GE Meter and Control

An Evaluation of 34.5kV Outdoor Voltage Transformers

GE Type JVT-200
vs
Westinghouse VOZ-20

Meter and Control Business
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Somersworth, NH 03878

34.5kV Outdoor Voltage Transformer Evaluation

Preface

This report is an extension of our 1985 report on 15kV Voltage Transformers in that many of the tests performed and their significance are essentially the same. One should refer to the appendix in this publication for a detailed description of the tests. Environmental tests were not performed for this 34.5kV evaluation, as the external insulation systems used in these products are the same as for the 15kV products previously studied.

34.5kV Outdoor Voltage Transformer Evaluation

I. Perspective

High voltage instrument transformers are used by utilities for their largest revenue commercial and industrial customers and for overall systems protection. Long term system reliability and uninterrupted service are extremely important to utilities. Hence, this is why GE is publishing this report.

II. Evaluation Highlights

GE JVT-200 voltage transformers were evaluated to be superior in performance, electrical tests and product features.

As in the 15kV study, both the GE and Westinghouse 34.5kV products performed well on applied potential (hipot) and ratio/phase angle tests (typical utility incoming tests). However, the more critical design tests, such as impulse and partial discharge, revealed significant differences in the performance of the GE and Westinghouse products evaluated.

It is these more critical tests which are key tests in evaluating a product's ability to function reliably in the field. However, these same tests are difficult for users to perform and are, in fact, seldom done.

The implications of this are:

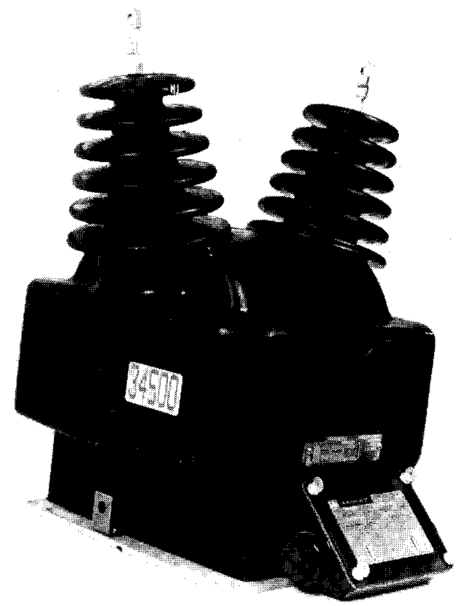
A) Typical user incoming tests may not adequately evaluate a product's capability to provide long-term, trouble-free service.

B) Users should give due consideration to evaluating instrument transformer suppliers in greater depth than has typically been done in the past, and consider reliability objectives as a key factor in establishing individual manufacturer approvals.

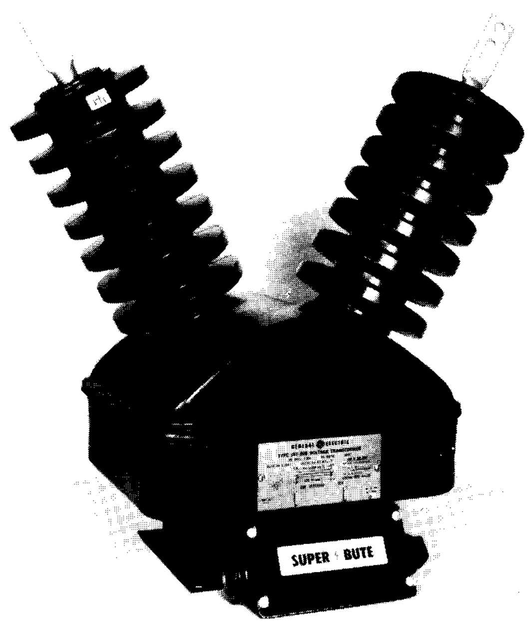
34.5kV Outdoor Voltage Transformer Evaluation

