Rochester Gas and Electric Corporation

R. E. Ginna Nuclear Power Plant

Adequacy of Station Electric Distribution
Systems Voltages

September 21, 1981

EWR 2810

1.0 Purpose

The objective of this report is to summarize the results of a special test to verify the system model used for the load flow analysis contained in the report "Adequacy of Station Electric Distribution Systems Voltages," reference 2.1. Testing consisted of taking field measurements of the on-site electrical distribution system during both steady state and transient operating conditions at Ginna Station. The measured electrical parameters were compared to the calculated values based on the system model for similar operating conditions established in reference 2.1.

2.0 References

2.1 Rochester Gas and Electric's Report, Adequacy of Station Electric Distribution Systems Voltages, dated December 6, 1979.

3.0 Test Procedure

Nine four-channel strip chart recorders were used to simultaneously measure line voltages, amperes and watts on each of the four safeguard buses, the 4 kV buses and the 34.5 kV off-site bus. The chart recorders continuously monitored these electrical parameters during a number of significant operating modes, which were also examined in reference 2.1. Specifically, field measurements were obtained for normal and light bus loads with Ginna on-line and off-line while circuit 767 was in service. Measurements were also taken with the second off-site 34.5 kV line, circuit 751, in service. Also, data was recorded while the reactor coolant pumps were being started in order to assess transient responses.

4.0 Results

The comparison of calculated voltage results to actual values, for the various operating modes is presented in Appendix 1 and is summarized in Table 1. This table divides the various buses into three voltage levels and then averages the difference between calculated and measured values for each level. For example, within the 480 volt category there are actually six buses. The value of percent difference, for the 480 volt bus in Table 1, is therefore an average of the six values. In all cases the mean square deviation was very small. It should be noted that a great deal of data was actually recorded, over a time period of greater than a year, and that the information contained in this report is only a representative sampling of the results that were obtained.

Table 1

Operating Conditions	Load Flow Case	Parameter	Average Percent Difference Between Calculated Results And Actual Values
Ginna On-Line, Normal Load, Circuit 767 Supplying #12 Transf., Normal Off-Site Grid Voltage	ONN 1-2	480 Volt Buses	2.28%
		4160 Volt Buses	3.38%
		34500 Volt Buses	0.14%
Ginna On-Line, Normal Load, Circuit 767 Supplying #12 Transf., High Off-Site Grid Voltage	ONN 1-3	480 Volt Buses	0.85%
		4160 Volt Buses	1.23%
		34500 Volt Buses	1.41%
Ginna On-Line, Light Load, Circuit 767 Supplying #12 Transf., Low Off-Site Grid Voltage	ONL 1-1	480 Volt Buses	3.38%
		4160 Volt Buses	1.80%
		34500 Volt Buses	0.29%
Ginna On-Line, Light Load, Circuit 767 Supplying #12 Transf., High Off-Site Grid Voltage	ONL 1-3	480 Volt Buses	0.69%
		4160 Volt Buses	1.67%
		34500 Volt Buses	0.14%
Ginna Off-Line, Light Load, Circuit 767 Supplying #12 Transf., High Off-Site Grid Voltage	OFL 1-4	480 Volt Buses	1.44%
		4160 Volt Buses	0.48%
		34500 Volt Buses	1.39%
Ginna Off-Line, Light Load, Circuit 751 Supplying #12 Transf., High Off-Site Grid Voltage	OFL 2-4	480 Volt Buses	0.55%
		4160 Volt Buses	0.92%
		34500 Volt Buses	0.55%

Summary

Overall Average Difference Between Calculated and Actual 480 Volt Values	1.53%
Overall Average Difference Between Calculated and Actual 4160 Volt Values	1.58%
Overall Average Difference Between Calculated and Actual 34500 Volt Values	0.65%

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The results of the analysis contained in Table 1 illustrates the accuracy with which the computer model was able to predict the results of the various operating conditions. Specifically, the overall average difference between the calculated and actual 480 volt values, for the six cases, was 1.53%. Also, the overall average differences for the 4160 volt and 34500 volt values was 1.58% and 0.65% respectively. Inspection of Appendix 1, which contains the supporting documentation for Table 1, shows that the calculated values of voltage, although close to the actual values, tended to be slightly lower, showing the model to be somewhat conservative. For example the calculated values for the 480 volt buses were an average of 5.4 volts lower than the actual bus voltages, for the six operating conditions documented in Appendix 1.

