DESIGN OF THE ACCELERATOR SERVICE SHAFTS

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DESIGN OF THE ACCELERATOR SERVICE SHAFTS

A comprehensive study has been made on the use of various materials and methods of construction for the Accelerator Service Shafts. This report is a summary of the study and reviews the reasons for recommending that spirally corrugated steel pipe, galvanized and externally coated with asbestos fiber impregnated asphalt be used for the accelerator service shafts, and that installation be made in drilled holes after placement of the earth shielding fill.

TYPES OF PIPE CONSIDERED

After preliminary consideration of various pipe materials, a final detailed comparison was narrowed down to the following reasonably comparable types:

1. Spiral welded steel pipe, 3/16 inch wall, epoxy coated inside and outside, conforming to ASTM A 211: This is a minimum cost, welded steel, pressure pipe. The wall thickness was selected to provide reasonable rigidity for handling, and a crushing strength comparable to the other types. The coating was selected as the minimum cost material which would give adequate corrosion resistance and not be adversely affected by radiation exposure.

2. Steel cylinder type, cement mortar lined and reinforced cement mortar coated: This is another minimum cost type of pressure pipe which has excellent anti-corrosion properties. The pipe would conform to Federal Specification SS-P-00385 except for minor modifications. The steel wall is 14 gage; interior lining thickness is 1/2 inch, and exterior coating thickness is 3/4 inch.

3. Asbestos-cement, nonpressure pipe: This pipe is Type II, Class 3300, conforming to Federal Specification SS-P-331b. Wall thickness is 1.11 inches. Maximum available length is 13 feet; hence one coupling is required at the middle of each installation. The asbestos-cement develops an ultimate bending stress of approximately 6,000 pounds per square inch.

4. Corrugated metal pipe, galvanized and asbestos impregnated asphalt coated: This pipe conforms to Federal Specification QQ-C-806a with Class 1 corrugations, 14 gage steel. It is fabricated from corrugated sheets with riveted transverse and longitudinal lap joints.

5. Spirally corrugated metal pipe, galvanized and asbestos impregnated asphalt coated: This pipe conforms to Federal Specification QQ-C-806a with minor modifications. It is fabricated from a 14 gage steel sheet, spirally corrugated with a folded seam which can be welded to produce a water tight pipe.

6. Reinforced concrete pipe: This pipe conforms to Federal Specification SS-P-375, and is conventional nonpressure sewer pipe. It is not available in long lengths. Normal joints are tongue and groove type and cement mortar is normally used for making joints.

FUNCTIONAL REQUIREMENTS

Each type of pipe considered was judged on the basis of the following functional requirements:

1. Water tightness: Although soil moisture conditions adjacent to the accelerator service shafts are not expected to be severe, water tightness is desirable.

The elevated temperature of the wave guides during machine operation will induce a moisture migration away from the service shafts in a manner similar to that discussed in ABA-25, "Humidity in Accelerator Housing". The location of the service shafts beneath the Klystron Gallery floor and the subdrains for the accelerator housing tend to insure that no hydrostatic head of water or saturated soil condition will exist adjacent to the service shafts.

Prior to the adjacent soil drying out, however, the moisture content of the soil would tend to maintain a humid atmosphere in the service shafts. The relative inaccessibility of the service shafts once installed, would also make it very difficult if an accident such as a water main break, or excessive irrigation were to saturate the adjacent soil and cause leakage.

2. <u>Radiation resistance:</u> To insure continued service, it is essential that coatings, joint materials and the pipe have adequate resistance to expected radiation levels.

3. <u>Crushing strength:</u> The pipe must have adequate strength to resist the lateral pressures exerted by the surrounding soil. The magnitude of the lateral pressures is influenced by the method of installation and is discussed later.

4. <u>Longitudinal flexibility, strength and toughness:</u> Longitudinal compressive loading on the pipe is influenced by the construction and is discussed later. Other longitudinal loadings could result from handling during construction or from seismic disturbances and are not subject to more than a qualitative analysis.

Moderate longitudinal flexibility of the pipe would reduce stresses from these loadings to a safe range. Toughness, or the ability to undergo severe overstress without rupture, is desirable as an added safety factor as it limits damage in the event of an unforseeable overload.

5. Electrical conductivity: If the service shaft is a good electrical conductor, at least one joint must break direct contact between the accelerator housing reinforcement and the Klystron Gallery.

6. Ease of installation: Difficulty in installation is reflected in increased cost of installation. Undesirable properties are brittle pipe materials, fragile coatings, and short lengths of pipe which require intermediate joints.

7. Corrosion resistance: The relative inaccessibility of the service shafts after construction requires that they have a degree of corrosion resistance adequate to insure against the necessity of shutdowns to repair the service shafts. Protection against stray ground currents is the primary corrosion resistance problem. The increase in soil resistivity, which will occur because of the moisture migration away from the service shafts, will reduce the stray ground current problem after the accelerator is in operation. The net affect is that the accelerator service shafts must have good corrosion resistance for an initial period of perhaps two years. After this initial period a moderate degree of corrosion resistance should be adequate.

For metal pipes the requirement of good initial corrosion resistance implies that no welding should be done inside the service shafts after installation since this would damage the exterior coating and this damaged area would not be accessible for repairs. If heavy welding is to be done at the top of the pipe shaft during equipment installation, a heavier gauge, such as No. 12, could be used. The additional cost would be about $2.50 per foot or $33,000 total for 518 shafts.