III. Products Tested

*** Westinghouse Type VOZ-20 Voltage Transformer (Qty 2 Tested)**



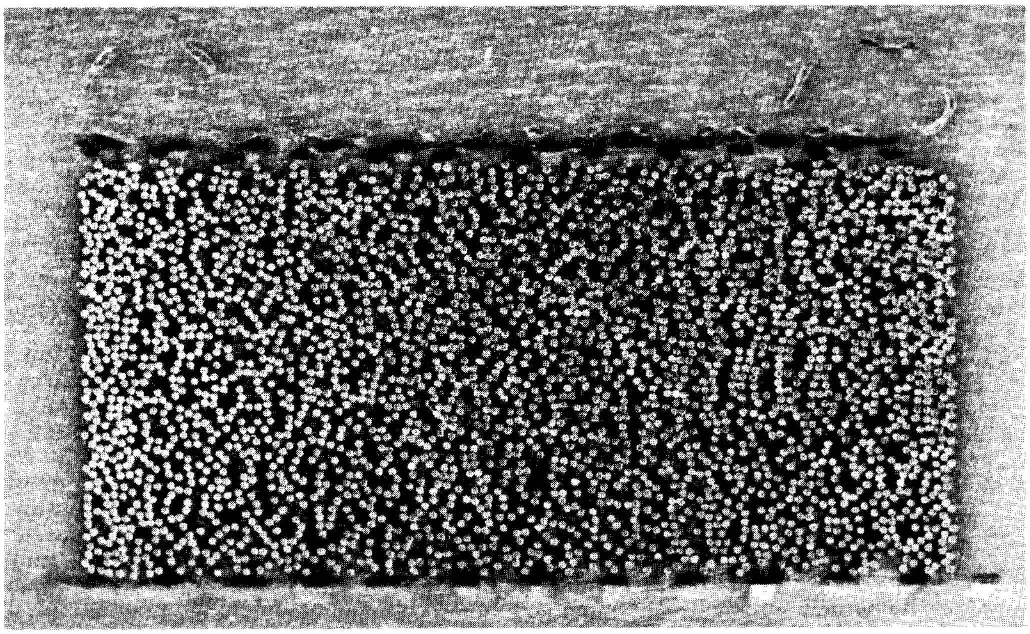
GE Type JVT-200 Voltage Transformer (Qty 4 Tested)



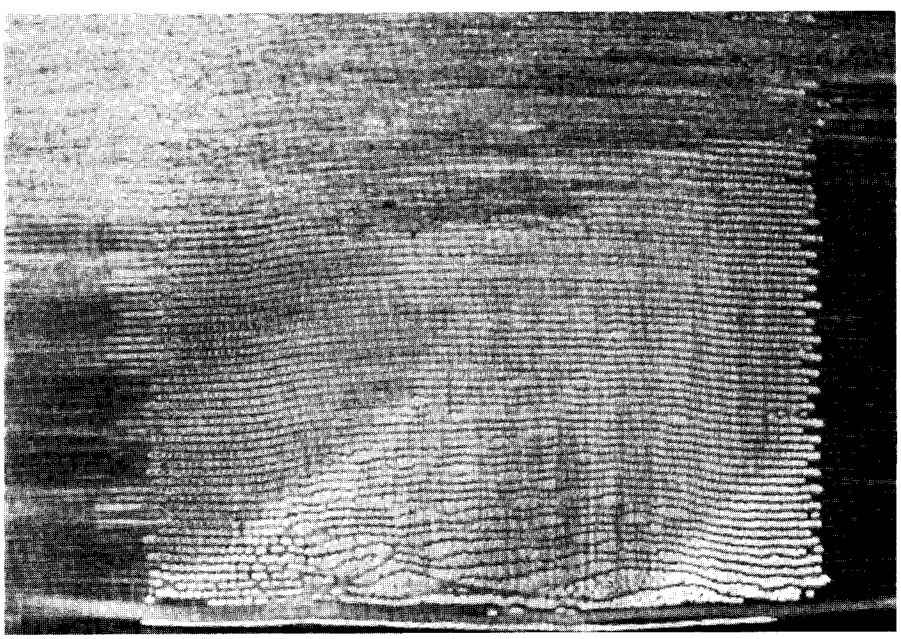
* *Tests on the VOZ-20 units were performed in October of 1989. The units were new. Since that time, ABB has acquired the Westinghouse Instrument Transformer business.*

IV. Nameplate Data and Technical Observations

Manufacturer	Type	BIL (kV)	Voltage Ratio	Primary Bushings	Weight Lbs.	ANSI Accuracy 0.3W Thru:	Thermal Rating VA at 30C AMB.	External Insulation	Nameplate Material	Nameplate Grounded
Westinghouse	V0Z-20	200	300/500:1	2	148	Z (200VA)	2000	Polyurethane	Stainless	Yes*
GE	JVT-200	200	300:1	2	235	ZZ (400VA)	3000	Butyl	Stainless	Yes



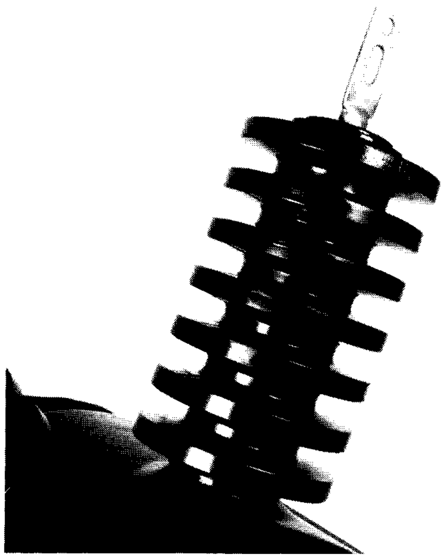
GE JVT-200 Cross Section of Lattice Wound Primary Coil with Evenly Spaced Conductors and Epoxy Impregnation for High Reliability.



