天然气集输与处理技术

靳明三 主编

双语培训教材

石油工业出版社
PETROLEUM INDUSTRY PRESS

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内 容 提 要

近年来，随着我国天然气工业的快速发展，引进了许多国外的先进工艺和设备，现场的施工人员和技术人员急需掌握这些先进技术。本书包括天然气集输与处理技术等内容，具有系统性和实用性，以英汉两种语言编排，有利于读者学习专业外语，既是实用性很强的培训教材，又可以作为现场技术人员的参考用书。

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《天然气集输与处理技术(双语培训教材)》
编　委　会

前　言

自20世纪70年代末期以来，我国天然气工业快速发展。20世纪90年代后，随着陕甘宁中部盆地、南海崖城13-1等大型气田及其他一批中型气田的陆续开发，我国天然气工业逐渐壮大。我国东部许多油田也不同程度地含有天然气。近年来，普光气田的勘探和开发又把我国的天然气工业推向一个新的发展高度。我国政府对该项目十分重视，将其视同于“京九铁路”和“西气东输”项目，投入巨大人力、物力和财力，其中从国外引进了许多先进的设备及相关工艺技术。然而目前国内相关技术和设备与国外差别很大，现场施工人员和技术干部以及管理者急需学习国外先进技术。我国南堡油田目前也在进行大规模的勘探和开发，部分区块也涉及天然气技术问题，培养天然气技术人才也是当务之急，尤其在引进和消化国际先进技术方面需要加大力度。

在此形势下，我们决定尽快编写一本紧贴天然气集输和净化处理两大专业的汉英双语培训教材。在靳明三同志的指导下，经过数名高级技术人员几个月的不懈努力，这本实用性培训教材——《天然气集输与处理技术（双语培训教材）》已经完成。编者从大量天然气技术资料中选出了一些使用性的片段，紧密结合先进技术，具有可操作性，这是与其他培训教材不同之处。全书包括天然气集输与处理等内容，并以两种语言（汉语和英语）编排。英文译文对于技术人员学习专业外语具有指导意义，汉语部分由于时间限制，可能存在这样或那样的错误。考虑到许多专业人员在引进和吸收国外先进技术的过程中有可能出国或与外方专家交流，我们又结合实际编写了相关专业对话，即天然气处理专业英语对话300句，也是以双语形式出现。天然气处理部分是按照工程顺序从气体预处理、脱硫、脱水、硫黄回收、酸水汽提、尾气处理、污水处理以及安全措施编写的，这样既符合工作的实际需要，又体现出较强的系统性和逻辑性，这部分内容主要由徐恩信同志完成。靳明三同志编写了本书的前半部分。张广勤同志参与了天然气处理部分原始资料的收集和编写指导工作，为本书的编写做出了前期工作；靳瑞环同志编写了天然气处理专业英语会话、全书专业英语词汇和短语；全书的统稿工作、前言的编写、部分内容前期的教学使用、验证及修改工作由徐恩信同志负责。天然气集输部分介绍了集气、输气的环节、天然气中水合物形成的原因、天然气井场脱水、地下输气管线的防腐以及管道的安全措施等。天然气处理部分的工艺和设备培训已在普光气田应用，深受欢迎，因此本书既是一本实用性很强的培训教材，又可以作为该领域工作人员的参考用书。

由于资料有限、时间仓促，本书难免存在一些不妥之处，欢迎读者批评指正。

编者

2009年3月10日

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第一部分　天然气集输

第一课　天然气集输概述

天然气在矿场条件下的采集和输送被称为集输，它是非常重要的生产过程。天然气从井口通过管网到达集气站可视为集气过程；天然气在集气站经过预处理后输送到净化厂入口这个过程称为输气（不包括净化处理以后输送的商品天然气）。

