July 26, 1966 M. D. NELSON, JR 3,262,274

CONTAINMENT OF RADIOACTIVE WASTES

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FIG. 1.

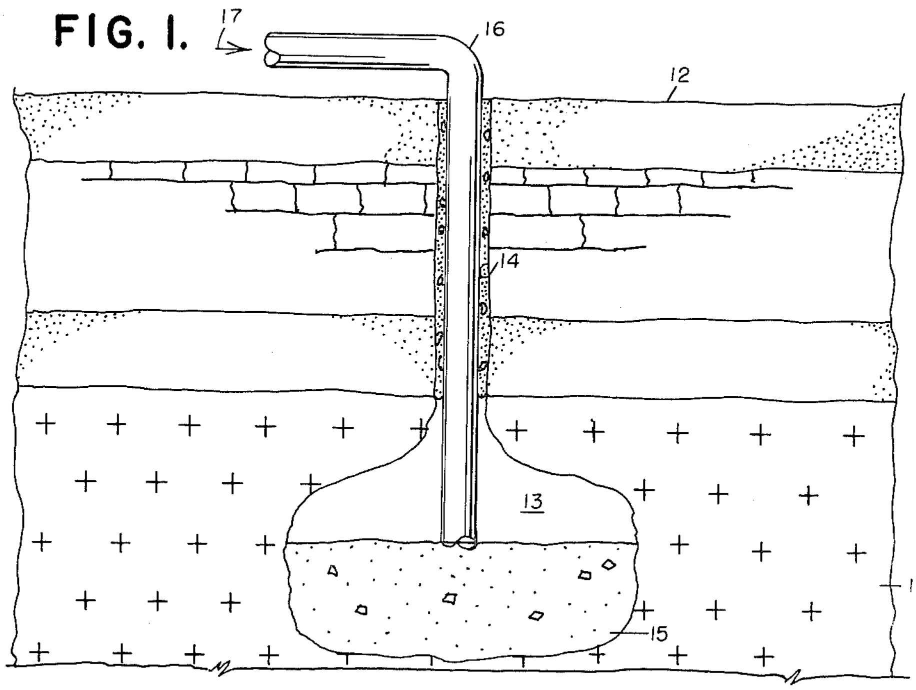
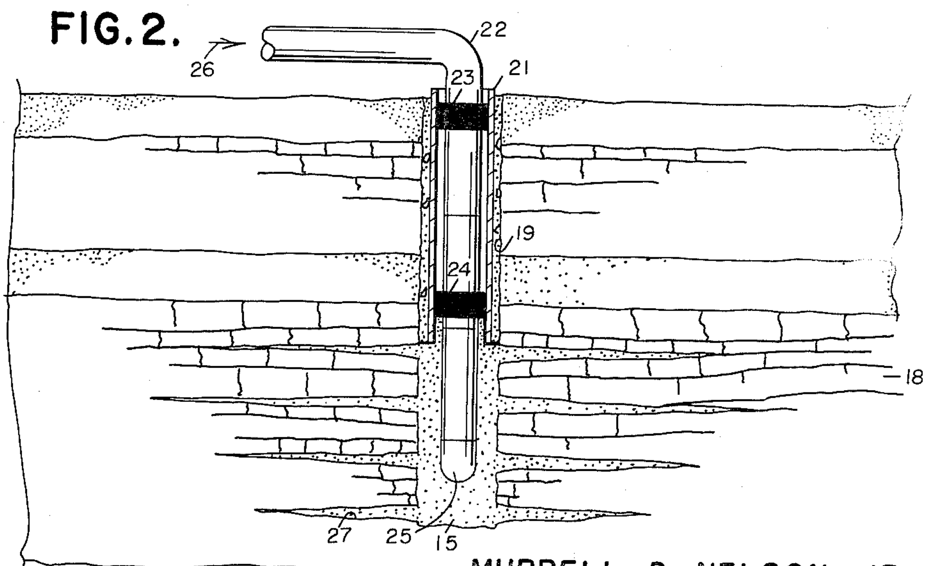


FIG. 2.



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CONTAINMENT OF RADIOACTIVE WASTES

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This invention relates to the containment of radioactive matreials. More particularly, it relates to a method and composition for the safe and complete containment of high level radioactive wastes.

