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Subsurface Saltwater Injection and Disposal

Book Three
of the
Vocational Training Series

Third Edition,

October 1995

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Subsurface Saltwater Injection and Disposal



Exploration and Production Department

Book Three
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FOREWORD

The underground injection of water, whether into waterfloods or disposal systems, is an integral portion of the cost of producing oil. The magnitude of this cost has increased because more water is being produced as:

- More reservoirs are nearing completion.
- Wells are being produced to higher water-cut due to the demand for oil.
- Many older waterfloods are being expanded and new ones started in order to recover once marginal reserves.

The expense of injecting larger volumes of produced water is further compounded by the rapid rise in the cost of energy needed to inject this water and the increasingly higher costs of measures needed to protect the environment.

The objective of this manual is to provide information for field operating personnel on the systems, methods and practices to most economically operate an underground injection program while maintaining the schedules and volumes required.

The manual is written to help the overseer of the system solve many of the problems associated with underground water injection. Its intent is to provide the reader with information regarding the following:

a. Suitable design of the injection system including wells, lines and surface facilities.
b. Regulations and other restrictions related to subsurface water injection.
c. Measures to be taken to protect life, property and the public interest.
d. Factors which affect injection cost.

The material in this manual is of a basic, cursory, and introductory nature. The reader should consult technical experts for more detailed information on specific items of interest.

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Subsurface Saltwater Injection and Disposal

SECTION 1—INTRODUCTION TO SALTWATER INJECTION

1.1 Introduction

Deep beneath the surface of the earth lie layers of soil containing the oil and gas used to fuel our world. Unfortunately for oil and gas producers, water is also found in those very same formations. Since technology has developed no effective method to date for selectively producing hydrocarbons only, this water, known as produced water or brine, is produced with the oil or gas, and separated at the surface.

Sometimes the water is fresh. In those cases, many options are available for its management when it reaches the surface and is separated from the oil. However, in other cases, the water is very saline.

With rare exceptions, only four acceptable methods exist for saltwater management:

a. Injection into underground saltwater-bearing formations.
b. Injection into oil-bearing underground reservoirs.
c. Disposal of carefully treated water into the ocean in the case of offshore production platforms.
d. Beneficial use.

This manual discusses options (a) and (b)—injection into deep wells for disposal or for enhanced product recovery. It presents minimum guidelines covering well construction, operation and monitoring.

1.2 Referenced Publications

The following bulletins, recommended practices, and codes are cited in this publication.

API

Bull E2 *Bulletin on Management of Naturally Occurring Radioactive Materials (NORM) in Oil and Gas Production*

Bull E3 *Well Abandonment and Inactive Well Practices for U.S. Exploration and Production Operations*

Bull D16D *Suggested Procedure for Development of Spill Prevention Control and Countermeasure Plans*

RP 55 *Recommended Practices for Conducting Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulfide*

Environmental Guidance Document: Onshore Solid Waste Management in Exploration and Production Operations

OSHA[1]

29 *Code of Federal Regulations* Part 1910:1200

NACE[2]

TM0194-94 *Field Monitoring of Bacteria Growth in Oilfield Systems* (1994)

1.3 Disposal Versus Enhanced Recovery

The primary difference between injection wells used for disposal and those used for enhanced recovery is the purpose each serves.

■ The disposal well is used for the subsurface disposal of unwanted salt water. In many cases, only one disposal well serves a field or system. Suitable formations for disposal may include depleted oil reservoirs and portions of oil-producing reservoirs' down dip from the water-oil contact.

■ The enhanced recovery well is used for the subsurface injection of water into an oil-bearing formation to displace movable oil toward producing wells. The enhanced recovery well is usually part of a pattern of several injection wells serving an enhanced recovery project.

Unless otherwise noted, in this manual the term *injection well* will be used to refer to either type. The more specific terms *disposal well* or *enhanced recovery well* will be used when discussing issues particular to one or the other. Both types of wells have a common objective—to furnish an avenue, or well bore, for the subsurface management of salt water. Because of this common objective, most completion and operational practices fit both.

■ The salt water is injected through a cased and cemented well to protect other underground reservoirs, especially those containing potable ground water.

■ If the project is to be installed and operated at minimum cost, the best materials for distribution lines must be selected.

■ Planning of an injection system may include a water treatment program that will control corrosion of the piping system and prevent plugging of the injection formation. Careful selection of plant equipment and treating facilities is important.

■ Injection well permits are required from the U.S. Environmental Protection Agency (EPA) or the applicable state regulatory agency. The wells must be designed, constructed, and operated in accordance with regulatory requirements.

[1]OSHA, *The Code of Federal Regulations* is avilable from the U.S. Government Printing Office, Washington, D.C. 20402.
[2]NACE, P.O. Box 218340, Houston, Texas 77218.

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However, some differences exist.

