ACCEPTANCE TESTS FOR LOADED SUBSCRIBER LOOP PLANT "ONE-MAN" STRUCTURAL RETURN LOSS METHOD FROM THE CENTRAL OFFICE

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, contractors, and other interested parties with technical information for use in the design and construction of REA borrowers' telephone systems. It provides in particular technical information on the "one-man" open-circuit structural return loss method when making measurements required in REA Bulletin 383-2, "Acceptance Tests--Outside Plant," and in the Construction Contract, REA Form 511, as part of the final acceptance testing of loaded subscriber loop plant.

1.2 The basic intent of this section is to accomplish the following:

(a) Verify the absence or presence of major impedance irregularities.
(b) Provide information on the method of measurement and test equipment required.
(c) Provide the telephone company with a record which can be used for routine plant maintenance or in cases of trouble.

This section does not provide information on corrective action needed if the expected performance does not materialize. In those cases where corrective action is needed, reference should be made to REA TE & CM-433, "Detection and Location of Impedance Irregularities". Information on acceptance tests for subscriber loop voice frequency repeaters is contained in REA TE & CM-434, "Acceptance Tests for Loaded Subscriber Loops - "One-Man" Method for Testing Voice Frequency Repeaters at the Central Office".*

1.3 The one-man structural return loss measurements described herein will verify the absence or presence of major impedance irregularities in the as-built plant. Correction of construction errors, if required, can thus be made before installation of the repeaters and eliminate division of responsibility for repeater performance. REA Bulletin 383-2, "Acceptance Tests--Outside Plant," and the REA Construction Contract, REA Form 511, establish structural return loss measurements as a requirement for outside plant acceptance testing for loaded subscriber loops with or without voice frequency repeaters. It is the purpose of this section to describe the methods for making these measurements, and to provide a basis for interpreting the results.

1.4 The one-man method is intended primarily for use on subscriber loops. From strictly a technical standpoint, however, the method itself could be used for trunk applications or at any time that measurements of structural return loss are required. The measurement procedure discussed herein is valid for D-66 loaded loops with exchange type cable having uniform or mixed gauges and for those D-66 loops having non-loaded cable or open wire or both for end-sections. The "one-man" method does not apply to circuits derived entirely by non-loaded cable or open wire conductors or combinations thereof. For H-88 loaded cables, the procedures discussed in this section should be used as a guideline at best because a rigorous analysis is not possible with the "one-man" method. This is because existing H-88 plant had been built to different transmission standards and it is not possible to account for all the variations to be found. In general, however, the noise type of measurement discussed in paragraph 3.3 will yield more meaningful results than the single frequency method of paragraph 3.2 when used with H-88 loading.

1.5 The unique characteristic in the method described herein is that only one man is required for the tests and he remains at the Central Office. When making the conventional structural return loss measurements, personnel are required at both ends of the circuit, at the sending and terminating ends. For testing subscriber loops, the latter method would be economically unattractive because the tests must be made from the end of each subscriber loop. In the "one-man" method, the far end of the subscriber loop is left unterminated (i.e., open-circuited) and, therefore, no test personnel are required at this end. The tests can be made for the entire line or part of the line with or without telephone sets connected and

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* These two Sections will be issued at a later date.

with or without ringers on the line. The only requirement is that the measurement be made with the telephone set in the on-hook condition and that the office equipment be toothpicked out. The presence of bridged ringers (or divided-to-ground ringers) does not affect the accuracy of the measurement because of the relatively high impedance of the ringers in the range of voice frequencies.

1.6 The emphasis on obtaining and maintaining correctly loaded cables, free from the adverse effects of impedance irregularities is dictated by the increasing application of two-way electronic gain devices such as provided by negative resistance voice frequency repeaters. If the design gains are to be realized without singing, hollowness or echo, attention must be paid to the line regularity characteristics. The performance of the repeater equipment depends not only on its design characteristics but also on the electric characteristics of the outside plant facilities on which they operate. Because voice frequency repeaters are obtained on a guaranteed performance basis from other than those who construct the outside plant facilities, it is essential that structural return loss measurements be made on the outside plant facilities, prior to the installation of the repeaters to assure their suitability for repeater application.