The processing of radioactive matter produces large amounts of radioactive wastes. The principal state of these radioactive wastes is liquid. Although the liquid wastes contain nuclides in a small concentration, the level of radioactivity may be very high. These wastes are usually stored as a means of disposal. The storage of wastes containing nuclides which have a long life requires absolute confinement for extended periods of time, generally between 15 and 20 years. However, in certain cases the period of storage may be centuries in duration. The most common means of storage for the disposal of high level atomic wastes is the method of complete containment. The method of complete containment of high level radioactive wastes consists in storing the wastes in absolute confinement until all or most of the radioactivity has decayed. The absolute confinement can be obtained by storing the radioactive wastes in leakproof shielded containers. At present, the leakproof shielded containers usually are provided by underground storage tanks having enclosing walls of concrete approximately 8 feet in thickness with an inner fluidproof liner of stainless or mild steel. These tanks are surrounded by a second storage facility, spaced from the first, with means for monitoring the intermediate space to detect the escape of radioactive matter or nuclides. Further, expensive high speed fluid transferring equipment must be available at all times to transfer the high level radioactive wastes from one storage facility to another in case of a leak.

At present, the above complete containment method requires expensive storage facilities with continuous supervision and maintenance. It is known to reduce the cost of storage by reducing the amount of the stored radioactive liquid wastes such as by evaporation or other means of concentration of the liquid wastes. However, even the storage of concentrated liquids is very excessively expensive.

There is always the possibility with the present method of complete containment that as a result of an earthquake, or other catastrophe, the contents of such facilities may escape confinement and migrate to inhabited areas and thereby contaminate them to a high level of radioactivity.

It would be desirable to confine the radioactive wastes within the earth in conventional cement, especially where the wastes are solids. However, because of the danger of formation fluids leaching the conventional cement, and the loss of fluids from the cement before and after the initial setting period, the cement-contained radioactive wastes are not disposed within the earth, but rather are cast in steel barrels or other small impervious containers. This method is expensive because of the large number of containers which must be disposed usually by dumping at sea.

Radioactive liquid wastes can be confined in certain impervious geological structures, such as in voids present within an impervious formation. However, such storage facilities require a specific type of formation which is free from migrating fluids which can leach the wastes and then escape confinement. In particular, migrational formation water must be absent. Further, the storage facilities may be ruptured by earthquakes or the like, thereby permitting the radioactive wastes to escape containment.

It is therefore an object of the present invention to provide a new and economical method and composition for the complete containment of radioactive materials to insure the absolute protection of the public health for the period of time required for the radioactivity of the radioactive materials to decay to a safe level. Another object of the present invention is to provide a means of complete containment of high level radioactive wastes that cannot be disrupted by any known catastrophe or act of nature. Another object of the present invention is to provide a composition and method for storing radioactive materials in complete containment regardless of whether the nuclide containing materials are fluids, powders, particles of aggregate size, or mixtures thereof. Another object of the present invention is to provide a method for the complete containment of radioactive wastes which does not require expensive surface storage facilities or special impervious geological structures. Another object of the present invention is to provide a method and a composition for the containment of radioactive wastes by which the radioactive waste may be easily passed into a subsurface storage area where water or other migrational formation fluids are present, without any possibility of the radioactive waste material migrating from the storage area. Another object of the present invention is to provide for the complete containment in a storage system of radioactive wastes, in the form of a radioactive material, which system and material avoid the difficulties and expenses suffered by known methods for the disposal of radioactive wastes.

Further objects of the invention will become apparent from the following detailed description, the appended claims, and the attached drawing wherein the same parts will be designated by like numerals in the various views.

FIGURE 1 is a vertical section through the earth showing, as an illustrative embodiment, an application of the invention to a cavern formed in a subsurface salt formation; and

FIGURE 2 is a vertical section through the earth showing, as another illustrative embodiment, an application of the present invention to fractures residing in a subsurface formation.

In accordance with the present invention there is provided a radioactive containment composition comprising a mixture of an inverted emulsion cement and the radioactive wastes. Further, there is provided a method of placing such composition into a subsurface storage area for the complete containment of the radioactive wastes. Additionally, there is provided a system for storing the disposed composition and a nonmigrational, cementlike radioactive material from which nuclides cannot escape.