Appendix 2 contains the transient voltage conditions that exist when the 6,000 H.P. reactor coolant pump A was started. The percent difference values for this case are considerably higher than those of the previous six cases. For example, the overall average difference between calculated and actual 480 volt values was 9.92%. This difference can be explained when two factors are examined. The first factor was an inability to find a field test which closely duplicated the load flow assumptions. Since only a limited number of reactor coolant pump start-ups actually took place during this test period, it was not possible to match, to the degree desired, actual bus loadings to calculated values. For this comparison, the measured bus loads immediately before motor start-up were signficantly lower than the calculated values. In addition, the steady state 34.5 kV bus voltage was higher than that assumed in the load flow case. The second factor, contributing to this difference in comparing results, was the power factor used for motor start-up. The computer model assumed a 20% power factor. Actual field measurements have shown that a less severe, 30%, power factor is more realistic. As expected, the calculated voltages were therefore consistently lower than the actual voltages. This resulted in the measured 480 volt bus voltage level being higher than the calculated values. These results are consistent with the findings of other transient operating tests.

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The calculated maximum voltage anticipated on the 480 volt buses is 528 volts and the minimum voltage is 368 volts. The consequences of these conditions are discussed in reference 2.1. Assurance that these limits were not exceeded was achieved by examining the actual voltages for the entire duration of the field test. The highest voltage recorded during the test was 502 volts and the lowest voltage experienced was 408 volts.

The off-site grid voltage operating range has been established over a ten year period, using the electrical operating logs at Ginna station. When Ginna is on-line the operating range is 117 kV to 122 kV. During off-line operation the voltage range is between 113 kV and 122 kV. A review of these logs, during the test period, revealed that the off-line range has been extended to 123 kV.

5.0 Conclusion

Every effort was made, during the year that this test program was being conducted, to verify as many of the load flow cases investigated in reference 2.1 as possible. However, it was not feasible to duplicate every case due to operating restrictions to both Ginna Station and the off-site Transmission System. For example, the heavy load operating conditions postulated in reference 2.1 assumes that the load on each bus is equal to the full nameplate rating of the service transformers. While these cases are significant in that they depict a "worst case" situation they cannot actually occur. Verification of this family of load flow runs, by actual field measurements, is therefore not possible. However the number of system configurations that were simulated give a high degree of confidence in the model. Inspection of Table 1 shows that comparisons between calculated and actual values of bus voltages yielded a difference of less than 2%.

The reactor coolant pump start-up, which is documented in Appendix 2, was an example of the degree of conservatism intentionally incorporated in some load flow cases. This particular comparison illustrates a significant difference between the actual and calculated values. The computer model estimated values which were more severe than actually measured due to the conservative assumptions made for power factors. This tendency was therefore expected and was desirable since investigations concerning operating conditions, which cannot be easily measured, typically results in a reliance on calculated values.

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The comparisons contained in this report of actual to calculated values have verified the design intent that the load flow analysis yield conservative results. It is therefore concluded that the voltages levels, on all safety related buses, are within the operating limits specified in reference 2.1. Specifically, the calculated voltages at the terminals of each safety load were found to be within the required voltage range for normal operation and starting of that specific load. Also, the voltage levels for safety loads did not result in excessive (high) voltage, assuming the maximum expected value of voltage at the connection to the off-site circuit.

Based on the measured results that were taken during the starting of the two Reactor Coolant Pumps (simulating plant start-up), the low voltage limits, established in the Conclusion Section of Reference 2.1 are overly conservative. Specifically, the measured data taken for starting the reactor coolant pumps at grid levels of 122 KV, indicated that the inplant IE buses do not experience a voltage as low as originally calculated. The lowest calculated IE voltage for this transient case was 364 volts while the measured value was 420 volts. This difference is attributed to the motor starting power factor assumed in the analyses as discussed in Section 4.0 of this report. This comparison demonstrates that the 120 KV and 35 KV levels are, in fact, conservative and can be reduced without any increase in the likelihood of spurious trips. It is fully anticipated that the normal "on line" lower limit of 117 KV is fully acceptable as a start-up voltage. However, should conditions change such that the grid voltage during start-up is at the 117 KV level, instead of the present start-up voltage of 120 KV or higher level, and the plant auxiliary loads should increase resulting in unacceptable safeguard bus voltages, then the new undervoltage relays will automatically separate the IE buses from the grid and place them on the on-site diesel generators. Since the new undervoltage system is designed to mitigate any and all degrated voltage conditions, no administrative lower limit need be established. The offsite voltage range, established with over ten years of operating history, is sufficient and acceptable for all plant operating conditions.

APPENDIX 1

P.T.I. Load Flow Case - ONN 1-2
Description - Ginna on-line, normal load, circuit 767 supplying #12 transf., normal off-site grid voltage
Date and Time of actual measurements - 5/31/80 @ 505 hrs.

