Developing, Designing, Engineering, Constructing and Operating Crude Oil, Refined Products, and Gas Transmission Pipelines

Prepared by

Pipeline Knowledge & Development

June 2015

Foreword

Since 1975 I have been involved in designing, constructing, operating, maintaining, and managing a variety of oil and gas pipelines. For about 25 years, I was employed by Conoco Pipeline in various engineering, operations, business development, strategy, and executive roles. The balance of that time has been as a consultant.

Since 2008, I have been privileged to train approximately 1,500 people about pipelines while teaching classes I designed and produced. I also authored several books and numerous studies, reports and article, all about pipelines. In addition, I helped settle a myriad of pipeline disputes, and served on numerous boards of directors and management committees, both on the operator and supplier side of the table.

This report was produced to share knowledge I have gained over that time about how crude oil, refined products, and natural gas transmission pipelines are developed, designed, engineered, constructed, and operated, as well as how they are financed and managed.

The text is of a general nature beginning with the conceptual stage and carrying right through to operations. Individual project specifics may cause them to diverge from the particulars contained in this report. Consequently care should be taken to ensure the unique nature of each project is considered and adjustments made as needed to allow for the specifics of the individual project.

Any questions regarding this study should be addressed to me at Mr. Tom Miesner, Principal, Pipeline Knowledge & Development. tom@pipelineknowledge.com or 00+1-512-710-6069.

Tom Miesner

Copyright

Disclaimer

The information contained in these materials was secured from sources believed to be reliable. However, Tom Miesner, Miesner, LLC, and Pipeline Knowledge & Development;

1. Make no warranty or representation, expressed or implied regarding the accuracy, completeness, reliability, or usefulness of the information contained in this presentation
2. Assume no liability with respect to the use of the materials contained in these presentations
3. Are not responsible for damages resulting from use of the information in these presentations.

Table of Contents

Purpose

Who first collected and used crude oil is lost in antiquity, but "Colonial" Edwin Drake is largely credited with drilling the first commercial oil well near Titusville, PA in 1865. The Americans were not the only ones looking for oil. Around the same time, near Baku, Azerbaijan (and in various other locations around the globe) others were also experimenting with digging oil wells.

Early transportation of crude oil from the production field to market involved teams of horses pulling wagons loaded with barrels. Barge and rail transportation quickly followed, but construction by Samuel Van Syckle of a five and one half mile long 2 inch diameter crude oil pipeline from a production field to a rail siding in 1865[1] quickly displaced horses and people, and by the early 1900's pipelines carried most of the US produced crude oil to refineries. Other areas lagged somewhat, depending instead on rail, but for the past 75 or so years people largely agree pipeline transportation is the safest, most environmentally responsible, and least costly means of transporting large qualities of crude oil.

Goals

Crude oil pipelines are constructed as key transportation links between crude oil production fields and refineries. Along the way custody (responsibility for) the crude oil may transfer from the pipeline to other forms of transportation or to other pipelines. As the crude oil moves along its way, the goal is always the same, safe, efficient, environmentally responsible transportation with due attention to maintaining the quality and quantity of the crude oil.

Challenges

Pipelines are long linear assets constructed primarily outside the battery limits on land owned by others. Crude oil pipelines transport hazardous liquids. Construction requires clearing along the route and operations dictate the route remain clear. Pipelines have a large number of stakeholders and the primary challenge for pipeline owners and operators is balancing the often divergent needs of their many stakeholders. Stakeholders range from shippers who want their crude oil transported at the lowest cost consistent with reliable operations and due regard for the environment, safety, and various other factors, to the environmental extremists who simply do not want pipelines build regardless of the pipeline's environmental and economic value, to owners who want a reasonable return and host government who want adequate compensation.

Pipeline Ownership

From a legal or corporate entity standpoint pipeline ownership is the same as for other entities, the most common being either a corporation or a partnership. Developing, constructing, and operating large diameter pipelines involves considerable capital, operating, and maintenance costs and includes risks such as cost overruns, declining volumes, and security. Consequently joint venture ownership for pipelines is quite common. The value proposition for forming joint ventures includes the following:

[1] Waples, David A. The Natural Gas Industry in Appalachia, McFarland & Company, Inc. Jefferson, North Carolina and London, 2005, p. 132.

- Spread financial risk
- Capture economies of scale
- Combine complimentary competencies
- Access to resources of owners

Ownership of joint ventures is commonly in the form of owning shares in a corporation, owning a portion of a partnership or limited liability company, or owning the assets directly through an Undivided Joint Interest (UJI) form of ownership. Joint venture pipelines are operated either by one of the owners under contract to the joint venture or to the other owners or by a separate operating company formed to operate the pipeline. In the case of joint ventures, management of the business affairs of the company is accomplished through a board of directors or management committee.

Examples of joint venture crude oil pipelines are the BTC pipeline from Baku, Azerbaijan to Ceyhan, Turkey – owned by BP, SOCAR, Chevron, Statoil and 7 other companies – and the CPC Pipeline which transports crude oil from the Tengiz Field in Western Kazakhstan to a marine terminal in Novorossiysk, Russia. Ownership of CPC includes Transnevft, KMG, Chevron, and 8 others. Both of these companies are managed management boards consisting of shareholder representatives. Operations of the pipeline are performed be operating companies which report to the management boards.

Project Steps to Completion (Phases)

Starting with a concept, the pipeline "project life cycle" is quite similar to other large capital projects. Figure 1, taken from Oil and Gas Pipeline Fundamentals produced by Pipeline Knowledge & Development shows the life cycle.

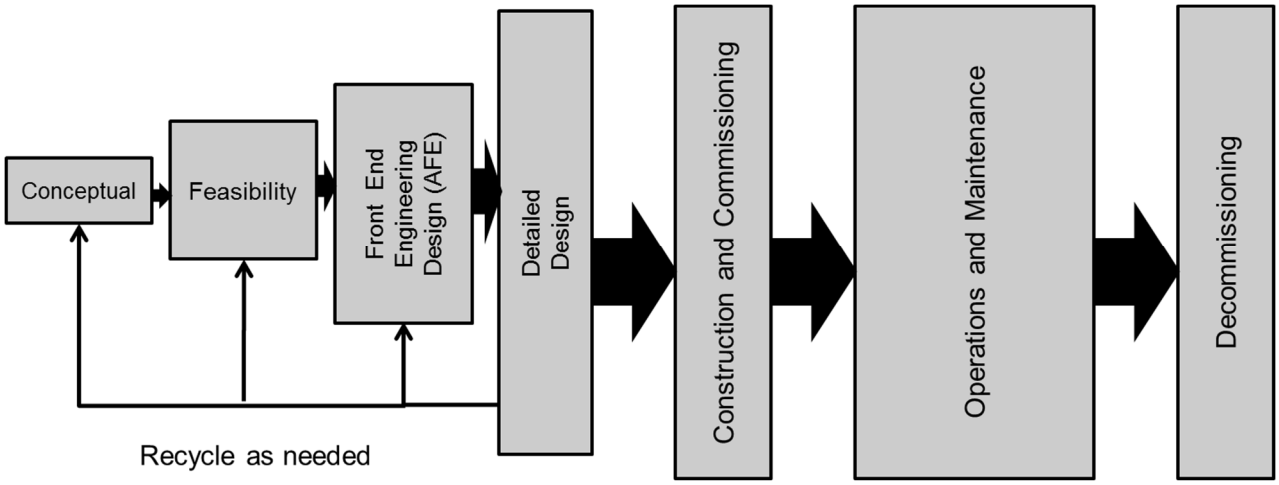

Figure 1. Project Life Cycle. Courtesy Pipeline Knowledge & Development.

Conceptual through Feasibly

Crude oil pipeline projects start with a new supply source, a new demand location, or a desire for less expensive or more secure transportation routes for existing supply or demand. Drawing a bright line between the conceptual stage and the feasibility study stage is difficult and has more to

do with the amount of work performed during that stage that with the type of work performed. Regardless of where the line is drawn, these two stages seek to address four fundamental issues:

1. Will building this project earn an acceptable return?
2. What are the major risks and uncertainties associated with the project?
3. How can those risks be mitigated?
4. What are the commercial terms and business structure of this project?

Project Assumptions

Addressing these questions requires developing various assumptions or estimates regarding items including:

- Design crude properties
- Environmental impact
- Cultural impact
- Security considerations
- Host government involvement
- Shipper involvement
- Capital costs
- Operating costs
- Volumes
- Tolls or rates
- Ownership structure
- Funding sources and rates

Rather than attempting to develop cost, revenue, and other numerical assumptions as points, they are normally developed as a range. For example, capital cost estimates are often developed as ± 50% or +50%/- 25%.

Funding and Staffing

This stage is normally led and funded (at least partially) by a project developer – a person, company, or governmental agency seeking to move the project forward to the next stage. Host governments, potential customers (shippers), World Bank, investors, and a myriad of other parties may be involved in this stage as the project developer seeks to understand the potential return, how to mitigate the risks associated with the project. Figure 2 contains an example of the various entities involved during the conceptual and feasibility stages of projects.

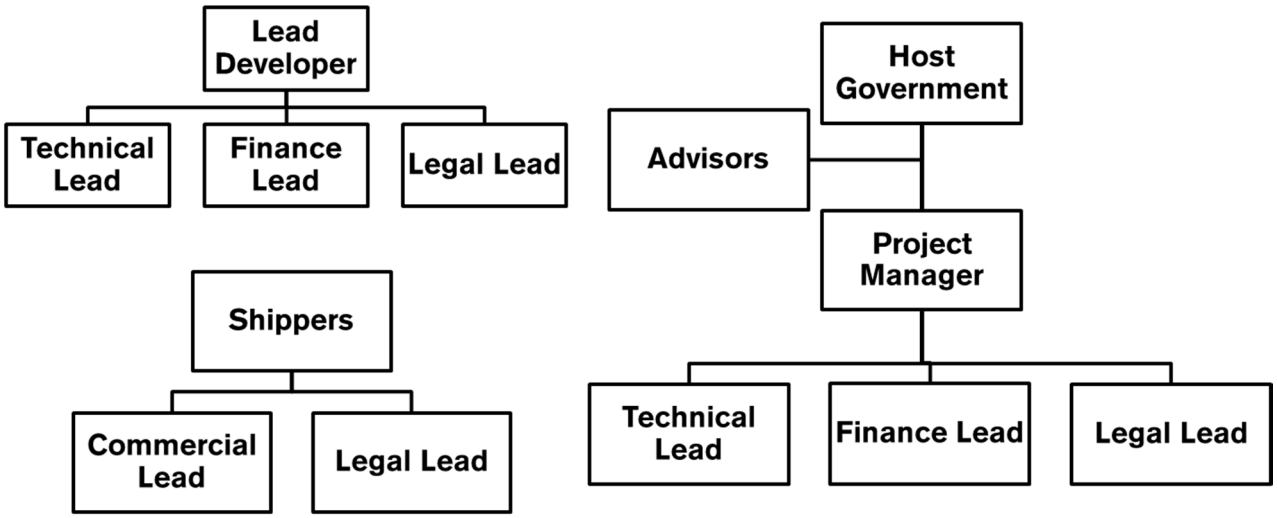

Figure 2. Representative Organization – Conceptual and Feasibly. Courtesy Pipeline Knowledge & Development.

