

HIGH POTENTIAL DC TESTING OF WIRE COMMUNICATION FACILITIES SERVING POWER STATIONS

1. GENERAL

1.01 The telephone cable plant facilities serving *some* power stations are subject to high voltage stress during fault conditions on the power system. This stress is caused by induction and/or ground potential rise and is a result of the large momentary power system currents that flow during fault conditions. The telephone cables serving these power stations must possess high dielectric (insulation) strength if cable damage is to be avoided and satisfactory service is to be provided for critical communication circuits. It is for this reason that 19 gauge Polyethylene Insulated Conductor PAP or PASP cable is generally employed since as can be seen from Table 1, its conductor-to-conductor and core-to-sheath dielectric strength is vastly superior to pulp insulated cable. Western Electric tests indicate .066 mfd. 19 gauge PAP or PASP Polyethylene Insulated Conductor Cable (CA 1727) is the best choice from a dielectric strength standpoint. Unfortunately the high dielectric strength of PIC cable can be seriously degraded during installation and maintenance work operations. Tests have shown that PIC cable dielectric strength can and usually is reduced to a small fraction of its rated value from the following causes:

- (a) Punctured insulation in conductors and B Wire connectors resulting from the use of scissors and test set clips in pair identification work.
- (b) Insulation failure due to conductor fold-backs or sharp bends in closures or pedestal terminals.
- (c) Insulation failure due to improper removal of lead cable sheath.
- (d) Bare copper exposure at B Wire Connectors caused by the removal of excess wire insulation. This occurs when scissors instead of B Wire Strippers are employed for the removal of wire insulation.
- (e) Water in the cable core.
- (f) Manufacturing defects.

While good workmanship and careful mechanical inspection will materially reduce the number of weak points in cables, the only sure method of determining dielectric strength is by means of high-potential testing of the conductors.

1.02 Although the actual stress voltage applied to cable plant facilities during a power fault is AC, the use of an AC high potential test set is not recommended. AC high potential test sets must supply the out-of-phase (or quadrature) current due to the cable capacitance as well as the cable leakage current. In cable testing the requirement for quadrature current could run as high as 0.5 amperes and AC high potential test sets capable of supplying this amount of current are expensive and not suitable for portable operation.

1.03 As can be seen from Figure 1, the application of a DC high potential to cable plant facilities causes a high initial current which gradually decays to a lower steady-state value. The high initial current results from the requirement for charging current due to the cable capacitance. As this charging current decays, the steady-state current left is the true leakage. The magnitude of the charging current is determined by how rapidly the voltage applied to the cable pair is changed and the magnitude of the circuit series resistance. It is possible to charge several miles of cable with a very small dc test set by raising the voltage slowly enough to keep the initial current below the maximum capabilities of the test set. Experience has shown that a 2.5 milliamperere DC high potential test set is capable of performing satisfactorily with long lengths of telephone cable.

1.04 In DC high-potential testing, every pair subject to high voltage stress must be tested both to the sheath and every other pair in the sheath if assurance of satisfactory performance is to be obtained. Since high DC voltages are used in these tests, the cable section being tested must be completely sectionalized, i.e., disconnected from cable going to the central office as well as to stations. This sectionalization is required in order to eliminate pulp insulated conductor cable and station equipment from the test since this facility and equipment would break down well before a meaningful test could be made on the PIC cable.

