Final Report

Triggered Lightning Testing of a Section of Florida Gas Transmission Pipeline and Pipeline Connectors

for

Florida Gas Transmission
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Executive Summary

At the International Center for Lightning Research and Testing at Camp Blanding, FL, a five-stroke lightning flash was directed along pipelines and through three different insulating joints commonly used by Florida Gas Transmission. The joints chosen for this test were a two-inch flange with a Pikotek VCS gasket having wax poured into the flange gap and two smaller diameter Swagelok tubing insulators encapsulated in a 3 M epoxy underground splice kit, one of which was wrapped externally with "Trenton Wax" tape. The gas inside the pipeline was air at atmospheric pressure. All three joints showed significant internal damage to the pipe metal from arcing, but electrical measurements indicated no damage to the joint insulation. The Pikotek joint had an external flashover for one stroke only, that arcing being clearly visible on TV and 5-msec resolution photographic film records. Hence, most of the lightning current crossed the insulating joints via internal flashover with one stroke providing an external flashover at one joint. It is not clear that the results obtained would have been similar if the internal pipeline gas was maintained at its normal high pressure since higher joint voltages would then be required for internal breakdown thus encouraging external flashover.

1. Introduction

The University of Florida operates the International Center for Lightning Research and Testing at Camp Blanding Army National Guard Base for the purpose of triggering lightning from natural thunderclouds to objects on the ground. Details of that facility and its present and past research and testing projects can be found at www.lightning.ece.ufl.edu.

On August 18, 2001, a five-stroke lightning flash was triggered through four segments of Florida Gas Transmission pipeline containing three insulating joints. Details of the experimental set up and the results of the experiment are presented in this report. The purpose of the experiment was to determine if the insulating joints are compromised by lightning and if there are external flashovers of the joints that could potentially ignite any existing mixture of pipeline gas and air.

2. The Experiment

A photograph of the vertically-mounted Florida Gas Transmission pipeline sections containing three insulating joints is given in Figure 1. The tops of six lightning-triggering rockets are shown mounted in launch tubes at the bottom of the photograph. A close-up view of the lowest insulating joint, the Pikotek joint, is shown in Figure 2, and those of the two upper joints, Swagelok joints, are shown in Figure 3. A rough drawing of the whole pipeline and joint structure is found in Figure 4. A description of the pipeline and joint structure follows:

> At the base is a 1 foot long section of pipe of 1 ½ inch diameter installed for mounting purposes. Attached above that is a 2 foot long section of 2 inch pipe and to that is connected a 2 inch flange with a Pikotek VCS insulator gasket, wax being poured into the flange gap to fill its void. Above the flange is a 3 foot section of 2 inch pipe which is reduced down to 3/8 inch on which is mounted a 3 foot section of 3/8 inch, .316 stainless steel tubing, and on top of that is installed a Swagelok tubing insulator that is encapsulated in a 3M Epoxy underground splice kit. On top of this joint is a second section of 3/8 inch, .316 stainless steel 3 inch long tubing and another Swagelok insulator. This top insulator was wrapped with a "Trenton Wax" tape product to encapsulate it. Finally, a 1 foot section of stainless steel tubing is at the top for intercepting the lightning. All the 1 ½ inch and 2 inch piping was carbon steel, mechanically welded together, while the stainless steel tubing was all screwed fittings and hand tightened.
>
> The Pikotek VCS insulating gasket consists of a .316 stainless steel core to which a high strength insulating laminate is bonded to each side. Opposing dovetail seal grooves are machined through the laminate insulating material and into the stainless steel core. Spring-energized PTFE (Teflon) internal face seals are then installed into these grooves to provide pressure activated sealing. Fiberglass-reinforced epoxy insulating sleeves and washers are used in conjunction with the VCS gasket to provide complete electrical insulation of the flange assembly.

