assigned from the government since 1981, PTT has been responsible to undertake the natural gas pipeline to serve as an energy vein of the country which aims to reap the fullest benefit for the public as a whole. The collaboration between the people, the owner of the country, and PTT will generate a paramount social capital, a vital component that leads to the development of the country in a sustainable manner.