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DESIGN ENGINEERING UNIT

OCTOBER 15, 1952

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PROTECTION OF EXTERIOR BURIED WASTE LINES

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PREPARED BY G. U. Udine

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September 24, 1952

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October 15, 1952

W. B. Webster
Process Engineering Unit
HANFORD WORKS

RDS-12 - SEPARATIONS PLANT DESIGN DEVELOPMENT
PROTECTION OF EXTERIOR BURIED WASTE LINES

In accordance with your request this office has made a study of existing and proposed methods of protecting exterior buried waste lines.

The study investigates the problem of protecting underground lines in general and reviews the various methods of protection employed. The types of protection employed at Hanford Works including cathodic protection are reviewed and analyzed. The probable effect of leaks are evaluated. New encasement designs are developed. Cost analyses are made on all types of encasements considered. Finally recommendations concerning the type of encasements to use and the locations in which they should be used are made.

The following report has been written as a part of the above study and presents all the information accumulated on the above subjects. This copy is transmitted herewith for your information.

H. F. Peterson, Designing Engineer
Architectural, Civil & Structural Group
Design Engineering Unit

By G. U. Udine

GU Udine:jj

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ENGINEERING STUDY NO. 6

PROTECTION OF EXTERIOR BURIED WASTE LINES

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Drawing No.	Sht. No.	Title
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I. INTRODUCTION

The process wastes from the separation plants at Hanford Works are transported by underground pipe lines to underground tanks for storage in the case of high level activity wastes and to underground cribs and tile fields for disposal by seepage into the ground in the case of low level activity wastes.

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It is essential that the underground lines employed in this service operate with no maintenance or leakage, and that failures be reduced to a minimum. The reasons for this are as follows:

1. A failure of a high level activity waste line can cause a serious hazard on the ground surface and may in addition contaminate the ground water.
2. It is almost impossible to repair a line that has failed because of the radiation hazards involved.
3. The failure of all waste lines to a plant may cause it to shut down until new lines can be built or until difficult and costly repairs are made under SWP restrictions.

Previous to 1947 several of these waste lines failed. Because of the seriousness of the problem a considerable amount of research and study has been done since then in an effort to determine the cause of the failures and prevent additional failures of existing lines. As a result it has been determined that the chief cause of failure was exterior galvanic action. In addition it is recognized that failure can also be caused by excessive external mechanical forces, poor design and faulty construction and workmanship.

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Exterior galvanic corrosion has been eliminated through the application of cathodic protection to all lines. Prevention of mechanical failure and control of the process wastes in the event of a leak has been accomplished through the provision of encasements for these waste lines.

To date, although lines developed since 1947 have followed a standard design, there has been no concerted effort made to develop the most suitable and economical encasement or protection of buried steel lines based on a study of past experience and general practice. Therefore, this study was authorized to:

1. Investigate and evaluate the different methods of protection of underground pipe used in general practice.
2. Review and appraise the different methods of protection of underground waste lines used at Hanford Works.
3. Discuss the probable effects of waste line failures.
4. Recommend the most suitable and economical protection for buried steel lines.

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II. RECOMMENDATIONS

The following recommendations are submitted:

1. All exterior buried process lines shall be provided with cathodic protection in accordance with Specification HW-3946.
2. All exterior process lines carrying solutions with a high activity level shall be encased in a reinforced concrete encasement where they are located in congested areas, around structures, under roads or railroads and in the near vicinity of other pipe lines.

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Where the lines are located in isolated areas and there is no danger of wide spread contamination in case of line failure they may be buried directly in the ground without the use of encasements provided that direct burial is economical, feasible and a positive leak detection system is used.

3. The concrete encasement recommended for multiple line encasements shall be similar to that shown on Drawing SK-2-1082 Sh. 10. The encasement shall be constructed without any special concrete finish and without a water proofing membrane except in special cases. There shall be no selected backfill and no special compaction will be required.

   Only the interior surfaces of the sections of encasements within 25 feet of a connection to a building, diversion box, tank, etc. shall be coated or painted to permit decontamination if necessary. The type of coat or paint required shall be determined at the detail design stage.

4. All exterior buried waste lines carrying solutions with a low activity level need not be encased except where mechanical protection is needed because of location in congested areas, under roads or railroads, or near other lines and structures.

5. The character of the solution carried shall be analyzed at the detail design stage and the necessity of an encasement determined.

6. The encasement for single exterior buried waste lines shall be similar to that recommended for multiple lines with the dimensions changed to suit the single line.

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III. DISCUSSION

A. A DISCUSSION OF METHODS FOR PROTECTING STEEL LINES AS USED IN GENERAL PRACTICE.

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1. Deterioration of Buried Steel Pipe

a. Cause

Buried pipes are subject to deterioration as a result of their contact with the soil. The extent of disintegration will depend upon local conditions such as the type of soil and the presence of destructive salts, bacteria, or other unfavorable factors or agencies. The attacks may be prevented or minimized by proper protection.

b. Methods to Determine the Degree of Protection Required.

The presence or absence of conditions that may act adversely on buried pipe and the degree of protection required for a proposed pipe line may be estimated by several methods among which are the following:

1. Soil Rods or Shepard Canes

This instrument is used to measure the soil resistivity in field surveys.

2. The Denison or Bureau of Standards Soil Tests

Soil samples are tested by measuring the depth of the pits on the anode of a Denison Cell. The corrosivity is determined from pit times depth curves.

3. The Putnam Corrosivity Cell

This device is an electrolytic cell subject to an induced current with the soil sample as an electrolyte. The re-

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sulting current flows are measured by a delicate galvanometer which has been calibrated under known conditions.

4. Actual field experiences and experiments conducted by the General Electric Company at Hanford Works.

2. Protection of Steel Pipe Lines by Coatings

a. The fundamental requirements of a satisfactory pipe line coating are:

1. It must be chemically inert in order that its characteristics may remain unchanged.

2. The coating must remain in intimate contact with the surface of the pipe it protects.

3. It must have a low electrical conductivity.

4. It must be capable of resisting damage under external loads.

5. The coating must adhere tightly to the pipe metal at any temperature to be encountered by the pipe. The coating must not become brittle at low temperatures or become soft or tend to run at high temperatures.

b. Types of coating which meet the above requirements are as follows:

1. Asphaltic Pipe Coatings

This coating consists of a high grade asphaltic dip in combination with an external wrap of first quality pipe line felt, firmly bonded to the pipe. The coating is applied by pre-heating the pipe and then dipping the pipe in the hot coating.

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2. Asphaltic Enamels

Enamels have been developed for coating pipe that consist of highly refined asphalt and inert mineral fillers. By the use of an asphaltic enamel it is practicable to apply a heavier coating to metals than is obtained where pipe is dipped. The primer and asphalt are applied by hand brushing or spraying.

3. Coal Tar Enamels

Enamels have been developed for coating steel pipe that consist of processed coal tar pitch mixed with the proper amount of inert mineral fillers. At the present time very little coal tar pitch is used for coating steel pipe.

4. Wrapping Steel Pipe

For the most satisfactory protection it is considered necessary to wrap the steel pipe after it has been coated. This is done by using a heavy tough wrapper such as asbestos pipe line felt of 15 or 23½ pound grade. The wraps should be applied mechanically and bonded to the coated pipe with additional hot coating under the wraps.

5. Concrete

An outside layer of concrete is sometimes applied to welded steel pipe. This is usually applied by the gunite method, after first covering the outside of pipe with wire mesh to serve as reinforcement.

6. Neoprene jackets are applied to small pipe and cables. These jackets may have a cathodic protection consisting of anodes of magnesium bars.

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c. Excavation of Coatings

1. One small pin hole or break in the coating can cause a failure in the line under unfavorable electrolytic condition.

2. Field experiments by the General Electric Company at Hanford Works have found coatings and tapes unsatisfactory for waste line protection. (Reference: Hanford Works Standard Committee on Stainless Steel Pipe Protection - Sub-Committee Report dated 8-15-49, Part C paragraph 2.)

3. Cathodic Protection

a. Methods

A pipe line is protected from electrolytic action by being made the cathode of a D.C. voltage electrical system throughout its entire length. This is done by preferential electrical drainage in the following manner. Scrap steel used as anodes is buried in groups along the line, each group being interconnected by a suitable conductor cable. A rectifier is connected to the pipe lines and to the anodes in such a manner that when operating, current flows from the pipe line to the rectifier and from the rectifier to the anodes and then back through the soil to the pipe. The anodes are gradually corroded away and the pipe line being the cathode is protected.

4. Encasements

a. Types

Some pipe lines are protected by placing them in a concrete tunnel, tile pipes, tile conduits or concrete encasements.

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It is the practice of the Hanford Works to protect the stainless steel waste lines by using concrete encasements. The encasements consist of a reinforced concrete curbed base on which is placed a reinforced concrete cover slab. A membrane is applied over the top and sides to make the structure waterproof. A system of anchors and expansion loops is used to permit thermal movement of the pipe.

b. Reasons for Encasements

1. To prevent the possibility of pipe failures due to external disturbances.

2. In the event of pipe failure to control and conduct the flow of leaking contaminated waste or leakage to a collection point.

3. To keep pipe in line, on grade, and allow for thermal movement.

4. To keep pipe free from contact with soil which might serve as an electrolyte.

5. To serve as a radiation shield.

B. A DISCUSSION OF EXISTING WASTE LINE DESIGNS USED AT HANFORD WORKS, THEIR ADVANTAGES AND DISADVANTAGES.

1. Direct Burial on Concrete Slabs

a. General

This method was used in the original construction of the 200-E and 200-W Areas at Hanford Works. At the time of construction no cathodic protection was used. All lines installed since 1947 have had cathodic protection. (See SK-2-1082, Sh. 1).

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b. Description

The waste lines are laid in trenches on top of curbed concrete slabs running the full length of the lines. The trenches were backfilled with original earth, after the pipes were installed and pressure tested.

c. Advantages

1. The purpose of the slab is to keep the pipe on a true grade and in line.

2. The slab offers some protection against mechanical failure

3. The slab offers protection against uneven local settlement.

d. Disadvantages

1. In case of a failure, the contaminated waste can flow uncontrolled into the surrounding ground.

2. In September, 1947, pits and holes due to exterior galvanic action were discovered in some of the existing lines. On this type of construction without cathodic protection the pipe is susceptible to galvanic action as it is in direct contact with the earth. The slab, due to its shape, will impound seepage water which favors galvanic action.

c. Small leaks can not be readily detected.