3. Results

A photograph of a triggered lightning flash to the pipeline is shown in Figure 5. Current records show that five return strokes attached to the pipeline. High speed photography confirms that each return stroke attached to the top of the pipeline, and thus that current flowed through each insulating joint. The current waveform of the first stroke is found in Figure 6, measured by a resistive shunt at the base of the pipeline. An external flashover at the Pikotek joint is evident in the TV frame shown in Figure 5 and in other photographs of the experiment. Comparison of current and photographic records shows that the external flashover occurred during the first return stroke which attached to the pipeline (peak current ≈27 kA). After the lightning strike, the pipeline joints were tested electrically and all were found to be still essentially open circuits. A small arc mark was evident on a bolt of the Pikotek joint, as shown in Figure 7, consistent with the external flashover seen in Figure 5. High-speed photography with 5 msec resolution indicates that the external flashover occurred for only the first stroke of the five-stroke flash. The joints were disassembled to inspect for internal damage. All joints show significant internal arc damage. Photographs of that damage are shown in

Figures 8 - 10. Visually there is not serious damage to the joint insulators, only dark surface tracks, although clearly very large currents and charges arced internally from pipe to pipe across the insulators.

4. Conclusions

A five-stroke lightning flash triggered through one Pikotek and two Swagelok connectors resulted in one external flashover at the Pikotek joint for one stroke and internal flashovers for all three joints. While there was metal damage to the pipeline interior, the insulators of the connectors were not significantly degraded. Additional external arcing might have occurred if the interior of the pipeline had been pressurized at 900 psi as is the case in working pipelines rather than at atmospheric pressure. Additionally, any internal arc damage might well have been different in the higher pressure environment.