- There are more injection wells in an enhanced recovery project than in a disposal project.
- The volume of water to be used for enhanced recovery is selected for each well; with disposal, however, whatever water is produced must be managed. Injection volume in a disposal well is limited only by permit condition or the injectivity of the well.
- In enhanced recovery projects, the formation and its properties are already known from production history. For disposal, this is not always true. It may be necessary to select the best formation from information that must be gathered.
- Enhanced recovery systems generally require much longer surface lines to distribute the water to the injection wells than those for a disposal system.

Installation and operation of a saltwater system are expensive. Careful planning is mandatory before beginning construction to allow time for the following:

a. Designing the system.
b. Notifying the offset operator.
c. Planning safety, environmental and health considerations.
d. Selecting materials and equipment.
e. Securing required environmental and operational permits.
f. Scheduling possible hearings before state and federal regulatory bodies.

1.4 Components of an Injection System

Whether for enhanced recovery or disposal, the basic components of the injection system are the same. These include the following:

a. A gathering system to move the salt water from each tank battery or watersource well to the treating and injection facilities.
b. Water treatment facilities to remove oil or other impurities that might impact the system or the injection formation.
c. Injection facilities, including storage tanks, pumps, piping, and the well itself.

This section provides a brief overview of the various system components, some initial planning considerations, and a discussion of environmental, health and safety concerns associated with injection well facilities.

1.4.1 GATHERING SYSTEM

The gathering system is a network of pipelines that moves salt water from the tank battery or watersource well to a collection center or treating plant. Where possible, gravity flow is utilized, however, pumping is usually required. The following must be considered for the gathering system:

a. Pipe and pump sizes and types.
b. Installation of the pipelines.
c. Collection center equipment.
d. Metering equipment.
e. Inspection and maintenance of the system.

Additional information on the gathering system is provided in Section 2.

1.4.2 WATER TREATMENT FACILITIES

Although preliminary separation of salt water from other components (oil, solids, and the like) begins at the tank battery, additional treatment is often required prior to injection to protect the surface facilities, the well, and/or the formation. Additionally, further product recovery can occur. Various types of treatment may be necessary, depending upon the types of contaminants to be removed. Some of the most common include the following:

a. Skimmers or coalescers to remove oil.
b. Filters to remove solids.
c. Chemical treatment to remove or control scales and sludges, or kill bacteria.
d. Stripping to remove oxygen.

It is necessary to determine which types of treatment might be required so that proper facilities can be planned and designed. This may require sampling the water or deposits. The saltwater contaminants and the treatment methods are discussed further in Section 3.

1.4.3 INJECTION FACILITIES

Once the salt water has been moved to the central facility and treated, it is ready for injection. Pumps are used to move the salt water down the well and into the injection formation. Equipment should be selected that is resistant to corrosion, and sized properly to ensure optimum injection rates and pressures. Additional information on the injection facilities can be found in Section 4.

1.5 Environmental Concerns

As with other oil and gas operations, protection of the environment is a primary concern when managing produced water, especially that which is saline.

- All injection activity must be designed, operated, monitored, maintained, and plugged and abandoned to prevent produced fluid from moving into or between underground sources of drinking water (USDWs). Monitoring and mechanical integrity testing will help to demonstrate that there is no unwanted fluid movement.
- The surface equipment—pipes, pumps, storage tanks, and the like—also should be designed to prevent leaks or spills of the materials they hold, and to minimize emissions to the air.
- Proper management includes routine well inspection and repair, monitoring, and cleanup.

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■ In emergency situations, such as breakdown of disposal facilities, temporary storage of salt water in lined surface pits may be allowed. However, applicable regulatory agencies should be consulted before constructing such emergency facilities. Tanks are the preferred means of providing emergency storage.
■ It should be stressed that failure to comply with appropriate regulations for salt water disposal or injection can result in fines and orders to cease production entirely, until the operation is in regulatory compliance.

This section provides an overview of some of the environmental regulations that impact saltwater injection. In general the following should be considered:

■ Governmental regulatory requirements must be met by the operator for drilling, completion, and operation of injection or disposal wells;
■ These regulations include such topics as spill response and reporting, waste disposal, hazardous chemicals inventory, and the protection of drinking or potable water; and
■ The operator must be acquainted with the regulations of all governing bodies having jurisdiction over the injection system and operate within the framework of government regulations.

Some of the regulatory bodies that could have jurisdiction are the following agencies and departments:

a. Department of Interior (DOI), including:
   1. Bureau of Fish and Wildlife (BFW).
   2. Bureau of Indian Affairs (BIA).
   3. Bureau of Land Management (BLM).
   4. U.S. Geological Survey (USGS).
b. Environmental Protection Agency (EPA).
c. Municipalities.
d. Occupational Safety and Health Administration (OSHA).
e. State Boards of Health.
f. State Highway Departments.
g. State Parks and Wildlife Departments.
h. State Oil and Gas Commissions.
i. State Water Districts.
j. State Water Quality Boards.
k. U.S. Army Corps of Engineers (US ACE).

An injection well or disposal well with the desirable characteristics outlined in this section should have little trouble meeting the requirements of these regulatory bodies.