The radioactive wastes contained in the mentioned composition may consist of nuclide-containing materials such as aqueous solutions, nonaqueous solutions, and other fluids, solids, such as powders and aggregates, and mixtures of such fluids, solutions and solids. The term "radioactive wastes" as used herein is intended to include all radioactive materials in a broad sense, but more particularly, in the disclosed embodiments of this invention refers to the radioactive materials formed as the byproducts in nuclear energy processes.

The inverted emulsion cement used in the containment composition is of the type having oil as a continuous phase and preferably is basically the cement disclosed in the United States patent to Dunlap et al., 2,878,875, and entitled "Cement." This patent is incorporated by reference into this description of the invention. The cement of the containment composition is comprised of an emulsion and a solids material. The emulsion is comprised of an aqueous medium, principally water, oil as a continuous phase, and a water-in-oil emulsifier in an amount to effect temporary emulsification of the aqueous medium and oil. The solids material is comprised, at least in part, of hydraulic cement. In the present invention, the radioactive wastes are combined with this inverted emulsion cement, preferably as one or more components or portions thereof. Thus, such radioactive wastes may be included as components, or portions of the emulsion, or of the solids material, or both, depending upon their physical state to form a mixture which is the containment composition. In general, the amounts of the radioactive wastes that may be included as one or more of the components of the cement, or portions thereof, will be controlled by the general considerations relating to the proportioning of concrete and to the dilution of cement pastes or slurries. For example, the aqueous solutions should not dilute the cement to such a degree that the resultant cementitious mass has insufficient strength and durability to last for the necessary period of time required for the decay of the radioactivity of the contained wastes. Also, the amounts of the solids as powders, aggregates, and mixtures thereof, should not be excessive in quantity or in the amounts of fine particle sizes so that the resultant cement mixture is excessively "stiff," and as a result is nonpumpable. The radioactive wastes should not be used in such amounts, when they contain principally large sizes and amounts of aggregates, that the resultant cementitious mass is lacking in cohesive plasticity, or contains a segregation of ingredients, or is honeycombed. If the radioactive wastes are not aqueous liquids but are oils, or are oil soluble fluids, care should be exercised to insure that an emulsion can be obtained from which the inverted emulsion cement is prepared. The amounts of the radioactive wastes used with the inverted emulsion cement as components, or portions thereof, should be within the above bounds in order that the beneficial cementlike qualities of the inverted emulsion cement and substantially retained in the containment composition.

In the inverted emulsion cement of the containment mixture the aqueous medium in the emulsion may be provided by water, aqueous solutions containing salts such as calcium chloride or sodium chloride, the aqueous solutions of radioactive wastes containing nuclides as soluble salts or fine particles or powders, and mixtures of such liquids and powders. Whatever the source for the aqueous medium, sufficient water always must be present in the final containment composition to hydrate the cement.

The oil is the continuous phase in the emulsion employed in the containment composition. Preferably, the oil is a hydrocarbon oil. Suitable oils comprise petroleum fluids, crude oil, diesel oil, kerosene, gas oil, distillate oil, and other petroleum oils. For example, an oil containing nuclides may be used as the oil in such emulsion even though it is radioactive providing it has the required physical characteristics to form water-in-oil emulsions common to the other mentioned examples of hydrocarbons. Hereinafter the term "oil" is used to denote a hydrocarbon oil. Nonhydrocarbon oils may be found useful. Nonhydrocarbon oils such as vegetable and animal oils may be used. Thus, vegetable oils, such as cottonseed oil, castor oil, rapeseed oil, tung oil, and linseed oil, may be employed. Animal oils, such as sperm oil and fish oils, may also be employed.

The water-in-oil emulsion may contain between about 10 percent and about 75 percent by volume of oil. With amounts of oil below about 10 percent by volume in the mixture of water and oil, difficulty is encountered in obtaining a water-in-oil emulsion. When the amounts of oil are above 75 percent by volume of the mixture of oil and water, insufficient water may be present to properly hydrate the cement so that the strength of the

set cement is severely reduced. Preferably, the emulsion contains between about 20 and 40 percent by volume of oil.

