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FOURTH
~~THIRD~~ PROGRESS REPORT

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TITLE: "ELECTRICAL ENERGY SUPPLY TO RURAL COMMUNITIES DIRECTLY FROM TRANSMISSION LINES"

PERIOD COVERED: April-September, 1987.

ACTIVITIES PERFORMED DURING THIS PERIOD:

I. Laboratory testing of pilot installation

II. Field construction of pilot installation (in progress)

These activities are briefly described below:

I. LABORATORY TESTING OF PILOT INSTALLATION

I.1. INTRODUCTION

At the time of writing of the last report, these tests were under way. The above-mentioned report covered only the first two tests: Short circuit on the 127 volt side and load rejection. Many other tests were perfomed. Some of them were repeated using different protection schemes. It was felt that additional tests were necessary other than the ones originally scheduled.

Before giving a brief description of the complete test program, two points will be treated concerning the last report. A fault in the transformer was reported. The unit was sent back to the manufacturer and repaired under the warranty. No further problems with this transformer were observed. It was also reported that flashovers occured between the first capacitor and the wood pole. This was solved simply by rearranging the units and increasing it insulation to ground.

I.2. <u>Transformer Energization</u>

The first test in these series consisted in energizing the transformer at no-load with the purpose of determining the inrush current. No onvervoltages or peak currents were observed. During the next two tests the transformer was energized with loads of 2.57 and 1.28 ohms. The distortion in the sinusoidal waveform is considered negligible. The equivalent secondary currents were 61.31 and 113.9 A rms.

I.3. <u>Short-circuit on the transformer secondary with surge arrester in the primary side</u>

For this test, the damaged transformer was replaced by one built in the Institute, with a capacity of 75 kVA. A 10 kV distribution class arrester was connected in the primary side of the transformer. The test was performed without the secondary protection of the 200 A-fuse. From a previous test, its operating time was considered too long: 2.33 s. So the system was left protected only with the 2 A fuse in the primary side. The test was similar to the one performed previously (described in the last report), in order to check the overvoltage protection provided by the arrester. The peak voltage was reduced from 30.87 kV to 23.44 kV peak. The operating time of the 2 A fuse was 0.33 s. The peak current was slightly increased since the transformer capacity was increased (75 vs. 50 kVA).

I.4. Short-circuit with partial load

During these tests, the surge arrester was replaced by a similar one, but with zinc oxide valves. The original transformer (50 kVA) was repaired and use again during these tests

a) Secondary short circuit with 25% of load.
This short cicuit was interrupted by the "consumer's protection", a 30 A fuse, in less than 3 cyles; and with peak current and voltage of 519 A and 19.2 kV respectively. This last oscilogram clearly shows how the ZnO arresters reduced the overvoltage in each cycle.

b) Secondary short cicuit with 50% of load.
Again, the 30 A fuse operated in less than 3 cycles. The peak current in the secondary was 142 A and the peak voltage in the primary was 19.8 kV. The effect of the arrester can be clearly observed once again.

c) Secondary short cicuit with 75% of load.
The same magnitudes as in the previous test were registered, except for the peak current, which attained a value of 179.6 A.

d) Secondary shor cicuit with a 100% of load.
The same values as in the previous test were observed, except for the peak current, which attained a value of 219.2 A.

e) Secondary shor circuit in the transformer terminals.
The purpose of this test was to verify the system protection using a 3 A fuse in the primary side.

After 3 seconds of mantaining the short-circuit, the fuse did not operate and it was necessary to clear the fault with the 115 kV breaker. The steady-state short circuit registered was 9.21 A rms. Following the results from this test, the use of a 3 A fuse was discarded.

During all five of the above tests, the voltage at the reactor terminals was measured. As stated by the theory, this voltage remains constant throughout the different load conditions.

I.5. <u>Voltage regulation and load rejection.</u>

Four tests were performed, with varying load conditions.

a) Load variation of 50-75-50%

The primary side current varied from 1.64 A rms to 2.3[illegible] A rms and back to 1.64 A rms.

b) Load variation of 8.3-50-8.3%.