1.5.1 UNDERGROUND INJECTION CONTROL (UIC)

Salt water can be very damaging to soil and ground water environments if not managed correctly. All surface facilities and the injection well must be designed to prevent spills and leaks of salt water. The EPA and states have specific regulations for Underground Injection Control (UIC) that address the construction and operating requirements for injection wells. UIC regulations are promulgated under the authority of the Safe Drinking Water Act (SDWA). These regulations are designed to prevent endangerment of USDWs.

Under state and federal regulations, there are five classes of injection wells. Those used to manage fluids produced from oil and gas subsurface reservoirs are Class II injection wells. The following is the EPA definition of a Class II well.

Class II Injection Wells are wells which inject fluids:

a. Which are brought to the surface in connection with natural gas storage operations, or conventional oil or natural gas production and may be commingled with waste waters from gas plants, which are an integral part of production operations, unless those waters are classified as hazardous waste at the time of injection.
b. For enhanced recovery of oil or natural gas.
c. For storage of hydrocarbons which are liquid at standard temperature and pressure.

The *Environmental Guidance Document: Onshore Solid Waste Management in Exploration and Production Operations* contains information on the UIC program, and is available from the API Publications Department.

In most states, the state regulatory agency has jurisdiction over the UIC program. In these states, the oil and gas agency usually approves UIC Class II permits. Applications for permits are heard before the regulatory bodies in some states and handled by correspondence in others.

The EPA issues injection well permits in states that have not obtained authority to operate the UIC program. Additionally, production on Indian Lands will require permits from one or more federal agencies.

A broad range of issues is addressed in a permit for a new injection well, including the following:

a. Siting.
b. Design.
c. Operating parameters.
d. Corrective action.
e. Mechanical integrity demonstrations.
f. Plugging and abandoning.
g. Financial responsibility.

Each of these factors must be addressed in the UIC permit application. All or some of the following information is generally required in the application:

a. Location of well.
b. Name, depth, and thickness of subsurface formation to be used for disposal or enhanced recovery purposes.
c. Size, weight, and depth of all casing strings in the well; amount of cement behind casing.
d. Approximate amount of water to be injected.
e. Expected wellhead pressures.

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f. Well log, if available.
g. Depth of USDWs (<10,000 mg/l total dissolved solids) or usable water (<3000 mg/l total dissolved solids) in some states such as Texas and California.
h. Name, mailing address, and location of the well operator.
i. Approximate Standard Industrial Classification (SIC) codes.
j. Operator's name, address, and telephone number.
k. Topographic map showing a 1-mile radius around the facility, including Treatment Storage or Disposal Facilities (TSDFs), oil and gas wells, injection wells, surface water bodies, and drinking water wells.
l. Name and address of all landowners within 1/4 mile of injection well being permitted.

Additional information may be necessary for wells on Indian Lands.

It is important to note that, although produced water is the largest component of volume injected into Class II wells, other fluids may be allowed. A complete list of those fluids intended for injection must be included in the permit application. If a fluid is not included in the application, and therefore not approved by the permit, it cannot be injected.

The regulatory authority must review and approve the application before construction begins on a new injection well. It should be contacted well in advance of construction of the well so that the proper forms can be obtained and enough time allowed to obtain the permit. No construction or revisions can begin until the permit is approved.

Based upon information presented in the permit application and other available data or testimony, the regulatory agency must determine that the disposal of salt water as intended will not damage USDWs, or oil and gas reservoirs. If there are any objections from offset operators that cannot be settled by the operators, they are usually heard and settled before the state regulatory body.

Technical and legal assistance may be needed to secure the necessary permits from landowners, royalty owners, state and federal regulatory agencies, and to obtain rights-of-way. A simple contract is the most common instrument of agreement used between the operator and land or royalty owners.

1.5.2 AIR POLLUTION CONCERNS

Much attention focuses on emissions of air pollutants, especially volatile organic compounds (VOCs). Benzene, ethylbenzene, toluene and xylene (BETX) are those VOCs most likely to be emitted at oil and gas operations. Other common pollutants that might be generated at injection facilities include nitrogen oxides, sulfur dioxides, and carbon monoxide from fuel consumption to run generators, compressors, and the like. Hydrogen sulfide (H_2S) may also be present.

- Both the EPA and many state agencies regulate air emissions; sometimes permits are required.
- As with UIC permits, those required under the air programs should be obtained prior to construction and operation.

1.5.3 WASTE MANAGEMENT—HAZARDOUS MATERIALS

Wastes generated from operation and maintenance activities must be properly managed to protect human health and the environment, and to ensure compliance with federal, state, and local laws and regulations.

- Some wastes, such as some solvents, or wastes containing heavy metals, may be considered hazardous. While all wastes should be properly handled, hazardous wastes require extra care.
- Be sure to evaluate waste generation activities associated with the injection facility, and ensure proper management of all wastes.