Business and Commercial Terms

The business and commercial terms, ownership structure and legal requirements, including host government participation and taxation have direct effects on the project feasibility. As a consequence these items are normally agreed among the parties prior to moving on to Front End Engineering and Design (FEED). Final ownership documents may be negotiated and agreed during the feasibility phase but sometimes the project moves to FEED with only a "heads of agreement" document which sets the stage for detailed negotiations and finalization of the governing agreements during FEED. At a minimum, prior to leaving this phase the parties agree on FEED funding.

Front End Engineering and Design

Rather than FEED, this phase is often called Front End Loading (FEL) to reflect the broader nature of the phase. To be sure, additional design and engineering work to narrow the capital, operating, and other cost range and reduce uncertainty are performed during this phase. But, other parameters including commercial, political, governmental, environmental, cultural, and security must be addressed as well. FEL is sometimes divided into three stages, FEL1, 2, and 3. Each stage addresses various issues including project economics and risk.

Objectives

The primary objective of FEED is producing a robust plan and design early in the project when the ability to influence the design and relatively high and the cost of making design changes is relatively low.

But, during FEED there are also a number of "non-engineering" objectives including the following:

- Complete the corporate documents and agreements required for project ownership,

- Select the operating entity which will be responsible for operations and maintenance of the pipeline and associated facilities,
- Complete required agreements with host governments,
- Hire a small team with the intent of transitioning them to permanent staff,
- Complete a local labor force skills assessment,
- Begin planning for recruiting, training, and operational readiness at startup,
- Secure volume and rate commitments to insure project economic viability, and
- Begin arranging long term financing.

Funding and Staffing

The decision to proceed with FEED means one of more parties believes the project will be economic and accordingly they are willing to commit funds to move the project along. As projects move from the feasibility stage to FEED, the developer, as a way to spread risk and gain commitment, normally asks others to join in with the funding. Exactly how funding proceeds depends on the particulars of the situation so there is not really a "normal" way funding occurs. Rather, the interested parties negotiate among themselves to agree which parties will take an economic interest going forward and how much of FEED costs will be provided by equity participants and how much by debt. Since a firm decision has not been made to proceed as the project enters FEED, most of the financing is normally equity. Even through the decision has not been made to move forward with the project, a legal entity, complete with ownership and governance documents, is normally formed to manage FEED activities.

Operational Readiness

The managing board decides the individual who will lead the project during FEED. Sometimes the development lead may continue as the president or managing director of the entity, or a new person may be hired to manage the next phase of the project. During FEED, a temporary team consisting of the key operational, maintenance, health, safety, environmental, social, public relations managers, supervisors, and trainers are hired with the intent to employ these key personnel on a permanent basis once the decision is made to proceed with the project. One of the keys to long term project success is operational readiness at the conclusion of the construction phase. And, the key to operational readiness is early planning and staffing of these key individuals. Reporting to the project lead or president is normally team or 8 to 10 full time individuals to lead the various elements of the project as shown in Figure 3.

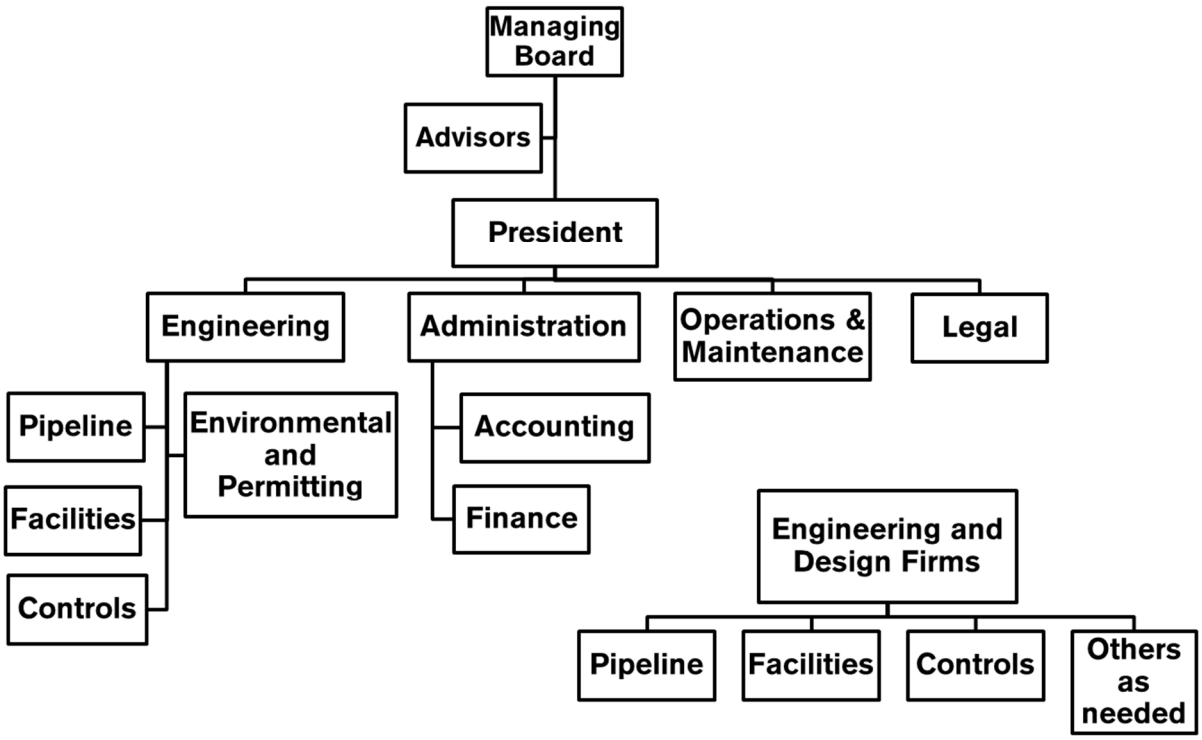

Figure 3. Representative Organization – FEED or FEL. Courtesy Pipeline Knowledge & Development.

The precise staffing during FEED depends on a number of factors, most importantly, the knowledge, experience, and skills of the individuals assigned to the roles. The key is to provide the proper mix of skills in an organization accountable to the owners who can then manage a much larger team of people contract engineers, designers, estimators and so forth.

Key to the ultimate success of any pipeline project is early involvement of those who will ultimately mange operations and maintenance during the longest project phase – Operations. While the project at this stage is likely several years from being an operating asset, experience shows providing for operations and maintenance input at this phase is well worth the cost of including this function during FEED. Each of the FEED activities is discussed in more detail in the balance of this text.

Technical

From a technical perspective outcome from FEL include items such as the following:

- Process flow diagram
- Schedule
- Definitive estimate
- Major equipment list
- Preliminary routing
- Control strategy
- Operating philosophy
- Maintenance philosophy

- Permitting strategy
- Housing and staffing strategy (for remote locations)
- Specifications for long lead time items
    - Pumps
    - Drivers (motors, engines, turbines)
    - Pipe
    - Other
- Project execution plan
- Design basis document

The major technical considerations should be agreed during FEED such that a strong and well defined design basis document can be supplied to for the Detailed Engineering and Design phase of the project. The design basis document could also include strong guidance to the operations and maintenance design which is performed during the detailed engineering and design phase of the project. During FEED, numerical estimates and assumptions are normally tightened to between $\pm$ 25% and $\pm$ 10%

Commercial, Political, Social and Regulatory

Commercial terms such as volumes and rates along with their impact on revenue must be identified. The cost of political governmental factors including taxes and other fees, social factors like employment of nationals and the cost of providing amenities along the route for local communities, and regulatory provisions must be understood and quantified in details as well during this phase of the project. Spending the time and resources to understand these factors during FEED avoids project impacting surprises later in the project when it may be too late to make the needed changes to deal with these factors.

Environmental, Cultural, and Security

Equally important are understanding environmental and cultural issues and developing plans to address and mitigate any negative impacts from the project. Security along the line must be maintained which means security plans and agreements must be developed in the considerable detail during this phase.

A click glance back at Figure 1 shows project recycle during the first three project phases. While moving through FEED to get to detailed engineering and design quickly is tempting, the project should be sufficiently defined such that no recycle is required. Especially important are having all commercial terms and agreements in place so there are no surprises as the project moves along.

Expenses

While considerable efforts go into engineering during FEED, operating and maintenance expenses are normally refined during this same time frame. Crude oil pipeline expenses fall into four broad categories which are the following:

- Power,
- People,
- Maintenance, and
- Other

Pipeline pumps are driven by electric motors, internal combustion engines, or turbines. For each case, the amount of power which will be consumed can be developed relatively easily based on the hydraulic analysis conducted. When robust electrical grids exist nearby, electric motors are normally used to drive the pumps. In the case of remote stations not supported by existing electrical grids, engines or turbines powered by natural gas, fuel oil, or in some cases crude oil from the line itself, are used either to power the pumps directly or to drive electrical generators. In the case of generators, the electricity is then used to power motors which drive the pumps.

Total power cost is the amount of electricity or fuel consumed multiplied times the rate paid per unit. But, estimating the rate per unit can be difficult where extensive infrastructure must be constructed to support the pump station. Consequently there are no "rules of thumb" as to what the rate will be. Sometimes, existing projects located nearby can be used as a guide, but often the rate must be developed based on the particular circumstances for the project under development.

Staff costs are estimated by first designing the ongoing organization to arrive at the number of people required for each position. People counts are multiplied times pay rates to arrive at salaries. Remote stations may require people to stay on site and rotate on some frequency such as 14 days on and 14 days off. Where required skills are not readily available on a local basis considerable costs may be involved in training staff, particularly during the pre-startup period.