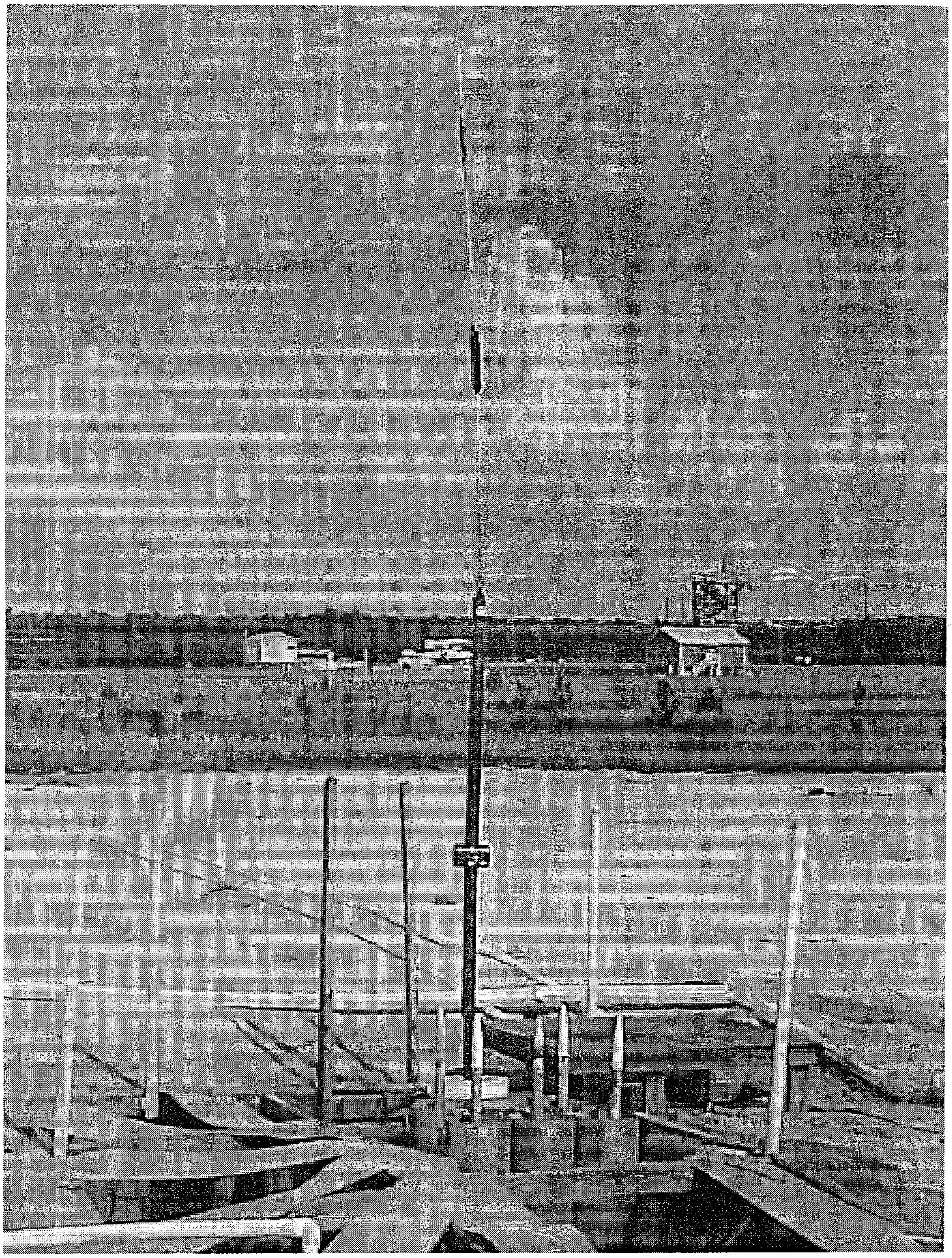

Fig. 1. Four-section 4.4 m gas pipeline containing three insulating joints. Triggering rockets in launch tubes are visible at the bottom of the photograph.

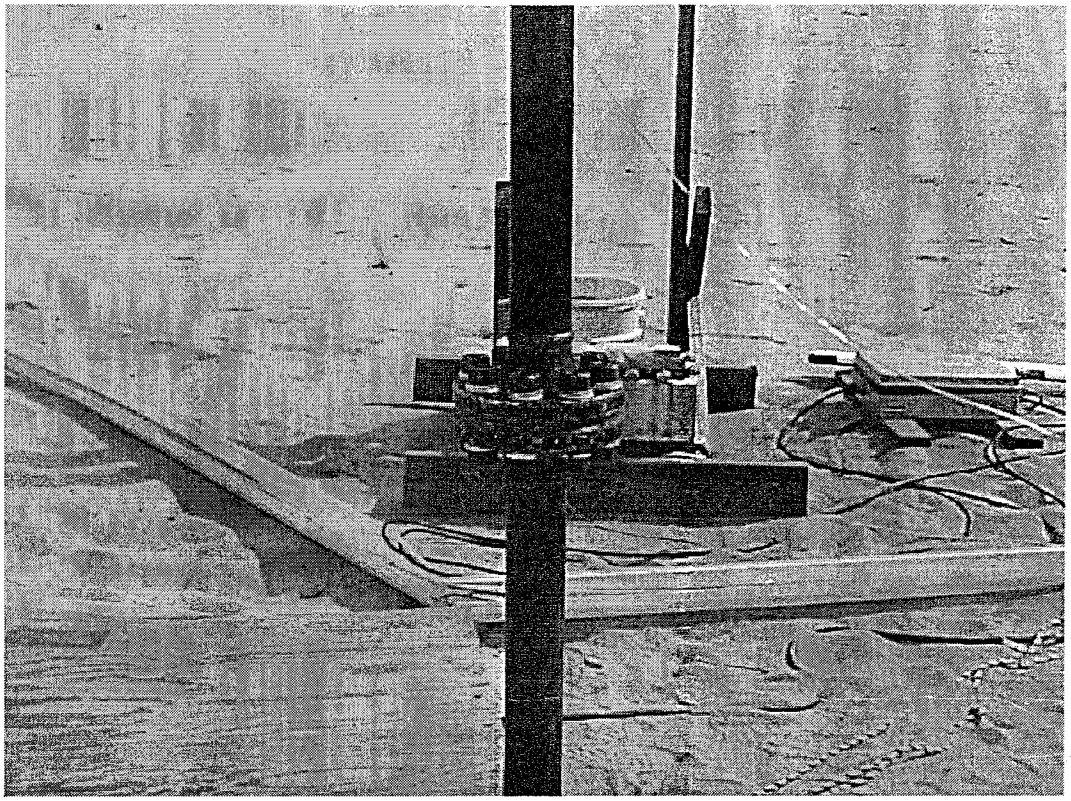

Fig. 2. Lower insulating joint of the pipeline structure.