1.5.4 SPILLS

Salt water can be especially damaging to soils, surface water, plants, fish and other wildlife. It is very important to design and operate the injection facilities to minimize the likelihood of leaks and spills.

- Due to its corrosive nature, salt water should be stored in metal tanks that are internally coated, or in fiberglass tanks.
- Steel pipes should be protected from external corrosion by coating and/or cathodic protection, and from internal corrosion by coating and/or chemical inhibition.
- Routine inspections should be made to look for potential problem areas.

If oil is stored at the site, the Spill Prevention Control and Countermeasures (SPCC) regulations may apply. If so, secondary containment around the oil storage vessels may be required; special precautions to prevent oil spills will be necessary; and a facility SPCC plan will have to be prepared.

API Bulletin D16, *Suggested Procedures for Development of Spill Prevention Control and Countermeasure Plans* contains information on SPCC plans and is available from the API Publications Department.

Spills of salt water, oil, and a variety of chemicals may need to be reported to the environmental agencies. Spill reporting requirements for the area where the injection facility is located should be researched to ensure proper and prompt reporting when required.

1.5.5 HAZARDOUS CHEMICALS INVENTORY

Certain hazardous chemicals can present a potential threat to the public. To help local authorities plan for emergency situations, companies must submit copies of their Material Safety Data Sheets (MSDSs) or a list of these materials to the local fire department and other emergency groups. If

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addition, an annual inventory report must be submitted providing the following information:

a. The maximum amount of chemicals present at the facility during the preceding year.
b. An estimate of the average daily amount of chemicals.
c. The general location of the hazardous chemicals.

The chemicals in the list and inventory may, at the discretion of state and local authorities, be reported by categories. Chemicals found at injection well facilities may be regulated.

1.5.6 NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)

NORM, low-level radioactive material, is naturally present in some formations where oil and gas are found. Generally, it is found in produced water, produced sand, and in scales formed inside production equipment, such as during pipe clean-out operations. NORM must be handled properly to ensure protection of human health and the environment. Health issues are discussed in 1.6.

Some states have regulations that govern NORM management and disposal, while other states do not. You should be aware of the NORM requirements for your state, and ensure that you are managing it accordingly. API Bulletin E2, *Bulletin on Management of Naturally Occurring Radioactive Materials (NORM) in Oil and Gas Production* contains information on management of NORM and is available from the API Publications Department.

1.5.7 OTHER ENVIRONMENTAL CONCERNS

There may be other EPA and state requirements that may have an impact on the design and operation of the injection facilities. Furthermore, other agencies, such as the Bureau of Land Management, Fish and Wildlife, and others, may impose additional requirements.

It is up to the operator to research these requirements and ensure compliance. If your company does not haven an environmental staff, other resources can help with environmental compliance issues. These include the following:

a. Regulatory agencies.
b. Oil and gas associations, such as the API or the Independent Producers Association of America (IPAA).
c. Other operators in the area.
d. Environmental consultants.

1.6 Health and Safety Concerns

As with any industrial-type activity, there are health and safety concerns associated with injection wells. Obviously, safety protection is important. Standard safety equipment, such as safety glasses, hard hats, and safety shoes, should be considered for any facility. Additional personal protective equipment (PPE) may be necessary for special conditions.

Additionally, Occupational Safety and Health Administration (OSHA) regulations require certain health and safety precautions in industrial settings. This section presents an overall discussion of safety concerns associated with injection facilities. Specific precautions are noted in other sections where appropriate.

1.6.1 CHEMICAL EXPOSURE

A variety of chemicals might be encountered around injection facilities. These might be chemicals normally present in the crude or produced water, or chemicals that have been purchased for water treatment. Regardless of the origin, employees should be made aware of the hazards they might encounter.

■ The Occupational Safety and Health Administration (OSHA) requires that employees be informed of hazards they might encounter in the work place. This Hazard Communication program, commonly referred to as HazCom, is designed to ensure that employees have all the information necessary to ensure proper and safe handling of hazardous chemicals.

■ In addition to the training requirements, employers are required to obtain Material Safety Data Sheets (MSDSs) for any chemicals being purchased for use at the facility. The MSDSs provide specific hazard information about the product along with precautions to take when handling the chemical.

MSDSs must be readily available to employees, and should be reviewed to assure safe chemical usage before work with the selected chemicals begins.

■ More information about the HazCom requirements can be found in Title 29 *Code of Federal Regulations* (*CFR*) 1910.1200 or from your safety representative.

■ In addition to the HazCom requirements, employers are required to ensure that proper personal protective equipment (PPE) is available to the employees. Basic PPE that might be required at most work sites includes safety glasses, hard hats, gloves and safety shoes. Other personal protective equipment may include impermeable gloves, aprons, suits and boots, face shields, goggles, and respirators. The MSDSs will provide information on the proper PPE to be used with the product.

1.6.2 CHEMICALS AT INJECTION FACILITIES

1.6.2.1 Benzene

Some crude oils contain significant quantities of benzene, a highly toxic, cancer-causing chemical. At any location where outgassing of benzene vapors may occur, special precautions should be taken to prevent employee overexposure. These might include the following:

a. Measuring benzene concentrations.
b. Utilizing appropriate personal protective equipment.