Westinghouse VOZ-20 Cross Section of Primary Coil with Evidence of Distortion

** Nameplate is Grounded via an External Copper Strip Placed Under the Nameplate. See Close-Up Photo on Page 5.*

Material	Conduit Box Material	Ground Terminal Near Secondary	External Ground	Secondary Hardware	Creepage Distance	Primary Coil Design: # Sections	Primary Coil Design: Winding Method	Primary Coil Design: Epoxy Impregnated
Aluminum	Aluminum	Yes	Yes	Screw	29 1/8"	2	Layer	No
Steel	Aluminum	Yes	Yes	Screw	36"	4	Lattice	Yes

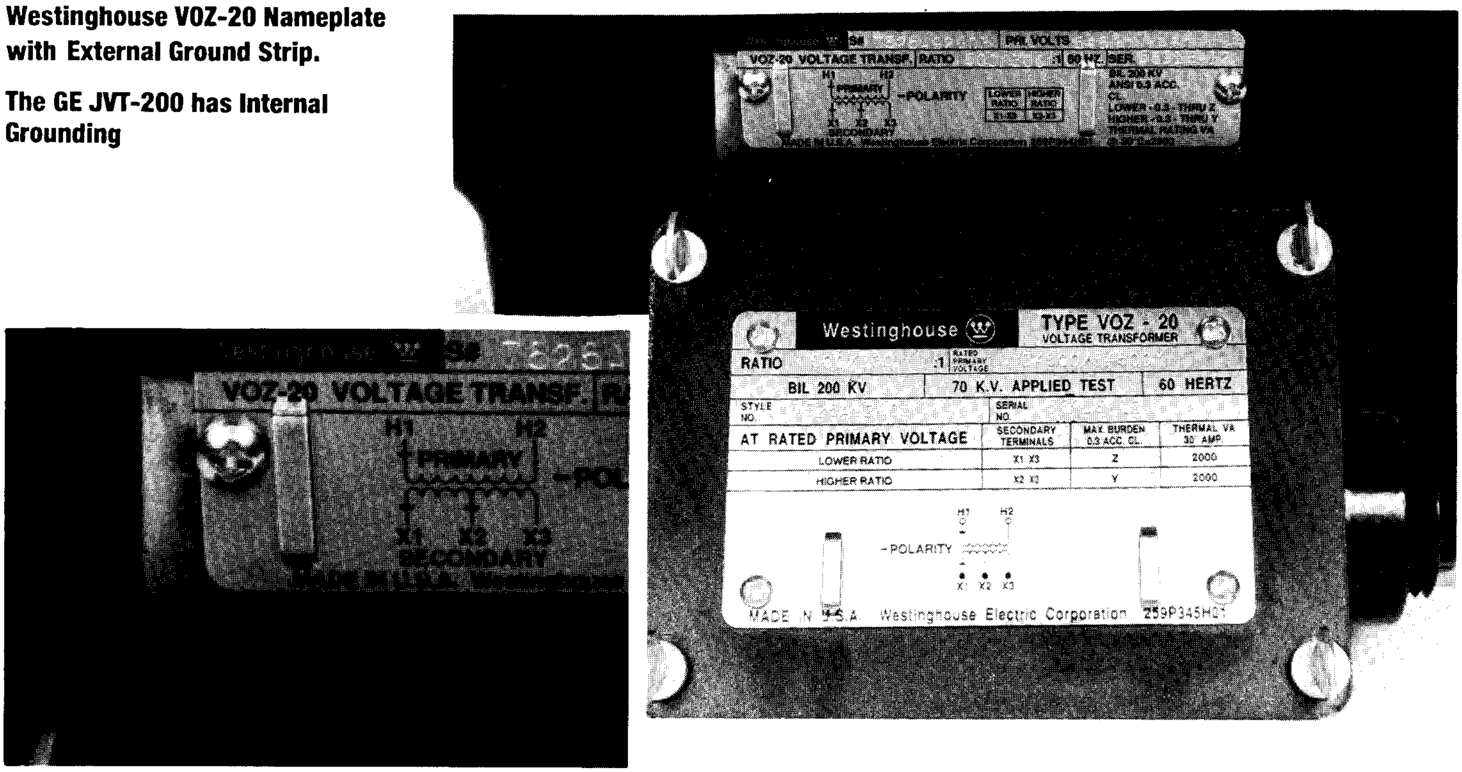


GE JVT-200 Bushing

Westinghouse VOZ-20 Bushing with Molding "Flash" Evident on Skirts.

