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TITLE TRANSPORTATION OF A 451 TON GENERATOR STATOR AND A 234 TON GENERATOR ROTOR FROM HARTSVILLE, TN, TO LOS ALAMOS, NM

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TRANSPORTATION OF A 451 TON GENERATOR STATOR AND A 234 TON GENERATOR ROTOR FROM HARTSVILLE, TN, TO LOS ALAMOS, NM[1]

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Abstract

A 1430 MVA steam turbine generator was acquired from a cancelled nuclear power plant in Tennessee to be used as the pulsed power and energy storage unit for the Confinement Physics Research Facility being built at Los Alamos, NM.

The transportation from Hartsville, near Nashville, TN, to Los Alamos, NM, of the two largest single pieces of the generator, a 451 t stator and a 234 t rotor presented a special challenge.

Details of the move, by barge from Hartsville to Catoosa, near Tulsa, OK, by rail from Catoosa to Lamy, near Santa Fe, NM, and by road from Lamy to Los Alamos are described. The greatest difficulty of the successful move was the crossing of the Rio Grande river on an existing reinforced concrete bridge. The two-lane wide road transporters for the stator and rotor were fitted with outriggers to provide a four-lane wide vehicle, thus spreading the load over the entire bridge width and meeting acceptable load distribution and bridge safety factors.

1. Introduction

In the summer of 1987 Los Alamos National Laboratory (LANL) acquired all components of a 1430 MVA steam turbine generator which was part of a cancelled nuclear power plant owned by the Tennessee Valley Authority (TVA). All the generator components were in storage at Hartsville. Part of the contract agreement was that LANL remove all generator parts from the storage site by the end of September, 1987, except for the stator and rotor, which were to be removed by the end of 1987.

Shortly after acquiring the generator, LANL accepted competitive bidding for two transportation contracts. One company won the contract to transport the stator and rotor from the storage site in Hartsville to Los Alamos and to place the stator and rotor on the foundation. Another company received a contract to move all the remaining generator parts to the Los Alamos generator site. These parts included components with an individual weight up to 78 t for a total weight of about 1250 t. About 20 heavy, oversized pieces of the remaining parts, such as the bearings, end casings, foundation sole and base plates, lube oil tanks and excitation transformer, were transported by truck from Hartsville to the nearest rail head at Gallatin, TN, and by rail to Alamosa, CO, and then by road transporters to Los Alamos. The lighter of the remaining pieces were transported directly by truck from Hartsville to Los Alamos.

All the crating of the pieces at Hartsville was done by Los Alamos personnel, often utilizing the original boxes which had been used for transporting the pieces from the generator manufacturer's plant in Switzerland to Hartsville.

2. Preparation for the Move

2.1 General. Before the contract with TVA was signed, LANL began investigating economical methods of moving the stator and rotor to Los Alamos. Realizing that for heavy loads water transportation is the cheapest means of hauling and recognizing that Hartsville had no rail connection, it was decided that the generator components should be brought by barge to either Houston, TX, or Catoosa, the ports nearest to New Mexico. Discussions with personnel from different railroads confirmed that the railroad tracks from Houston or Catoosa to the Santa Fe area were capable of accommodating the load, provided a Schnabel car arrangement was used for the stator. The most difficult section of transportation was obviously the transportation over land, requiring the crossing of the Rio Grande river.

Several months before the transportation contract was awarded, LANL contacted the New Mexico State Department of Transportation and all municipal, federal, and Indian Reservation authorities along the route, notifying them of the expected move. In addition, LANL hired a consultant with expertise in hauling of super-heavy loads to make a route feasibility study for the stator[1]. Since the rotor was considerably lighter than the stator it was assumed that it would be possible to transport the rotor over any route which would permit the transport of the stator. The feasibility study gave a detailed route description and identified two potentially successful routes for crossing the Rio Grande. One route would have required a low water crossing and the other one would utilize the existing Santa Clara bridge at Española, NM. A preliminary analysis of the bridge, an 11 span reinforced concrete bridge, each span equalling 85' long, indicated that a transporter could be designed to support the stator load. Such a transporter would use all four lanes in width and would span at least two sections of the bridge. This would be the heaviest load ever transported over such a reinforced concrete highway bridge. The New Mexico State Department of Transportation was provided with a possible transporter design for crossing the bridge as well as a bridge analysis for this transporter, and tentatively approved the transporter configuration. The feasibility study was made available to the seven companies bidding on the stator and rotor move. All bidders chose in their proposals the river crossing over the Santa Clara bridge, utilizing a transporter similar to the one designed in the feasibility study.