A very small variation of the voltage is observed, and only at the instant of the change in load.

c) Load variation of 8.3-75-8.3%.

An overvoltage is observed when the biggest load is disconnected (75%). The surge arrester operation is also observed.

d) Load rejection of 100%.

This condition is considered the most severe, but also quite improbable. The overvoltage in the primary side of the transformer is limited by the arrester to 19.5 kV peak, which is mantained during 0.3 seconds. This arrester operation is clearly appreciated in the oscilogram.

I.6. Conclusions

a) Effect on the 115 kV line.

No dangerous overvoltages were measured in the 115 kV supply line. The highest peak voltage measured was 126 kV. It is considered that the voltage divider will cause no major disturbances in the supply line. Besides, all tests were performed without the 90 kV ZnO arrester that will be installed in the field.

b) Capacitor effect.

The peak overvoltage of 126.5 kV registered in the supply line will be impressed in the six high voltage capacitors. This overvoltage is less than the 112% calculated. Therefore, no problems are foreseen in the insulation of these six units.

With respect to the medium voltage capacitors, the measured overvoltages did not surpass the calculated peak value of 35.5 kV. Therefore, no problems are foreseen in the insulation of these two units.

c) Effect on the distribution transformer.

An important conclusion after these series of tests is that the transformer is well protected with the distribution class ZnO arrester. It will be interesting to observe this arrester's performance during field operation.

d) Effect on the consumers.

In all cases, the secondary short circuit was cleared by the consumer's 30 A fuse no less than 3 cycles. With respect to voltage regulation, the secondary voltage is expected to vary between 110 and 135 V, for all load conditions.

e) Overvoltage protection.
The protection provided by the ZnO arrester is considered adequate. To protect the transformer, this arrester should always be connected between the 2 A fuse and the transformer.

In the high voltage supply line, it is also considered necessary to use a 90 kV ZnO arrester to protect the line from residual voltages and discharge currents from the other distribution class arrester.

f) Overcurrent protection.
As stated previously, the use of a 3 A fuse was discarded. It is preferrable to use the 2 A fuse originally specified. It was also concluded that the 200 A secondary fuse is not strictly necessary. On the contrary, its long operating time causes overvoltages on the transformer primary side.

II. <u>FIELD CONSTRUCTION OF PILOT INSTALLATION</u> (in progress)

At last moment, the Federal Electricity Commission (CFE) of Mexico decided to change the site where the field energization of the voltage divider was to take place. The reason was that the originally chosen site, Venta Vieja, is not yet electrified. It was felt that any minor or major adjustment to the voltage divider in the experimental stage would mean that CFE would have to find a way to continue supplying electricity to this rural community in order to avoid any events of social consequences.

So a second site was chosen, in the outskirts of the city of Chilpancingo, state of Guerrero. This small community is already electrified. The voltage divider will feed half of the load through its 50 kVA transformer. The other half is fed from another unit whose feeder originates in a separate substation. In any event, if the voltage divider is taken out from service, this transformer can take the whole load.

Immediately after the tests were finished and this last site chosen, all the equipment from the pilot installation in the lab was moved to Chilpancingo, where the necessary construction began immediately. Unfortunately, one of the sections of the high voltate reactor was damaged during transportation. The damage section was brought back to the IIE for repairs. The repaired section was ready on october 14th and was taken to Chilpancingo two days after.

We are wating for the installation to be completed by CFE personnel. Immediately after, we will proceed to energize and test the capacitive voltage divider

III. ACKNOLODGEMENT OF PARTICIPATION

The following personnel have fully collaborated in the last stages of this project:

Pilot Testing: Ruben Ochoa, Daniel García, Ramón de la Rosa and Sabas López from the Equipment Division.

Repair of damaged reactor section: Inocente Rosales from the Equipment Division.

Pilot construction in Chilpancingo: Manuel Urbaez, Abundio Contreras and Marcos Ayala from CFE.