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The concentration of benzene in crude oil is higher than the concentration in produced water.

1.6.2.1 Hydrogen Sulfide

Hydrogen sulfide (H_2S) is also present in some injection systems. H_2S is sometimes present in the formation (sour operations), or it may be introduced into the system by chemical reactions that might occur. H_2S is a very dangerous and potentially deadly gas which at some concentrations smells like rotten eggs. However, at higher concentrations, it is undetectable by smell. Therefore, it is very important to use instruments to detect H_2S rather than depend upon sense of smell.

- H_2S may be found around surface equipment where leaks may occur, and in unventilated or poorly ventilated areas such as pump houses. Signs that indicate such a hazard should be on entrances to such areas.
- H_2S may accumulate in tank vapors at much higher concentrations than are present elsewhere in the system. Special precautions should be taken when working in and around tanks.
- Additionally, special air monitoring systems that indicate excessive levels of H_2S should be provided in such areas.
- Where H_2S is present in concentrations above 10 ppm, respirators are required. Employees who are potentially exposed to excessive quantities of H_2S must receive specialized training. Contact your safety representative for PPE and training requirements.

API RP 55, *Recommended Practices for Conducting Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulfide* contains information on H_2S and is available from the API Publications Department.

1.6.3 OTHER CHEMICALS

1.6.3.1 Acids

Acids are strongly reactive chemicals that are useful for many purposes.

- Acids may be used for pH adjustment or for treating the well to increase injectivity.
- They are corrosive to tissues, like the skin and eye.
- Furthermore, they can react with chemicals in the water to produce H_2S (see precautions in 1.6.2.1).

1.6.3.1 Organic Chemicals

Many organic chemicals, like benzene, are hazardous. MSDSs should be consulted for proper handling and PPE requirements.

- Solvents may be used for treating the formation. These may present an employee exposure hazard from inhalation of vapors or by skin absorption of the liquid.
- Plastic pipe glues and cements may also present an inhalation hazard.
- Chemicals used to kill bacteria and algae in the system contain amines, aldehydes, and quaternary ammonium derivatives. These chemicals are highly toxic to humans and appropriate PPE must be provided to employees who handle such bactericides and bacteriostats.

1.6.4 ASBESTOS

Asbestos is considered a hazardous chemical under the OSHA regulations as it can cause cancer and respiratory disease. Its management is strictly regulated.

- Asbestos insulation may be present at older facilities.
- Asbestos pipe may also be found.
- Asbestos particles may become airborne during handling of pipe if it is deteriorated to the point of being friable (crumbles easily), or if sawing, chipping or cutting occurs.
- Care must be taken to prevent employee exposure to asbestos dust, and the need for appropriate asbestos handling should be evaluated.
- Only certified workers should remove asbestos.

1.6.5 NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)

Certain materials in the earth's crust are radioactive. NORM, brought to the surface in the produced water, is usually found in scale and sludges that deposit in tubing, gathering liens, tanks, and other vessels.

- NORM exposure around tank batteries or other equipment is usually well below levels of concern. However, gamma radiation surveys should be conducted to determine if special precautions are advisable. See API Bulletin E2 for information on detecting and managing NORM.
- However, when the NORM scale is disturbed, such as in dry sawing operations, it can present a health risk, if inhaled or ingested.
- Care should be taken to minimize exposure to airborne dust that might contain NORM by ensuring that proper PPE such as gloves, respirators, and the like is worn.

1.6.6 PHYSICAL HAZARDS

Physical hazards are present around any equipment, especially that which might have moving parts.

- All pumps and motors that have exposed rotating shafts, flywheels or belts, must be guarded to prevent employee injury.
- Equipment should be carefully designed and installed to avoid situations where employees might slip, trip, or fall. Guard rails and hand rails should be used where falls might occur.

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1.6.7 NOISE

Pumps and their drive mechanisms, such as electric motors, and engines, may be sources of high noise levels.

- Adequate precautions to prevent employee overexposure to noise must be taken in such cases.
- This would include a hearing conservation program which provides hearing protection, audiometric testing, engineering controls, and employee training.

1.6.8 CONFINED SPACES

Tanks and other vessels are considered confined spaces under the OSHA regulations. In fact, even a ditch, such as a pipeline ditch, may be sufficiently deep to be considered a confined space.

- Hazardous vapors may be present.
- Oxygen levels may be inadequate, such as in tanks where inert gas (usually nitrogen) blankets are in use.
- Confined space entry procedures should be used by personnel before entering.
- Only trained personnel should enter confined spaces. Check with your safety representative prior to working in any confined spaces.

1.6.9 ELECTRICAL HAZARDS

A lockout/tagout program is required for protection from electrical hazards and other forms of energy.