TABLE 1

DIELECTRIC STRENGTH OF TELEPHONE CABLES

TYPE OF CABLE	GAUGE	INSULATION	CORE INSULATION	OUTER JACKET	FACTORY TEST (KV)		SURGE DIELECTRIC (PEAK KV)	
					COND. TO COND.	CORE TO SHEATH	COND. TO COND.	CORE TO SHEATH
Lead	26	Pulp	Paper		0.35 ac	0.85 ac	1.00	2.4
	24	Pulp			0.35 ac	1.00 ac	1.07	2.8
	22	Pulp			0.35 ac	1.00 ac	1.37	2.8
	19	Pulp			0.50 ac	1.00 ac	2.15	2.8
Lepeth	26	Pulp	Paper and Polyethylene		0.35 ac	20.0 dc	1.00	60.0
	24	Pulp			0.35 ac	20.0 dc	1.07	60.0
	22	Pulp			0.35 ac	20.0 dc	1.37	60.0
	19	Pulp			0.50 ac	20.0 dc	2.15	60.0
Stalpeth	26	Pulp	Paper	Polyethylene Note 1	0.35 ac	0.85 ac	1.00	2.4
	24	Pulp			0.35 ac	1.00 ac	1.07	2.8
	22	Pulp			0.35 ac	1.00 ac	1.37	2.8
	19	Pulp			0.50 ac	1.00 ac	2.15	2.8
PASP	26	Solid Poly.	Rubber-Mylar and Polyethylene	Polyethylene Note 1	3.0 dc	20.0 dc	6.75	60.0
	24				5.0 dc	20.0 dc	13.50	60.0
	22				8.0 dc	20.0 dc	20.30	60.0
	19				10.0 dc	20.0 dc	27.00	60.0
Alpeth-PIC Note (2)	26	Solid Poly.	Rubber-Mylar	Polyethylene Note 1	3.0 dc	5.0 dc	6.75	17.0
	24				5.0 dc	5.0 dc	13.50	19.0
	22				8.0 dc	10.0 dc	20.30	21.0
	19				10.0 dc	10.0 dc	27.00	23.0
PAP	26	Solid Poly.	Rubber-Mylar and Polyethylene	Polyethylene Note 1	3.0 dc	20.0 dc	6.75	60.0
	24				5.0 dc	20.0 dc	13.50	60.0
	22				8.0 dc	20.0 dc	20.30	60.0
	19				10.0 dc	20.0 dc	27.00	60.0

Note 1: Surge withstand dielectric strength of outer polyethylene jackets of stalpeth, PASP, Alpeth-PIC, and PAP cables may be taken as 60 kv peak.

Note 2: Alpeth sheath is no longer standard for cables having pulp or paper-insulated conductors.

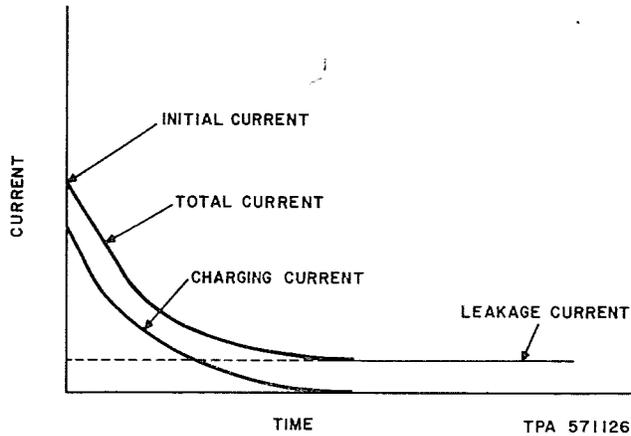


Figure 1

Current Versus Time In A DC High Potential Test

1.05 The requirement for sectionalization outlined in paragraph 1.04 can create administrative and operational problems. Some recommendations for minimizing the magnitude of these problems are given below:

2. DC HIGH-POTENTIAL TESTING

A. Preparation

2.01 The following preparations must be made prior to test. It is assumed for purposes of illustration only, that an additional 25 pair PIC bypass cable is employed for the reasons stated in paragraph 1.05. (See Figure 2.)

- (a) Cable to be tested (Cable A in Figure 2) must be cleared of working circuits by either transferring them to cable B or by circuit release.
- (b) Sectionalization of cable under test may be effected by removing cross-connections at the cable terminals at both ends of the cable.
- (c) All protectors must be removed from the cable under test.
- (d) If the terminal at one end of the cable under test is to be unmanned during the test interval, then a High Voltage Caution sign should

<u>PIC Cable Subject to Voltage Stress</u>	<u>Recommended Procedure</u>	<u>Advantages</u>	<u>Disadvantages</u>
25 pair or less	Secure release on all circuits in cable.	Economical	Unfavorable customer reaction to circuit outage.
Greater than 25 pairs	Place an additional PIC bypass cable from the point of maximum voltage stress to a point where it is less than 300 volts (see Figure 2). The cable must be capable of handling all of the power company services.	Circuit release is now only required on Power Company services.	Cost of additional cable.