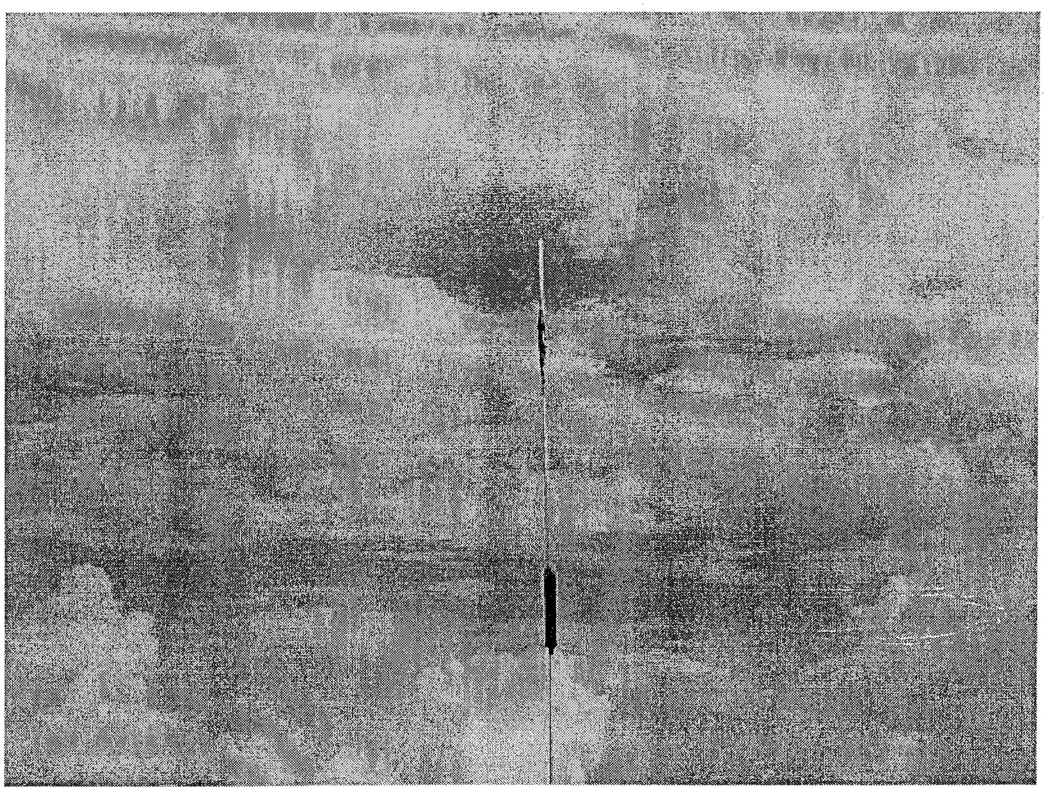

Fig. 3. Middle and upper insulating joints of the pipeline structure.