Westinghouse VOZ-20 Nameplate with External Ground Strip.

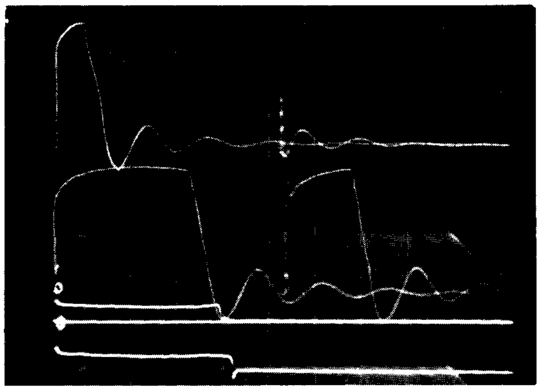
The GE JVT-200 has Internal Grounding



Test Results

Westinghouse VOZ-20

• Impulse Test: Failed (Qty 2 Tested)



VOZ-20 Impulse Failure

• Induced Voltage Test: Passed
Avg. Current Drawn: 1.79 AMPS

• Primary Hipot: Passed

• Secondary Hipot: Passed

• Primary Power Factor: High*
% Power Factor @ 10kV=8.16 Avg.

• Accuracy: Passed
Average Readings (2 Units)

120V		132V		120V	
No Load		No Load		Z Burden	
RCF	PA	RCF	PA	RCF	PA
0.9978	+3.6	0.9979	+4.0	1.0005	+0.1

• Partial Discharge Test: **
220 to 800 Times GE Levels

Average Readings:

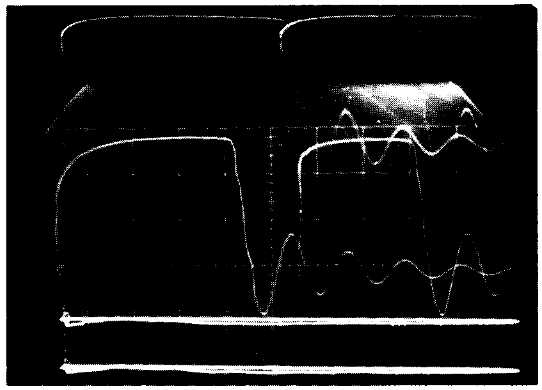
Conn #	Start kV	Start CV	Measured crest volts (CV) for specific kV test levels					Stop kV	Stop CV
			kV	20.0	17.9	15.2	10.0		
1	6.3	0.1	CV	.26	.21	.21	.19	7.5	0
			kV	38.0	34.5	29.3	21.9		
2	10.8	0.06	CV	5.0	4.0	2.2	1.3	7.9	0
			kV	38.0	34.5	29.3	21.9		
3	9.8	0.05	CV	6.0	4.4	.33	.24	12.0	0

** Compared to the 2% level typically considered commercially acceptable by users establishing a flat limit for solid-insulated units.*

*** The test levels and limits used were those which GE could consider applicable to the JVT-200. There are no U.S. industry standards governing test procedure or limits on partial discharge test of these instrument transformers. Arbitrary assignment of partial discharge limits to all insulation systems is not appropriate because of the variations between insulation systems.*
The conversion factor "C" for Q=CV in conversion of crest volts to pico coulombs of apparent charge is not known, however, experience with the GE designs tested in GE equipment suggests C=500 and thus 0.05CV indicates 25 pico coulombs. This does not suggest that this value of "C" is authoritative for non-GE designs tested in GE equipment.

GE JVT-200

• Impulse Test: 100% Passed (Qty 4 tested)



Normal Impulse Oscillograms JVT-200

• Induced Voltage Test: Passed
Avg. Current Drawn: 0.75 AMPS

• Primary Hipot: Passed

• Secondary Hipot: Passed

• Primary Power Factor: Passed
% Power Factor @ 10kV=0.28 Avg.