Pipeline maintenance costs are dependent on a number of factors such as local terrain, installation quality, types of materials installed, and quality of past maintenance. In the case of new, well-constructed, pipelines maintenance costs for the pipeline itself are relatively low and consist primarily of maintaining the surface features of along the route. As the pipe ages maintenance costs typically increase. Pump and other station maintenance costs depend on the same factors as pipeline maintenance as well as the run time of the equipment.

Other costs include a myriad of factors. One of the other cost to consider carefully is the cost of providing housing, catering, security, and other related items at remote pump and other station sites. Again, no particular "rules of thumb" apply and these costs are estimated based on comparable facilities similarly situated, or they are estimated based on the staffing, facilities, or other particulars planned for the various facilities.

Revenues

Pipelines generate most of their revenue from the volumes the move at the rates they charge. Consequently, accurately establishing the volumes is critical to the success of the pipeline venture. To assure volumes and therefore revenues, pipeline companies often ask shippers to sign volume commitments or guarantees. If shippers move less than the guaranteed volumes they still pay for the movements. Often this takes the form of "prepaid transportation". So, shippers are actually paying in advance for movements.

Local Labor Force Skills Assessment

Having a strong management team including a high percentage of capable nationals helps ensure project acceptance and success, and is critical to controlling staffing expenses. During FEED, a labor force skills assessment should be conducted to determine local availability of executive, management, supervision, and general work force skills. Conducting the skills assessment early allows for identification of skill gaps which the recruiting, hiring, and training plans can prepare to close post startup.

Detailed Engineering and Design

The move from FEED into detailed engineering and design is another milestone in the project, and may involve a realignment of ownership and management interests as some parties gain interest and others decide they do not want to participate. At this point the project agreements and governance documents are normally reviewed and updates as needed, or new documents are agreed. Along with ownership and governance, the funding mechanisms often change.

Funding and Staffing

The decision to proceed with detailed engineering and design usually means one or more entities intends to take the project all the way to construction and operations so long term financing can now be obtained. Again, there are many ways this financing can proceed. Any borrowing will involve guarantees to the lenders.

Since detailed engineering and design involves a larger number of people, the managing organization is again updated. At this point the company organization is usually comprised of between 20 and 40 people supplemented with contract personnel as needed. A typical organization during detailed engineering and design is shown in Figure 4.

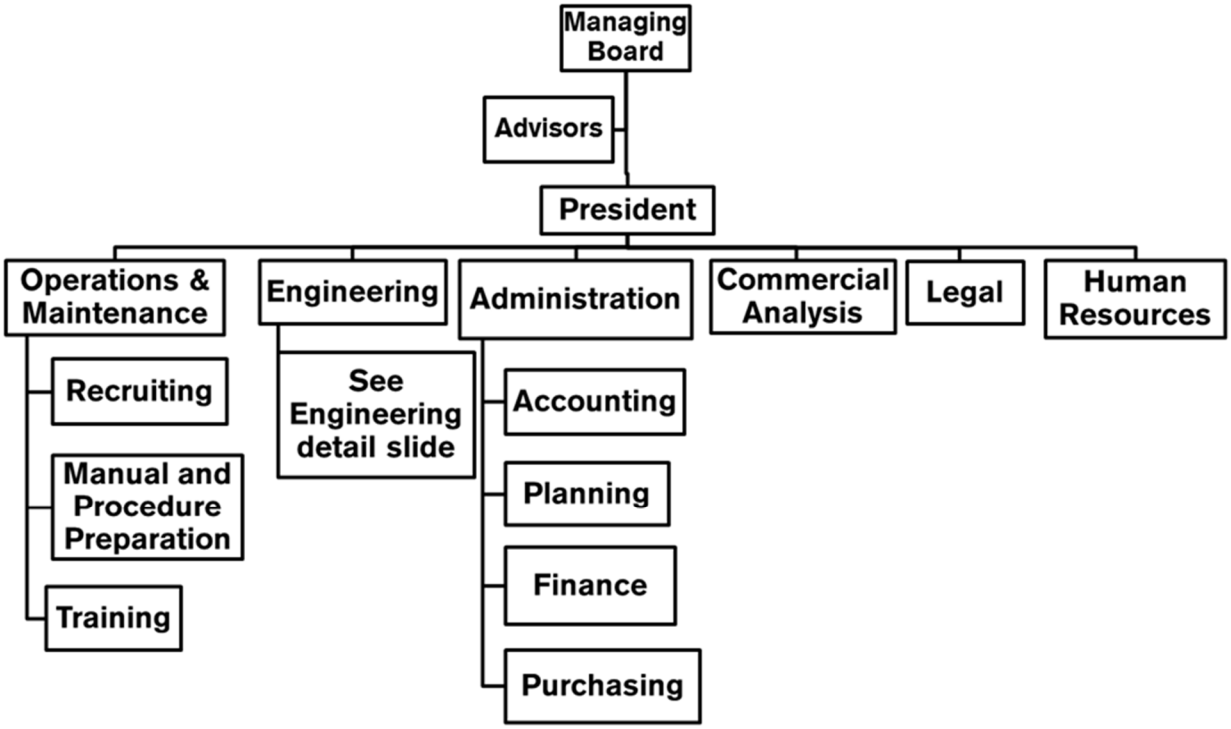

Figure 4. Representative Organization during Detailed Engineering. Courtesy Pipeline Knowledge & Development.

While this activity is often called "detailed engineering and design" considerably more than just engineering happens during this phase of the project. These additional activities are addressed later in this section.

Design Basis Document

Detailed engineering and design begins with a design basis document produced during FEED. The design basis document contains (at a minimum) the following:

- Design capacity – flow rate where design is to optimized
- Operating range – range of expected flow rates
- Fluid properties (density, viscosity, specific heat)
- Operating temperature range
- Applicable codes and standards
- Process control philosophy
- Operating philosophy
- Maintenance philosophy
- Preliminary route receipt and delivery locations
- Sensitivities regarding customers, regulators, public opinion, geological, environmental, or other considerations which would affect line design or routing,
- Project economics and economic sensitivities
- Special operating considerations
- Economic basis

Engineering Staffing

During detailed engineering and design the design basis document is translated into detailed drawings and written specifications. The engineering organization built during FEED is expanded to manage this activity and additional consulting engineering firms are hired to complete the detailed plans and specifications. Figure 4 is an example of the engineering staffing for a major pipeline project during the detailed engineering stage.

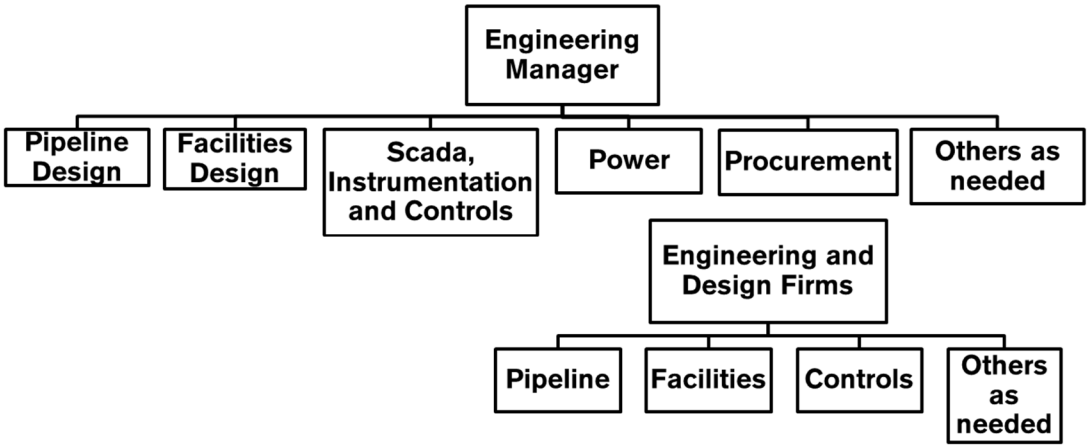

Figure 5. Representative Engineering Organization during Detailed Engineering. Courtesy Pipeline Knowledge & Development.

Engineering and Design

Engineering and design complement each other, but are not the same thing. Design involves determining which components (pipe, coatings, fittings and flanges, valves, actuators, pumps

prime movers, variable speed drives, meters, provers, tanks, instruments, and the like) will be used, where they will be located, and how they will be connected together to best meet the customer's needs. In the process of design, considerable engineering is employed. But design depends a lot more on knowledge and experience than on equations, codes, and standards.

Engineering, on the other hand, applies technical, analytical, scientific, and mathematical knowledge to the design such that it safely, efficiently, and reliably serves the customer's needs.

Regulations, Codes and Standards

Regulations and codes are specific to a country or governmental agency. They may differ from country to country depending on local preferences and practices. So, when designing a pipeline an extensive knowledge of the specific governmental agency laws on which the regulations and codes are based is important.

Standards are based, not on the laws of the country, but on the laws of physics – which apply universally. Consequently looking beyond the title and into the specifics of the standard reveals a great deal of similarity across issuing bodies. A list of some of the most common standards include the following:

- ASME/ANSI
    - B31.4 "Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids"
    - B31.8 "Gas Transmission and Distribution Systems"
    - Various other B31 standards apply
- American Petroleum Institute (API) – multiple standards and practices
- ISO 13623 Petroleum and natural gas industries – Pipeline transportation systems
- British Standards Institution (BSI) PD 8010
- Canadian Standards Association (CSA) Z 662 (183 & 184)
- European Standards EN 1594 and 14161
- European Committee for Standardization (CEN)
- Russian Industry Standards (SNIP)
- American Society for Testing and Materials (ASTM)
- ASTM International (ASTM)
- Gas Technology Institute (GTI)
- Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
- NACE International (NACE):
- National Fire Protection Association (NFPA)
- Pipeline Research Council International (PRCI)

Objective of the Technical Phase

The objective of the technical phase of engineering and design is producing a sound design to a sufficient level of detail such that the pipeline and all associated facilities can be constructed in a quality manner. The construction contractors must be able understand the documents produced during this phase in sufficient detail to construct what was designed.