2. Direct Burial on Wood Sleepers

a. General

This method was used for the BX tank farm which was con-

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structed in 1946. These lines did not have cathodic protection and failed within three months. (See SK-2-1082, Sheet 1, attached, also H-2-610 and H-2-653.

b. Description

In this method the pipe was laid in notches on 6" x 6" timber sleepers. The sleepers were spaced at 10 foot intervals along the trench. The lower portion of the back fill was compacted with water. Compacting the backfill with water has a tendency to concentrate the natural salts and form water pockets at the bottom of the ditch thereby creating an electrolytic condition. The wood block will also soak up moisture making possible electrolytic action between the pipe and the wood sleeper.

3. Inverted, "U" Shaped Cover Concrete Encasement

a. General

This type of encasement was used for the 241-BX installation in 1947. These lines now have cathodic protection which the original design did not specify. (See SK-2-1082, Sheet 2 attached and Drawings H-2-860 and H-2-853).

b. Description

This type of encasement consists of a continuous reinforced concrete base slab and a reinforced concrete inverted "U" shape cover, with side walls and top precast together in sections. The base slab slopes from the outer edges to the center for drainage. Expansion joints in the base are constructed at intervals of 100 feet. Each joint has a stainless steel strip for a water stop and is filled with asphalt.

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The base is covered with two layers of roofing felt and a sheet of fiberglass 1/8" thick. Each layer is mopped with asphalt. The cover section is ten feet long and has lifting hooks. The inside of the cover is painted with asphalt.

The joints between cover sections are covered with a foot wide strip of 55# felt mopped with asphalt over which is placed a strip of 8# lead. The process pipes are supported on a piece of wood fitted into a 3" channel. These channels are at right angles to the pipe, bolted directly to the slab, and are spaced at ten foot intervals. A system of pipe bends, loops and anchors is used to take care of the thermal movement of the pipe. The encasements drain into a catch tank at the diversion boxes.

c. Advantages

1. The slab keeps the pipe on a true grade and in line.
2. The encasement protects the pipe against mechanical failure from external loads.
3. In case of a line failure the contaminated waste will be contained in the encasement and caught in the catch tank.
4. Small leaks can be readily detected.
5. The waste lines are not in contact with the soil.
6. The top slab serves as a radiation shield.

d. Disadvantages

1. The lead used is a critical material
2. There is no mechanical bond between the base and cover slabs. The thermal movement of the base and cover slabs

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may not act together which may result in openings through which seepage water can enter.

e. Estimated Cost is Given Under Part IV "Comparison of Cost of Existing Methods and Proposed Methods.

4. Single Process Line Encased in a Carbon Steel Pipe

a. General

This method of protection is used on single lines of the 241-BX. (SK-2-1082, Sheet 3, attached, and Drawing H-2-856.

b. Description

On straight runs the 3" stainless steel process lines are encased in 6" carbon steel pipe. Stainless steel straps are welded to the 3" stainless steel pipe at five foot intervals for supports. The outside line is welded together after the process line has been tested. A 4½" slot is cut in the carbon steel pipe at bends to receive the stainless steel pipe. The cut piece is then replaced and tack welded.

c. Advantages

This method makes a tight continuous encasement.

d. Disadvantages

1. Both the carbon steel and stainless steel lines must have cathodic protection.

2. Two dissimilar metals are in contact.

3. Two lines of this type failed in 1951. The cause is being investigated at this time.

5. Reinforced Concrete Encasement with "U" Shaped Base and Flat Cover Slab.

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a. General

This type of encasement was first used on the 241-TX and 241-UX process lines in 1947. Similar designs have been used at Hanford Works since that time. (SK-2-1082, Sheet 4 and 5 attached, Drawing H-2-845, H-2-5217-3 and Specification HW-3937.)

b. Description

The base is a continuous reinforced concrete slab with 8 inch high curbs on each side. The floor slopes to the center for drainage.

The top is a flat reinforced concrete slab, precast in ten foot sections with bails for lifting.

The encasement is sealed by the applications of Amercoat #16, vinyl plastic mortar between the cover slabs and base curbs. The cover slab ends are butted against a 1/2 thick fiber expansion filler and the joint is filled with a hot sealing compound. A 2 ply waterproofing membrane is applied to the outside surface of the cover slabs and encasement sides.

The waste pipes are supported on concrete tubular sleeves spaced on 15 foot centers.

Inside surfaces of the encasement and the concrete sleeves are given five coats of Amercoat #33 vinyl plastic paint.

A system of bends and anchors are used to permit controlled thermal movement of the pipe. (See SK-2-1082, Sheet #5 attached). The waste lines have cathodic protection.

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Test risers are spaced about 400 feet apart along the line.

c. Advantages

1. In case of pipe failure all contaminated waste is contained within the encasements and is drained into a catch tank.

2. The pipe has double protection against exterior galvanic corrosion. It has cathodic protection and is not in contact with the earth.

3. The encasement protects the waste lines against mechanical failure from outside loads.

4. Small leaks can be readily detected by sampling through the test risers.

5. The encasement serves as a radiation shield.

d. Disadvantages

1. It is estimated that the vinyl plastic coating costs $3.60 a running foot and the plastic mortar costs $1.48 per running foot for a five line encasement assuming the work is done under ideal weather conditions. The vinyl coating is to protect the concrete from the chemical effects of the waste solution in case of a leak.

2. Earth tremors may possibly dislodge the cover slab as there is no mechanical tie between the cover slab and base.

e. Estimated Cost of A 5-Line Encasement

The estimated cost of this encasement is given under Part IV "Comparison of Cost of Existing Methods and Proposed Method".

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6. Modified Concrete Encasements With "U" Shaped Base and Flat Cover Slabs

a. General

This type encasement is used for the 241-EW process line, project C-362 III constructed in 1951.

The encasement is almost the same as described under Paragraph (III-B 5) with a few minor improvements. (SK-2-1082, Sheet No. 6 attached, Drawing H-2-43084, Sheet 1 of 5).

b. Description

The description of this encasement is the same as that described under Paragraph (III-B-5) above but with the following differences:

1. A taper screw cone nut lifting stud is used in place of lifting bails.
2. Vitrified tile tubular support sleeves for the pipe are used in place of concrete sleeves.
3. Design of the cast anchor block was improved resulting in a savings of material.

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c. Advantages

1. The advantages of this encasement are the same as those listed under Paragraph (III-B-5) above.
2. The use of vitrified tile supports in place of concrete sleeves save approximately 14 cents per running foot of encasement because no painting is required for the tile.
3. The use of lifting studs permite a more water tight construction and reduces the cost of laying the water proofing

membrane as no cutting or fitting is required around lifting studs. must studs removed

d. Disadvantages

The disadvantages of this encasement are the same as those in Paragraph (III-B-5) above.

e. Estimated Cost of a 5-Line Encasement

The estimated cost of this encasement is given under Part IV "Comparison of Cost of Existing Methods and Proposed Method".

C. A DISCUSSION OF PROPOSED TYPES OF WASTE LINE ENCASEMENTS, THEIR ADVANTAGES, AND DISADVANTAGES.

1. Waste Lines Enclosed in a Parting Membrane and Buried in a Reinforced Concrete Slab.

a. General

A method similar to this one has been used successfully for protection of underground steam lines. (SK-2-1082, Sheet 7 attached.)

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b. Description

The pipe is wrapped in water proofed corrugated paper membrane and buried in a reinforced concrete slab. A system of anchors and expansion loops are used to permit controlled thermal movement of the pipe. Any outside seepage or leakage is caught in the expansion loop chamber and carried in a vitrified tile drain line to the catch tank. The corrugated paper will allow the pipe to move freely as the temperature changes. Any leakage will drain to the expansion loop chambers through the annulus between the pipe and the concrete.

A pipe riser is installed at each loop chamber for taking samples.

c. Advantages

1. The encasement protects the waste lines against mechanical failure.

2. The encasement keeps the pipe from possible electrolytic action resulting from contact with the soil.

3. In case of leakage the encasement prevents contaminated waste from flowing into the surrounding earth.

4. The encasement is of monolithic construction.

d. Disadvantages

1. The encasement is not protected against solutions harmful to concrete. However this can be overcome by wrapping the paper membrane with a thin sheet of vinyl plastic which will give the proper protection to the concrete.

2. The encasement can not be readily decontaminated in case of a leak.

e. Estimated Cost of a 5-Line Encasement

The estimated cost of this encasement is given under Part IV "Comparison of Cost of Existing Methods and Proposed Method".

2. Pipe Enclosed in a Half Section of Vitrified Tile and Buried in Reinforced Concrete.

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a. General

A method similar to this one has been used successfully for protection of underground steam lines. (SK-2-1082, Sheet 8).

b. Description

The waste lines are laid on a flat reinforced concrete slab.

Stainless steel shoes are tack welded to the bottom of the pipe at 10 foot intervals. Half sections of vitrified clay pipe are set in mortar on the slab and over the stainless steel pipe. Concrete is then poured around the clay pipe. A system of anchors and loops in a chamber is used to permit controlled thermal movement of the pipe.

Each line drains into the expansion chamber and from there into a vitrified tile pipe line to a catch tank.

The expansion loop chambers have test riser for sampling. The floor of each chase may be painted with plastic vinyl and the tile set in plastic vinyl mortar if concrete protection is required.

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c. Advantages

1. The encasement protects the waste lines against mechanical failure.
2. The encasement keeps the pipe out of possible electrolyte.
3. In case of leakage the encasement prevents contaminated waste from flowing into surrounding earth.
4. The encasement is of monolithic construction.

d. Disadvantages

The half sections of vitrified clay pipe may be hard to procure at the time they are needed.

e. Estimated Cost of a 5-Line Encasement

The estimated cost of this encasement is given under Part IV "Comparison of Cost of Existing Methods and Proposed Methods.

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3. Concrete Base With a Part Circle Culvert Corrugated Iron Top.

a. General

This type of construction is used by towns and cities as a drainage structure under streets and pavements. (SK-2-1082, Sheet 9)

b. Description

The encasement consists of a reinforced concrete base and a corrugated iron part circle culvert top. There are two types, in one the top is covered with a thin layer of concrete and a two ply water-proofing membrane. In the other the part circle top is covered with a thick slab of concrete and no membrane.