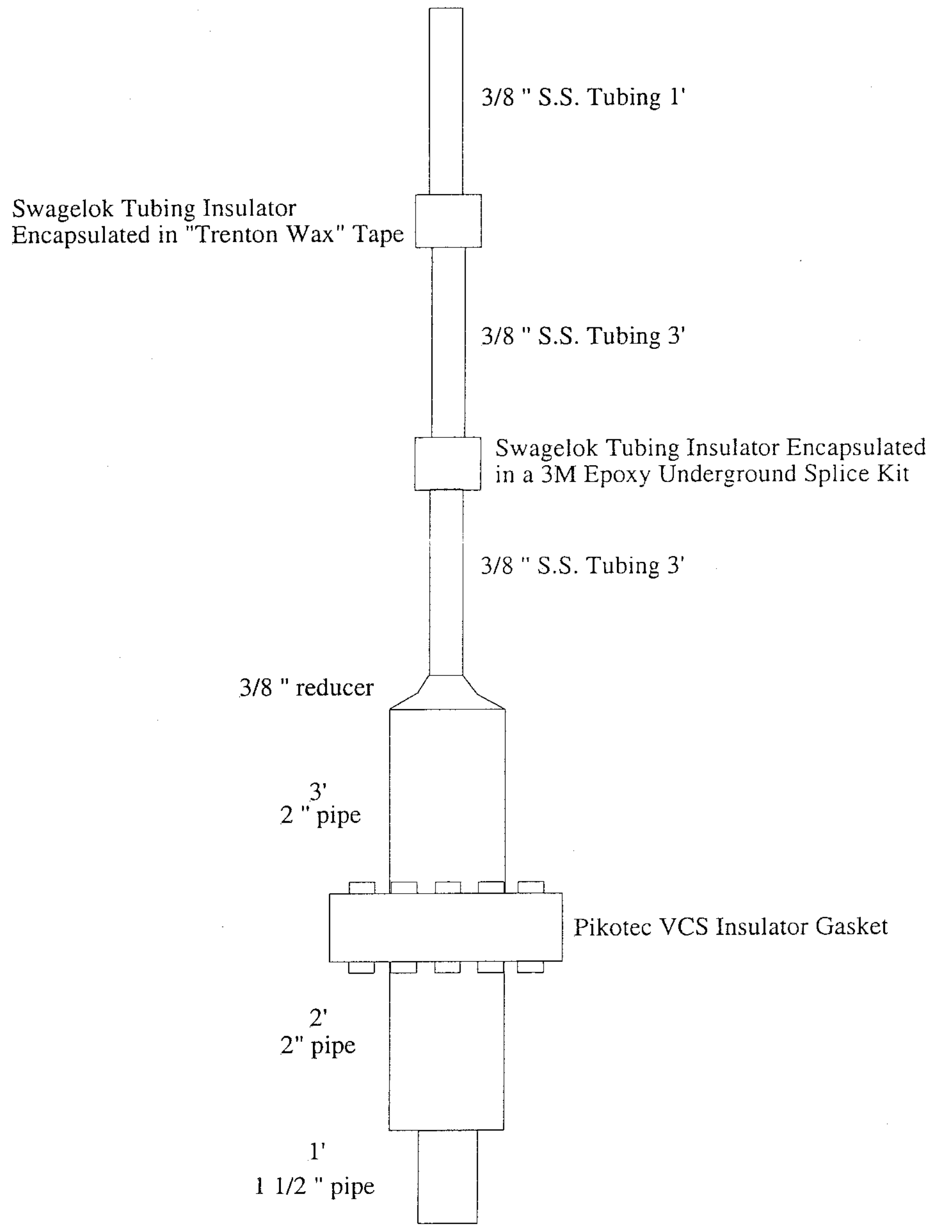

Fig. 4. Drawing of pipeline and joint structure.

Fig. 5. Triggered lightning flash to the pipeline. Note the flashover at the lowest joint, the Pikotek joint.