由气井井口到集气站的采气管道和由集气站、单井站到天然气净化厂之间的输送管道所构成的网状管路系统称为集输管网，它覆盖所有产气井，为天然气采集和预处理提供通道，所有的集输管网都是密闭而统一的连续流动通道系统。集输管网布局的基本方式包括放射状、枝状、环状三种，也可组合使用。如果气田有两个以上气藏同时开采，应根据不同产层的气体质量、压力等设置多套管网。集气管网的压力是根据地层压力、气液分离工艺和输气系统的压力要求等因素来确定的。含硫气田的集气管网，常选用低碳钢或抗硫低合金钢管材，以防止硫化物造成应力腐蚀。

集输场站是天然气采集和预处理的专用生产场所，包括集气站（含单井站）、脱水站、调压计量站、分输站、增压站、储配站、阀室、清管站和阴极保护站等。场站的种类、数量、布点、设备配置也与天然气的气质条件、气井分布和预处理工艺要求有关。

在气田开发过程的主要阶段，井口压力一般都远高于集气管网的压力，而在气田开采的后期，气井产量和压力都会降低，天然气不能靠自身压力进入集气管网，就要设置压气装置，可采用压缩机将气体增压输入管网，一般选用燃气发动机带动的往复式压缩机机组，机组可装在井场或集气站。

在集气站进行的集气和各种预处理流程是：将多口气井用管线接到集气站，在集气站对天然气进行节流降压、气液（油、水、机械杂质）分离、调压、计量，防止天然气水合物生成，进行管道腐蚀控制，保证集气过程正常进行。

计量站一般设置在输气支线的起点或输气干线的终点，也可设置在输气干线中途某个位置，它可以有很多个，确保计量工作准确无误。

为清除管道内的积液和污物以提高管线的输送能力，在集气干线上设置管道清理站。

为防止和延缓埋在地下的输气管线的电化学腐蚀，在输气干线上每隔一段距离就设置一个阴极保护站。

利用自动控制和数据采集系统（Supervisory Control and Data Acquisition System）有效地对管网和关键站点进行远程实时监控，采集各种生产数据，确保集输工作安全顺利进行。

除了上述集输流程和工作内容外，集输系统的安全保护十分重要，因为该系统是一个含天然气的承压系统，天然气易燃、易爆，有时含 H_2S 这种毒性很强的气体，所以现场采取了配套安全措施，例如加强通风设施、电器防爆、电器安全接地、开工前后用惰性气体吹扫系统、采气管道限压保护、防火措施，并且对操作人员进行 HSE 培训。

参考译文

Lesson 1 Outline of Natural Gas Gathering and Transmission

Gathering and transmission of natural gas is an important production course at well sites. Gathering of gases is referred to be the course from well heads to the gathering station through the pipelines. By the rough treatment, natural gas can be transmitted to the inlet of purification station, this course is called the transmission or transportation (not including the transmission of pure commercial gases after purification).

Pipelines used to transmit natural gas from well head to gathering station and purification station are called gathering pipe network, which connected to all the gas wells to provide the passages for gathering and pre-treatment of natural gases. All the pipelines are closed to keep the gases flowing continuously. The pattern of pipeline basically includes three types: radial, branch and loop - shape patterns, they are combined sometimes. If there were two or more gas reservoirs need to be developed at the same time, several sets of pipe networks would be put according to the quality and pressure of natural gases. The pressure kept inside the pipelines can be determined by formation pressure, technology of gas - liquid separation and pressure requirement of transmission system. In some gas fields that contain H_2S, the pipe networks need to be constructed with low carbon steel pipe or sulfide resistant low - alloy steel pipes, to prevent the stress corrosion caused by sulfide.

Stations for gathering and pre-treatment of natural gas are the specific sites, including gathering station (single well station included), dehydration station, pressure-adjusting and metering station, distribution station, booster station, storage station, valves room, pipe cleaner station and cathode protection station, etc. The patterns, numbers, spots of stations and equipment are determined by the quality of natural gas, gas well locations and pre-treatment techniques.

In the initial and middle periods of gas development, well head pressure is usually higher than that pressure inside the gathering pipe networks, but at the final period of development, the production rate and pressure of gas well will be reduced, and the gases can not flow into pipe networks by itself, and need to be boosted by compressors. The reciprocating compressors powered by gas turbine engine can be used widely at well site or gathering station.