The base may be painted with a vinyl plastic coating, and the underside of the culvert may be painted before installing. A system of anchors and bends is used to permit controlled thermal movement of the pipe. Risers are installed at intervals for taking samples.

c. Advantages

This type of encasement is of monolithic construction. It has all the advantages of the 241-EW line and 241-TX line. See Paragraph (III-B-6) of this report.

d. Disadvantages

1. Corrugated iron is critical material at present. The weight of the reinforced steel and corrugated iron is estimated at 65# per foot compared to 48# of reinforcing

steel per foot for the concrete cover slabs presently used on the Hanford Works type waste line encasements.

2. Part circle culverts of a size capable of accommodating more than 5 lines are unavailable. Where encasement of more lines is required a multiple span arrangement must be used.

e. Estimated Cost for 5-Line Encasement

The estimated cost of this encasement is given under Part IV "Comparison of Cost of Existing Methods and Proposed Method."

4. "U" Shaped Base and A Flat Slab Cover (SK-2-1082, Sheet 10)

This type of encasement is similar to the 241 EW type. In this system the pipe lines are spaced at 6 inch centers, the encasement is 3'-8" wide and contains .19 cu. yards concrete per lineal foot. In the 241 EW type the pipes are spaced at 7 inch centers, the encasement is 4'-4" wide and contains .22 cu. yards of concrete per lineal foot.

The inner surface of the cover slab is dropped 2 inches to prevent it from shifting sideways in case of earth tremors.

Mortar is used between the base and cover slab. Mortar is also used between the end of the cover slab instead of mastic expansion joint material as used on 241 EW. It is assumed the mortar unites the base and cover slab causing them to move together in the event of expansion or contraction. For this reason the expansion joints are unnecessary between each cover slab.

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D. A DISCUSSION OF PRESENT CATHODIC PROTECTION USED AT HANFORD WORKS AND RESULTS OF PREVIOUS STUDIES.

1. Present Cathodic Protection

Cathodic protection is applied to all buried stainless steel lines including lines in encasements in accordance with Specification HW-2946. On new construction it is applied immediately after placement of the stainless steel pipe in the ground or in the encasements. The General Electric operating forces supervise the installation and make final adjustments such as voltage regulations. The following requirements and recommendations are set forth in Specification HW-3946.

a. Rectifiers should generally provide direct current voltage, equal to 0.001 ohmic resistance/C cube for stainless steel.

b. The following voltages, anode or cathode, have been established.

Area	Direct Current Volts
200 East	30 volts
200 West	60 volts or more

c. Current consumption is usually small. Twenty amperes rating D.C. is normally ample for any installation in Hanford Works soil.

d. The rectifiers presently used are: copper oxide type, fan cooled, single phase, 60 cycle, 115 volt, General Electric Model 6RC 109F5, Voltage 115 AC/30 DC and Amperage 10 AC/20 DC.

For future installation an oil immersed type of the same rating is preferred.

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e. Anodes are constructed of old R.R. rails.

f. No provisions are made for either manual or automatic connections in case of power outage.

The application of cathodic protection to stainless steel pipe in storage is not practical, mainly because it cannot be controlled under storage conditions. Any new installation can influence the protective value of an existing one and/or influence corrosion of other buried metal structures so that a new application must be correlated to existing protective schemes. Maps showing existing cathodic installations are available.

2. Results of Previous Studies

In September, 1947, immediately after the discovery of a failure in existing buried line, studies of galvanic corrosion and protection against it were undertaken by the Electrical Division. These studies were completed August 15, 1949, and the data and recommendations were reviewed by the Stainless Steel Pipe Sub-Committee of the Hanford Works Standard Committee.

Cathodic protection was applied to all buried stainless steel lines during the time of the study. Field experiments were made and the data was presented to the committee.

Controlled tests of buried samples were also made. Although no pitting was discovered on protected buried samples in six months time, similarly buried unprotected samples were definitely pitted during the same period of time.

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Forced tests led to pitting of all pipe samples covered with tapes or other protective coverings with the exception of Tape Coat. Tape Coat is not suitable for high temperatures as it becomes soft at about 120° F. No failures were discovered in any protected pipe lines during the 20 months the studies were continued. Experiments were made to determine line failure by checking variations in protective currents. It was found that such variations are too sensitive to serve as a reliable indication of possible leakage in the pipe.

As a result of these studies, and recommendations in the Subcommittee Report of August 15, 1949, and of November 30, 1949, the Hanford Works Standard Committee approved Specification HW-3936. This specification has been used for all stainless steel pipe line installations since that time.

During 1951 two new pipe line failures were discovered in the 200 East Area. These lines connect the 221-B Building with the diversion box. The lines are single and encased in a steel pipe. The encasement carried the leakage to the catch tank where it was discovered. The causes of the failures are being investigated at this time.

The above two leaks are the only failures known to have occurred between September, 1947 to January, 1952. (See SK-2-1082, Sheet 3 attached.)

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E. A DISCUSSION OF THE EFFECT OF POSSIBLE LEAKS IN EXISTING LINES AND THE HAZARDS THEY MIGHT CAUSE.

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1. Waste Line Failures in Lines in Encasements

Any leakage from a pipe in an encasement will be carried along the low point of the base to the catch tank at the diversion box. The location of the leak may be found by taking swab samples through risers which are spaced about 400 feet apart along the encasement. The encasements may be decontaminated by running acid through a sample riser, and subsequently flushing through the riser. before you [illegible] the [illegible]

In 1951 two leaks were found in a steel encased line of the 200-E Area. The leakage flowed in the encasement to the catch tank where it was detected. No hazards were created on the surface due to the leakage.

2. Waste Line Failures In Lines Not In Encasements

a. In case of a pipe line failure the hydraulic head may cause a washout or cave in, or the waste may rise to the surface and in either case will cause a radiation hazard. In 1947 a failure of this type of a line in the 200-E Area caused a cave in and created a very high radiation hazard on the ground surface and surrounding area.

b. Capillary action may bring contaminated waste from small leaks to the surface.

c. Plants may bring radiation from small leaks to the surface through their root systems.

d. Waste from leaks may enter into the water table. This may be serious depending upon the quantity of waste leakage and certain water table conditions at that time.

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e. Waste leaks may contaminate near by service lines or seep into nearby basements, tunnels, pits, etc.

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3. Conclusions

There is always the possibility of an uncontrolled radiation hazard existing where lines are not in encasements. A line failure may take place in an encasement but the hazards can be adequately controlled.

IV. COMPARISONS OF COST OF EXISTING METHODS & PROPOSED METHODS OF ENCASEMENTS

A. COST COMPARISON OF EXISTING & RECOMMENDED FIVE LINE ENCASEMENTS.

Par. No.	Type	Drawing	Average Cost Per L.F.
1. Existing Waste Line Designs			
III-B-3	Type 241-BX	SK-2-1082 Sheet 2	$ 33.33
III-B-5	*Type 241-TX	SK-2-1082 Sheet 4 & 5	32.28
III-B-6	*Type 241-E&W	SK-2-1082 Sheet 5 & 6	31.21
2. Proposed Waste Line Designs			
III-C-1	Concrete Embedded Type	SK-2-1082 Sheet 7	15.00
III-C-2	5 Tile Type	SK 2-1082 Sheet 8	58.00
	1 Tile Type	SK-2-1082 Sheet 8	43.50
III-C-3	*Corrugated Culvert Type, Scheme I	SK-2-1082 Sheet 9	32.89
	*Corrugated Culvert Type, Scheme II	SK-2-1082 Sheet 9	29.00
III-C-4	*"U" Slab Base & Flat Slab Cover Type, Recommended	SK-2-1082 Sheet 10	21.74

*For comparative purposes costs are based on Amercoat #33 applied on interior concrete surfaces.

Average costs per lineal foot are based on quantities and labor required to construct a minimum of 200 feet of 5 line encasement.

The costs shown do not include piping excavation, contingencies, overhead and distributions.

Costs are based on normal conditions using wooden forms and include pipe anchors. For a large amount of encasement a well designed steel form would appreciably lower these costs.

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B. COST ANALYSIS OF EXISTING AND PROPOSED FIVE LINE ENCASEMENTS

Item	Description	SK-2-1082 Sheet #6 With Precast Conc. Covers Existing			SK-2-1082 Sheet #9 Scheme #1 With Corr. Iron Cover Proposed			SK-2-1082 Sheet #10 with Concrete Covers Proposed (Recommended)		
		Quan.	Unit Cost	Total Cost	Quan.	Unit Cost	Total Cost	Quan.	Unit Cost	Total Cost
1.	Concrete, cu. yds.	0.25	65.00	*16.25	0.27	60.00	*16.20	0.19	65.00	*12.35
2.	Reinf. steel, lbs.	48.00	0.15	* 7.20	33.00	0.15	* 4.95	25.00	0.15	* 3.75
3.	Corr. steel liner, lbs.	----	----	----	32.00	0.25	* 8.00	----	----	----
4.	Cement mortar, lineal ft.	1.00	0.21	0.21	----	----	----	1.00	0.21	* 0.21
5.	Total [1]			23.66			29.15			16.31
	Other Misc. Costs Not Included in The Above Items[2]:									
6.	Waterproof membrane sq. ft.	7.00	0.17	* 1.19	----	----	----	6.00	0.17	* 1.02
7.	Select compact backfill cu. yds.	0.50	5.00	2.50	----	----	----	0.50	5.00	2.50
8.	Amercoat #33 sq. ft.	8.00	0.45	* 3.60	8.00	0.45	* 3.60	6.70	0.45	* 3.02
9.	Amercoat #55 sq. ft.	8.00	0.56	4.48	8.00	0.56	4.48	6.70	0.56	3.75
10.	Amercoat plastic mortar lin. ft.	1.00	1.48	* 1.48	----	----	----	1.00	1.48	1.48
11.	Bituminous paint, sq. ft.	8.00	0.16½	1.32	8.00	0.16½	1.32	6.70	0.16½	1.10
12.	Tile sleeves, lin. ft.	1.00	0.14	* 0.14			* 0.14	1.00	0.14	* 0.14
13.	Conc. sleeves, lin. ft.	1.00	0.28	0.28	1.00	0.28	0.28	1.00	0.28	0.28
14.	Smooth, hard interior finish for painting, lin. ft.	1.00	0.10	* 0.10	1.00	0.10	0.10	1.00	0.10	0.10
15.	Select Backfill cu. yds.	0.50	2.50	* 1.25	----	----	----	0.50	2.50	* 1.25
	*Totals shown on Cost Comparison[3]			$31.21			$32.89			$21.74

1. These figures represent estimated costs of minimum encasements. Although the existing encasement shown included more items of work than are represented by the $23.66 figure, this has been included to furnish a basis of comparison between the existing encasement and the proposed minimum encasements.