Technical Tasks

There are a myriad of engineering and design tasks which must be completed during this phase, some of which are the following:

- Implement operating and control strategies
  - Local vs. central vs. human control decisions
  - Devices automation
  - Redundancy and backup
  - Types of sensing devices
  - Senor sensitivity
  - Communications strategy
  - Polling frequency and strategy
  - Leak detection strategy
  - Alarms, alerts, indications, and filtering
  - Cyber security
- Finalize route and acquire right of way and land
  - Understand the route
  - Private land and ownership
  - Public land and agencies involved
  - Existing pipelines or other infrastructure
  - Locate environmentally sensitive areas (wetlands, threatened and endangered species, environmental cleanup areas)
  - Determine culturally sensitive areas (archeological, paleontological, and cultural)
  - Survey abrupt elevation changes or steep slopes
  - Establish earthquake and fault zones (landslide- or flood-prone areas)
  - Locate government lands
  - Determine politically sensitive areas
- Design PR campaign
  - Public meetings
  - Agency meetings
  - Advertisements
  - Web site
- Make permit fillings as needed
  - EIS (or version thereof)
  - Other land use filings
- Conduct hydraulic design
  - Fluid characteristics
    - Viscosity
    - Density
- Confirm pressures, flow rates and pipe specifications
  - Pressure loss per mile
  - Pipe diameter
  - Wall thickness
  - Steel strength
  - Pressure required at origin
- Energy requirements

- System configuration
    - Length
    - Diameter
    - Internal roughness
    - Layout
    - Elevation changes
- Establish hydraulic control scheme
    - Control valve
    - Variable speed drive
- Determine pumping rates
- Develop station layout
    - Buildings
    - Piping
    - Equipment
    - Storage
    - Power
- Select equipment
    - Compressors and pumps
    - Prime movers
    - Metering
    - Instruments and communications
- Ancillary equipment
- Conduct operations review and hazards analysis
- Develop specifications
    - Materials
    - Pipe
    - Equipment
    - Other materials
- Construction contracting
    - Contracting strategy
    - Number of spreads
    - Division of work
- Quality control
    - Inspecting
    - Testing
- Reconfirm economics

Operational

At the same time engineering is designing the pipeline and facilities, a small group of people begin developing high level recruiting, organizational, training, and other plans and procedures. Operations consists of both field operations, that is employees physically stationed a locations along the pipeline, and central control room operations; employees in a centralized location who use scada and controls to continuously monitor and control the pipeline. Both field operating technicians and central control room operators should have extensive pipeline operating backgrounds and experience. In addition to developing the operating plans, procedures, and manuals, these experienced people work closely with the pipeline designers and engineers to

ensure the pipeline and facility designs are efficient and well planned. These people also participate with the design team to conduct hazardous analysis to identify, eliminate, and mitigate hazardous design features. This group would also develop training plans and materials, develop position descriptions and generally prepare for operations start up post line filling and commissioning.

Examples of the operational plans and procedures which are normally developed during this phase are the following:

- Recruiting Plan
- Training and Competence Assurance Plan
- Operations Support Subcontracting Plans
- Pre-Operations Plan
- Operations Procedure Manuals

Maintenance

Likewise a small team of experienced pipeline maintenance professionals develop the needed plans, procedures, systems, manuals, and training required by the maintenance and integrity departments. They also participate with the design team as needed for design reviews and work to ensure the design facilities future maintenance activities. They also prepare to recruit and train down to the field technician levels. Examples of plans, procedures and manuals include the following:

- Engineering Information Management Plan
- Maintenance Management Systems Plan
- Technical Integrity Management Systems Plan
- Pipeline Integrity Management Scheme
- Maintenance Manual
- Corrosion Management Plan
- Emergency Pipeline Repair Plans and Procedures

Health, Safety, Environmental, and Security

Crude oil pipelines transport hazardous liquids which can ignite or cause severe pollution so health, safety, environmental and security professionals develop plans to ensure safe and secure operations as well as plans to respond in the unlikely event of a pipeline release or security breach. Examples of plans, procedures and manuals include the following:

- Security Plan
- HSE Management Plan
- Crisis Management Procedures
- Spill Response Management Procedures

Social and Public Relations

Pipelines are unique. Unlike refineries, power plants, or even oil field production, they traverse lands owned primarily by others. They can impact a number of cities, towns, and villages along the way. As a consequence, pipeline companies must design and maintain ongoing and effective public relations both with the landowners and local officials. Pipeline companies must understand governmental expectations regarding the obligation to hire local citizens, not only for pipeline

operations and maintenance as direct employees but also for camp upkeep, catering, and the like in the case of remote camps.

Pipeline Construction

While every project may be different, ownership decisions are normally made prior to entering the detailed engineering and design phase of the project so moving from detailed engineering and design into normally does not entail changes in ownership. It does, however require increased levels of funding, normally from borrowing with the exact nature of the funding depending on the particular project specifics. The organization structure during construction often looks very similar to the organization during detailed engineering and design as shown in Figure 6.

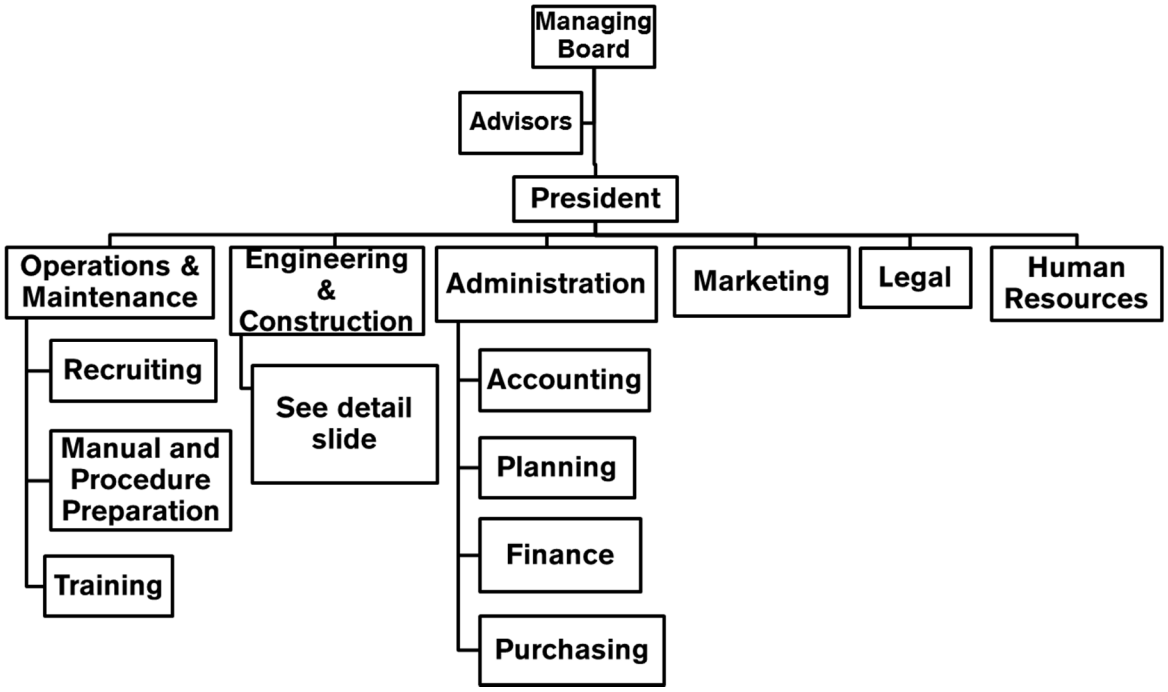

Figure 6. Representative Organization during Construction. Courtesy Pipeline Knowledge & Development.

While the organization structure looks quite similar to the structure during detailed engineering and design, important differences happen to the organization during construction – it increases in size. Depending on the particular pipeline the organization may grow from around 50 to several hundred as the employees who will operate, maintain, administer and manage the pipeline during the operations phase are recruited, hired, and trained.

Design engineers produce drawings depicting how the facilities should be installed, and specifications for materials, equipment, and construction. These form the basis of material and equipment procurement, and project construction bids documents. Construction project managers, engineers, and supervisors interface with design engineers during this transition to ensure the care taken during design is reflected in the final work. After construction contracts have been awarded and as materials and equipment begin to arrive at staging yards along the route the shift to construction begins in earnest.

The linear nature of pipeline projects creates the requirement for constant movement of workers and equipment, often over wide varieties of terrain. High equipment and personnel utilization is the key to managing construction costs and each day of reduced productivity is expensive. Communication along the project between engineers, projects managers, project inspectors, and the contractor's crews can be challenging because of the distance and sometimes because of remoteness.

Construction Tasks

The gamut of construction tasks begins with permitting, contracting and procurement and continues through documentation. The key tasks are listed below.

- Permitting
- Contracting and Procurement
- Route Selection
- Right of Way and Land Acquisition
- Surveying and Staking the Line
- Pipeline Construction Spreads
- Preparing the Right of Way
- Stringing
- Welding
- Weld Inspection
- Trenching
- Lowering In
- Backfilling
- Bends, Crossings, and Tie Ins
- Quality Control
- Cleaning and Sizing
- Hydrostatic Testing
- Commissioning
- Station Construction
- Clean up and Restoration
- Handoff for Operations
- Documentation

Company Construction Staffing, Planning, and Project Management

Project size and complexity determines project staffing. Large projects such as the BTC crude oil line from Baku, Azerbaijan to Ceyhan, Turkey or the REX gas line from Rio Blanco County, Colorado, to Monroe County, Ohio, U.S. require a large project management staff. Small projects may be managed by one person. No matter the size, the roles of managing and directing a pipeline project are complex and varied. The roles may be filled by employees of the owner company, or, by trusted and talented consultants dedicated to the project. Roles include:

- Program Manager – Executive level individual with extensive talents in planning, communications and content knowledge of pipelines.