The gathering course and pre-treatment of natural gas include: many wells are connected by pipe networks, gases flow from pipeline to the gathering station for choking and lowering its pressure, separation of gases and liquids (oil, water and solids), pressure adjusting, metering, to prevent the hydrates to be formed in natural gases, control of corrosion in the pipeline, keep the normal operation of gas gathering.

The metering station is usually located at the start point of branch - pipeline and the end of main line, or at some points of midway along the main line. Sometimes several metering stations can be built to keep the measurement correctly.

In order to remove the liquids and sewage inside the pipeline for improving its transmitting ability, the cleaner stations are built along the pipelines.

The cathode protection stations are also built at many places along the pipelines to prevent the electrochemical corrosion of steel pipes underground.

SCADA (Supervisory Control and Data Acquisition System) is also used to monitor the pipe networks and key spots in real - time remotely, collect various production data correctly to keep the gathering operation smoothly.

In addition to the gathering course and working contents mentioned above, the safety about gas gathering is also very important, because it is a pressurized system with inflammable and explosive gases, and some gases contain toxic H_2S, so many safety measures have been taken at the processing sites, for example, ventilation devices, explosion - proof equipment, safe earth leads, sweeping with inert gases before and after the operation, limit - pressure protection in the natural gas production pipelines, fire - proof measures, and training the operators with HSE knowledge.

词 汇

transmission	[trænz'miʃən] n. 播送，发射，传送，传递，传染
purification	[ˌpjuərifi'keiʃən] n. 净化（法，作用），纯净法，提纯
pattern	['pætən] n. 模范，榜样，型［样，模，款，程，方］式
reservoirs	['rezəvwɑ:] n. 水库，蓄水池，储液器（囊），储蓄器，储存器
sulfide	['sʌlfaid] n. 硫化物
cathode	[kæ'θəud] n. 阴极的，负极的
hydrate	['haidreit] n. 【化】水合物，水合（作用）
supervisory	[ˌsju:pə'vaizəri] adj. 监督的，管理的
acquisition	[ˌækwi'ziʃən] n. 取得，获得，获得物
ventilation	[ˌventi'leiʃən] n. 通风
toxic	['tɔksik] adj. 毒的，中毒的，有毒的

短 语

1. gathering and transmission of natural gas 天然气集输
2. from well heads to the gathering station 从井口到集气站
3. radial, branch and loop - shape patterns 径向、分支和环形模式
4. gas - liquid separation 气液分离
5. pre-treatment of natural gas 天然气预处理
6. reciprocating compressors 往复式压缩机
7. metering station 计量站
8. cathodic protection stations 阴极保护站
9. SCADA (supervisory control and data acquisition system 监控和数据采集系统
10. purification station 净化站

第二课　天然气汇集方法

天然气井与油井相似，需要通过采气管将其与气体处理和加工设备连接起来，或把气体输入大型集气系统的分支管线。大部分气井有足够的压力以克服管内的摩阻将气体送至处理厂。在气井内不必使用深井泵，对一些压力较低的气井，使用安装在井口附近的小型压缩机来提供能量，以便将气体驱动到处理厂。

气井压力的变化范围较大，对于低压气井必须在井口安装压缩机。但多数气井井口压力很高，气体必须在井口减压后才能进入采气管，这样可以使用薄壁、价格低的采气管。使用节流阀或减压阀可以降低气体压力。阀门操作可通过手动或自动控制，可使阀下游的压力维持在额定的数值。

井口气由采气管送往气体处理厂。气体经处理后进行销售，从天然气中分出的液态烃也可销售。有些地方，若干采气管与一条大直径管道相接后，再把混合气体送往处理厂。

根据销售合同的约定，进入输气干线的净化气的含水量受到严格限制，一般应低于 7×10^{-6}lb/ft^{3}❶。

气体处理厂脱水应达到规定的水平。在销售合同中也约定了硫的最高含量。如果井口气是酸性气体，即气体中含有 H_2S、CO_2 组分，必须在处理厂把这些组分除去。大多数气体处理厂也脱除气流中的液态烃。在液态烃中，不同组分的脱除量取决于处理厂的设计能力、经济指标、天然气液体和天然气的市场供应条件。但一般的处理厂都可以从气流中分离出乙烷、丙烷、丁烷和较重的液态烃。比丁烷重的各种组成的混合物被称作天然汽油。