- This program provides for certain procedures that must be followed to ensure that any powered system is inoperable before maintenance is conducted.
- Pump maintenance must be done utilizing the lockout/tagout procedures.
- Check with your safety representative before any electrical work is initiated.

1.6.10 FIRES AND EXPLOSIONS

Hydrocarbons present a special danger with regard to fires and explosions.

- Explosive gases may be present in the saltwater pipeline.
- Even though dealing with water injection systems, the use of a gas blanket or the presence of oil carry over into the water may cause an area to be classified as hazardous because of combustible vapors or liquids.
- See your safety representative for proper and adequate procedures for safe use of explosives.

1.6.11 CONSTRUCTION HAZARDS

Construction sites present their own set of hazards that might not normally be encountered in day-to-day operations.

- If a ditch or other excavation is five feet or more deep in unstable soil, it must be sloped or shored to prevent cave-ins, and excavation must follow regulations governing training and shoring.

1.7 Summary

The proper design and construction of injection wells takes time and preparation. Proper planning of well location, selection of injection formation, and the proper equipment is crucial to a successful operation. Environmental and health and safety concerns must be carefully considered, and environmental permits must be obtained prior to conducting any operations at the facility. Significant time is often required to prepare the applications and have them approved by the regulatory agency.

SECTION 2—THE GATHERING SYSTEM

2.1 Introduction

The gathering system transports produced materials from the well to the separation and storage facilities. Salt water produced with the oil or gas is separated initially from the product at the tank battery. From here, it is transferred to a collection center or treatment facility, and then to the injection well.

If produced water volumes are fairly small, it may be more economical to transport salt water by tank truck, rather than add the expense of installing a pipeline and transfer pumps. For larger volumes, the salt water can be more economically transported through a pipeline. Proper pipeline design, installation, and maintenance is crucial to a successful gathering system. This section discusses the various components of the gathering system, including the following:

a. Initial oil/water separation at the tank battery.
b. Pipeline system design.
c. Pipeline installation.
d. Pipeline system maintenance.

2.2 Initial Oil/Water Separation

The water handling tanks at the tank battery provide not only for initial separation of the product from the salt water, but also working and storage capacity before the salt water enters the gathering system. These tanks also provide a working volume for automatic float level pump control.

- An additional tank may be installed to handle emergency overflow in case of equipment failure.
- Tanks used in saltwater service should be made of fiberglass, internally coated steel, galvanized steel, or other mate-

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corroding materials. Cathodic protection should be considered for metal tanks.

- Tanks must be vented at a sufficient height to allow any release of H_2S in the head gas to safely disperse.
- Grounding of fiberglass tanks will help prevent damage by lightning strikes.

Figure 1 shows a typical fiberglass accumulation tank, transfer pump, and spare pump. The hook-up for the transfer pump and spare pump is shown in Figure 2.

Before it is pumped to the treating plant, water from several tank batteries may accumulate in one or more collection centers. The collection centers include the following:

a. Accumulation tank.
b. Fluid level controlled transfer pumps.
c. Sometimes the saltwater storage capacity for emergency down time.

Emergency storage capacity at collection centers permits the continued operation of producing leases during short periods of down time due to equipment failure. A collection center containing a fiberglass tank and transfer pumps is shown in Figure 3.

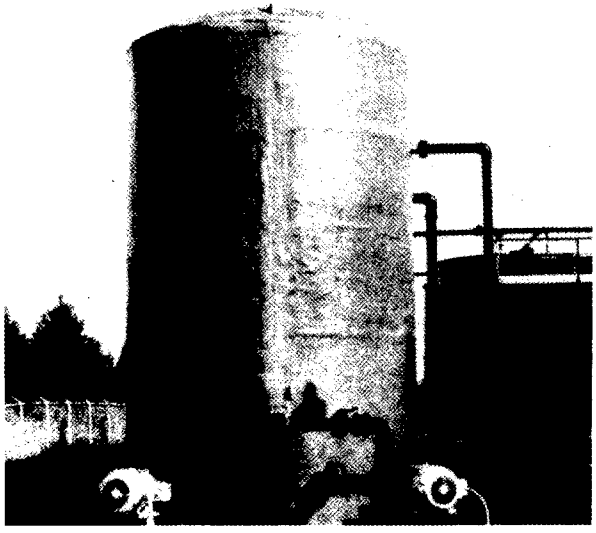


Figure 1—Fiberglass Saltwater Handling Tank

2.3 Pipeline Design

Pipelines in the gathering system should be designed so they will be capable of handling present, near-term, and long-term expected saltwater volumes and pressures. Nodal analysis techniques and computer programs are available which can accurately evaluate the interplay of these factors in the total system design.

2.3.1 DESIGN CONSIDERATIONS

The possibility of mineral scale deposition, corrosion by-products and/or bacterial debris—and the resulting loss of pipeline flow capacity—should be considered in the system design. These effects can be eliminated or mitigated by the following:

a. Chemical treatment of the water.
b. Internal coating of the pipe, or
c. Periodic use of pipeline scrapers to clear the lines of accumulated scale or debris.