2. Items 6 through 15 show estimated costs of items of work which may be added to the basic minimum encasements.

3. These figures represent the estimated cost of the existing encasement shown together with comparative estimates of comparable proposed encasements.

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C. COST ANALYSIS OF PROPOSED ELEVEN LINE ENCASEMENTS

Item	Description	Proposed Eleven Line Encasement With Single Span Concrete Covers[1]			Proposed Eleven Line Encasement With Double Span Concrete Covers[2]			Proposed Eleven Line Encasement With Double Span Corr. Iron Covers[3]		
		Quan.	Unit Cost	Total Cost	Quan.	Unit Cost	Total Cost	Quan.	Unit Cost	Total Cost
1.	Concrete, cu. yds.	0.4	65.00	26.00	.38	65.00	24.70	.5	60.00	30.00
2.	Re-steel, lbs.	90.0	.15	13.50	60.00	0.15	9.00	40.0	0.15	6.00
3.	Corr. Steel Liner, lbs.							60.0	0.25	15.00
4.	Cement Mortar, lineal ft.	1.0	.23	.23	1.00	0.23	0.23			
5.	Total [4]			39.73			33.93			51.00
	Other Misc. Cost Not Included in Above [5]:									
6.	Waterproof membrance sq. ft.	12.0	0.17	2.04	12.5	0.17	2.13	--	--	--
7.	Select compact backfill, cu. yds.	1.0	5.00	5.00	1.0	5.00	5.00	--	--	--
8.	Amercoat #33 sq. ft.	10.0	0.45	4.50	11.33	0.45	5.10	13.0	0.45	5.85
9.	Amercoat #55 sq. ft.	10.0	0.56	5.60	11.33	0.56	6.35	13.0	0.56	7.28
10.	Amercoat Plastic Mortar lin. ft.	1.0	1.60	1.60	1.00	1.60	1.60	--	--	--
11.	Bituminous paint sq. ft.	10.0	0.16½	1.65	11.33	0.16½	1.87	13.0	0.16½	2.14
12.	Tile sleeves, lin. ft.	1.0	0.31	0.31	0.31	0.31	0.31	1.0	0.31	0.31
13.	Conc. sleeves, lin. ft.	1.0	0.62	0.62	0.62	0.62	0.62	1.0	0.62	0.62
14.	Smooth hard interior finished for painting lin. ft.	1.0	0.20	0.20	0.21	0.21	0.21	0.21	0.21	0.21
15.	Select backfill cu. yds.	1.0	2.50	2.50	1.00	2.50	2.50	--	--	--

1. This encasement is similar to the five line encasement shown on SK-2-1082 Sheet 10 except it has been widened to accomodate eleven lines.

2. This encasement is similar to the five line encasement shown on SK-2-1082 Sheet 10 except it has been widened to accomodate eleven lines and a center wall has been provided to support the concrete cover.

3. This encasement is similar to the five line encasement shown on SK-2-1082 Sheet 9 Scheme 1 except that an additional section has been added to encase the additional six lines.

4. These figures show estimated costs of basic minimum encasements.

5. Items 6 through 15 show estimated costs of items of work which may be added to the basic minimum encasements.

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V. REFERENCES

A. HANFORD WORKS STANDARDS COMMITTEE - MINUTES OF MEETING DATED AUGUST 31, 1951; AUGUST 10, 1950; NOVEMBER 30, 1949; AND AUGUST 15, 1948.

B. HANFORD WORKS DRAWINGS AS FOLLOWS:

H-2-999	241-TX Index
H-2-845	241-TX Encasements
H-2-610	241-BX Encasements
H-2-43000	Index Map E-W Lines
H-2-43086	241-UR Encasements

C. HANFORD WORKS SPECIFICATION HW-3946, STANDARDS FOR APPLICATIONS OF CATHODIC PROTECTION FOR STAINLESS STEEL BURIED IN THE GROUND.

D. HANDBOOK OF WELDED STEEL PIPE BY CALIFORNIA CORRUGATED CULVERT COMPANY, BERKELEY, CALIFORNIA. CHAPTER IX, PROTECTION OF STEEL PIPE.

E. EFFECTS OF VARIOUS SUBSTANCES ON CONCRETE AND PROTECTIVE TREATMENT, WHEN REQUIRED, BULLETIN BY PORTLAND CEMENT ASSOCIATION.

VI. APPENDIX

Sheets 1 through 10 of Drawing SK-2-1082.

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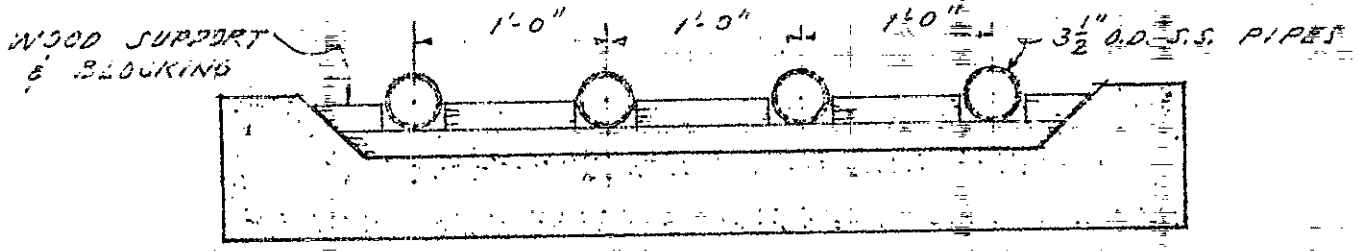
HW 24500



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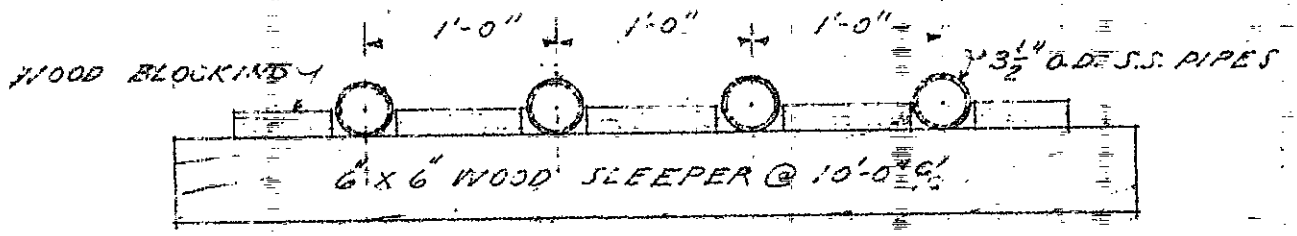

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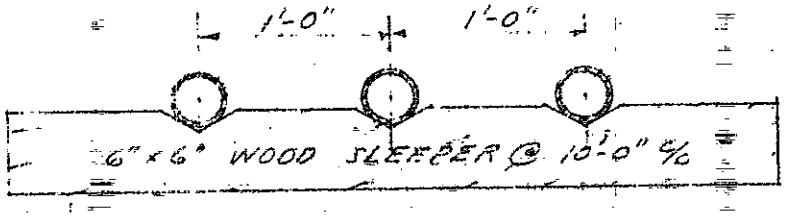