井口气体中的水和酸性气体会对长输管道及其附属设备产生腐蚀，并造成其他的危害，因此要对其进行分离。由于气体中的液态烃可作为石油化工原料或其他用途而具有特殊价值，所以需对液态烃进行分离。

采气管道的长度是不同的，从不足 1mile❷ 到几英里长。采气管的直径相对较小，一般为 2in 到 4in。采气管的操作压力变化范围很宽，一般比出油管的操作压力高。采气管的工作压力可达几百磅力/英寸^2，有的可以达到 2000lbf/in^{2}❸或更高。

当井口压力比较高时，有时井口压力可为气体处理厂提供能量。如果压力在井口被气嘴或减压阀节流，是一种能量损失。如果到达气体处理厂的气体压力比较高，这部分能量可用来驱动设备，或为处理过程制冷。

采气管的长度、操作压力、管径和流量是由气井的生产能力、气体的种类、处理厂的操作条件、处理厂的位置和其他因素决定的。

目前，对采气管的总长度还没有一个精确的统计。仅在美国就有 850 多座天然气处理厂，在世界的其他地方，也有 420 多座这样的处理厂。

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❶ 1lb/ft^3 = 16.0185kg/m^3。

❷ 1mile = 1609.344m。

❸ 1lbf/in^2 = 6.89kPa。

参考译文

Lesson 2 Gas Gathering

As in the case of oil wells, gas – well flow lines connect individual gas wells to field gas – treating and processing facilities or to branches of larger gathering system. Most gas wells flow naturally with sufficient pressure to supply the energy needed to force the gas through the gathering line to the processing plant. Downhole pumps are not used in gas wells; but in some very low pressure gas wells, small compressors may be located near the well to boost the pressure in the flow line to a level sufficient to move the gas to the process plant.

Flowing gas well pressures vary over a wide range. At the low end of the range are those for which a compressor must be installed near the well. However, many gas wells produce at such high pressures that pressure must be reduced at the wellhead before the gas enters the flow line. This permits use of lighter – weight, less – expensive steel pipe. Pressure is reduced at the well by a choke or pressure – reducing valve. These can be manually operated or of the type that automatically maintains a prescribed pressure downstream of the valve.

Flow lines from individual wells carry gas to the field processing plant where the gas is treated to make it suitable for sale. Liquid hydrocarbons are also separated from the wellstream for sale. In some cases, several individual well flow lines feed into a larger line, which then carries the combined flow to the plant.

Contracts for the purchase of natural gas from a processing plant by a gas pipeline operator limit the amount of water that can be contained in the gas when it enters the gas transmission line. This limit is normally 7lb/MMcf (million cubic feet).

A dehydration process in the plant removes water to an acceptable level. Also specified in gas purchase contracts is the maximum amount of sulfur the sales gas may contain. If the produced gas is sour – contains acid gases hydrogen sulfide or carbon dioxide – these components must be removed in the process plant. Most field gas processing plants also remove hydrocarbon liquids from the produced gas stream. The amount of each component removed varies with the capability and design of the plant, general economic conditions, and market conditions for natural gas liquids and natural gas. But a field gas processing plant typically removes varying amounts of ethane, propane, butanes, and heavier hydrocarbon liquids from the gas stream. A mixture of components heavier than butane is often marketed as one product, natural gasoline.

Water and acid gases are often removed from the wellhead gas stream because they can cause corrosion and other problems in long – distance pipelines and associated equipment. Hydrocarbon liquids are removed because of their value as individual products for petrochemical feedstock and other uses.

Lengths of individual gas well flow lines vary, but they are normally from less than a mile to a few miles long. The lines are relatively small; diameters typically range form 2 in. through 4 in. Operating pressures also vary over a wide range but in general are higher than the operating pressures

of oil – well flow lines. Gas – well flow lines may operate at several hundred psi, and in some cases up to 2000 psi or more.