• Accuracy: Passed
Average Readings (4 Units)

120V		132V		120V	
No Load		No Load		ZZ Burden	
RCF	PA	RCF	PA	RCF	PA
0.9974	+0.5	0.9974	+0.5	1.0020	-5.1

• Partial Discharge Test: Passed

Average Readings:

Conn #	Start kV	Start CV	Measured crest volts (CV) for specific kV test levels					Stop kV	Stop CV
			kV	20.0	17.9	15.2	10.0		
1	20.0	0	CV	0	0	0	0	-	0
			kV	38.0	34.5	29.3	21.9		
2	36.6	.004	CV	.007	.005	0	0	34.5	0
			kV	38.0	34.5	29.3	21.9		
3	34.0	.014	CV	.02	.02	.009	0	30.8	0

Discussion of Visual Observations, Tests, and Teardown

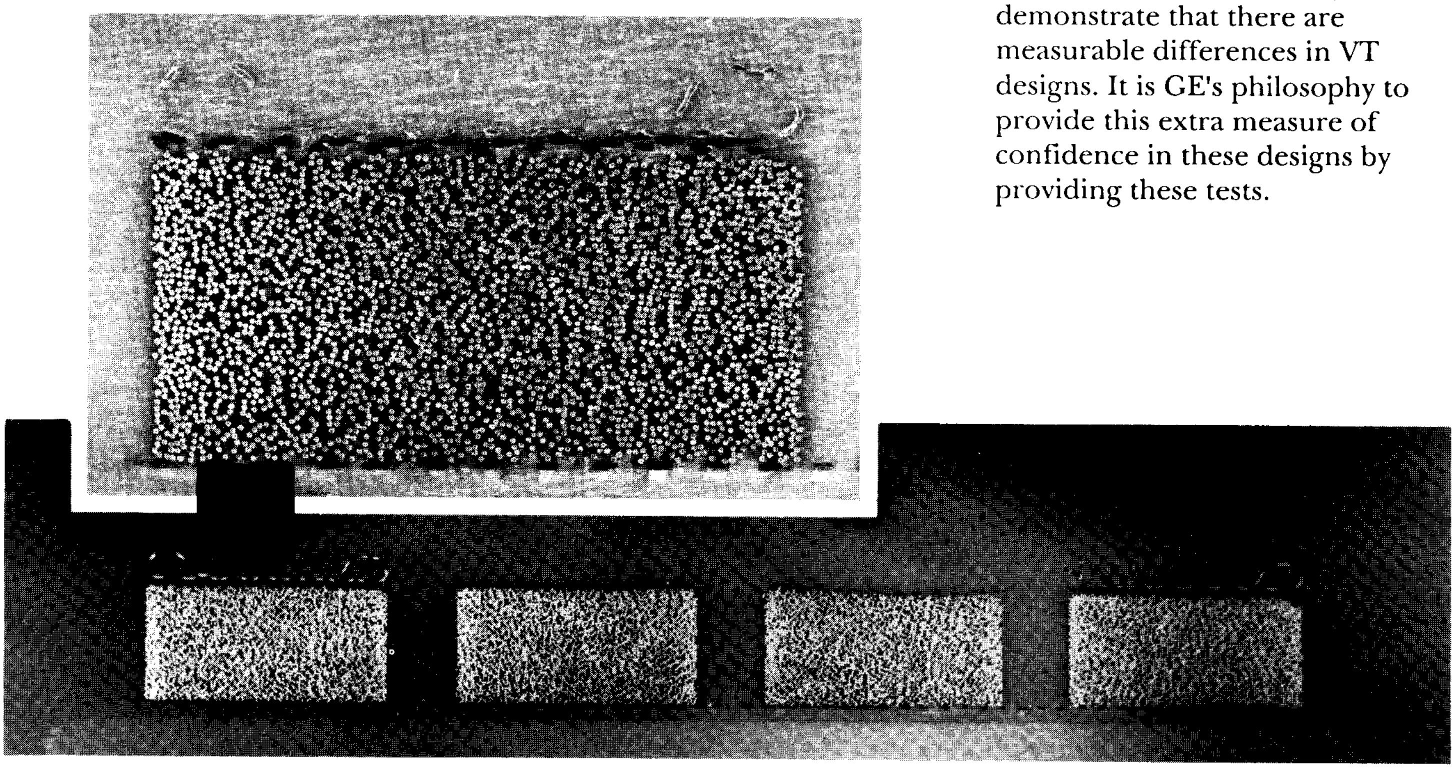
GE JVT-200

Electrical test results showed the performance of this product to be superior to the VOZ-20 in this evaluation. The primary coil design of the JVT-200 consists of a four-section, "lattice"-wound primary coil with voltage distribution shields. The coil is cast in epoxy to impregnate the winding, and to provide major insulation. External insulation consists of butyl rubber.