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DWG. NO. — DRAWING TITLE

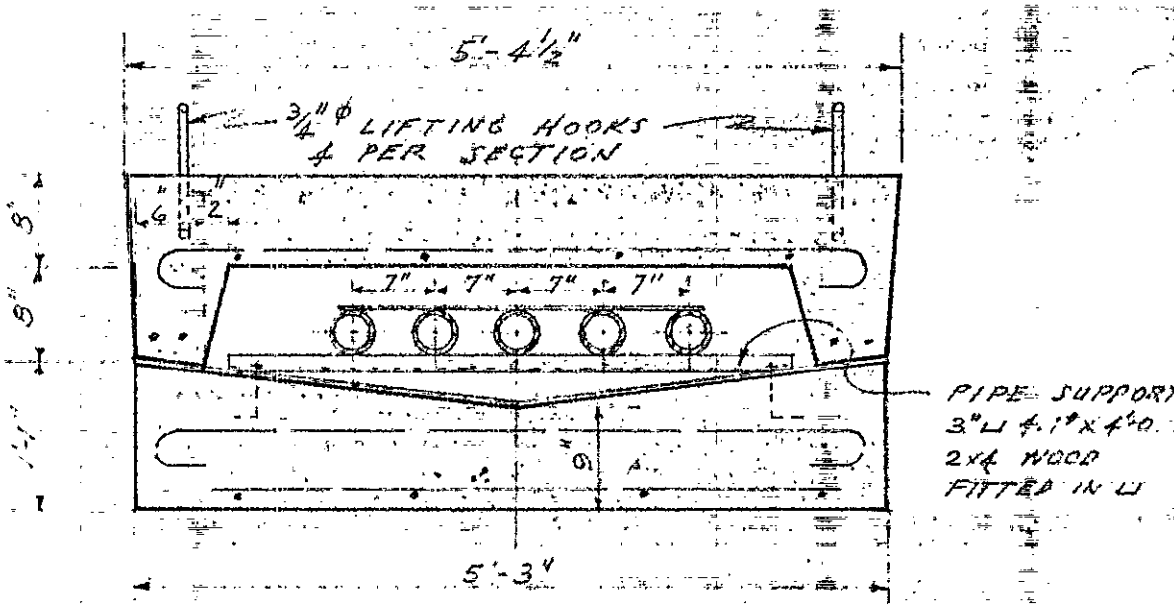
REFERENCE DRAWINGS

U.S. ATOMIC ENERGY COMMISSION
HANFORD WORKS
GENERAL ELECTRIC

PROTECTION OF EXTERIOR
BURIED WASTE LINES
DIRECT BURIED METHOD

FORM NO. 1-34-ES—L&H CO. 8-51

HW 24500



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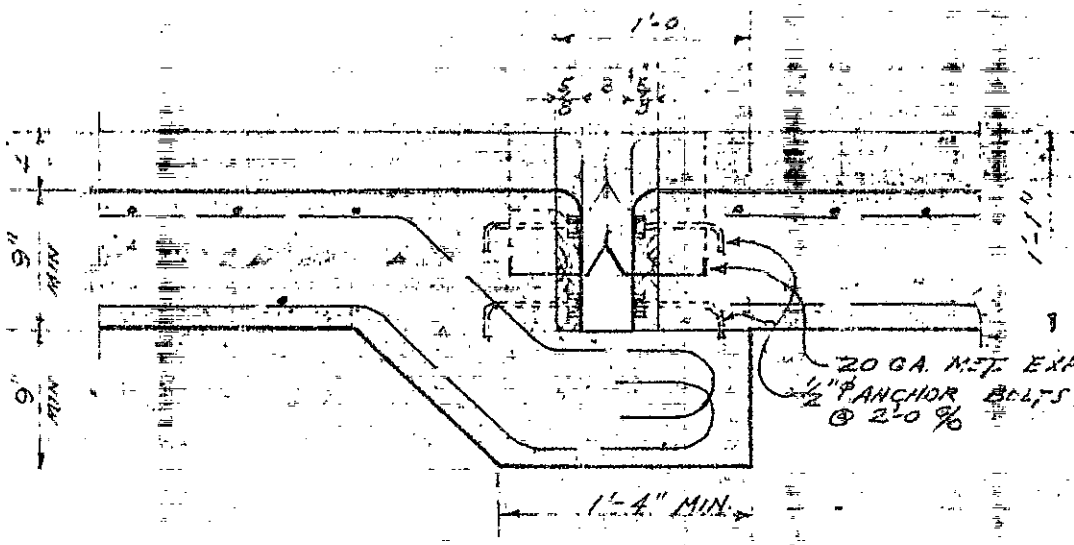

DETAIL OF EXPANSION JOINT

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DWG. NO. — DRAWING TITLE

REFERENCE DRAWINGS

U.S. ATOMIC ENERGY COMMISSION
HANFORD WORKS
GENERAL ELECTRIC

PROTECTION OF EXTERIOR
BURIED WASTE LINES
241 c METHOD

FORM No. 1-54-ES—L&H Co. 6-51

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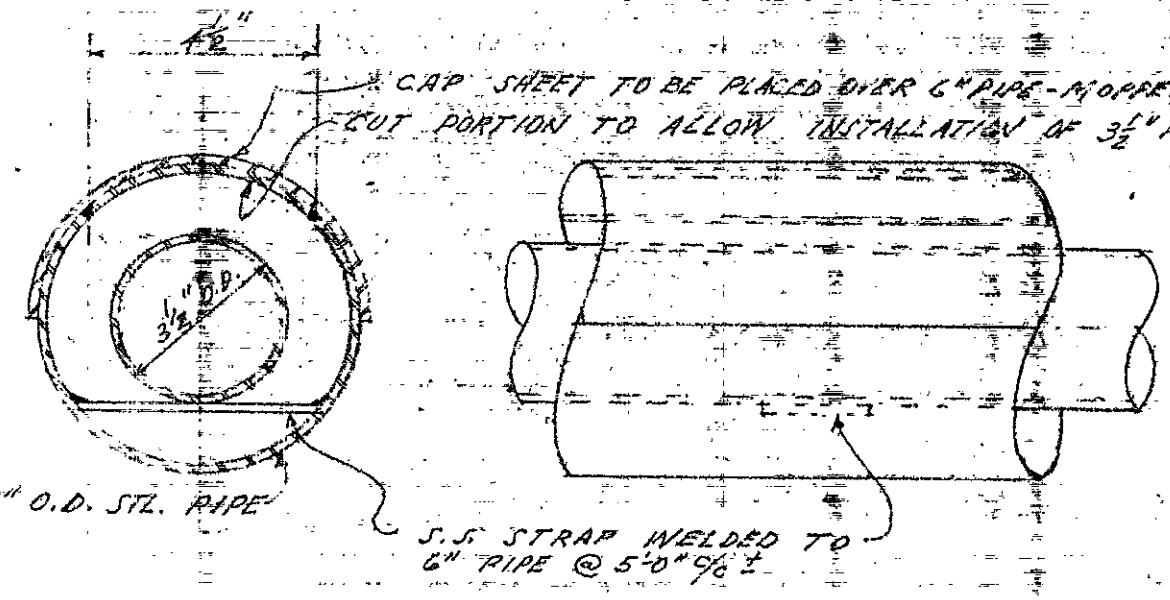

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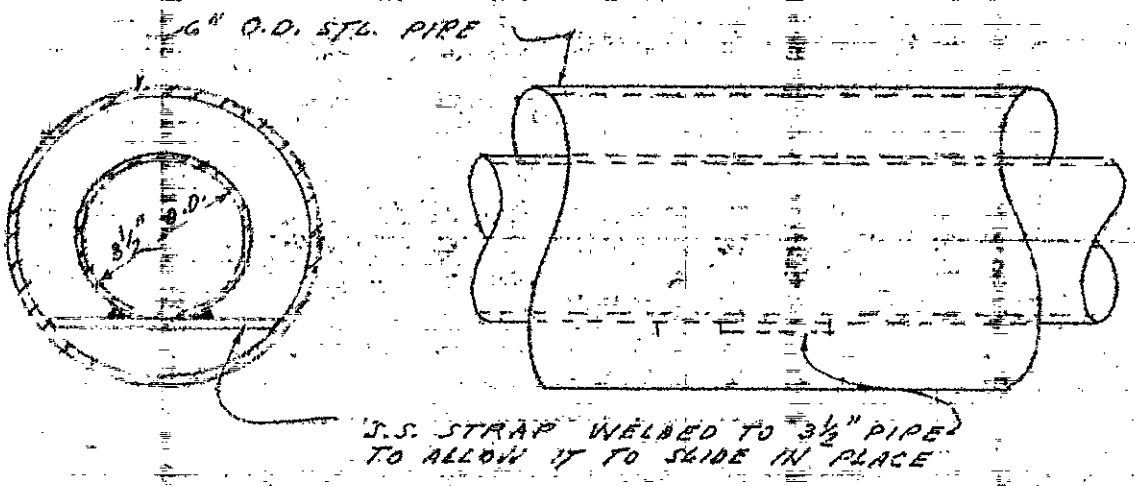

TYPICAL SECT. & ELEV. FOR TANGENT PORTION OF LINES

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U.S. ATOMIC ENERGY COMMISSION
HANFORD WORKS
GENERAL ELECTRIC

PROTECTION OF EXTERIOR BURIED WASTE LINES
241 C. SINGLE LINE METHOD

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	DES. ENG	DIV. D.E.U.	
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FORM NO. 1-34-ES—L&M CO. 8-51

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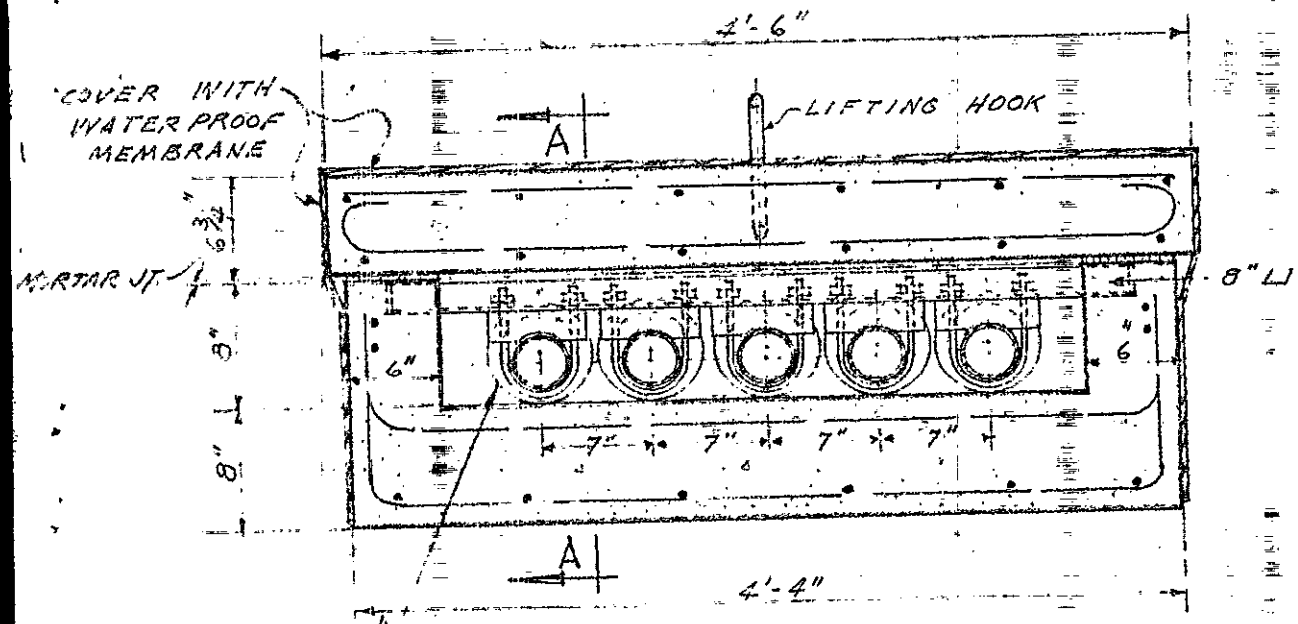
HW 24500