The emulsion also contains a surface-active emulsifier for water-in-oil emulsions. As an emulsifier, an oil-soluble sulfonic acid, or oil-soluble derivative thereof, may be employed. Included among suitable oil-soluble derivatives of a sulfonic acid are the mono-, di-, and trivalent salts of a sulfonic acid, and mixtures thereof. By sulfonic acid is meant an organic compound represented by the formula $R{-}SO_2OH$, or $R{-}SO_3H$, where, in the formulas, R may be an alkyl, aryl, aralkyl, or alkaryl group. These sulfonic acids are oil soluble. The sulfonic acids are obtained by a reaction between a suitable hydrocarbon and a sulfonating agent, such as sulfuric acid, sodium sulfite, etc. The hydrocarbon may be in a mixture with other hydrocarbons, such as a crude petroleum oil, or an animal or fish oil, or fat, and the mixture may have been subjected to sulfonation treatment.

Sulfonated hydrocarbons, such as an oil-soluble petroleum sulfonate, or an oil-soluble sulfonated sperm oil, may be used. A satisfactory sulfonated petroleum sulfonate is one having a molecular weight between 440 and 470. A satisfactory sulfonated animal fat is one having a molecular weight between 250 and 600. Particularly satisfactory results have been obtained by employing the petroleum sulfonate sold under the trade name "Petronate" and by employing the sulfonated animal fat sold under the trade name "Control Emulsion."

Other suitable emulsifiers may also be employed. These emulsifiers include sorbitan monooleate, sorbitan sesquioleate, sorbitan, trioleate, sorbitan tristearate, lecithin, amino propyl tallow amine, polyoxyethylene sorbitol tetraoleate, and polyoxyethylene sorbitol pentaoleate. Mixtures of various emulsifiers may be employed, if desired.

The emulsifier may be employed in an amount up to about 10 percent by weight of the emulsion. Preferably, the emulsifying agent is employed in the amount between 2 and 6 percent by weight of the emulsion. Satisfactory results have been obtained employing the emulsifying agent in the amount of about 3 to 4 percent by weight of the emulsion.

Where the emulsifying agent selected is any particular derivative of any particular sulfonic acid, the effect on emulsification will reside primarily in the particular sulfonic acid from which the derivative was obtained and the amount used in the emulsion. The reason is that the sulfonic acid, or its derivative, upon orientation at the water-oil interface will react with the calcium ions from the cement present in the water phase to form the less soluble calcium salt. This produces a stable film of the type necessary for water-in-oil emulsions. The time lapse between preparation and setting of the inverted emulsion cement depends on this stable film and is proportional to the concentration of the emulsifier in the cement. Sodium ions also may be present in the aqueous phase by the addition of a sodium compound such as sodium chloride or sodium hydroxide.

The addition to the emulsion of sodium or calcium ions is of another advantage in respect to compensating for the variable electrolyte content of the radioactive wastes. The sodium or calcium ion concentration in the emulsion may be adjusted, if desired, to maintain a constant level at a relatively high concentration. For example, the concentration may be maintained at 3 or 5 percent by weight of the sodium or calcium salt with respect to the aqueous medium employed in the inverted emulsion cement. Preferably, the calcium salt is calcium chloride and the sodium salt is sodium chloride. The amount of the sodium or calcium ion containing salt may be adjusted to the desired constant level and includes, as part of such amount, the electrolyte content of the radioactive wastes in the containment composition.

As has been stated, the inverted emulsion cement of the containment composition includes a solids material which is comprised, at least in part, of hydraulic cement. When the radioactive wastes are powders, or aggregates, or mixtures of both, they may be included in such solids material in addition to the hydraulic cement. By hydraulic cement is meant a cement which will set under the action of water. Portland cement is generally employed. However, any mixture containing lime, silica, and alumina, and commonly used as a hydraulic cement, is satisfactory. Inasmuch as high temperatures may be produced by the decay of the activity of the radioactive wastes, some consideration should be given to using a temperature-resistant hydraulic cement. For example, where the equilibrium temperature of the containment composition in the subsurface storage area reaches temperatures in excess of about 250° F., silica flour or other heat-resistive agents may be used with most hydraulic cements to increase their resistance to heat-produced deterioration.

The amount of emulsion with respect to the amount of hydraulic cement, excluding other solids material, may vary within the general limits from as little as 30 parts by weight of emulsion to 100 parts by weight of hydraulic cement, or it may be as much as 70 parts by weight of emulsion to 100 parts by weight of hydraulic cement. The amounts of the remaining solids material that can be used in conjunction with the emulsion and hydraulic cement is determined by the general consideration, as heretofore mentioned, relating generally to the additions of fine particles, such as sand, and aggregates to cement slurries.