Bus Number	Calculated Voltage	Actual Voltage	% Difference
11A	4208.1	4252.5	1.0
11B	4237.0	4305.0	1.6
12A	4172.4	4410.0	5.4
12B	4170.5	4410.0	5.4
13	465.9	480.0	2.9
14	470.4	486.0	3.2
15	473.9	480.0	1.3
16	473.2	480.0	1.4
17	460.9	480.0	4.0
18	471.9	468.0	0.8
34 kV	34700.0	34650.0	0.1

P.T.I. Load Flow Case - ONN 1-3
Description - Ginna on-line, normal load, circuit 767 supplying #12 transf., high off-site grid voltage
Date and Time of actual measurements - 6/13/80 @ 2230 hrs.

Bus Number	Calculated Voltage	Actual Voltage	% Difference
11A	4319.6	4305.0	0.3
11B	4347.6	4305.0	1.0
12A	4278.7	4357.5	1.8
12B	4277.0	4357.5	1.8
13	479.4	480.0	0.1
14	483.0	480.0	0.6
15	487.1	480.0	1.5
16	485.7	486.0	0.1
17	473.7	480.0	1.3
18	484.4	492.0	1.5
34 kV	35600.0	35550.0	0.1

P.T.I. Load Flow Case - ONL 1-1
Description - Ginna on-line, light load, circuit 767 supplying #12 transf., low off-site grid voltage
Date and Time of actual measurements - 5/20/80 @ 1100 hrs.

Bus Number	Calculated Voltage	Actual Voltage	% Difference
11A	4162.9	4095.0	1.7
11B	4163.7	4200.0	0.9
12A	4103.7	4200.0	2.3
12B	4105.1	4200.0	2.3
13	469.4	486.0	3.4
14	463.3	486.0	4.7
15	469.5	492.0	4.6
16	465.2	474.0	1.9
17	464.9	486.0	4.3
18	463.5	468.0	1.0
34 kV	34100.0	34200.0	0.3

P.T.I. Load Flow Case - ONL 1-3
Description - Ginna on-line, light load, circuit 767 supplying #12 transf., high off-site grid voltage
Date and Time of actual measurements - 6/9/80 @ 1645 hrs.

Bus Number	Calculated Voltage	Actual Voltage	% Difference
11A	4350.1	4305.0	1.0
11B	4350.9	4305.0	1.1
12A	4283.4	4410.0	2.9
12B	4284.8	4357.5	1.7
13	491.5	486.0	1.1
14	484.4	486.0	0.3
15	491.6	486.0	1.2
16	486.3	486.0	0.1
17	486.0	486.0	0.0
18	484.7	492.0	1.5
34 kV	35600.0	35550.0	0.1

P.T.I. Load Flow Case - OFL 1-4
Description - Ginna off-line, light load, circuit 767 supplying #12 transf., high off-site grid voltage
Date and Time of actual measurements - 5/7/80 @ 1637 hrs.

Bus Number	Calculated Voltage	Actual Voltage	% Difference
11A	4266.9	4252.5	0.3
11B	4267.7	4252.5	0.4
12A	4266.9	4252.5	0.3
12B	4267.7	4305.0	0.9
13	481.7	492.0	2.1
14	482.5	492.0	1.9
15	481.8	492.0	2.1
16	484.3	486.0	0.4
17	484.0	492.0	1.6
18	482.7	480.0	0.6
34 kV	35500.0	36000.0	1.4

P.T.I. Load Flow Case - OFL 2-4
Description - Ginna off-line, light load, circuit 751 supplying #12 transf., high off-site grid voltage
Date and Time of actual measurements - 5/16/80 @ 1635 hrs.

Bus Number	Calculated Voltage	Actual Voltage	% Difference
11A	4317.5	4252.5	1.5
11B	4318.2	4252.5	1.6
12A	4317.5	4305.0	0.3
12B	4318.2	4305.0	0.3
13	487.7	486.0	0.4
14	488.5	492.0	0.7
15	487.8	486.0	0.4
16	490.2	492.0	0.4
17	490.0	486.0	0.8
18	488.7	492.0	0.7
34 kV	36200.0	36000.0	0.6

APPENDIX 2

P.T.I. Load Flow Case - OFTS 1-12
Description - Ginna off-line, reactor coolant pump start-up, circuit 767 supplying #12 transf., normal off-site grid voltage
Date and Time of actual measurements - 5/16/80 @ 1721 hrs.

Bus Number	Calculated Voltage	Actual Voltage	% Difference
11A	3423.1	3570.0	4.1
11B	3694.9	3885.0	4.8
12A	3424.4	3675.0	6.8
12B	3695.1	3938.0	6.2
13	375.2	414.0	9.4
14	363.9	420.0	13.4
15	403.7	444.0	9.1
16	399.8	456.0	12.3
17	407.7	444.0	8.2
18	384.6	414.0	7.1
34 kV	31.6	33.3	5.1