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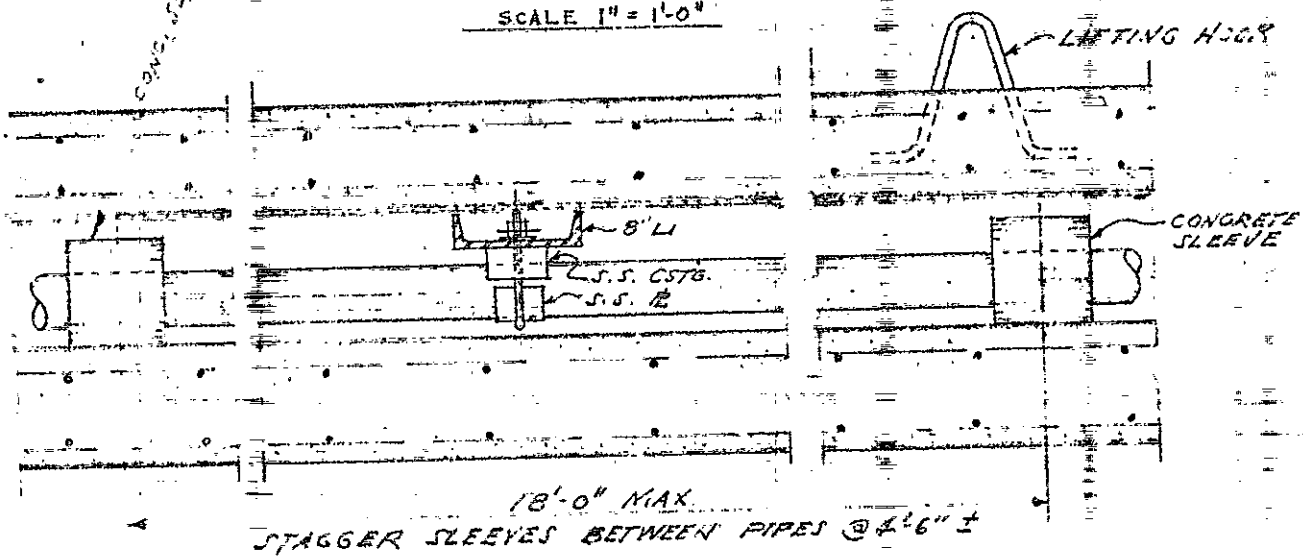

SECTION A-A

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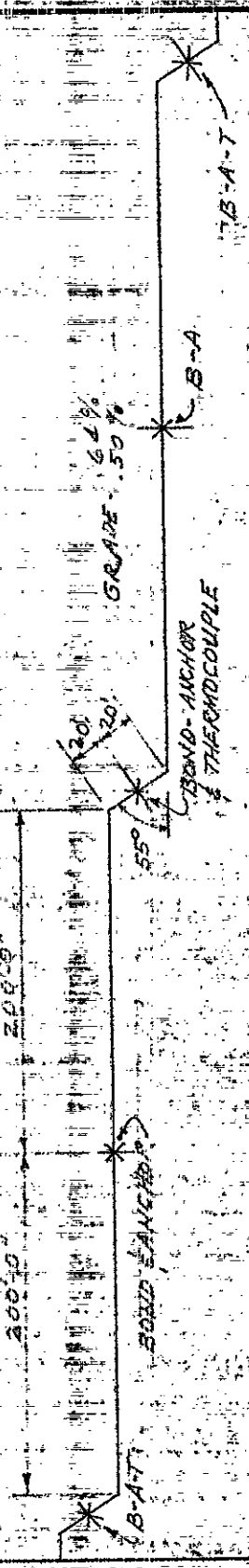
HANFORD WORKS
GENERAL ELECTRIC

PROTECTION OF EXTERIOR BURIED WASTE LINES 241 TX METHOD

1st ISSUE 1-17-52

FORM No. 1-34-ES—L&H Co. 8-51



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GENERAL ELECTRIC CO.
HANFORD WORKS

PROTECTION OF EXTERIOR
BURIED WASTE LINES
241-TX EXPANSION METHOD

SCALE
APPROVED
DED

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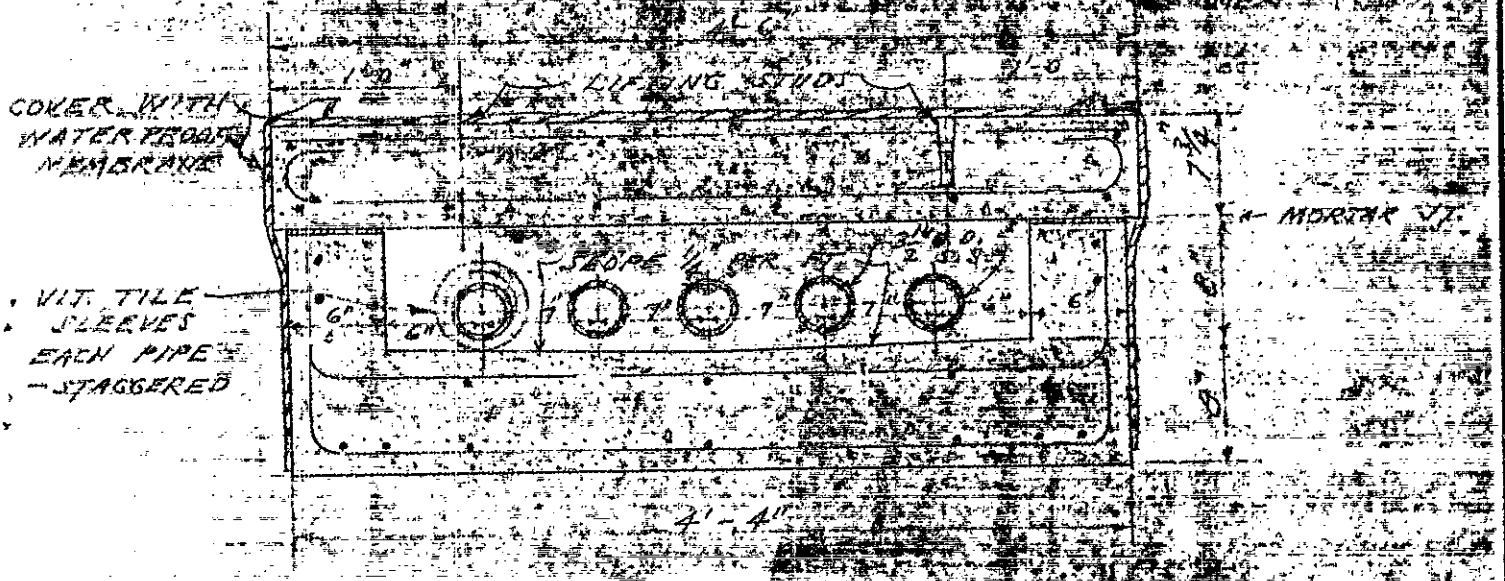
C. S. CO., NO. 376 4-50



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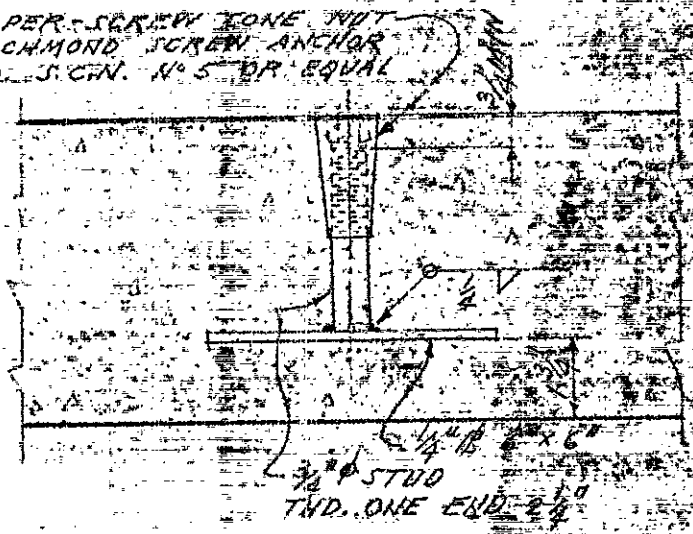

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SK-2-1082 DRAWING NUMBER

SHEET NO. 6 SHEETS 10

BLDG. NO. 200

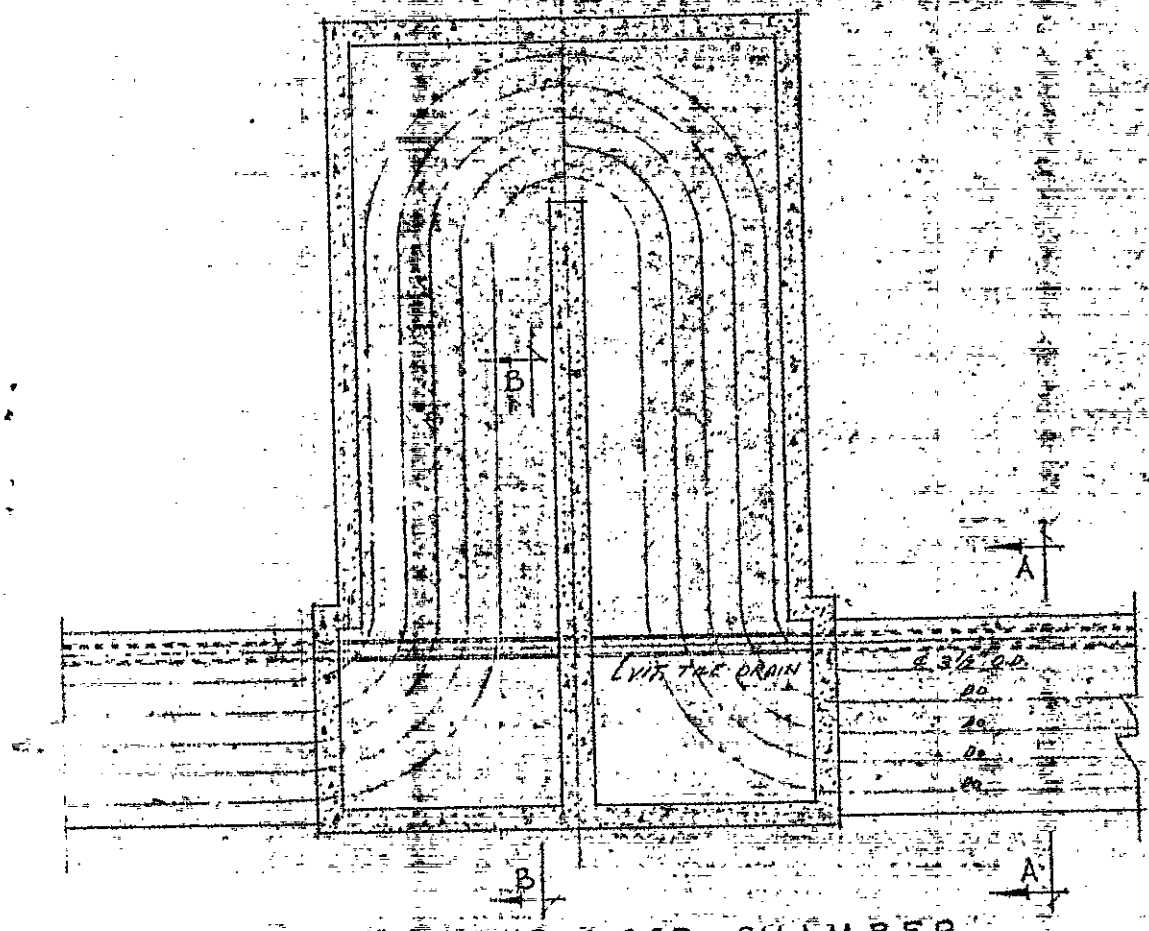
U.S. ATOMIC ENERGY COMMISSION
HANFORD WORKS
GENERAL ELECTRIC