- Project Manager; Pipeline - Executive level individual with extensive talents in planning, communications and content knowledge of pipelines. This role is for management of the cross-country pipeline.
- Project Manager; Stations - Executive level individual with extensive talents in planning, communications and content knowledge of pipelines. This role is for management of the pump stations or compressor stations and receipt and delivery facilities.
- Technical Manager or Project Engineer – Team lead to direct all technical activities of the project, including hydraulics, pump/compressor sizing and specifications, material specifications, surveying, detailed civil, mechanical and electrical design and construction specification writing.
- Controls Engineer – Team lead responsible for project scheduling and cost controls and reporting.
- Contracts Administration – Procurement specialist with appropriate legal support in development of contracting and procurement strategies.
- Environmental Manager – Team lead to direct all environmental studies and procurement of government permitting, including federal and state.
- Right of Way Manager – Team lead to direct all activities related to easement procurement over the pipeline route, and additional land requirements for construction, staging of equipment and materials.
- Materials Manager – Team lead to work with technical personnel on quoting, purchasing, transportation and warehousing of all project required materials.
- Regulatory Manager – Team lead to assure compliance with safety and environmental regulations during construction and establishing documentation for operations.
- Safety Manager – Team lead for establishment and enforcement of project safety procedures and incident reporting.
- Document Manager – Team lead responsible for organization, management and distribution of project critical documents, including drawings, specifications, permits, easements, correspondence, as-constructed records, weld maps, weld inspections and other project important documentation.
- Construction Manager – Team lead to plan and direct all quality control associated with construction and installation of the pipeline.
- Craft Inspection Team – Boots on the ground representing the owner with each contractor's crew to provide quality control inspection of construction and installation of the pipeline.
- Public Relations or Community Manager – Pipelines often required significant public communications sometimes as part of the permitting process and sometimes it's just good business.
- Engineers – Technical specialists responsible for technical analysis, calculations, design, drafting and design document management.

Figure 6 is an example of the engineering and construction organization for a major pipeline project during the construction phase of the project.

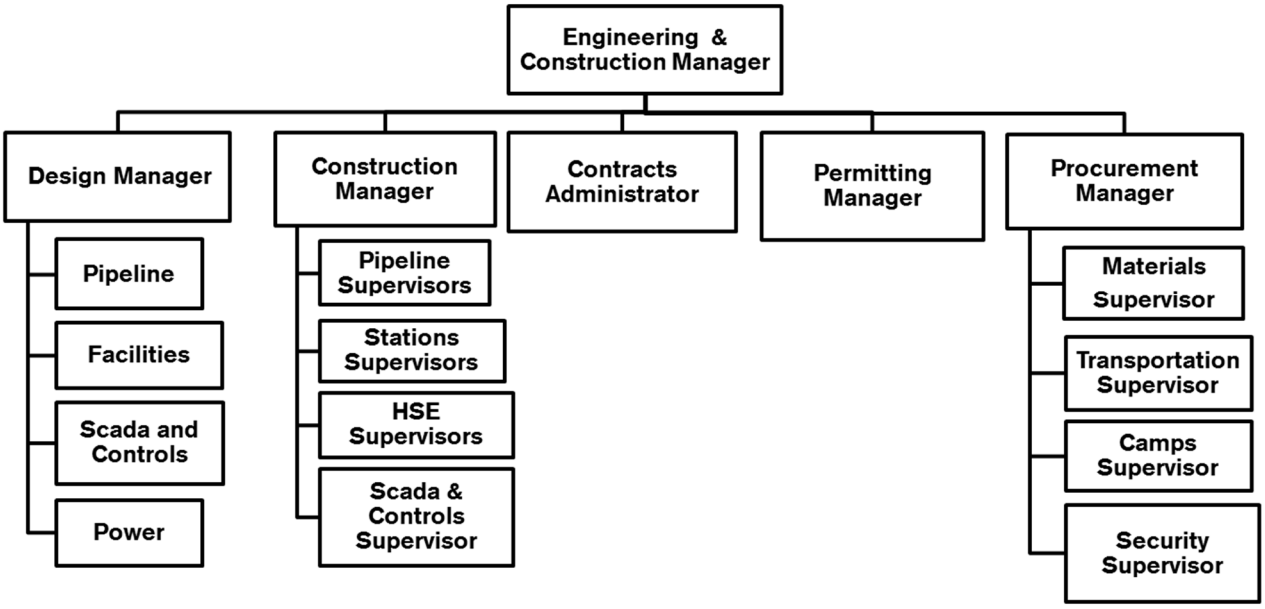

Figure 6. Representative Engineering and Construction Organization during construction. Courtesy Pipeline Knowledge & Development.

Contractor Construction Staffing, Planning, and Project Management

The contractor also requires a diverse and broad set of talents to execute the project. Each task of the construction project requires various crews consisting of the following roles and crafts:

- Project Manager – On site direct communication facility between Owner and Contractor
- Superintendent – Construction specialist responsible for over-seeing the foreman of each crew.
- Foreman – One foreman for each of the contractor's crews: Right of Way clearing and grubbing, stringing, ditching, bending, alignment and stringer, welding, coating, lowering, backfill, clean-up, restoration.
- Time Keeper – Team lead responsible for knowing and tracking each individual and each piece of equipment working each day on each crew.
- Personnel Manager – Construction crews often have some level of turn-over during a project, the contractor requires someone as a point contact for recruiting crafts as required for the project on a daily basis.
- Surveying – Once the right of way is established by the owner, the contractor is usually responsible for maintaining the ditch alignment.
- Safety Director – Assuring each crew follows company established safety policies and OSHA compliance. Also assuring that each piece of equipment is safe and working properly.

Figure 7 is an example of the various types of construction firms which would likely be involved during the construction phase of the project.

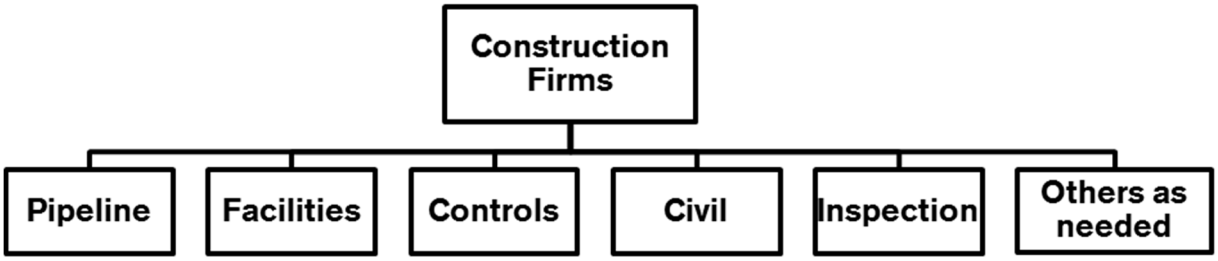

Figure 7. Representative construction firms during construction. Courtesy Pipeline Knowledge & Development.

Construction Logistics

Pipelines are long, linear, assets. They are built by construction "spreads" which can be thought of as moving assembly lines. Figure 8 shows a pipeline construction spread.

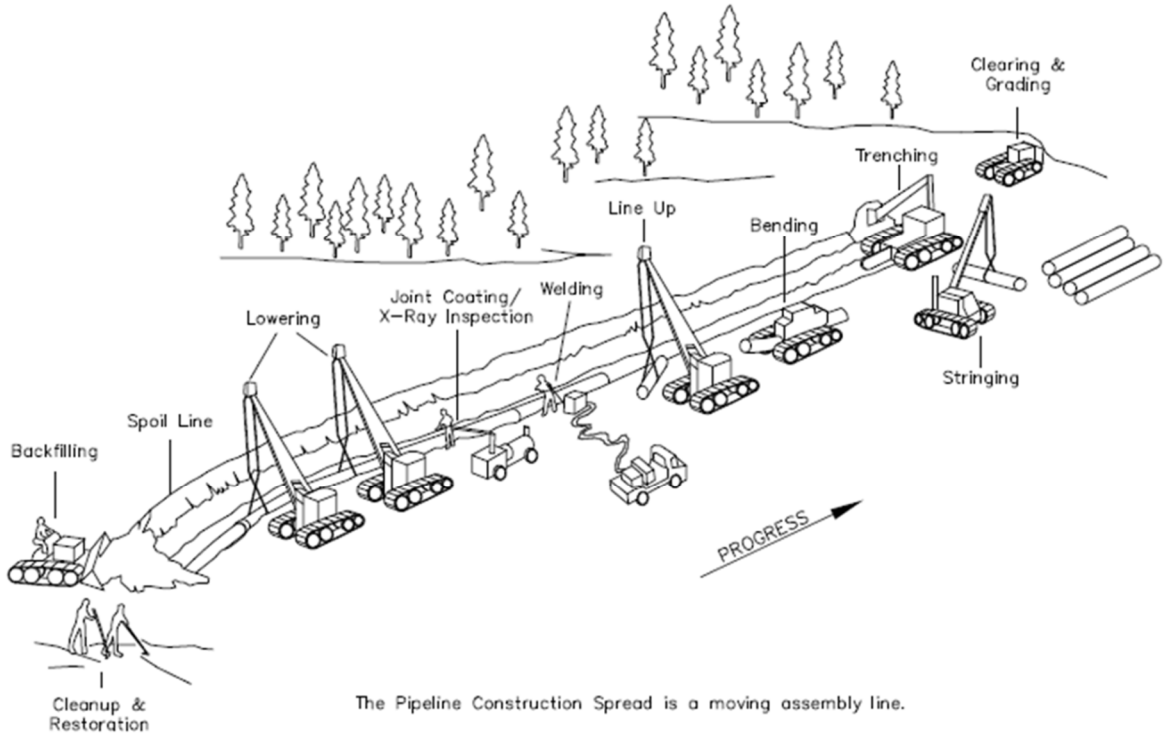

Figure 8. Pipeline construction spread. Courtesy Vanderpool Pipeline Engineers Inc.

Long lines of 1,000 km or so may have three to five spreads all working at once on different segments of the line. Shorter lines may be constructed by one spread. Since pipelines are linear assets which traverses the country side providing the logistics for materials, equipment and staff requires a coordinated effort.

For remote locations with limited infrastructure roads, construction camps and materials staging areas may be built in support of pipe construction. While the roads and other infrastructure can

benefit the native population, these same assets sometimes contribute to deforestation, pollution, and other undesirable consequences. Consequently the infrastructure must be built and maintained with care and respect.

Preparing for Ongoing Operations and Maintenance

As the construction phase of the project progresses the team of people who worked on operational readiness during detailed engineering and design is expanded to develop the details of the operations, maintenance, health, safety, and environmental and other plans and procedures. The team also hires and trains the balance of the work force to ensure when construction draws to a close the ongoing operations, maintenance, and support staffs are in place, trained and ready to assume control.

Organizational Design, Readiness Planning, Recruiting, and Training

As the pipeline and related facilities are constructed; hiring, recruiting, training, and the other activities required for operational readiness continue at an increasing pace. All of the activities must be carefully coordinated to ensure the people who will manage, operate, and maintain the pipeline are ready when the pipeline is ready. Some of the company people involved with constructing the pipeline stay on to operate and maintain it, but nearly all of the contractor personnel, welders, equipment operators and the like move on to the next project when this one is finished. Figure 9 is an example of the operating organization for the pipeline which must be ready at pipeline startup.