Pulp insulated conductor cable subject to high voltage stress from induction or ground potential rise must be bypassed by a PIC cable to ensure satisfactory service.

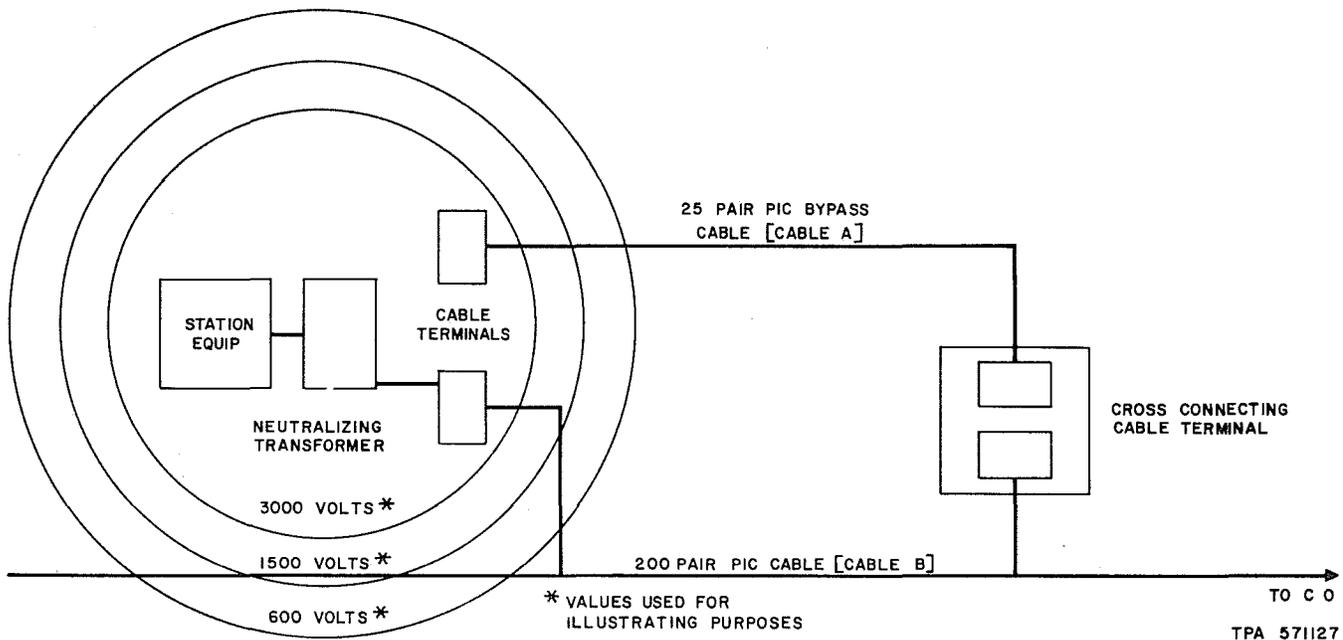


Fig. 2—Possible Cable Layout For Serving Power Station Having High Ground Potential Rise

be posted at that point. The reason of course is to avoid possible acoustic or electric shock to telephone company personnel who may not otherwise be aware that high voltage testing is underway.

(e) It should be emphasized that the test set operator has the responsibility for conducting a safe test. Notification of the test must be given to all telephone company personnel (test desk, cable maintenance, repair and installation) who might have occasion to work on the cable under test.

2.02 Figure 3 shows a suggested recording form which may be used in collecting test results.

B. Safety Precautions

2.03 Regardless of the safety features built into test equipment, high-voltage testing can be dangerous. It is therefore essential that the test set operator follow all accepted safety practices, proceed with caution, and in general do all in his power to assure a safe test. Some of these safety requirements are listed below:

- (a) All of the preparations listed in paragraph 2.01 must be completed before a test is undertaken.
- (b) Make sure that the on-off switch of the test set is turned to the off position, that the

high voltage switch is off and that the voltage control is turned to the zero voltage position. The cable sheath and unused cable pairs should be grounded and connected to the ground terminal of the test set.