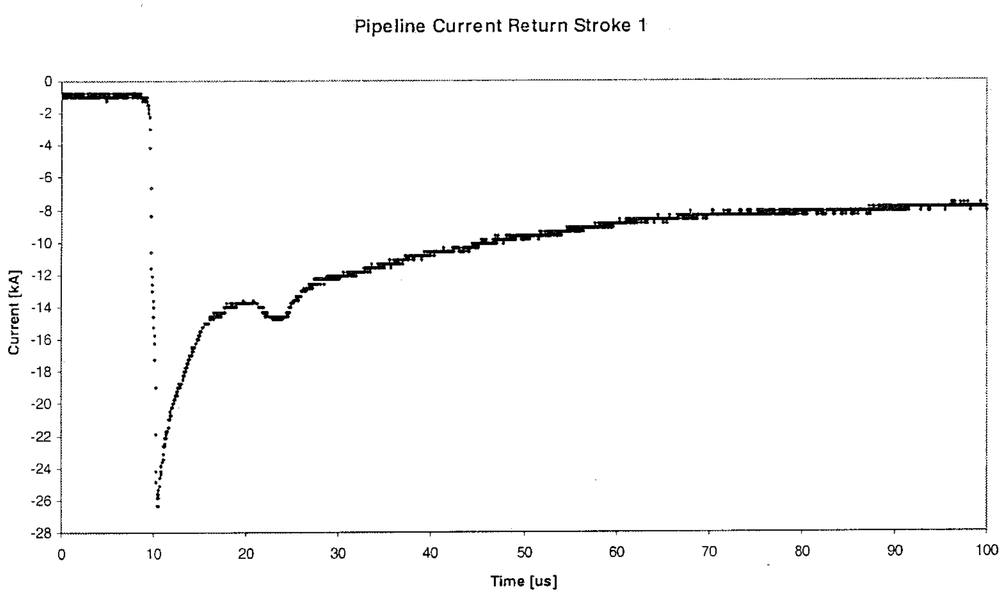

Fig. 6. Current waveform for the first of five return strokes, the only one that produced an external flashover.

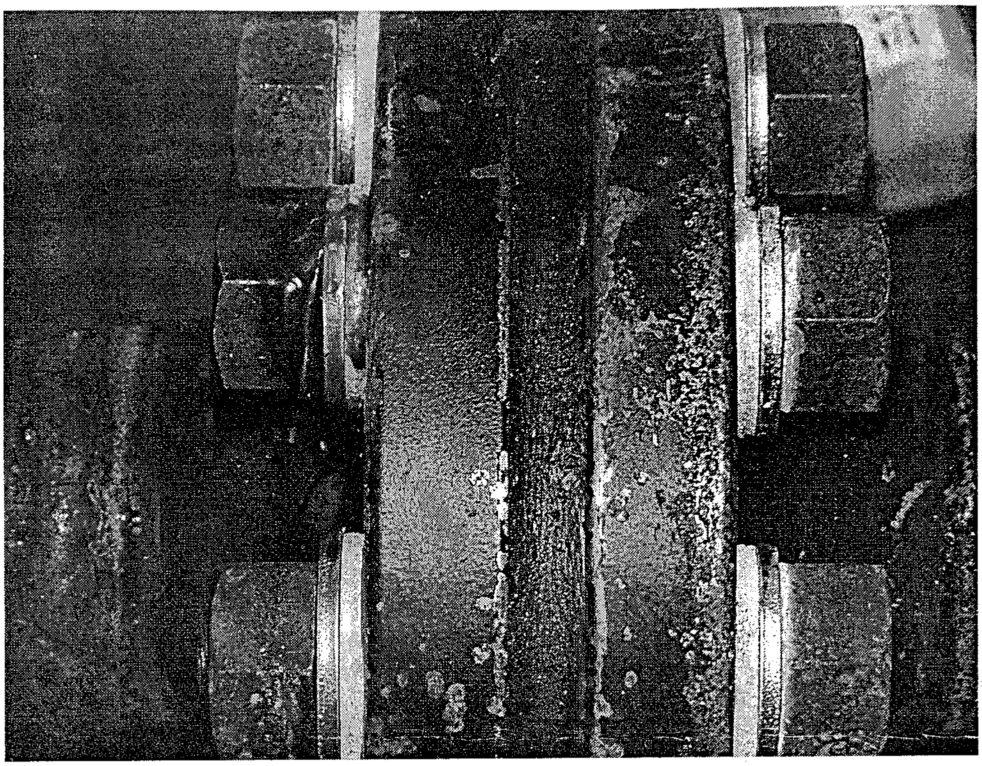

Fig. 7. Arc marks on the exterior of the Pikotek joint. In the photograph the marks appear as mottled silvery surfaces on the washers of the middle bolt on the left of the flange. Photo courtesy of Martin Winger.