PROTECTION OF EXTERIOR BURIED WASTE LINES
200E TO 200W LINE METHOD

FORM No. 1-34-ES—L&H Co. 8-51

ISSUE 1-17-52

HW 24500



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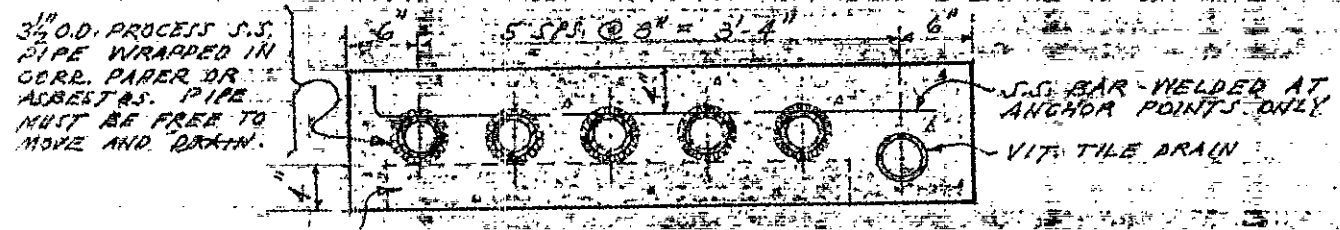

SECTION A-A

SECTION B-B

GENERAL ELECTRIC CO. HANFORD WORKS	SCALE	
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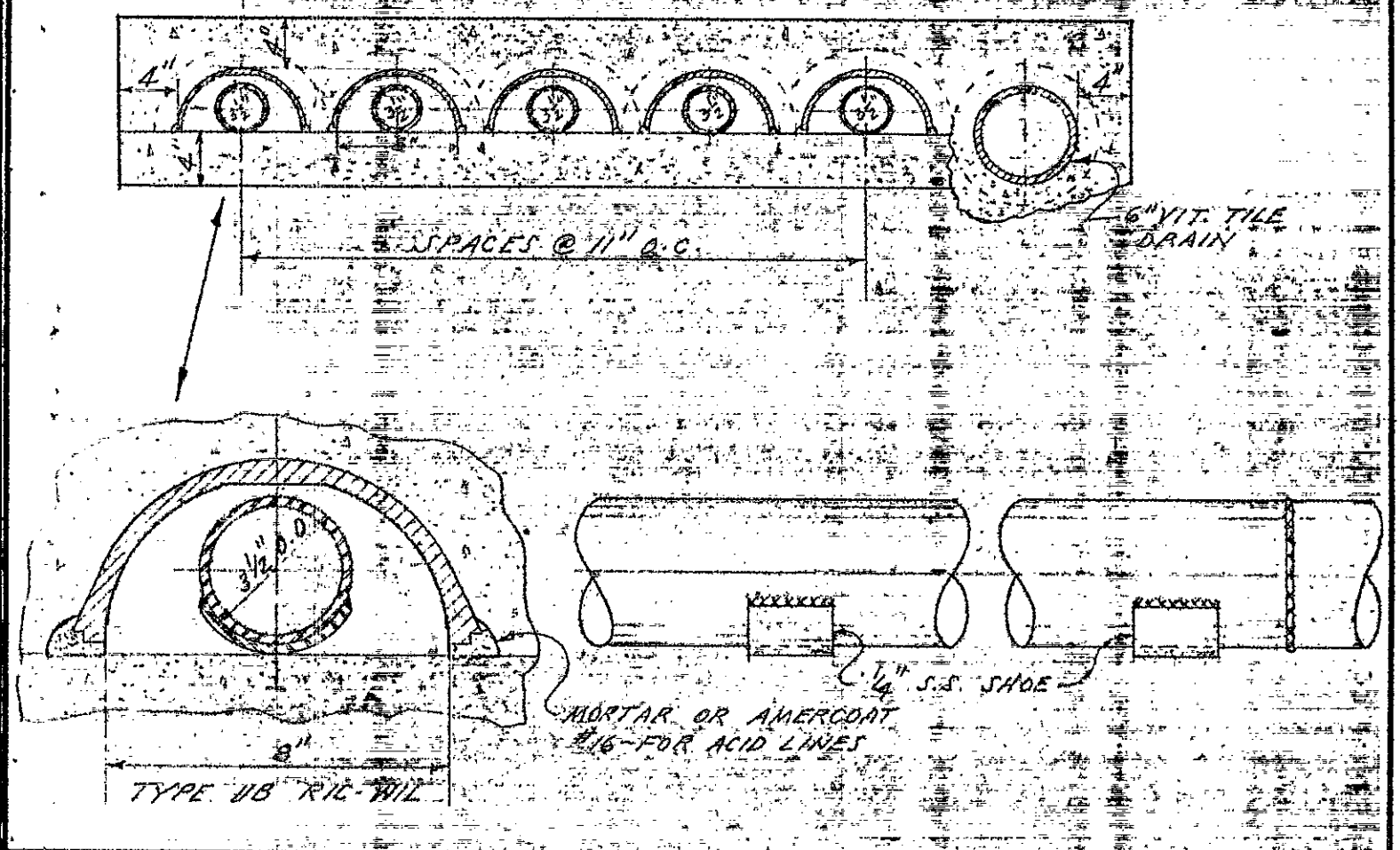
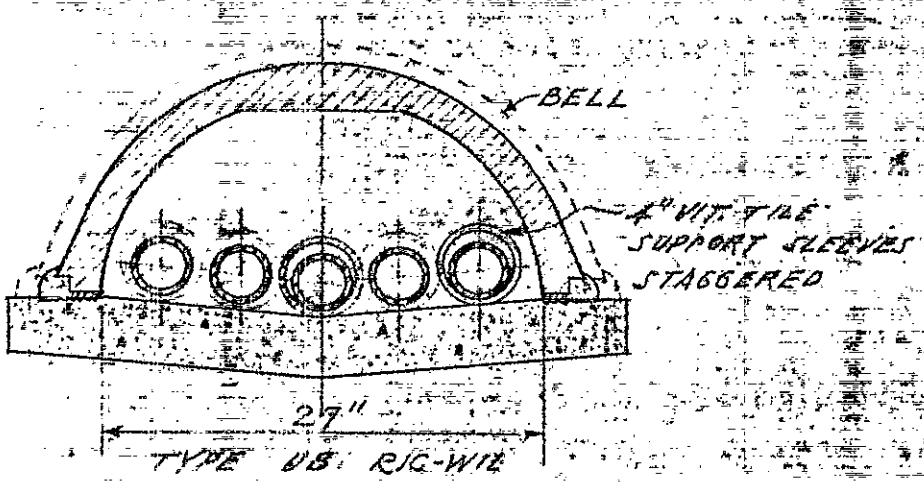
G. B. CO., NO. 378 4-50





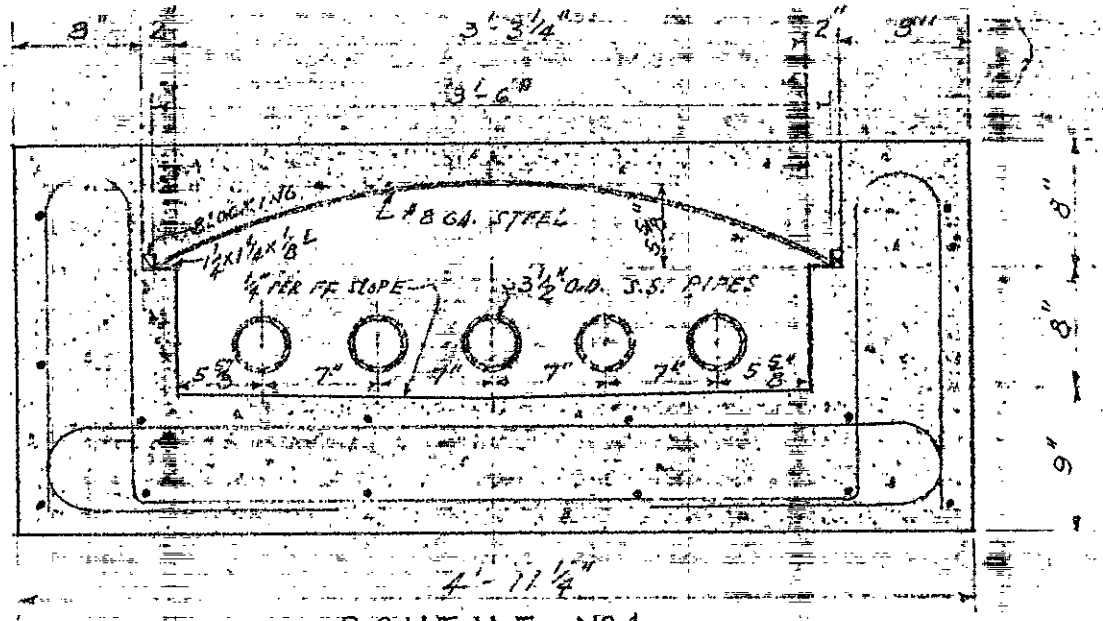
NONE

GENERAL ELECTRIC CO. HANFORD WORKS	SCALE APPROVED DU DEQ	DATE 1-19-52 DRAWN BY E.C. MANLARD CHECKED [illegible] PROJ. NO. RDA-4 E. R. NO. BLDG. NO. 200
PROTECTION OF EXTERIOR BURIED WASTE LINES TILE CONDUIT METHOD		DWG. NO. SK-2-1082 Sh #8