C. Testing Procedure

2.04 After the preparatory steps and safety checks have been made, connect the tip and ring of the cable pair to be tested to the hot side of the test set. Assuming pair 1 is the first pair to be tested in the 25 pair PIC cable, connect pair 1 to the hot side of the test set and pairs 2 through 25 and the cable sheath to a local ground and to the ground terminal of the test set.

2.05 The test set operator should take the following steps after receiving assurance that all personnel are clear of the cable under test.

- (a) Adjust the current range switch to its highest value.
- (b) Turn the on-off switch to the on position.
- (c) After the necessary warm-up time, turn the high voltage switch to the on position.
- (d) *Slowly* move the voltage control off its zero position taking care not to allow the charging current to exceed the current rating of the test set. Exceeding the current capacity of the test

Cable # _____ Date _____

Test Location _____ Tester _____

Max. Test Voltage _____ Volts

PAIR	TEST		APPROXIMATE BREAKDOWN VOLTAGE
	PASSED	FAILED	

Figure 3
Suggested Record Form

set will in most test sets cause the operation of a circuit breaker. When this occurs, the high voltage control must be returned to the zero voltage position before retesting is possible.

(e) Increase the voltage slowly to the specified test voltage. If the cable pair withstands this voltage for a period of a few seconds, indicate a successful test on the record form (see Figure 3). If the cable pair fails before

reaching specified test voltage, indicate the failure and the approximate voltage causing failure on the record form. Failure of the cable pair will be indicated by a rapid increase in test set current and circuit breaker operation.

(f) After the voltage has been run up to its final test value on the cable pair under test, shut off the high voltage and turn voltage control to zero volts. The Kilovoltmeter on the test set will continue to show readings as the voltage

gradually bleeds off through the internal circuitry. After the voltage reaches 500 volts, place an external ground on the cable pair for a minimum period of at least five seconds. The use of rubber gloves is recommended in order to avoid the possibility of getting an electrical shock. Disconnect the pair from the test set.

(g) Disconnect pair 2 from the rest of the grounded cable pairs and connect to the hot side of the test set. Remove the external ground from pair 1 and connect pair 1 to pairs 3 through 25. This ensures that all cable pairs not being tested are at ground potential and not floating. Repeat the testing procedure for pair 2 and all remaining pairs.

D. Troubleshooting Techniques

2.06 Cable pairs which fail the high potential test at approximately the same voltage are possibly arcing to one another. Depending on length of the cable run, one of the following techniques should be employed to clear the defects:

A. Short Cable Runs

1. Open splices one at a time.
2. Examine conductor insulation for black carbonized spots which indicates arcing has taken place.
3. If visual inspection fails, apply high voltage and listen for arcing noise. All safety precautions must be taken. Cable must not be handled while high voltage is applied. It is desirable to have instantaneous communication between the test set operator and splicers during this phase of the test. Since the use of cable pairs is precluded because of the presence of high voltage on the cable, it is recommended that radio communication be employed.

4. Repair all defects found in the splices.

5. **Completely** retest cable.

B. Long Cable Run

1. Split cable into two sections at a splice point approximately midway between the two end points.

2. Retest cable to determine which half of the cable has the most defects.

3. Open splices, one at a time, starting in the half of the cable having the majority of defects.

4. Examine conductor insulation for black carbonized spots which indicates arcing has taken place.

5. If visual inspection fails, apply high voltage and listen for arcing noise. All safety precautions must be taken. Cable must not be handled while high voltage is applied.

6. Repair all defects found in the splices.

7. **Completely** retest cable.

2.07 Retesting of the cable is always required after the completion of any cable work because of the distinct possibility of introducing conductor defects from any maintenance activity in the cable plant. The defects while minor in nature for ordinary telephone service can be a major source of failure for cable serving Power Stations which are subject to high voltage stress during fault conditions.