In preparing the containment composition the aqueous medium comprised of water, oil, and fluid radioactive wastes may be mixed together with the emulsifier to provide the emulsion, and thereafter, mixing the emulsion with the solids material comprised of hydraulic cement and solid radioactive wastes. Where this procedure is followed, it is desirable that the mixture of the aqueous medium contain the desired amount of calcium and sodium ions, if the latter are present, which ions may be provided by including within the mixture a suitable calcium salt such as calcium chloride and a sodium salt such as sodium chloride. It is preferred that the calcium ions are present when the aqueous medium is emulsified into the oil to form the desired emulsion. Other orders of mixing the ingredients of the containment composition may be used.

Where the amounts of emulsifier employed are less than about 3 percent by weight, difficulty occasionally is encountered in obtaining an emulsion wherein the oil is the continuous phase. This difficulty can be avoided by first admixing all of the emulsifier with all of the oil. Thereafter, the remaining ingredients are added alternately in increments to the oil containing the emulsifier. Of course, the inverted emulsion cement may be prepared and then the radioactive wastes added to such cement to produce the desired containment composition. In either method, the general considerations regarding preparation of concrete from cement slurries should be followed.

The containment composition, upon hardening by setting of the cement, provides a radioactive material which is cementlike and from which nuclides cannot escape. The containment composition prior to setting is readily transported, usually by pumping, and therefore is well suited for use in various methods for the containment of radioactive wastes in subsurface storage areas. For example, the containment composition has extended thickening and setting times if formulated to set at a high temperature, and, therefore, there is available a sufficient time for its preparation and transportation to the desired storage area under all circumstances before it sets. The composition may be pumped or otherwise conveyed for a period of time, in some cases up to 200 minutes, before it thickens. The desired emulsion life at the temperature of the surroundings in which the inverted emulsion mixture is to be placed can be readily controlled by the concentration of the emulsifier. The containment composition has a negligible fluid loss, i.e., the loss of fluids from the composition to adjacent geological structures which are more permeable before and after hardening. This property insures the absolute containment of fluid radioactive wastes during the placement of the containment composition into the desired storage area. The containment composition is not miscible with water prior to its setting into the rigid structure of the mentioned radioactive material. After setting of the composition, the resultant radioactive material is impermeable to water or other leaching fluids, including petroleum fluids. The composition after setting or hardening is hereinafter denoted as the "radioactive material." The radioactive material has a great compressive strength which prevents the catastrophic acts of nature destroying its absolute containment of the radioactive wastes. Thus, the advantages of the containment composition include the property of providing for the absolute containment of radioactive wastes throughout the steps of preparing the composition, transporting it to the desired storage area, and also, after the composition sets to a cementlike mass of radioactive material.

The basic method for the complete containment of radioactive wastes in a subsurface storage area comprises a number of steps. These steps include providing a passageway from the earth's surface to the subsurface formation in which the wastes are to be stored, connecting a storage area in such formations to the passageway, and inserting conveying means into the passageway for transporting the containment composition to the storage area in the subsurface formation. Prior to, contemporaneously with, or after these steps, a step of providing the containment composition is completed at a time sufficient to place the composition into the storage area before it sets. Lastly, the steps are practiced for transporting the containment composition through the conveying means into the storage area and maintaining the composition in the storage area until it sets. This method produces a system for the complete containment of radioactive wastes in the desired subsurface storage area.

This method provides many advantages. One advantage is that the earth's formations surrounding the stored containment composition need only to blanket the hazardous emissions from the radio active wastes as they decay in activity and not provide a specific geological structure to insure containment of the composition. Secondly, the surrounding formations are warmed by the heat released by the decay of nuclear activity of the stored radioactive wastes in the containment composition. Thus, where the formations surrounding the storage area contain petroleum, the heat conducted and radiated from the stored radioactive wastes reduces the viscosity of the petroleum and otherwise makes it more mobile. As a result, this method and composition may be used to stimulate the production of petroleum. Also, recovery of the heat generated by the radioactivity decay may be effected by positioning heat exchange means adjacent or in the containment composition.