Where wells produce at high pressure, this can sometimes be used to provide energy in the gas processing plant. If the pressure were reduced at the wellhead by a choke or pressure – reducing valve, that energy would be dissipated. If, however, the wells flow to the plant at high pressure, that energy can be used within the plant to drive equipment or provide refrigeration for the process.

Length, operating pressure, size, throughput of gas well flow lines depend on the capacity of the producing well, the type of gas produced, process plant operating conditions, plant location, and other factors.

An accurate measure of the total mileage of gas well flow lines is not available. There are, however, more than 850 natural gas processing plants in the United States alone, and more than 420 such plants exist elsewhere in the world.

词 汇

gather	[ˈgæðə] vi. 集合，聚集；vt. 使聚集，搜集，积聚
individual	[ˌindiˈvidjuəl] n. 个人，个体；adj. 个别的，单独的，个人的
downhole	[ˈdaunˌhəul] 向下打眼，井下的
compressor	[kəmˈpresə] n. 压缩物，压缩机
manually	[ˈmænjʊəli] adv. 用手
automatically	[ɔːtəˈmætikli] adv. 自动地，机械地
prescribe	[prisˈkraib] v. 指示，规定
suitable	[ˈsjuːtəbl] adj. 适当的，相配的
contract	[ˈkɔntrækt] n. 合同，契约，婚约
purchase	[ˈpəːtʃəs] vt. 买，购买；n. 买，购买
transmission	[trænzˈmiʃən] n. 播送，发射，传动，传送，传输，转播
acceptable	[əkˈseptəbl] adj. 可接受的，合意的
ethane	[ˈeθein] n. [化] 乙烷
propane	[ˈprəupein] n. [化] 丙烷
butanes	[ˈbjuːtein] n. 丁烷
gasoline	[ˈgæsəliːn] n. 汽油
petrochemical	[ˌpetrəuˈkemikəl] adj. 石化的；n. 石化产品
feedstock	[ˈfiːdstɔk] n. 给料（指供送入机器或加工厂的原料）
relatively	[ˈrelətivli] adv. 相关地
diameter	[daiˈæmitə] n. 直径
desirable	[diˈzaiərəbl] adj. 值得要的，合意的，令人想要的
refrigeration	[riˌfridʒəˈreiʃən] n. 冷藏，制冷，冷却
throughput	[ˈθruːput] n. 生产量，生产能力，吞吐量
mileage	[ˈmailidʒ] n. 英里数，英里里程

短 语

1. gas gathering 气体集输
2. gas – well flow line 采气管
3. field gas – treating and processing facilities 气体处理加工厂
4. downhole pump 深井泵
5. lighter – weight, less – expensive steel pipe 薄壁、价格低的钢管
6. choke valve 节流阀
7. pressure – reducing valve 减压阀
8. gas transmission line 输气干线
9. dehydration process 脱水工艺
10. hydrogen sulfide 硫化氢
11. carbon dioxide 二氧化碳
12. economic conditions 经济条件
13. market conditions 市场条件
14. natural gasoline 天然汽油
15. petrochemical feedstock 石油化工原料
16. operating pressure 操作压力

第三课　国外输气方法简介

经气体处理厂处理后的干燥、净化的天然气进入到输气干线并被运送到城市气体公共事业部门，然后再分配给工商企业、工厂和居民家中，使用小直径管子经计量后分配各用户。

像输油干线一样，输气干线系统也能覆盖很大的地区范围，可达几百英里或更长。例如，从得克萨斯州和路易斯安那州向人口稠密的美国东部地区输送大量的天然气。在阿拉斯加北坡外输天然气的计划中，输气管道全长4800mile。

从俄罗斯到西欧全长2800mile的大口径管道在20年前就开始施工了。还有其他的长输干线，包括从伊朗到俄罗斯的输气系统。在美国，天然气干线已被规范化，据联邦能源管理委员会的报告，20年前，天然气管道公司管理着大约73000mile的集气管道和197000mile的输气干线。