The successful bidder was requested to obtain all the necessary permits from local, state and federal authorities for the three sections of the move, by water, rail and road. The contractor which LANL selected for the move chose to use the barge transport to Catoosa and negotiated the rail route via Oklahoma, Kansas, Texas and New Mexico.

2.2 Road Transporters Description. To get the transportation permit from the New Mexico State Department of Transportation, the successful bidder performed a detailed route survey, identifying bridges and culverts along the route and other interferences such as low bridge clearances, potential traffic light interferences, etc. The contractor elected to move the rotor on a heavy duty platform trailer, having 10 axles with 16 wheels per axle (10 line, double wide Scheuerle trailer). The trailer was 21' wide, measured 44'4" in length between the centers of the outer axles,

[1] Work performed under the auspices of the US DOE

had a weight of 90 t and produced a wheel loading of 2.25 t/wheel with the 234 t rotor and 36 t shipping container. For the stator transporter a Schnabel car arrangement was chosen, consisting of two sections of heavy duty platform trailers, each having 10 axles with 12 wheels/axle (600 t capacity Nicholas trailer). The stator was to be hanging between the transporter sections. The weight of the trailer sections was 227 t. With the weight of the stator including two transport covers of 451 t, the total weight of the transporter was 678 t, resulting in a wheel loading of 2.8 t/wheel. The stator transporter measured 20'4" wide and 150' long. The minimum height of the transporter was 15'8" and the height could be raised by 26" using the trailer's hydraulic system.

2.3 Bridge Crossings. The traffic plan submitted to the New Mexico State Department of Transportation included methods of crossing each bridge or culvert. Small bridges less than 40' long, which could not support the transporter load, would be crossed by means of a 40' long portable bridge. Weak, longer bridge and culvert structures up to a length of 120' were planned to be spanned by a 120' long portable bridge. The 40' long bridge was going to be used 3 times during the move, the 120' long bridge 14 times. Two box culvert structures along the route were longer than 120' and were shored.

For the Rio Grande bridge crossing the contractor presented the New Mexico State Department of Transportation with a transporter layout similar to the one which had been tentatively agreed upon. However, the contractor used existing, sometimes modified equipment. Girders, as outriggers, 100' long, 8' high, and 2' wide, were placed parallel to the road transporter, each on 6 dollies, each dolly having 8 wheels and a 20 t load capacity. With a superstructure built over the stator, connected to the stator and girders, load from the road transporter was shifted to the outriggers. To achieve further improvement in uniform load distribution, two dollies were placed under the center of the stator and 32 wheels of the road transporter were hydraulically lifted off the ground.

Crossing a bridge, the vehicle would have 352 wheels, 32 of which making no contact with the ground, and a total width of 51'. The outriggers, superstructure and support struts were designed to be used both for the rotor and stator transporter. The total weight of the vehicle including the stator was about 760 t.

Although the Nambe River at Pojoaque, NM, could have been forded next to the highway bridge, the contractor chose to use the same bridge vehicle as designed for the Rio Grande bridge for this crossing, thus avoiding potentially difficult right of way negotiations.

The consultant for LANL performed an indepth analysis for the stator and rotor vehicles crossing of both bridges, which were presented to the State Highway Department. It was calculated that the lowest factor of safety against bending failure of any of the Santa Clara bridge girders was 1.76. While the last details for receiving the road permit were still being negotiated, the first two legs of the move were begun

3. Move by Water from Hartsville to Catoosa

The rotor and stator were stored in two temporary buildings approximately one quarter mile away from the loading dock on the Cumberland River. The rotor, 69' long and 61" in diameter, was stored in a nitrogen filled plastic bag. After disassembling the storage building, the 234 t rotor was lifted by a 600 t jacking frame into a shipping container. The container was lifted by the crane onto a 192 wheel heavy duty platform transportation trailer and rolled onto the barge to the aft end with the hole of a prime mover. The rotor container was blocked on supports on the barge deck and the transporter removed for the stator transport. The generator stator with a diameter of 13'8" and a length of 40' was in storage, blocked on a metal beam structure, with adequate ground clearance to allow the same multi-wheel transporter to be driven under the stator. The transporter's built-in hydraulic system could raise the stator off its support blocks. With the assistance of the prime mover the transporter, including stator, was rolled onto the barge and placed centrally on the barge in line with the rotor. After securing both loads to the barge, the barge started its voyage down the Cumberland, Tennessee, Ohio and Mississippi River, and up the Arkansas River to Catoosa.