The storage area may be formed in many types of nonunique subsurface formations such as salt beds and shale strata. The storage area may be artificial or natural. It may be a void formed in a formation by leaching a salt bed, by fracturing strata, or it may exist as natural caverns, crevices, and fissures. Examples of strata containing naturally occurring storage areas are sands containing large-sized ungraded particles and gravels of a predominantly large size which produce large pore openings, cracked or fissured rocks, or limestone formations, caverns, or other voids in strata created in subsurface formations by the earth's stresses. Some of the cavernous limestone formations are of especial utility in their ability to receive and store large quantities of the containment composition. Various storage areas may be used where formation fluids, such as water and hydrocarbon fluids are present because of the nonmiscibility of the containment composition and the resultant radioactive material with such formation fluids. In this regard, the method of the invention even may be used to place the containment means on the floor of the ocean in a layer of mud. Other storage areas will be obvious to one skilled in the art.

In FIGURE 1 of the drawing there is shown for the purposes of illustration an embodiment of the invention where the containment composition is being placed into a storage area formed in a subsurface salt formation or bed **11**. A cavern **13** is formed in salt bed **11** and disposed a sufficient distance below the earth's surface **12** that the emissions from the radioactive wastes stored in the cavern **13** are substantially adsorbed. Thus, no emissions escape to the earth's surface to become a hazard to public health. The cavern **13** may be formed by any suitable method. For example, in the embodiment of FIGURE 1, the steps of the method are as follows: the cavern **13** is formed by providing a passageway **14** from the earth's surface **12** into the salt bed **11** and then forming the cavern **13** by conventional water leaching processes. As the next step, after the cavern **13** is completed, means for transporting a prepared containment composition **15** into the cavern **13** are provided by inserting a conveying means, such as fluid conduit **16**, into the passageway **14**. Fluid conduit **16** preferably extends from the earth's surface **12** through passageway **14** and into the cavern **13**. It is preferred to cement, or otherwise seal, the conduit **16** into the passageway **14**. Fluid conduit **16** may also be used in the leaching process for forming cavern **13**, if desired. In another step, the prepared containment composition **15** is conveyed through conduit **16** into the cavern **13** by any suitable means, such as gravity flow, in the direction of arrow **17**. After the composition **15** is in place, the final step of this method is to maintain the composition **15** in the cavern **13** until it sets to a substantially rigid and nonflowing mass. This mass is the cement like radioactive material. The method produces a system that provides for the absolute containment of radioactive wastes. If desired, a quantity of cement, without any radioactive wastes, may be passed through the conduit **16** to cleanse it of radioactive materials and to assist in maintaining the containment composition **15** in the cavern **13**. This method is of advantage in that the high heat conductivity of salt dissipates the heat created by the decay of high level radioactive nuclides. Further, solid radioactive wastes of large-sized aggregates which can pass through conduit **16** can be readily stored. Of course, the normal precautions regarding the handling of radioactive wastes should be observed when practicing the present invention.

In FIGURE 2 of the drawing, there is shown for the purposes of illustration another embodiment of the invention where the containment composition **15** is placed into a storage area formed by fracturing strata in a subsurface formation.

In this embodiment, the steps of the method are as follows: A storage area is formed in a subsurface formation **18** disposed a sufficient distance beneath the earth's surface to provide an effective shield against harmful radioactive emissions. The storage area may be artificial fissures, crevices, and other voids, or it may be created by any suitable means such as mining or formation-fracturing processes, particularly, hydraulic fracturing. The formation **18** may be a highly laminated shale which is readily fractured to produce the storage area in the form of a plurality of interconnected fissures.

More particularly, the method of this embodiment includes the steps of providing a passageway **19** from the earth's surface **12** into the formation **18** where the storage area is to be disposed. If naturally occurring storage areas are present, they also may be connected to the passageway **19**. As the next step, the fissures **27** are formed by hydraulic fracturing. In general, the passageway **19** contains a conveying means such as casing **21** cemented therein to insure protection to the intervening strata in case of the escape of fluids passing between the earth's surface **12** and the storage area. A tubing **22** is positioned within the casing **21** and a fluidproof seal means therebetween is provided and may be obtained by packers **23** and **24**. The tubing **22** preferably contains a back pressure valve **25** to insure the maintenance of the containment composition **15** within the storage area against high formation fluid pressures. The prepared containment composition **15** is forced by suitable means, such as by hydraulic pumps, not shown, in the direction or arrow **26** into tubing **22**. The force created by the hydraulic pumping means must be sufficient to convey the composition **15** through the tubing **22**, back pressure valve **25**, and to fracture the formation **18** to provide and fill fissures **27**. After the composition **15** is disposed in the fissures **27**, it is maintained therein by the back pressure valve **25**, or by other suitable means, until it hardens.