The lattice primary coil construction is unique to GE, and is a major factor in the ability of the product to exhibit excellent impulse withstand, and partial discharge test results, both extremely pertinent to long product life.

Referring to the cross-sectional photos on page 4 comparing the GE coil design to the VOZ-20, we see that the GE coil has a 50% space factor between adjacent turns, where the VOZ-20 has no space factor in some areas, nor does it have impregnation of the coil, or primary voltage shields.

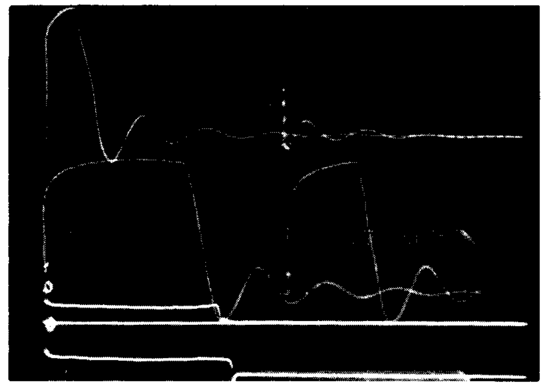
GE continues to use this unique construction in its entire line of VT products from 8.7kV through 69kV. Further, GE provides impulse testing and partial discharge testing on all VT's 25kV and up, free of charge. These tests are not required by ANSI to be performed on a production basis but as you can see in the test results of the VOZ-20, they demonstrate that there are measurable differences in VT designs. It is GE's philosophy to provide this extra measure of confidence in these designs by providing these tests.



JVT-200 4-Section "Lattice" Wound Primary Coil with Epoxy Impregnation

Discussion of Visual Observations, Tests, and Teardown

Westinghouse VOZ-20



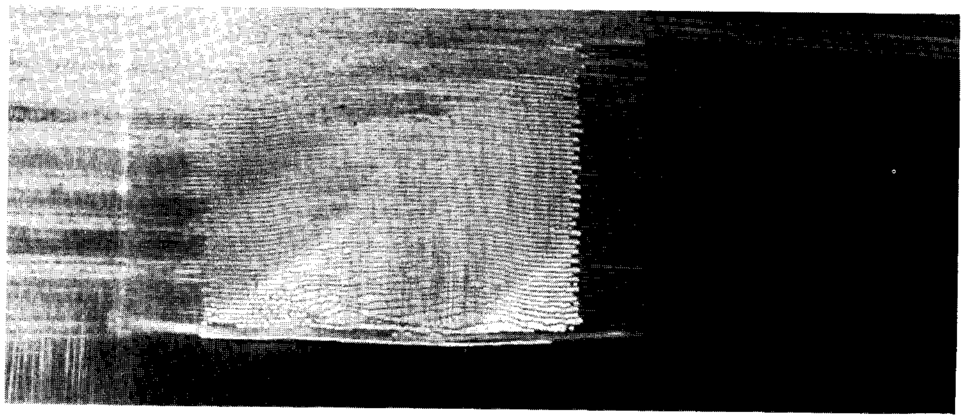
Based on GE interpretation of the wave form shown on the test oscillograms, both VOZ-20 units tested had failed impulse test. The failures were confirmed by subsequent repeat tests of both induced voltage and primary hipot. The failure mode was diagnosed as a primary-to-ground failure in both units.

Primary power factor tests at 10.0kV averaging 8.16% are high relative to typical user expectations and when compared to GE products. It is speculated that the high power factor readings are inherently characteristic of the polyurethane insulation used in the V0Z-20 products.

The partial discharge test results are extremely high compared to GE results. The corona inception levels for the V0Z-20 are approximately 10KV compared to 35kV for the GE JVT-200 with measured crest volt discharges at operating voltage being 220-800 times greater in the V0Z-20 than in the GE JVT-200.

Impulse tests and partial discharge tests are key tests in evaluating long term reliability of these products. It is therefore probable that in time, and in general, V0Z-20 units, similar to the units tested, will experience a higher percentage of failures from voltage surges than would occur if quoted BIL (impulse) capability were present.

Discussion of Visual Observations, Tests, and Teardown



Teardown of one VOZ-20 unit was undertaken to investigate the primary coil design, and to locate the position of the impulse test failure. The construction of the primary coil consists of two side-by-side layer wound sections, with layer paper. It appears the primary coil is not impregnated, but is molded in place during the molding of the entire unit in polyurethane insulation. The failure was found within one cross-section and appears to be emanating from the outer layers of the primary coil, through the major insulation, to ground. As seen in the photo above, the primary coil shows distortion in its outer layers, with many of the primary turns bunching together, possibly contributing to the failure of the VT.

