cially for some special purpose," and, "To keep track of, regulate or control." There are three principal areas of interest in monitoring subsurface injection systems: (1) the well, (2) the surface equipment, and (3) the subsurface. The importance of performing the function on active systems should be apparent, but the monitoring requirement for "abandoned" installations can, on occasion, be equally important.

The well structure is usually possessed of a string of cemented surface casing to protect the fresh groundwaters, a fully cemented string of casing to the disposal stratum, and an injection tube to conduct the waste stream to the formation. The minimum monitoring function for the well requires measurement of wellhead injection pressure, injection tube-casing annulus pressure, definition of corrosive effects of the waste on the well materials and, on occasion, bottom-hole monitoring of injection pressure and the location of a conductor-insulator interface. Several techniques are available that are useful to the injector.

The monitoring of the surface equipment should include records of the injection-pump discharge pressure, the rate and cumulative measurement of injected volume, injecta temperature and quality, and the corrosive-erosive effects of the injected stream upon the materials of construction.

As the real purpose of the monitoring process is to establish that the waste is going where it is intended to go—and remaining there—an examination of the subsurface takes on a special importance. The requirement will vary depending upon the geographic location, the properties of the waste, the subsurface geology, and the design and construction of the disposal well itself. An occasional monitoring requirement is the drilling of one or more wells to the disposal formation to obtain pressure data and, sometimes, to obtain fluid samples. Although there is some purpose for monitor wells of this type where relatively shallow formations are used, their employment for measurements in deep aquifers may not serve a purpose commensurate with the expense and possible hazards that may result.

Once the disposal-well system is no longer needed sound practice dictates that the hole be effectively plugged. Although this technique has been well developed for abandoned oil and gas wells, some additional care is required where industrial injection systems are concerned.

TAMURA, TSUNEO, Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

SORPTION PHENOMENA SIGNIFICANT IN RADIOACTIVE WASTE DISPOSAL

Disposal of radioactive liquid wastes poses a particularly vexing problem, as these wastes contain various radionuclides and chemicals used in processing operations which are potentially dangerous, even in low radionuclide concentrations. Sorptive properties of minerals, particularly ion-exchange reactions, have been studied for potential direct application in waste treatment and for defining the fate of radionuclides when released to soils and geologic formations.

Because most waste streams normally contain stable ion concentrations far in excess of radioactive ions, sorption reactions of interest are those which exhibit high selectivity for the radionuclides. Structural and/or steric factors are generally of highest significance in selective reactions. Micaceous minerals selectively sorb radiocesium from high sodium, aluminum, or calcium solutions, primarily because of favorable structure. Zeolitic minerals show selectivity for certain ions by excluding other ions whose size exceed lattice parameters. Some sorbents show selective sorption reactions under particular pH conditions; thus alumina and related hydrous oxides selectively sorb radioactive cobalt and radiostrontium in alkaline sodium systems. In addition to the exchange reactions, sorbent properties, such as flocculation, swelling, and absorption of liquids and chemical properties of radionuclides, are important considerations in waste-disposal operations and management.

In practical applications of the sorptive phenomena in waste disposal, it is necessary to know the solution characteristics, sorbent properties, and formation characteristics, as well as the interactions of these factors. In the hydraulic fracturing technique employed at Oak Ridge, the waste-solution characteristics influence the choice of sorbents used to prepare waste-cement slurries. The high sodium salt concentration requires attapulgite instead of bentonite, and illite is added to fix radioactive cesium. To immobilize the mix after injection underground, cement is added which further complicates the reactions and behavior of the clay slurries. The behavior during injection and ultimate setting of the grout is further influenced by the characteristics of the formation.

Each underground disposal operation will require understanding of the environment into which the waste is placed. The final facility and technique should be tailored to meet the requirements of maintaining safe operation, as well as of insuring long-term safety for future generations.

TRELEASE, FRANK J., Univ. of Wyoming, Laramie, Wyo.

LIABILITY FOR HARM FROM UNDERGROUND WASTE DISPOSAL

The general principles of civil liability for conduct which harms a person are that such a person must show a legal injury to a right protected by law, caused by an act of the defendant which the law regards as a wrong. The four theories of tort law most likely to be applied in a case of harm from underground waste disposal are (1) trespass, an intentional invasion of the physical property of the plaintiff; (2) negligence, the causing of harm through failure to use reasonable care to avoid injury; (3) nuisance, the use of property so as to cause unreasonable interference with the use and enjoyment of another's property; and (4) strict liability, imposed without regard to fault upon those who engage in abnormally dangerous activities. The plaintiff's remedies are damages and injunction. The plaintiff will choose that rule and that remedy most suitable to his case, most likely to be sustained by the local court, and easiest to prove. The actor has few defenses other than to attack the theory of the plaintiff for lack of (or lack of proof of) an element of his case.

The new trend in the law is toward "conditional fault" (reflected in the difference between the American Law Institute's Restatement of Torts of 30 years ago and the new Restatement of Torts, Second), which permits desirable conduct although it carries possibilities of harm, but requires the actor to pay if harm occurs.

WARREN, J. E., Santa Fe International Co., Los Angeles, Calif.

EFFECT OF RESERVOIR HETEROGENEITY ON UNDERGROUND WASTE DISPOSAL

Abstract not submitted.