4. Move by Rail From Catoosa to Lamy

In Catoosa the stator, mounted on the transporter, was rolled off the barge and driven to a nearby rail head. The stator end covers, which protected the end windings during storage, were mechanically not strong enough to support the stator. These covers were replaced by special transportation covers, which were rented by LANL from the generator manufacturer. These transportation covers were bolted to the ends of the stator. With the transportation covers, the total stator weight amounted to 451 t. In addition, 34 tie rods were inserted between the transportation covers under the stator to support the weight. Then the stator was lifted by the 600 t jacking frame and placed between the two halves of a special railroad car called a Schnabel car. The Schnabel car is designed for rail moves of large turbo generators. This special car was rented by LANL from the generator manufacturer. The rotor was rolled off the barge with the same transporter and the rotor container was lifted onto a flatbed rail car. The route for the special train from Catoosa to New Mexico was planned, considering railroad bridge loading and clearances. The route led north through Oklahoma to Paola and Hutchinson, KS, Amarillo, TX, and Albuquerque, NM, to Lamy. A considerably shorter route between Catoosa and Amarillo did not allow transport of the stator due to weight restrictions. The train arrived in Lamy in December, 1987. Figure 1 shows the 20 axle Schnabel car. The stator and the rotor were lifted off the railroad cars by the portable 600 t jacking frame and placed next to the railroad tracks on concrete blocks. Both components remained in Lamy for four months awaiting warmer weather, which would allow travel over frost free roads.

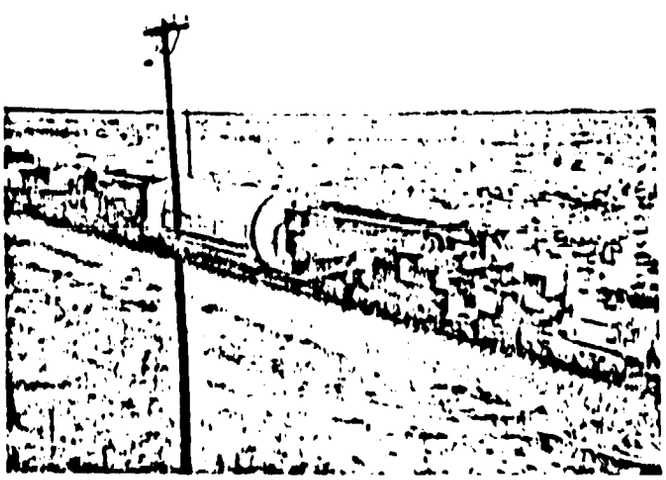


Fig. 1. Twenty axle Schnabel rail car for stator transport

5. Move on Road From Lamy to Los Alamos

For the 65 mile long road transport to Los Alamos the hauling procedure, as approved by the Highway Department, was followed

exactly. The 120 wheel heavy duty transporter was rolled under the rotor container and the load secured for transportation. The two sections of the road Schnabel car were attached to the transportation covers of the stator.

The stator and rotor travelled together on the route at a speed of 3 to 5 miles per hour except during the bridge crossings and on route sections with extremely steep slopes. On level roads or roads with a declining slope the stator transporter was moved by two 650 hp prime movers, one pulling and one pushing. The rotor transporter was pulled and pushed by two 525 hp prime movers. For inclining slopes an additional 525 hp prime mover was added in front of each transporter. The greatest slope of the route (8.5 %) occured at a section between the Rio Grande and Los Alamos. During this route section three prime movers pulled and one pushed the stator up the hill at a speed of about 2 miles per hour.

The total distance from Lamy to Los Alamos was traveled in 8.5 days. Travel was restricted to daylight hours. The entire route was travelled over mountain roads at an elevation between 5600' (Rio Grande bridge) and 7400' (outskirts of Santa Fe and Los Alamos). The use of the portable bridges was an economical solution for crossing weak bridge and culvert structures and slowed the convoy only minimally. Each portable bridge consisted of four 6' wide sections. One section of the 120' long bridge had a weight of 28 t, and was lifted from a truck by two cranes and then put in place. To assemble the bridge, cross over it with the convoy, disassemble the bridge into 4 sections, and load each section on a truck required 75 minutes. During the second to last day of the trip, the 120' portable bridge was used 8 times. Figures 2 and 3 show the rotor and stator transporter crossing the portable 120' long bridge.