If desired, the fissures **27** may be produced by initially using other noncompressible fluids in hydraulic fracturing of formation **18**. In such case, it is preferred that such fluids be removed after the fracturing step and before the containment composition **15** is forced into the fissures **27** to secure the greatest possible storage capacity from the fissures **27**.

The foregoing method is of especial utility when the formation **18** is shale for the reason that the permeability of such formations is usually exceedingly low and readily fractured. This physical characteristic insures that the possibility of migrational fluids coming into direct contact with the containment composition **15** is slight. This is another safeguard in the complete containment of radioactive wastes by the composition and method of this invention.

Although the shape of the storage area is shown as a cavern **13** and fissures **27**, it is to be understood that the storage area may have various other configurations. In particular, the fissures **27** may extend in vertical or in horizontal planes, or in both planes. The composition **15** in fissures **27** generally has a large surface in contact with formation **18** for a small thickness and, therefore, large amounts of heat can be conducted from composition **15** by formation **18** when the containment composition **15** incorporates very high level radioactive wastes.

If desired, the formations containing the storage area may be at least partially saturated with water to increase its heat conductivity if no formation water is present. As previously mentioned, the presence of water or other formation fluids in any amounts, do not effect the containment composition because of its inverted emulsion cement composition.

From the foregoing, it will be apparent that the containment composition, method, radioactive material, and system of this invention are well suited to achieve all of the stated objects. There is provided a composition containing radioactive wastes that is readily prepared and which can be easily transported in subsurface storage areas. A cementlike radioactive material is produced upon hardening of the composition and from which no nuclide-containing materials can escape. The method heretofore described is simple, yet efficient, for providing the absolute and complete containment of radioactive wastes below the surface of the earth. Once the radioactive wastes are contained in a subsurface storage area by the composition and method of this invention, a system is produced to which no subsequent maintenance is required. Further, in this system, the radioactive wastes are completely contained for a sufficient time interval to permit their level of activity to decay to a safe level. Thus, in accordance with this disclosure of the present invention, the radioactive wastes may be completely contained in a manner wherein the public health is protected at all times and under all foreseeable conditions.

Having described our invention, it will be understood that such description has been by way of illustration and not by way of limitation, reference for the latter purpose being had to the appended claims.

What is claimed is:

1. A method for the containment of radioactive wastes comprising the steps:

(a) mixing radioactive wastes; an emulsion formed of an aqueous medium, oil, a water-in-oil emulsifier in an amount to effect temporary emulsification of said aqueous medium and oil; and a solids medium comprised at least in part of hydraulic cement to produce a containment composition, said emulsion containing between about 10 and 75 percent by volume of said oil as the continuous phase, said emulsion being present in the containment composition in an amount between about 30 and 70 parts by weight of the emulsion to 100 parts by weight of hydraulic cement,

(b) passing the containment composition into a subsurface storage area, and

(c) maintaining said composition in said storage area unttil it sets to thereby obtain complete and safe containment of the radioactive wastes.

2. A method for the containment of radioactive wastes in storage areas in subsurface formations which comprises the steps:

(a) providing in the earth a passageway extending from the earth's surface to a subsurface formation in which the radioactive wastes are desired to be stored,

(b) preparing a storage area in said subsurface formation and connected to said passageway,

(c) inserting conveying means into the passageway for transporting fluids from the earth's surface to the storage area in said subsurface formation,

(d) providing a water-in-oil emulsion cement containing the radioactive wastes desired to be stored in said storage area,

(e) transporting the water-in-oil emulsion cement con-

taining the radioactive wastes through said conveying means into said storage area, and

(f) maintaining said water-in-oil emulsion cement in said storage area until it sets whereby the radioactive wastes are completely contained in said subsurface storage area.

3. The method of claim 2 wherein the water-in-oil emulsion cement comprises:

(a) an emulsion formed of an aqueous medium, oil as a continuous phase and a water-in-oil emulsifier in an amount to effect temporary emulsification of said aqueous medium and oil,

(b) a solids medium comprised at least in part of hydraulic cement, and

(c) said radioactive wastes when an aqueous fluid containing nuclides forming a portion of the aqueous medium, when solids containing nuclides forming a portion of the solids medium, and when a mixture of aqueous fluid and solids forming a portion of both the aqueous and solids mediums.

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