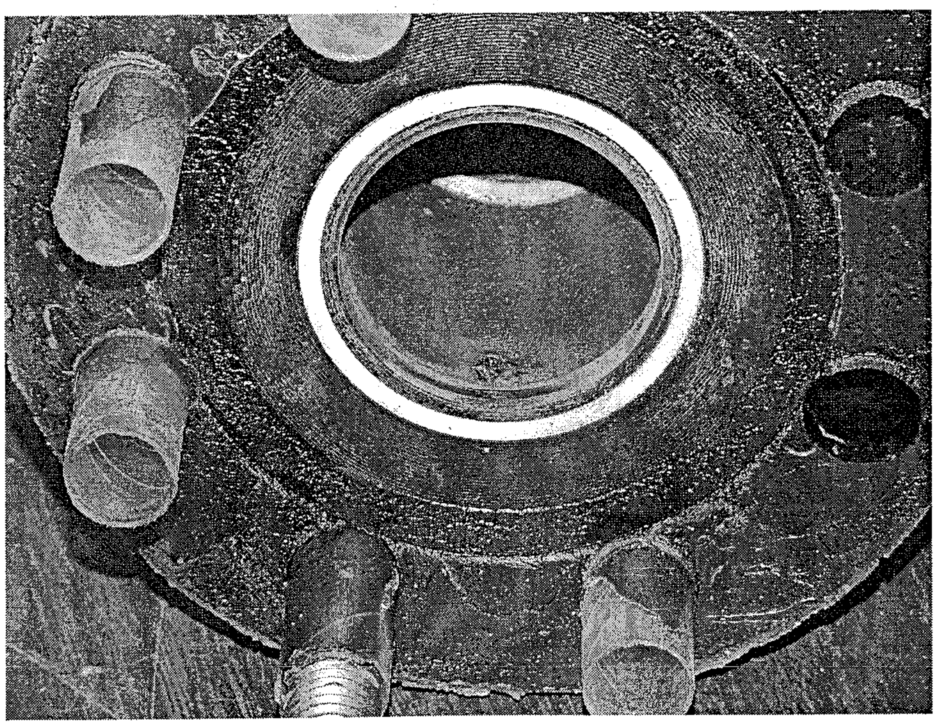

Fig. 8. Arc damage on the interior pipeline surface on one side of the Pikotek joint. Photo courtesy of Martin Winger.