G. B. CO., NO. 376 4-50

1st ISSUE 1-17-54

HW 2-4500



SCHEME Nº 1
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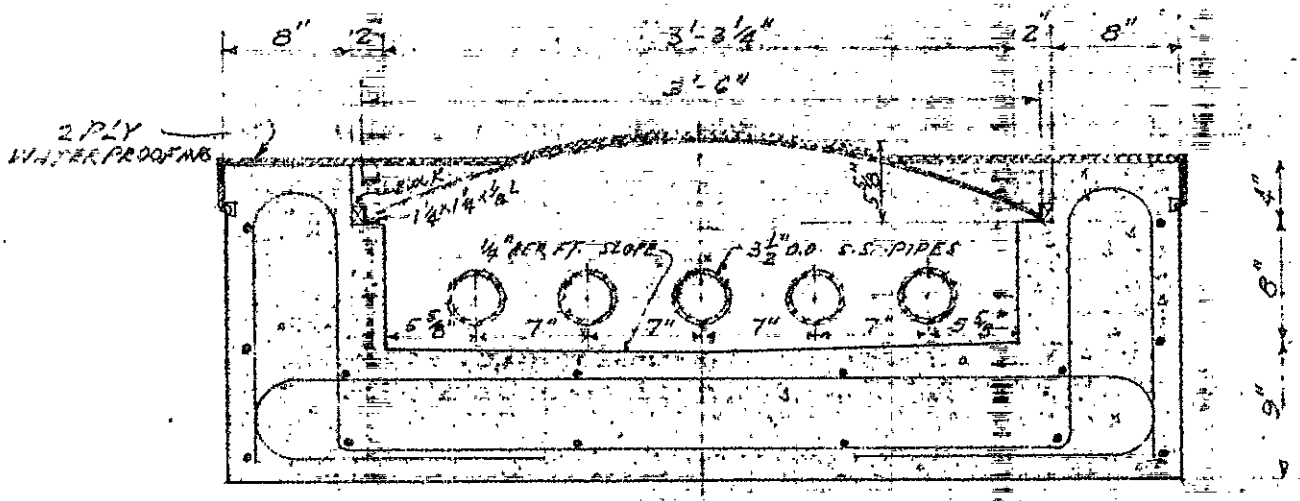


SCHEME Nº 2
TYPICAL CROSS SECTION

NONE

NO.	REVISIONS	REV. BY DATE	APPD. BY	DIV.	DATE

DWG. NO.	DRAWING TITLE

REFERENCE DRAWINGS

U.S. ATOMIC ENERGY COMMISSION
HANFORD WORKS
GENERAL ELECTRIC

PROTECTION OF EXTERIOR
BURIED WASTE LINES
STEEL CORRUGATED CULVERT METHOD

SCALE: 1" = 1'-0"

APPROVALS	DIV.

NEXT USED ON

DRAWN E. C. MAILLARD DATE 1-17-52
CHECKED [illegible] PROJ. NO. RDA-4
ISSUED E. R. NO.
DES. ENG G. U. DIV. DEV

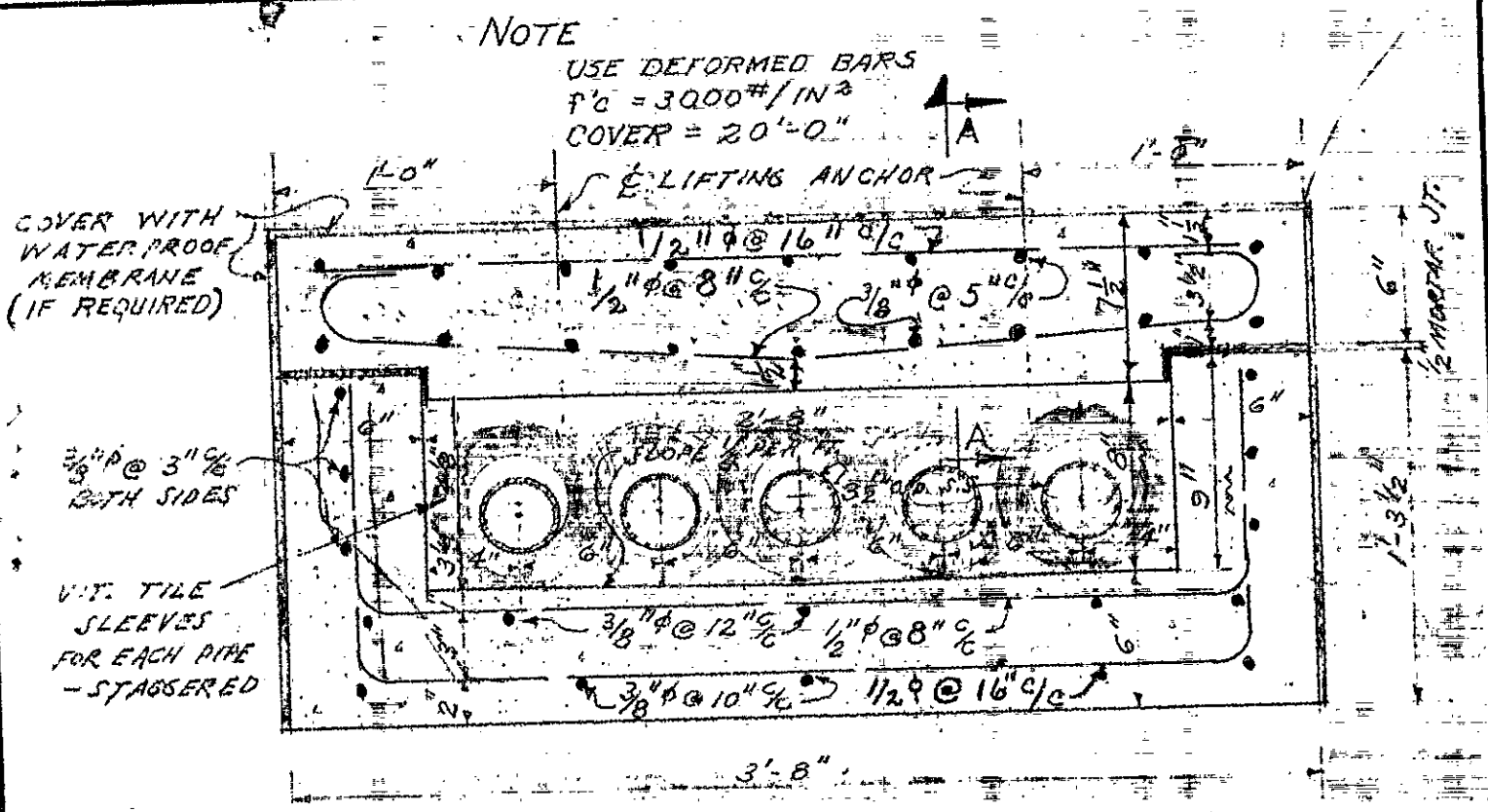
BLDG. NO. 200

SK-2-1082
DRAWING NUMBER

SHEET NO. 9 SHEETS 10

FORM No. 1-54-ES—L&H Co. 8-51

1st Issue 1-17-52



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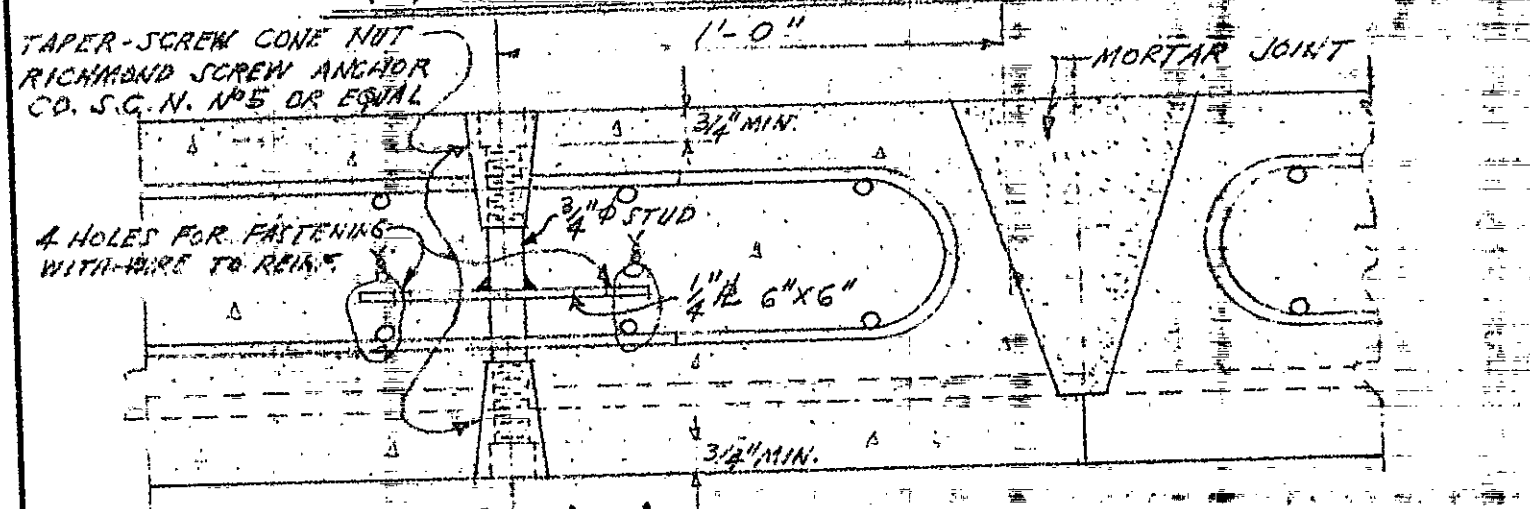

SECT. A-A
DETAIL AT COVER SLAB JOINT

NO.	REV. BY DATE	APPD. BY	DIV.	DATE
REVISIONS				

DWG. NO. | DRAWING TITLE
REFERENCE DRAWINGS

U.S. ATOMIC ENERGY COMMISSION
HANFORD WORKS
GENERAL ELECTRIC

SCALE: 1 1/2" & 3" = 1'-0"
NEXT USED ON
APPROVALS | DIV.
DRAWN E.C. MAILLARD DATE 4-9-52
CHECKED [illegible] PROJ. NO. RDA-4
ISSUED W/O 200.5257 E. R. NO.
DES. ENG Grant Udin DIV. DE U
SK-2-1082
DRAWING NUMBER
SHEET NO. 10 SHEETS 10
BLDG. NO. 200

PROTECTION OF EXTERIOR
BURIED WASTE LINES
PROPOSED ENCASEMENTS

2nd [illegible] 10-8 52

FORM NO. L-34-ES- L&H CO. 8-51