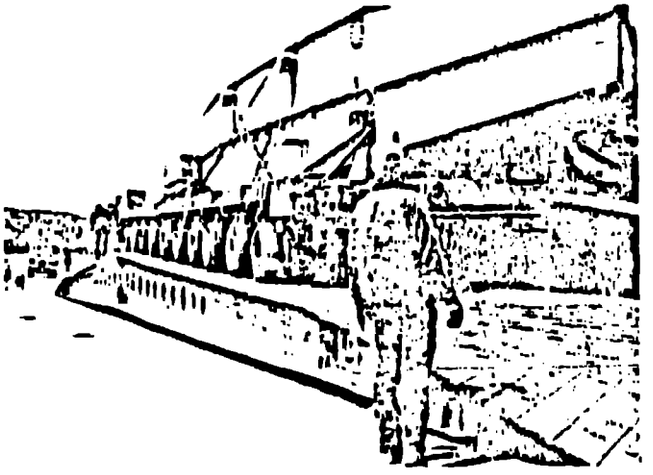


Fig. 2. Rotor transporter crossing a portable bridge.

Two days were needed for each major bridge crossing, one day for the rotor and one day for the stator transporter. Assembling the outriggers and the superstructure and checking the weight distribution with portable scales placed under the tires of the vehicle required most of one day (Fig. 4). The actual move across the bridge was accomplished in a few minutes. The rest of the day was spent disassembling and returning the vehicle to the normal road transport configuration. Work was facilitated by the fact that both bridges could be closed to traffic to allow sufficient, undisturbed room for the rigging activity.

The New Mexico State Department of Transportation granted the transport permit to the heavy hauling company under the condition that any damage to roads and road structures would be corrected by the hauler. To assess bridge damage to the Nambe and Santa Clara bridges, the authorities requested that the hauler instrument the two bridges to measure strain, displacement and rotation of various structural elements of the bridges. It was agreed by all parties involved, after a subcontractor for the bridge instrumentation could not meet the deadline, that LANL would do the instrumentation, because the equipment and expertise were available at Los Alamos. The data of the bridge instrumentation showed that no damage was caused by the loads as most readings returned to their initial values after the loads had been removed [2]. Figure 5 shows a strain gauge reading taken from [2] on a beam of the Santa Clara bridge during the stator move.

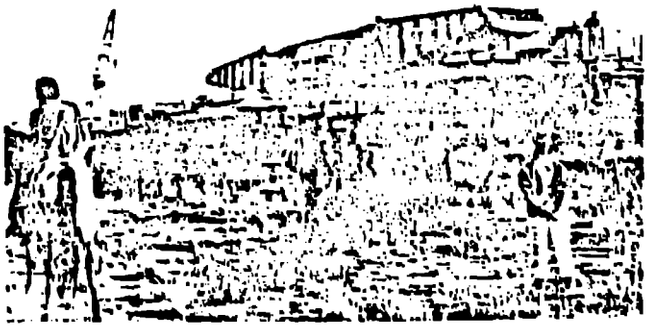


Fig. 3. Stator transporter crossing a portable bridge.

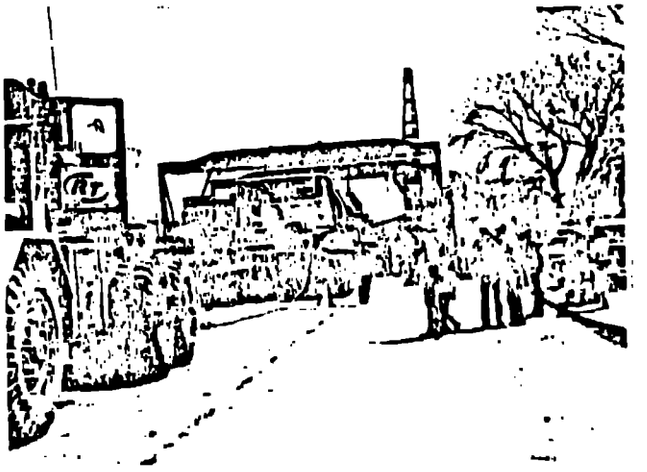
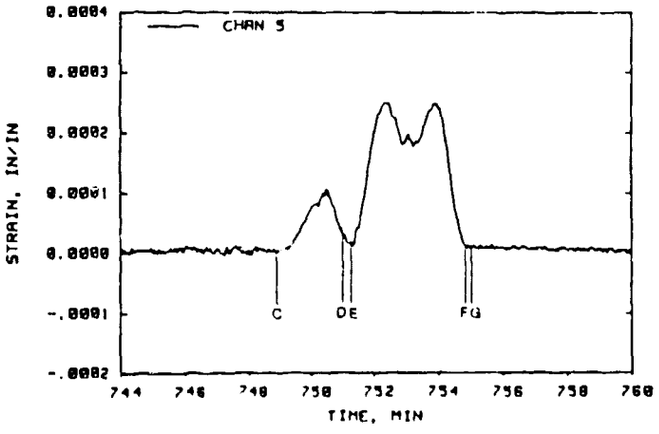


Fig. 4. Assembly of outriggers and superstructure for Rio Grande bridge crossing.