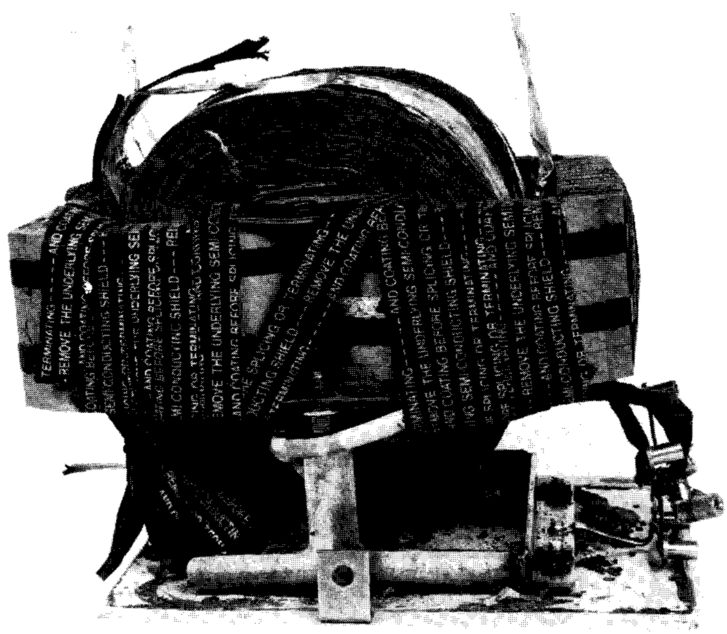
Further teardown on another unit was accomplished by dissolving the polyurethane insulation in methylene chloride, a commonly available chemical solvent. The entire process took approximately 30 days to completely strip the coils, core and other internal components of the polyurethane. As seen in the photo at the right, the primary coil on this unit is also distorted. Apparently the distortion occurs during the polyurethane molding process.

Some other visual observations worthy of discussion are the method of grounding the nameplate and also the presence of molding "flash" on the bushing skirts. As can be seen in the photos on page 5, the nameplate has an external copper strip under the nameplate screw, apparently for grounding purposes. This external connection could have been avoided as this connection would most logically have been made internally.

The presence of molding flash on the bushing skirts raises two concerns:

- First, it shortens the creepage distance to ground. This distance should be at its optimum, particularly for application in environmentally severe conditions ie: salt air, wind-borne dust, chemicals, fertilizers, etc. A compromise of this distance could result in undesirable external flashovers or surface scintillations.

- Secondly, this molding flash could possibly entrap airborne contaminants, which might otherwise have been washed off by rain or blown off by wind. Accumulation of contaminants could also result in undesirable external flashovers and scintillations.



- APPENDIX -
Tests Description and Significance

A. Primary Insulation Power Factor

Measured at 2.5 and 10.0kV. This is a key test for liquid immersed apparatus, and a test which has been used as an indicator of insulation quality in solid insulated instrument transformers. Some observations typically causing concern would be:

1) A change in power factor with time.
2) Tip-up (power factor increases with test voltage).
3) "Power factors" exceeding 2%, a level of commercial interest since those users establishing a flat limit for solid-insulated units typically select 2%. For purposes of this report, power factors below 2% will be considered both technically and commercially acceptable.

B. Accuracy

Tested per ANSI C57.13 at 60 hertz at 100 and 110% of rated voltage, no load, and at rated voltage with the heaviest burden where the accuracy is rated 0.3. This permits evaluation of accuracy versus quoted ratings. The requirement is to meet quoted accuracy.

C. Impulse Test

Typically consisted of 2 chopped wave shots (voltage detection) on connection #2 and #3 at 230kV crest as defined by ANSI, and 1 full wave shot (current detection) on connection #2 and #3 at 200kV crest, to check the ability to meet the published 200kV BIL. The requirement is that chopped wave voltage oscillograms and full wave current oscillograms be typical of those obtained in an unfailed unit of the type.

Impulse tests evaluate the quoted capability to withstand voltage waves which may be applied as a result of lightning, and also indicate to some extent, capability of withstanding waves from other disturbances. Failure to meet impulse levels indicates a probability that, in time and in general, a design will experience a greater percentage of failures from voltage surges than would occur if quoted capability was provided.