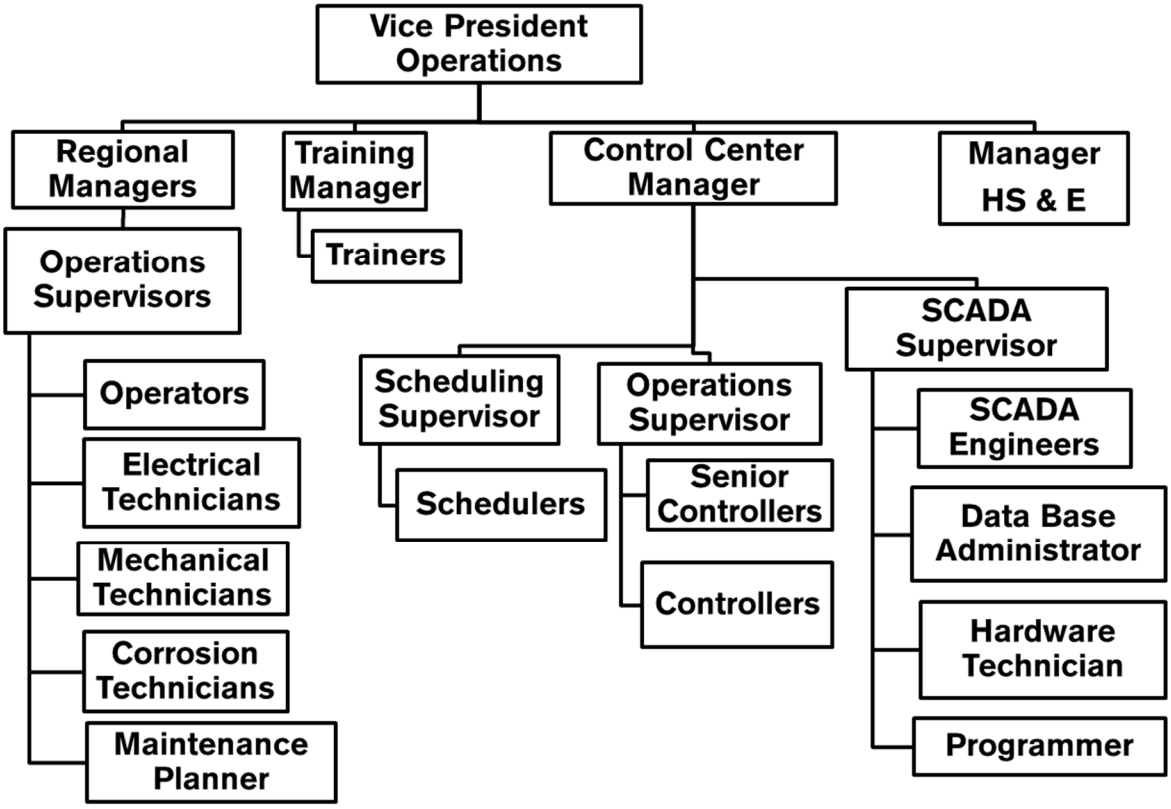

Figure 9. Potential operations startup organization. Courtesy Pipeline Knowledge & Development.

Typically the startup up organization has trainers, coaches and some additional positions which are phased out as the organization becomes proficient in operating and maintaining the pipeline.

Commissioning and Start Up

The final steps of the construction phase is filling the line and other facilities with crude oil and testing to ensure everything is ready safe, efficient, reliable, and environmentally and culturally responsible ongoing pipeline operations and maintenance. Special care is required during this stage as for the first time hazardous liquids are introduced into the pipeline. Commissioning and line filling is a time of transition as those who built the line pass it to those who will operate and maintain the line. This concentration of people, many of which have not worked on the line before, coupled with new equipment and newly introduced hazardous liquids creates a situation which required careful planning and coordination. At this point both the construction organization and the operations organization with their unique manage structures co-exist creating potential communication problems.

Pipeline Operations

When pipelines are owned by only one party, that party normally makes the long term business and strategic decisions, and also operates and maintains the pipeline. Since the operator is the same entity as the owner, no operating agreement is needed. The same company owns, operates, and maintains the pipeline. That company also receives the revenue and pays the expenses.

In the case of joint ventures, however, a management team or committee composed of one or more representatives from each of the owner companies normally manages the company's longer term business and strategic business issues, but then employs an entity (the operator) to manage short term tactical and day to day decisions and operate and maintain the pipeline. The operator may also manage various administrative and financial duties in support of operations and maintenance. In this case, an operating agreement is normally put in place to differentiate owner from operator duties.

As mentioned earlier, pipeline joint venture operators may be one of the owners, but often a separate company is formed to operate the pipeline. One of the main reasons for forming a separate company to operate is that if one of the owners is appointed the operator of the pipeline that owner may be tempted, by virtue of knowing shipper volumes and by virtue of their ability to schedule pipeline shipments and make other operating decisions, to use this information and operating control to gain a competitive advantage in the market place over the other owners.

The solution to this potential for competitive disadvantage is to form a separate, neutral, entity to operate the pipeline, thereby maintaining neutrality from the owners.

Operating Agreements

As mentioned earlier, the intent of pipeline operating agreements is to delegate the short term tactical decisions to the operator who also ensures day to day operations of the pipeline run smoothly while receiving strategic and long term guidance from the management team or

committee which is ultimately accountable for the performance of the asset. In addition to what might be called "boilerplate" terms and conditions normally found in legal agreements, operating agreements set forth the following:

- Compensation provided to the operator,
- Types of services provided,
- Service level quality and standards of performance,
- Decisions and approval levels,
- Division of costs,
- Term length and provisions for changing operators.

Compensation of the Operator

Pipeline operators typically are reimbursed for costs incurred and in addition they receive a small profit. The practice of an operator recovering its costs plus a small profit is employed for a number of reasons, including:

- It is very important that an operating company is a strong and well-motivated company, with the ability to recruit professional and highly experienced staff, maintain professional internal procedures, and utilize the latest technologies. The practice of an operator being sufficiently remunerated so as to have its costs covered plus a small profit goes a long way to ensuring that the operating company is capable and has sufficient resources to operate the pipeline for the entire period of the operating agreement.

- Given the time period over which operating agreements are typically in place, it is very difficult to predict with any certainty the costs that will be incurred by an operating company. The way in which to ensure that an operating company will be economically viable is to provide that its costs plus a reasonable profit will be covered.

- Since the operating company did not make the investment, they are not entitled to a return from it. And, rather than attempting to determine how much operating risk the operator was assuming and compensating them for that risk through a commensurate profit, it is easier for the owners to continue to carry the operating risk and simply reimburse the operator at cost with a small profit to maintain a going concern value.

Types of Service Provided

The types of service provided by pipeline operators, broadly speaking, include the following:

- **Providing Pre-Operation Services –** Activities required to design an organization structure including: determine reporting relationships between employees and knowledge and skills needed; recruit and hire the people to populate the structure; train the people to do their assigned jobs; prepare internal structures such as financial, HR, public relations, procurement, finance, accounting, and other support related procedures, plans, and manuals; prepare operations, maintenance, and asset integrity plans, procedures and manuals; prepare oil spill and other emergency response plans; and assist with the startup and commissioning of the system and related facilities.

- **Operating the Line and Related Facilities** – Activities required for the pipeline to physically fulfill its intended purpose, that is, to move the desired volumes from one point to another safely, reliably, efficiently and in an environmentally and socially responsible

manner. Examples include opening and closing valves, starting and stopping pumps, launching and receiving batching spheres and conducting volume measurements.

- **Maintaining the Pipeline and Related Facilities** – Activities required to collect data regarding the condition of the pipeline and related facilities, analyze that data, develop and implement plans to ensure the pipeline retains its capacity and condition, and implement those plans to prevent failures and finally, repair things when they fail. Examples include conducting pipe to soil cathodic readings, inspecting block valves, conducting internal line inspection activities, performing right-of-way surveillance, launching and receiving maintenance pigs, maintenance planning, replacing or repairing components, parts or equipment, prior to failure, and replacing components parts or equipment after they fail.
- **Scheduling and Dispatching Shipments** – This includes: activities required to receive nominations from shippers, developing and updating schedules as needed to meet changing shipper needs and reacting to changing line conditions. Central control room activities required to remotely operate the pipeline are sometimes also included in this category.
- **Managing External Stakeholder Relations** – Activities required to build trust and credibility, ensure amiable relations with landowners, governmental officials, and other interested parties, and comply with governmental laws and regulations. Examples of such activities include informing landowners regarding pipeline activities in advance of those activities, supporting local charitable causes with contributions of time and money, developing and reporting emissions levels to the proper authorities on a timely basis, and meeting with environmental and special cause groups to understand and address their concerns.
- **Managing the Administrative Affairs of the Company** – Activities required to accomplish the previously listed activities in a responsible financial manner and to manage the financial affairs of the pipeline and related facilities. Examples include preparing and monitoring annual and monthly operating expense, capital, major maintenance, and other budgets; procuring equipment and supplies and other items as needed; handling payables and receivables; processing payroll; and providing insurance and risk management.

Operating agreements normally include both operating and maintenance services. They are negotiated between the owners and the operators and contain detailed listings of the types of each service to be provided.

This listing of services is broad as the services required to operate petroleum pipelines are broad. This broad approach normally works well when the operators are reimbursed by the owner for providing these services. Therefore, the operator and owner are both similarly motivated, that is both want to have quality operations at the best value. When the motivations of the owner and operator are at odds, as in the case of when the operator is paid a flat fee regardless of its costs, there is clearly the potential for disagreements if an operator feels the owner is requiring too much in the way of services and is therefore either cutting into the operator's profits or causing the operator to incur a loss. Indeed, this case is a text book example of just such a disagreement.

The listing of services does however have limits. When services in addition to those normally expected are encountered, the operator and owner negotiate to agree how the operator will be compensated for the additional services. The key is that both the owner and operator must agree

to such services in advance, which means also agreeing on the cost of the services and how those costs will be compensated.

Service Level Quality and Standards of Performance

The service level and standards of performance language contained in pipeline operating agreements is normally quite broad, and requires the operator to operate the line in a prudent and workman like manner in accordance with the principles in the agreement and consistent with customary or generally accepted industry practices, codes and standards of the pipeline industry, and in compliance with all applicable rules and regulations of governmental authorities. Agreements may also require that all systems and processes be compliant with quality standards such as the International Standards Organization (ISO). A list of specific standards is often included in the agreement.