The possibility of external corrosion failures should also be considered in the design of flowlines. External corrosion can be eliminated or mitigated by externally coating the pipe and/or by using cathodic protection.

Other factors which should be considered in the design are the following:

a. The estimated life of the project.
b. Operating pressures.
c. Pumps.
d. Fuel or power costs.
e. Monitoring needs.

The system should be equipped with safety relief valves or monitored with signal alarms that will shut down the system or alert operating personnel to abnormal flow conditions.

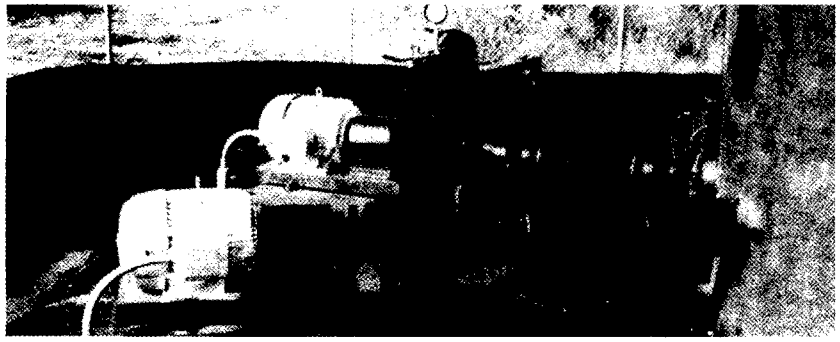


Figure 2—Transfer Pump and Back-Up Pump

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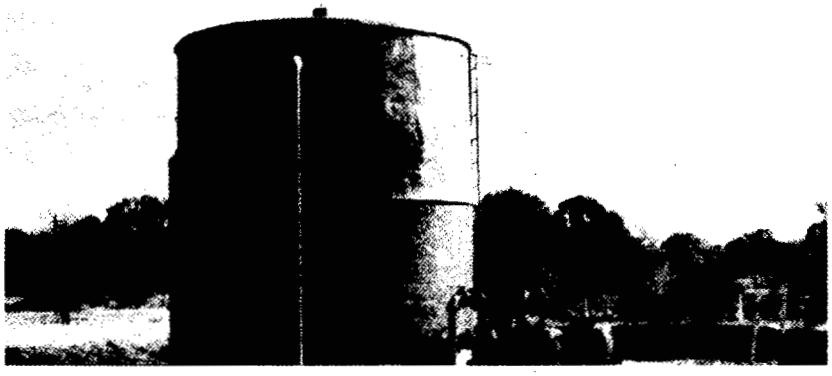


Figure 3—Fiberglass Tank and Transfer Pump

2.3.2 GRAVITY FLOW AND PUMPING TECHNIQUES

The salt water can be moved through the gathering system by gravity flow, pump pressure, or a combination of the two.

Gravity flow means that the salt water flows downhill through the pipelines without the use of a pump. Generally, gravity flow can not operate a complete gathering system. However, parts of a system (such as from tank batteries to a collection center) often can be designed for gravity flow and thereby minimize the cost of pumping the salt water.

- The route for gravity flow pipelines must be selected carefully so that the pipelines continuously slope toward the collection center. This may cause the pipeline to be elevated above the ground across low ground elevations, such as swamps, or installed deeper than usual across places of higher ground elevation.
- This continuous sloping prevents high spots in the pipeline in which gas could accumulate, reducing the flow of water through the line.

Pumping may be necessary because of the terrain, other surface conditions, or right-of-way problems.

- Sometimes the system pressure of a heater treater or other treating vessel can be used to move salt water to the collection center.
- For the same water volume, the size or diameter of the pipelines in a gravity flow system will be larger than the lines in a pressure gathering system.
- The increased cost for installation of the larger-sized pipe may be offset by elimination of pumping cost. Economic factors of gravity flow should be considered during system design.

2.3.3 PIPELINE SIZE

The pipeline size is determined by the flow rate of salt water to be handled and the pressure available to move salt water through the line. Figure 4 shows a chart for use in determining the friction loss in a particular size and length of pipeline for a volume of salt water moving through the line. The chart can be used to determine the size of pipeline needed for a complete gathering system or any of its parts.

2.3.4 PIPELINE VENTS

Pipelines in gravity flow systems are installed with a continuous downhill flow, but there may be unavoidable high points in the line. If these high points have sufficient height to permit separated gas to accumulate, a gas lock will form and prevent flow through the line.

a. These high point locations are determined during the initial survey of the line.
b. Each high point requires venting of the gas through a vent pipe riser.
c. The vent pipe riser must be high enough to prevent fluid loss.
d. These vent risers should be located in an open, well-ventilated area to prevent the accumulation of toxic or explosive gases in a confined space.
e. Also, if hydrocarbons and/or H_2S will be venting, there may be a need to obtain applicable air permits.
f. A check valve or other device is used to prevent entry of air through the vent in a closed type system.