New Mexico State Department of Transportation personnel accompanied the convoy during the entire trip, assessing road surface, bridge and culvert damage. The damage was minimal, limited only to the asphalt surface in a few locations, and this was repaired by the transportation contractor.

Once the stator and rotor arrived in Los Alamos, both units were temporarily stored on concrete blocks, because the construction of the generator foundation was not yet complete. The two

transportation covers of the stator were removed, returned to the generator manufacturer and replaced by the storage covers. During the entire move from Hartsville to Los Alamos, including the storage periods at Lamy and Los Alamos, the stator and rotor were always pressurized with dry nitrogen gas to avoid any condensation.



Location of Equipment During the Stator Crossing of the Santa Clara Bridge

Time (min:s)	Location	Position
748:56	C	Prime mover enters instrumented span
750:57	D	Front trailer enters instrumented span
751:14	E	Dollies enter instrumented span
754:50	F	Dollies leave instrumented span
755:01	G	Rear trailer leaves instrumented span

Fig. 5. Strain gauge reading on a beam of the Santa Clara bridge during the stator move.

6. Erection of Stator and Rotor onto Foundation

In June, 1989 the final move of the stator and rotor from the temporary storage site onto the generator foundation block occurred. A 700 t gantry crane was erected over the generator foundation. To accomplish lifting of stator and rotor with the same crane location, a railroad track was built over the stator foundation opening, extending 50' in line with the stator. The rotor shipping container including rotor was moved from the temporary storage site to the generator foundation site under the crane on a 192 wheel platform transporter and parked parallel to the generator foundation. Using the crane, the rotor was lifted out of the shipping container and placed on two trolleys, riding on the railroad tracks and located over the stator opening. The rotor then was pushed forward on the foundation and parked in line with the stator opening. The stator was transported on the same 192 wheel transporter to the generator site and placed under the crane. The storage covers were removed and the endcasings bolted to the stator. The temporary rail track over the stator foundation opening had already been removed. Fig. 6 shows the final 504 t lift of the stator onto the foundation. The stator was positioned within 1/8 of an inch of its desired final location.

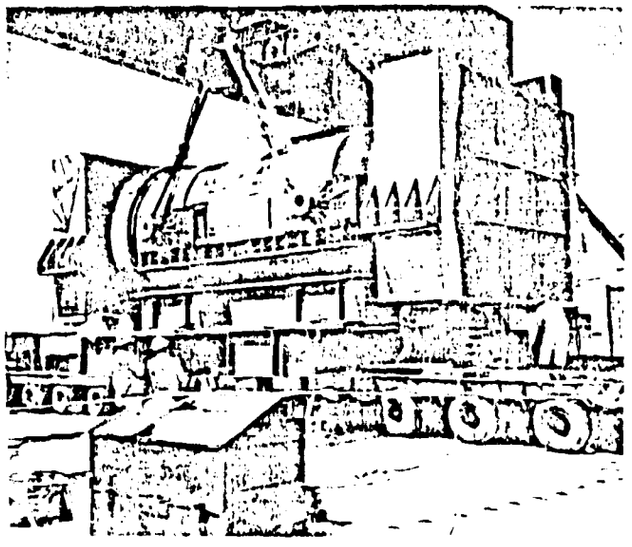


Fig. 6. Final lift of stator from transport vehicle onto foundation.

7. Summary

A 451 t generator stator and a 234 t generator rotor were successfully transported from Hartsvile, TN, to Los Alamos, NM. A special transporter was designed to move the stator and rotor over two multispan highway bridges. The stator move was probably the heaviest piece of equipment ever transported over standard reinforced concrete highway bridges.

8. Acknowledgements

The success of the move can be directly attributed to the close cooperation of all parties involved. The author wishes to thank the New Mexico State Department of Transportation, New Mexico State Department of Public Safety, Santa Fe, Española and Los Alamos city and/or county authorities, Tesuque, Pojoaque, Santa Clara and San Ildefonso Indian Pueblo authorities and the dedicated LANL personnel committed to the success of this project.

9. References

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