METHOD OF INSTALLATION

There are three basic methods of installation which can be followed:

1. Install prior to placement of the shielding fill.
2. Install concurrently with placement of the shielding fill.
3. Install after placement of the shielding fill.

The latter method has been selected because of overall economy and more certain structural behavior of the accelerator housing, service shaft, shielding fill and Klystron Gallery complex.

Either of the first two methods impose severe restrictions on the use of conventional heavy equipment for compaction of the shielding fill in the most critical zone. Extremely rigid inspection and costly construction would be required to obtain reliably uniform compaction of the zone of shielding fill adjacent to the service shafts if this fill is compacted with small compaction equipment such as is used for trench backfilling. In spite of intensive development of such equipment in recent years, trench backfill has still not attained the degree of reliability which heavy compaction equipment produces on mass embankments.

The method of placement also has a marked influence on the loads the surrounding soil exerts on the service shafts. For the first two methods soil compacted around the service shafts will exert a minimum lateral force equal to the "at rest" earth pressure.

Roughly this is equivalent to the pressure from a fluid about half as heavy as the soil. If good compaction of the soil is obtained, the lateral pressure will be somewhat higher than this, but will be less than the "passive" pressure of the adjacent soil. As a reasonable maximum it will be less than the pressure from an equivalent fluid twice as heavy as the soil. A reasonable estimate is that lateral pressure against the service shaft will be equal to the vertical pressure, or that of an equivalent fluid equal to the weight of the soil.

In addition, the adjacent soil will exert a "down drag" or vertical load on the service shafts. This loading primarily results from elastic compression of the portions of the fill previously placed as additional fill is placed on top of it. A rough approximation of this load is from 10 to 15 tons. It might be as low as 5 tons or range as high as 25 tons.

In the recommended method of placement, an oversized hole is drilled through the completed shielding fill and a temporary cover of the penetration through the top of the housing is removed. The service shaft is set in place, aligned, and sealed at the bottom. Dry sand is then poured into the annular space between the service shaft and the oversized hole. This method of installation reduces earth loads on the service shaft materially. At the time of placement loads are quite nominal. Prior to placement of the sand there is no loading and the interior face of the hole is in a stress condition where the radial lateral pressure is zero. Placement of the sand is analogous to a "bin" type of loading wherein the maximum lateral pressure is limited to that of a material with a height equal to twice the width. Elastic compression of the fill will have occurred previously and will not produce appreciable "down drag" forces.

Over an extended period of time, the adjacent soil will probably undergo a gradual relaxation of its stress condition at the time of placement and will approach an "active" pressure state in which the lateral pressure is approximately equivalent to that of a fluid with 0.3 the weight of the soil. The maximum probable lateral pressure would be the "at rest" pressure.

By using the recommended method of placement, the pipe for the accelerator service shafts can safely be of less strength than would be required if either of the other methods were used. In addition, a much more uniform and higher soil compaction can be attained in the shielding fill, and at the lowest cost.

TABLE OF COMPARISONS

The attached table summarizes the relative merits of the pipe materials considered and includes the estimated installed cost of each type.

CONCLUSIONS

Steel pipe, spirally corrugated, welded seam,galvanized, and coated with asbestos fiber impregnated asphalt should be used for the accelerator service shafts. This material provides best economy and is adequate for the functional requirements.

COMPARATIVE RATINGS OF VARIOUS TYPES OF PIPE FOR THE ACCELERATOR SERVICE SHAFTS

FUNCTIONAL REQUIREMENTS

No.	Type of Pipe	Water Tightness	Radiation Resistance	Crushing Strength	Longitudinal Flexibility Strength, and Toughness	Electrical Conductivity	Ease of Installation	Corrosive Resistance	Estimated Total Cost Per Shaft Including Installation
1	3/16" 3/16" Steel Pipe Epoxy coated inside and outside	Excellent	Good	Adequate	Good (High strength and toughness)	Good (requires separation from rebars in Accel. Housing)	Good	Good	$ 672
2	14ga. Steel Pipe, Cement lined and coated	Excellent	Good	Adequate	Fair (Good strength but coating cracks when overstressed)	Good (requires separation from rebars in Accel. Housing)	Fair	Excellent	$ 570
3.	Asbestos-Cement Pipe	Good to fair, (depending on "O" ring damage caused by radiation)	Good (possible damage of "O" rings in joints due to radiation)	Adequate	Poor (Good strength but brittle failure if overstressed)	Non-Conductor	Fair	Excellent	$ 612
4.	14ga. Corrugated Steel Pipe, Galvanized and coated with asbestos impregnated asphalt	Fair	Good (asphalt coating subject to possible radiation damage)	Adequate	Excellent (Poor strength but excellent flexibility and toughness)	Good (requires separation from rebars in Accel. Housing)	Excellent	Initially Excellent. (radiation damage of asphalt could downgrade to good)	$ 496
5.	14ga. Spirally Corrugated Steel Pipe, Galvanized and coated with asbestos impregnated asphalt	Excellent	Good (asphalt coating subject to possible radiation damage)	Adequate	Excellent (Poor strength but excellent flexibility and toughness)	Good (requires separation from rebars in Accel. Housing)	Excellent	Initially Excellent. (radiation damage of asphalt could downgrade to good)	$ 506
6.	Reinforced Concrete Pipe (8' Lengths)	Fair	Good	Adequate	Poor (lacks flexibility and toughness)	Non-Conductor	Poor	Excellent	$ 600