Decisions Which will be Made by the Operator and Owner

Delineating which decisions the operator can make without consulting the owner, and for which they must receive prior owner approval is an important operating agreement provision. Whether the operator can make an independent decision or must receive permission from the owner often depends, at least in part, on the way in which the operator is remunerated. The typical decision making process by category is listed in the following sections.

- **Normal Operating and Maintenance Costs –** Prior to the start of the year, the operator typically prepares an operating and maintenance budget and the owners have approval rights. Once approved by the owner, the operator is normally free to spend against the approved budgets provided the costs of the decisions are below a pre-agreed level (it being agreed that all of the operator's costs will be covered). Single expenditures above the pre-agreed level require owner approval as do individual expenditures which would cause total expenditures to exceed the approved budget. Operating agreements usually give the operator the right to make expenditures needed to respond to emergencies without prior owner approval, but the operator must inform the owners as soon as practical following the expenditure. Operators also have the right to make expenditures as required to maintain safe operations of the system and comply with applicable laws and regulations even if the owners withhold approval for those expenditures. Examples of normal operating and maintenance costs include fuel and power, pump, engine, and meter repairs, right of way surveillance, communications costs, internal line inspections, anomaly repair, and measurement duties just to name a few.

- **Personnel Hiring Decisions** – Some operating agreements require the operator to have their staffing plan or at least their total complement of positions approved by the owners and some do not. Regardless, operators normally have the right to make hiring decisions up to certain pay grade levels without receiving owner approval as long as those hiring decisions do not drive costs above the approved budget level. But, many operating agreements reserve to the owners the right to approve the specific people who are hired into certain key management positions. For example, when I was Chairman of the Board of Explorer Pipe Line Company, the president retired and I lead the search team to hire the new president. The person hired into that position required board approval, but none of the other positions did. Additionally, owners sometimes retain the right to second a limited

number of employees to fill key management and supervision roles for a period of time following startup of new lines.

- **Major Maintenance and Capital Projects** – In addition to the normal and routine operations and maintenance budgets, the operator is typically obliged by the operating agreement to prepare a budget for major projects – that is projects which individually will cost more than an agreed level of expenditure. The major maintenance budget includes single large maintenance projects which will cost more than an amount specified in the operating agreement, and the capital projects budget includes single large projects which will cost more than an amount specified in the operating agreement. Once the major maintenance and capital budgets are approved, the operator is entitled to operate according to the approved budget as long as the total projected costs remain below the approved level. Prior to exceeding these levels, the operator must receive approval from the owner for the higher level of expenditures. For maintenance or capital projects which increase the cost of operations to the operator, the operator would receive reimbursement of that additional cost through the payment mechanisms in the operating agreement. For example, the operator might be reimbursed under the operating agreement on a cost plus profit basis, or reimbursement might be pursuant to an agreed and then fixed annual budget regime for certain costs, which would be adjusted as needed**.**
- **Administrative and Other Decisions** – In addition to simply operating and maintaining the pipeline and related facilities, operators frequently perform administrative duties such as providing accounting services, processing receipt and delivery tickets and invoicing shippers, purchasing insurance, managing cash, producing payrolls, setting claims, interfacing with governmental agencies, and filing taxes. Operating agreements typically prescribe the level of authority and decision making power; the operator is delegated by the owners for each of these tasks. Owners remain responsible for making those decisions not delegated to the operator and typically the remuneration regime will allow for the operator to be compensated for any additional cost of operations (with appropriate profit) or addition or variation to the facilities or the services.

Division of Costs

Operating agreements provide for how the costs of:

- pre-operation services,
- operating the pipeline and related facilities,
- fuel and power,
- maintaining the pipeline and related facilities,
- scheduling and dispatching shipments,
- managing external stakeholder relations, and
- managing the administrative affairs of the company,

are charged to the owners.

Pre-operations services, operating the pipeline and related facilities, and maintaining the pipeline and related facilities, are typically charged directly to the owners at actual costs. Pre-operation services are a special case as they only happen once in the life of a pipeline. Consequently, while

the treatment of pre-operations costs may be included in the operating agreement, sometimes they are covered in a separate agreement.

How costs will be handled for the major maintenance and capital projects discussed above as well as any infrequent, additional, or varied services or capital expenditures is agreed as part of the budgeting process.

Fuel and power, which is categorized as a variable cost, is typically charged directly to the owners at cost.

Scheduling and dispatching shipments, managing external stakeholder relations, and managing the administrative affairs of the company are usually either passed through to the owner directly as a cost (and as a part of the annual budget) or provided by the operator for a fixed fee, which is typically a lump sum either established annually or at the outset of the operating agreement's term, and then escalated based on an agreed inflation factor. Whether these items are passed through directly as a cost or provided on a lump sum basis will often be driven by whether the entity operating the pipeline is dedicated to operating only one specific pipeline and therefore all cost can be identified directly to that pipeline or operates several different pipelines from the same control center and with the same administrative staff.

When administrative head office costs are passed through directly, no escalation factors are needed. When the administrative or head office services are priced on a lump sum basis as mentioned above, the lump sum charge is typically inflated based on an agreed factor such as an amount equal to the average percentage wage increase granted to their people by the operator, or some other escalation factor reflecting the rise in overall local salary levels

Compensation Provided to the Operator

As explained in the previous section, direct operations and maintenance costs, and fuel costs are typically compensated or remunerated directly based on costs incurred. Overhead, or general and administrative expenses might be charged at levels agreed annually during the budget preparation process and might or might not include a profit component. The method of compensating the operator for providing unexpected or infrequent services is normally agreed in advance of providing the service, except that justification and approval for emergency expenditures or those required for safety and environmental reasons are normally not required in advance.

When one of the owners serves as the operator, profit levels are not normally agreed or listed separately, rather they are included as part of the overhead fee. When the operator is a company set up specifically by the owners to operate the pipeline, the company may earn a profit but the profit is paid back to the owners in the form of dividends or distributions.

Term Length and Provisions for Changing Operators

The term of operating agreements is typically between 5 and 20 years. Most pipeline operating agreements contain provisions for automatic extension of the term and contain provisions which allow the owners to remove the operator under specified conditions such as insolvency or negligence. The operator is also allowed to resign and the agreement provides for how the successor operator will be chosen and how the transition will occur.

Risk Sharing Among the Owner, Operator, and Customers

For crude pipelines, the owner normally carries the risk. The operator normally is reimbursed for expenses and is paid a small profit and the shipper normally ships at an agreed rate.

Ongoing Operations and Maintenance

The ongoing goal of the pipeline operator is safe, efficient, reliable and environmentally sound operations and maintenance of the pipeline and related facilities. Each pipeline is different and the most effective organization depends on the people involved. Figures 10 show a typical pipeline organization designed for ongoing operations and maintenance. It should be used as a guide and the actual organization will likely vary.

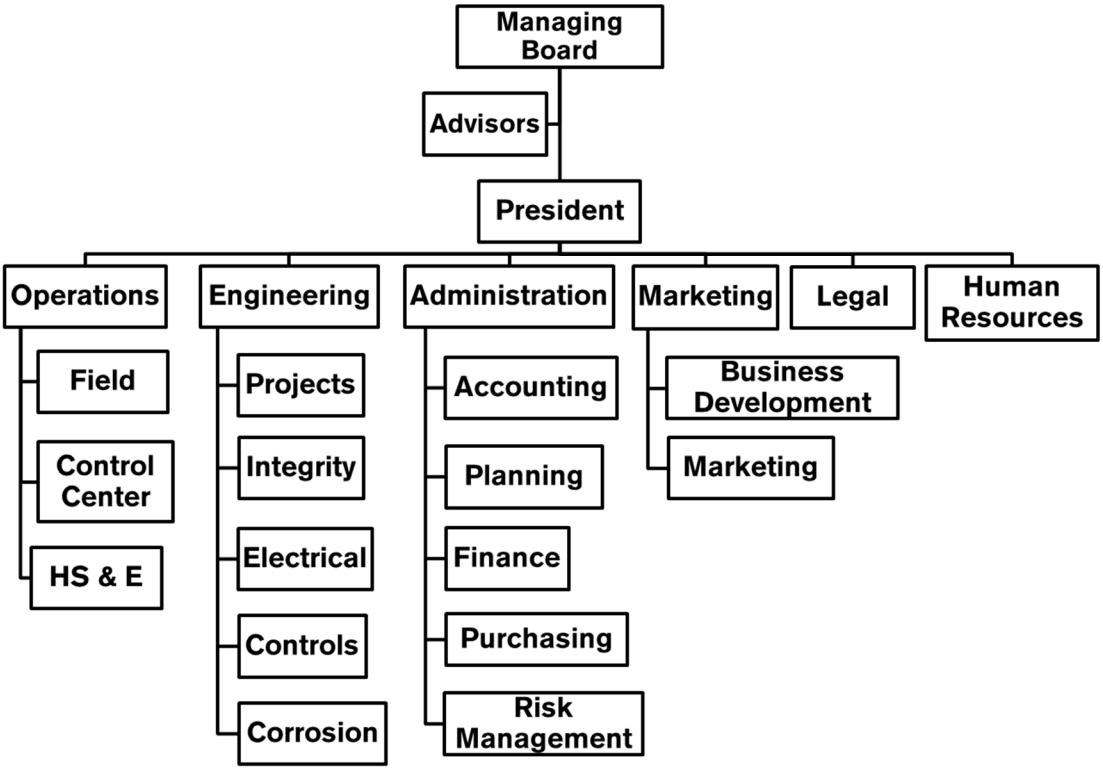

Figure 10. Post startup pipeline organization. Courtesy Pipeline Knowledge & Development.

Operations

Broadly speaking, operations causes the pipeline to function such that it performs its intended purpose and is divided into the following:

- Field operations, those conducted along or near the pipeline's route and may include the following activities:
    - Line Control
        - Starting and stopping the entire line
        - Changing flow rates
        - Starting, stopping or diverting flow
        - Optimizing line operations
- Measurement and Testing

    - Flows and quantities
    - Quality
- Indirect Operating Tasks
    - Healthy, Safety, and Environmental
    - Education of and relations with the various publics
    - Emergency response preparation and training
- Control room operations, those conducted at limited numbers of locations remote from the pipeline. Central control room operations consist of many of the same activities as field operations but are staffed around the clock and provide these functions for the entire system rather than for just one location.

Figure 11 shows a typical operations organization.