ANSI C57.13 does not require impulse testing as a 100% production test. GE believes 100% impulse testing is a good manufacturing practice on products where a high impulse test failure rate is anticipated. GE also believes type testing and production sampling should be used to provide assurance that quoted impulse strength is met by a very high percentage of each voltage transformer design.

Impulse strength is one of the quoted ratings pertinent to product life. The design, evaluation, and product costs to assure desired impulse strength may be substantial.

D. Induced Voltage Test

On two-bushing VT's, 2 times rated secondary voltage is applied at 120 Hz for 60 seconds, with the primary winding open as specified by ANSI C57.13. The requirement is that the exciting current not exceed a magnitude judged to be typical for the design.

E. Primary Applied Voltage (Hipot) Test

On two bushing VT's, this test is run per ANSI at 70kV, 60Hz, for 60 seconds. Ionization (corona) levels were recorded. The requirements are that the test equipment not be tripped out, which would indicate failure, and that the ionization levels not be clearly excessive.

F. Secondary Applied Voltage (Hipot) Test

Run at 2.5kV, 60Hz, 60 seconds per ANSI. Requirements are as in Section E on this page.

G. Partial Discharge Test

The test was performed using connection 1,2, & 3. The test levels and limits used were those which we could consider applicable to the JVT-200. There are no U.S. industry standards governing test procedure or limits on partial discharge test of these intrument transformers. Arbitrary assignment of partial discharge limits to all insulation systems is not appropriate because of the variations between insulation systems.

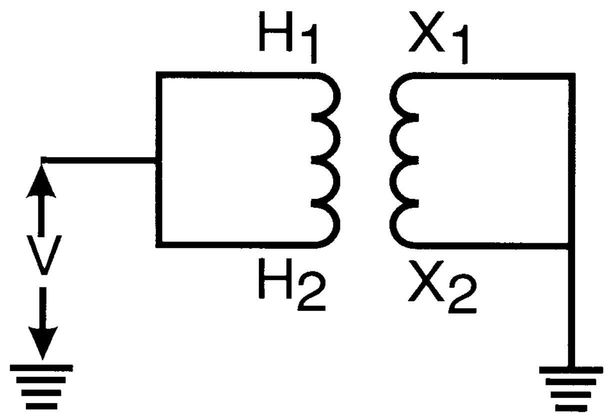
The partial discharge tests indicate discharges bridging portions of the insulation under electrical stress. Discharges which are excessive for a particular insulation system can lead to reduced life.

The results are measured in units of crest volts. Start and stop are defined as 0.01CV and any lower CV is considered 0.

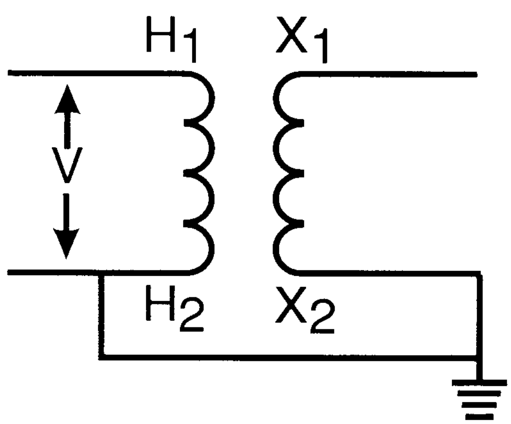
The conversion factor "C" for Q=CV in conversion of crest volts to pico coulombs of apparent charge is not known, however, experience with the GE designs tested in GE equipment suggests C=500 and thus 0.05CV indicates 25 pico coulombs. This does not suggest that this value of "C" is authoritative for non-GE designs tested in GE equipment.

- APPENDIX -
Wiring Diagram For Test Connections

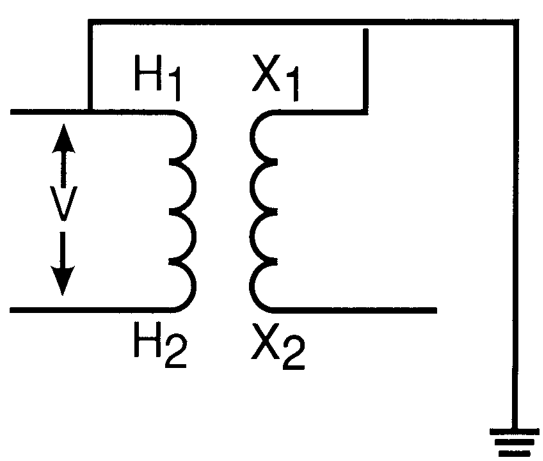
Connection #1



Connection #2



Connection #3



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