输气干线的操作压力相当高。在管道起点，由压缩机提供能量，沿管道若干位置由中间压气站提供能量。压气站间距离取决于气体流量、管道直径及其他因素。通过增加压气站的压缩机台数或增加压气站数可以提高系统的输送能力。压缩机的功率各不相同，但许多站的压缩机功率都在几千马力以上。

输气干线都使用钢管埋于地下。管子通过焊接相连，外部涂有防腐层。美国使用的管子最大直径为42in，前苏联则使用直径达60in的管子。

与原油干线一样，输气干线的输送能力变化也很大。据FERC的报告，美国每年销售天然气约为$1.85\times10^{13}ft^3$❶。

对于一条长距离、拥有多座压气站和附属设备的管道系统，操作管理是一个非常复杂的问题。计算机和先进的通信设施使操作者能控制管道输送量和减少事故隐患。

由于用户对天然气的需求量经常发生大幅度变化，因此天然气管道的操作控制要比原油干线复杂。由于天然气用作居民、工业和企业的燃料，在某些情况下，天然气供应不足要比中断炼厂原油供应所产生的影响更直接。

阿尔伯达天然气干线（为NOVA在阿尔伯达的公司所有）是一个大型集气、输气系统。NOVA公司负责收集和外输加拿大阿尔伯达省的全部天然气。

NOVA公司管理着超过6500mile的气体管道，直径为3in到42in。该系统拥有500多座集气站和32座压气站。压缩机的总功率为5×10^5hp❷，输气量约为$50\times10^8ft^3/d$。

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❶ $1ft^3=0.0283m^3$。

❷ $1hp=745.7W$。

参考译文

Lesson 3 Introduction to Gas Transmission Abroad

From field – processing facilities, dry, clean natural gas enters the gas transmission pipeline system for movement to cities where it is distributed to individual businesses, factories, and residences. Distribution to the final users is handled by utilities that take custody of the gas from the gas transmission pipeline and distribute it through small, metered pipelines to individual customers.

Like crude trunk lines, gas transmission systems can cover geographical areas and can be several hundred miles long or more. More gas is moved, for example, from Texas and Louisiana to the populated areas of the northeastern United States. A plan to bring natural gas from Alaska's North Slope would involve a gas pipeline system about 4800 miles long.

Work was also underway in 1982 on a large gas line about 2800 miles long to bring Russian gas to Western Europe. Other long – distance gas transmission lines include a system that transports gas from Iran to Russia. In the United States alone, where natural gas transmission pipelines are regulated, the FERC reported that natural gas pipeline companies in 1981 operated about 73000 miles of field – gathering lines and 197000 miles of transmission lines.

Gas transmission lines operate at relatively high pressure. Compressors at the beginning of the line provide the energy to move the gas through the line. Then compressor stations are required at a number of points along the line to maintain the required pressure. The distance between compressors varies, depending on the volume of gas, the line size, and other factors. Capacity of the system can be increased by adding compressors at one or more of the compressor stations or by building an additional compressor station. The size of compressors within the station varies over a wide range, but many stations include several thousand horsepower in one station.

Gas transmission pipelines are made of steel pipe and buried below ground surface. The individual sections of pipe are joined by welding, and pipe is externally coated to protect against corrosion. Pipe size ranges up to 42 in. in the United States, and pipe as large as 60 in. in diameter has been installed in the USSR.

Volumes handled by individual systems, as in the case with crude trunk lines, vary widely. the FERC reported that United States natural gas pipeline sales amounted to 18. 5 trillion of per year.

The operation of a gas transmission system that moves gas over a large geographic area and contains several compressors and other facilities is a complex control challenge. Computers and sophisticated communications systems have been joined to allow pipeline operators to deliver the volumes required and to minimize malfunctions of system.

Because the needs of customers change more frequently and more rapidly, control of natural gas pipeline deliveries can be even more complex than the operation of a crude trunk line. The effects of a lack of natural gas, because gas provides home heating and fuel for business and industry, can be felt more immediately in some cases than a disruption in the delivery of crude to a refinery.

Alberta Gas Trunk Line (now NOVA, An Alberta Corporation) is an example of a large gas –