2.3.5 TYPES OF PIPE USED IN GATHERING SYSTEMS

Plastic, fiberglass, non-coated cast iron, and internally lined or coated steel are types of pipe material and coatings used for handling salt water. All these materials will give long-lasting and trouble-free service in the saltwater system if they are correctly selected for operating conditions and installed properly.

- Careful consideration should be given to operating temperature and pressure when selecting the type of pipe for a system or line.
- The type of pipe selected should also be suitable for handling small volumes of oil and gas with possible small-to-moderate hydrogen sulfide (H_2S) concentrations.

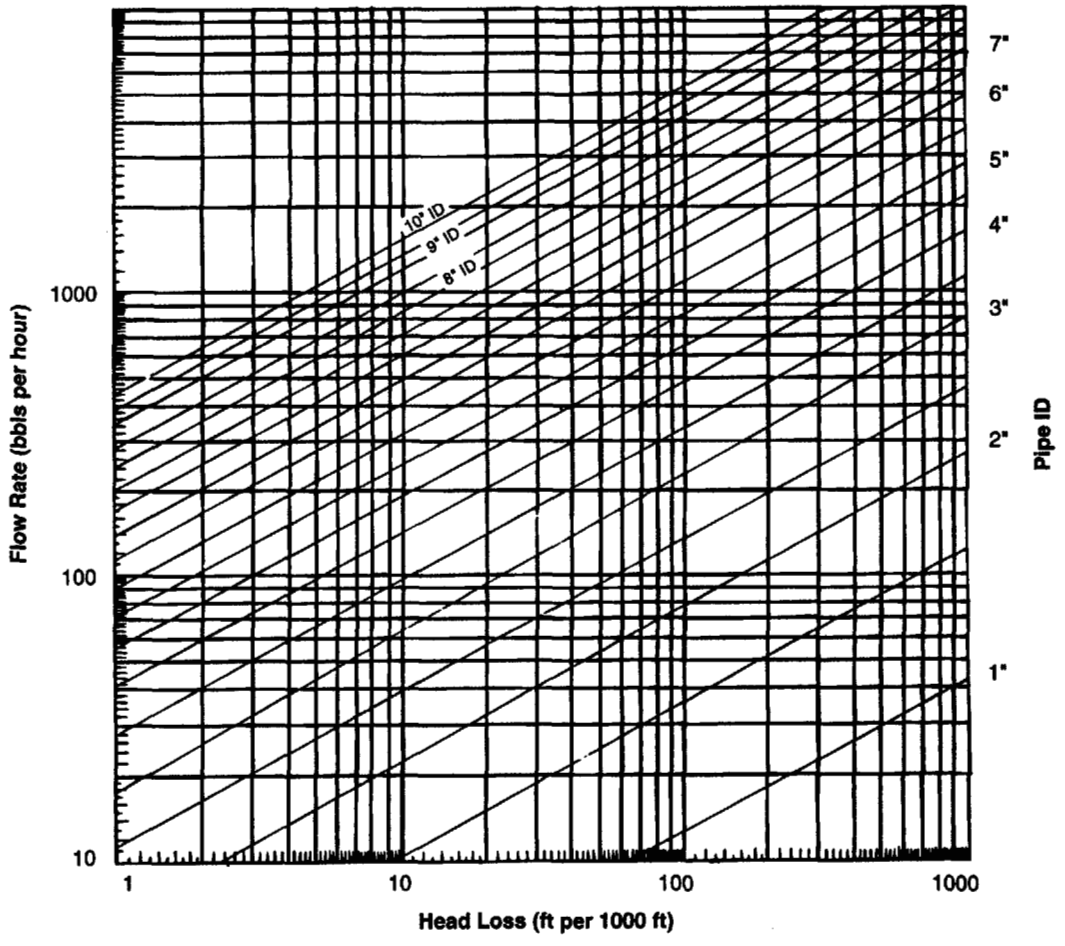
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2.3.6 CONNECTIONS

Thread and coupling, bell end, flanged, bolted coupling, ring coupling, welded end, and glued connections are types of joint connectors available with different types of pipe. A bundle of plastic pipe with bell end joint connectors is shown in Figure 5.

2.3.7 PUMP SELECTION

The pumps used to deliver water should have sufficient capacity to move all of the daily produced water in the desired pumping time period. In addition, since the water from an individual tank battery generally enters a central gathering system, the transfer pump must have sufficient



Coefficient	Factor
110	0.85
120	0.72
130	0.62
140	0.54

Typical "C" Factors	
Used Steel Pipe	$C = 100$
New Steel Pipe	$C = 120$
Plastic or Plastic Lined Pipe	$C = 130$ to 150

This is the Hazen-Williams friction-loss chart for water flow through pipe. Flow coefficient, C, = 100. The flow coefficient is expressed in feet loss of head per 1000 ft length. The C factor used in pipeline design is the coefficient of roughness of the pipe wall.

Note: For coefficients other than 100, multiply loss-of-head values found on this chart by the above factors.

Figure 4—Friction-loss Chart

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