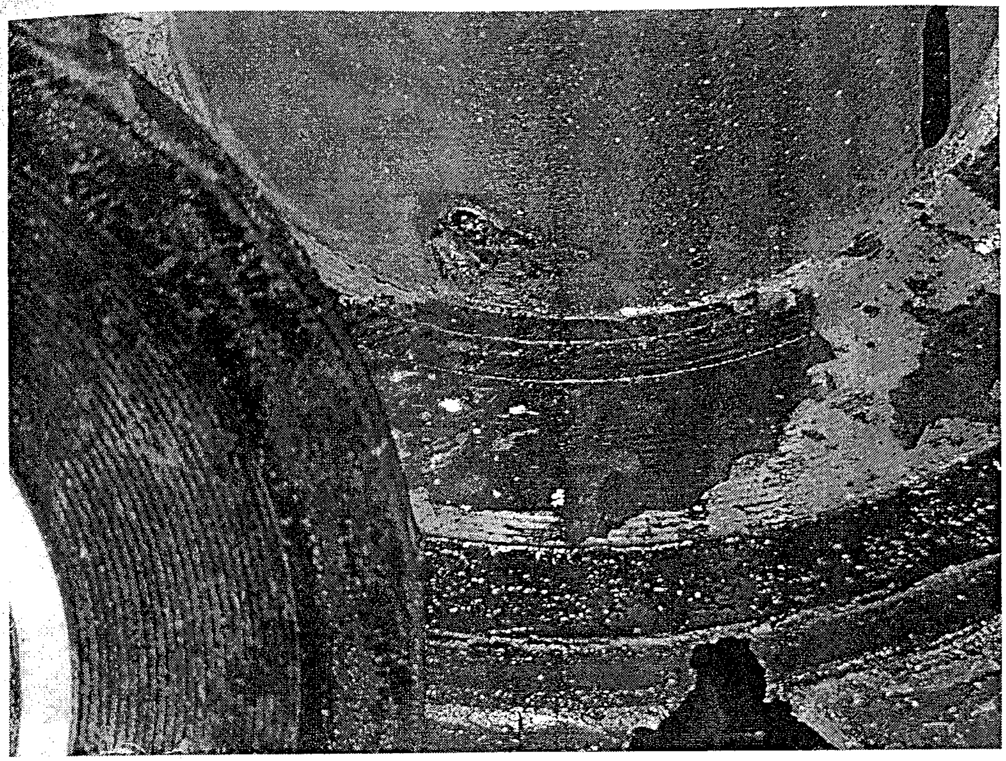

Fig. 9. A close-up view of the Pikotek joint shown in Fig. 8 with the insulating gasket removed. Photo courtesy of Martin Winger.

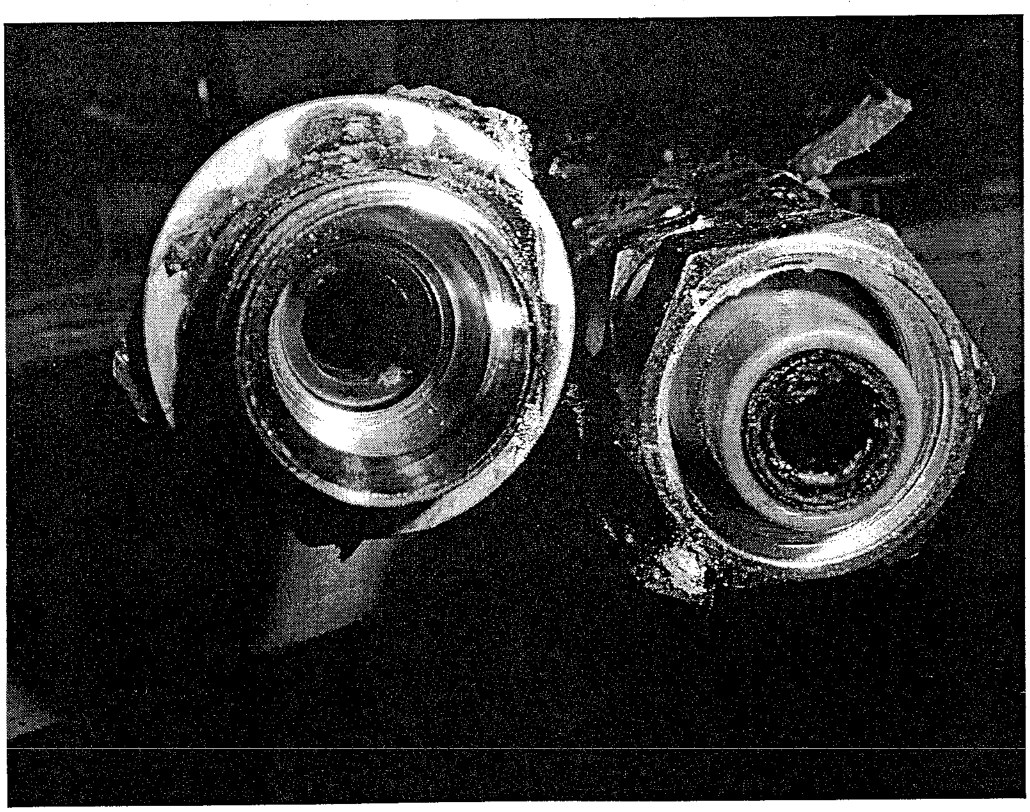

Fig. 10. Interior arc mark on one of the Swagelok joints evident on the lower right of the left pipe connector.