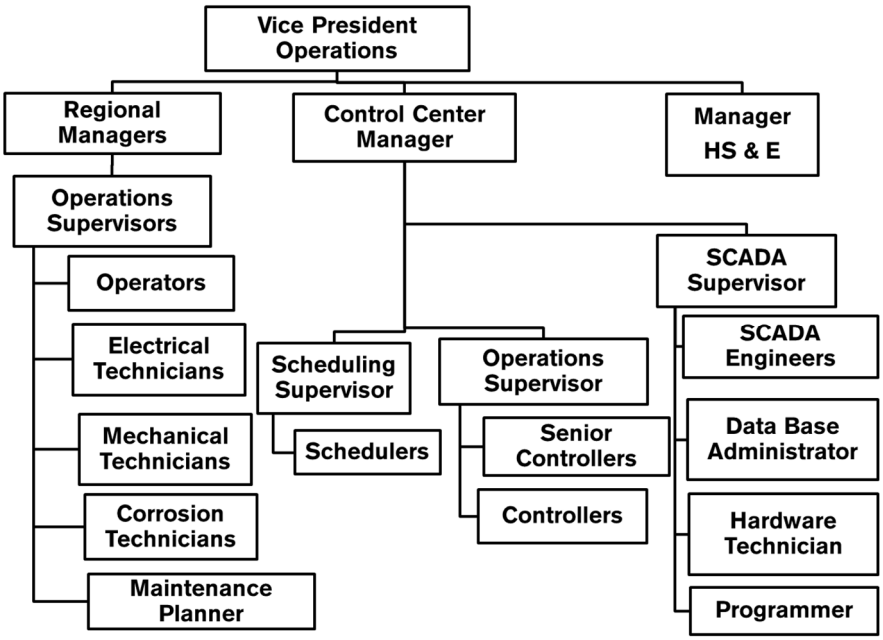

Figure 11. Post startup pipeline operations organization. Courtesy Pipeline Knowledge & Development.

Maintenance

The maintenance function is responsible for keeping the pipeline in sound operating condition at its current capacity. Some maintenance activities such as planning are conducted remote from the pipeline but most maintenance activities are conducted along the route

Figure 12 shows a typical maintenance organization.

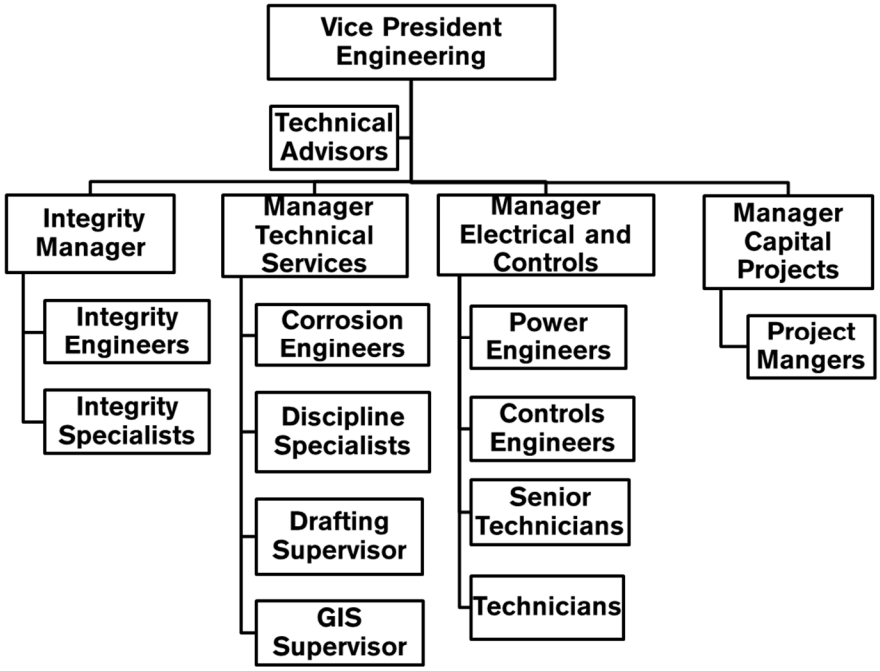

Figure 12. Post startup pipeline engineering organization. Courtesy Pipeline Knowledge & Development.

Integrity Management

Maintaining the pipeline is sometimes also referred to as integrity management and involves the following broad activities:

- Understanding the condition of the asset through testing and inspection,
- Predicting, based on data and scenarios the potential for failures,
- Taking actions to prevent failures, and
- Repairing and returning to pipeline and facilities to operating conditions and capacity if a failure occurs.

In actual practice, operation and maintenance functions are frequently

Equipment Maintenance

The equipment located at pipeline facilities, pumps, valves, motors, engines, meters, instrumentation, controls and so forth is very similar if not exactly the same as these same items located at refineries, power plants, and other heavy industrial settings and is maintained in much the same way. This is through preventative maintenance checks, condition monitoring and repairs and replacement as needed. As a consequence, hiring maintenance staff from these types of installations and training them about the unique aspects of pipelines is a common approach when trained pipeline maintenance staff are not available in the local.

Decommissioning

Finally, at the end of their useful life pipelines must be decommissioned. This can range anywhere from emptying them and abandoning them it place to completely removing all pipelines and the

associated stations and equipment and returning the route and stations sites as nearly as practical to the original condition of the land.

From a practical standpoint, most crude oil pipelines remain in useful service for so many years the cost of commissioning does not have a material effect on the pipeline returns calculated during the development phase. That is, unless the pipeline company is required to escrow funds upon project commencement for eventual decommissioning.

Tariff Considerations

Tariffs are generally separated into two categories, rates and rules and regulations. Rates or tolls are the charge per barrel, tonne, or cubic meter the pipeline charges for moving the volumes and the rules and regulations set forth how the pipeline will provide services. Some pipelines are private and do not publically disclose their rates or rules and regulations. Rather they pipeline negotiated with shippers to establish the rates and how the shipper will be treated. In some countries rates and rules and regulations are highly regulated. In others they are not.

Rates

Some counties regulate the rate pipeline companies can charge there shippers. Since pipelines are more efficient, safer, more reliable, and a better environmental solution than other forms of crude oil transportation pipeline companies could, if allowed, price their services just below the transportation alternative (as long as they faced no pipeline transportation) and provide an very attractive return for their owners. When no or limited pipeline transportation exists for a specific movement regulatory governments often limit the rate which can be charged. Cost of Service (COS) is the regulatory theory most commonly employed.

The cost of service theory of rate making is based on the philosophy that the entity should be allowed to recover its reasonably incurred costs plus earn a return on its investment while its money is invested.

The equations for establishing required (or allowed) revenue are quite straightforward:

Rate Base x Overall Rate of Return = Return

Return + Operation & Maintenance Expenses + Administrative & General Expenses + Depreciation Expense + Taxes (income and non-income) - Revenue Credits = Revenue Required

Revenue Required / Units = Rate per Unit

But the many details which go into these numbers mean that COS calculations are often detailed and complex.

A brief definition of each component follows.

Rate Base

Establishing the rate base on which to calculate the return involves the following equations:

Gross Plant - Accumulated Depreciation = Net Plant

Net Plant - Accumulated Deferred Income Taxes + Working Capital = Rate Base

Gross plant normally includes an Allowance For Funds Used During Construction (AFUDC). Assuming an ongoing venture with continuing investments accumulated deferred taxes is subtracted from the rate base. In the event investments decline and tax deprecation falls below financial depreciation, the accumulated deferred income taxes account will begin to fall. Rate bases are established on either a Depreciated Original Cost (DOC) or a Trended Original Cost (TOC).

Overall Rate of Return

Three components enter into determining the overall rate of return;

- capital structure
- cost of debt
- allowed rate of return on preferred and common equity

Capital structure is intended to reflect the debt/equity ratio of the entity owning the pipeline. Conceptually, the cost of debt should be recovered (with no return) and a risk adjusted return should be earned on the equity portion. Differences in the legal entity owning the pipeline and the legal entity incurring the debt, for example a pipeline company with no debt, owned by another entity which carries the debt, has driven the FERC to look through corporate structures when determining the appropriate debt/equity for the calculations.

Ideally, the cost of debt is the weighted average cost of all the long term debt issued and the cost at which it was issued. For new pipelines which have not yet issued debt but intend to do so, assumptions are made based on recent history and future projections of debt costs. The cost of equity component of a pipeline's rates determines the return on investment that the pipeline is allowed. Unless the pipeline and its customers agree upon a different method, rate of return is decided by the FERC using a FERC-prescribed Discounted Cash Flow analysis using a FERC-selected proxy group of pipeline companies.

Operations and Maintenance Expenses

Accounting standards determine how expenses are classified (i.e., fixed or variable). For COS purpose, projected operations and maintenance expenses can be recovered if they are recurring, known and measurable. Because operations and maintenance expenses can be associated with specific facilities, these costs can be directly assigned to pipeline services for cost allocation / rate design purposes.

Administrative and General Expense

Usually thought of as "overhead" expenses, these expenses may not be directly attributable to any particular facility or company. Rather they are incurred at the corporate level or by a subsidiary or head office group performing work on behalf of a group of pipelines. They are normally allocated among the various companies or facilities for which the work is performed

Depreciation Expenses

These expenses are considered a return of the investment over the useful life of the asset. Established by depreciation studies, the depreciable lives of transmission and storage plant are normally in the range of 20 to 25 years.

Taxes

Taxes on the equity portion of the return are calculated and added to the total cost of service. (Tax on the debt component is not, as it is an allowed tax deduction already.) Since the equity portion of AFUDC is included in gross plant, it is depreciated. Other taxes, such as payroll and property taxes, are added in to the total.

Revenue Credits

These reductions to the Cost of Service allowed revenue recognize regulated assets may generate income from sources other than moving or storing gas. Usually quite small in the overall calculation, revenue credits can arise from leasing out excess land, collecting penalties from violating excess flow orders, or selling extracted liquids.

Terms of Service

Common carrier pipelines are required to provide service to all customers who can meet their access and delivery requirements (and other requirements such as credit worthiness and the like). The access requirements are set out in the Rules and Regulations filed by the pipeline company with the regulator and include items such as the following:

- Delivery rates and pressures
- Receipt and delivery locations
- Product specifications
- Minimum batch size
- Minimum delivery size

Pipeline company rules and regulations also deal with items such as how the pipeline allocates their available capacity in case more shippers want to move volumes that the pipeline can handle.