1.7 It is to be emphasized that the practice of making plant acceptance tests and the systematic recording of the data provided in Tables I and II herein not only assures that the as-built outside plant is as engineered but it also provides the telephone company with a record which can be used for maintenance in testing the loops on a routine basis or when problems arise.

2. PRINCIPLE OF OPERATION OF ONE-MAN STRUCTURAL RETURN LOSS TEST

2.1 A characteristic of D-66 loaded cables is that their attenuation up to approximately 3500 Hz is directly proportional to the d.c. resistance in the cable. The greater the resistance in the cable the greater will be the attenuation, in the same proportion. For example, a length of loaded cable which has twice the resistance when compared to another loaded cable will also have approximately twice the loss. In the midband frequencies of a D-66 loaded cable, between approximately 1000 Hz and 3000 Hz where the loss is practically independent of frequency, the relationship between attenuation and line resistance is such that for every 100 ohms of outside plant loop resistance the cable loss is approximately .45 db. At 4000 Hz this becomes 0.55 db for every 100 ohms of resistance, approximately. The resistance referred to above includes the d. c. resistance of the cable conductors and the d. c. resistance in the loading coils. It also assumes that the loading coil resistance is a very small fraction of the cable resistance, which is the case in practice. The resistance loss relationship in loaded cables holds true for uniform gauge cables such as all 22 gauge plants or all 24 gauge plants, etc., or for mixtures of different gauges such as 24, 22, and 19 provided that no major impedance irregularities exist.

2.2 Another important characteristic when measuring the return loss in loaded cables is that the total return loss referred to the point of measurement is always equal to the sum of twice the attenuation of the cable (referred to as the round-trip loss) plus the terminal return loss between the characteristic impedance of the cable and the terminating impedance. The above obviously means that any time a return loss measurement is made on a cable the measurement includes an attenuation loss component and a return loss component proper. If the termination at the far end is removed so that the far end now looks like an open circuit, a return loss measurement can still be made, but the terminal return loss component now becomes zero because a return loss value corresponding to an open circuit (infinite impedance) or to a short circuit (zero impedance) is zero. It follows, therefore, that if a loaded cable is being measured for return loss and its far end is open circuited (or short circuited), the resulting return loss at the measuring point is really twice the attenuation of the line. That is, the test signal travels down the line where it encounters a one hundred percent reflection and returns to the sending end having undergone an attenuation equal to twice the loss of the line.

2.3 If a return loss value is obtained which is twice the attenuation as discussed above, the loaded cable can be considered to contain no major irregularities because the test signal in traversing the line has undergone an attenuation which is twice the normal line loss expected. If, however, the value of return loss obtained at the test point is less than the round-trip attenuation expected, the inference is that the line must contain irregularities. The effect of the irregularities is that they do not allow the entire signal to reach the far end of the line and a part of it is reflected towards the originating point much sooner resulting in a lower loss. The lower the value of the return loss the closer the irregularity (ies) is to the point of measurement. For example, a loaded cable under test whose one-way attenuation is 10 db but whose measured one-man return loss is 5 db would be judged to contain one or more substantial irregularities, in all probability very close to the test point. On the other hand, a line under test with a round-trip attenuation of 20 db having a measured return loss of 19 db would be considered acceptable but could, nevertheless, contain non-major irregularities at the far end of the line (e.g., a 7 KF end-section for example).

2.4 As discussed in paragraph 4 below some downward adjustment to the expected measured return loss must be made to account for the long far end sections and other dissimilarities encountered in real practice which tend to make the loaded loop non-symmetrical.

2.5 Good results can also be obtained if the far end of the loop is short circuited. The reason that this method is not preferred, obviously, is because additional personnel would be required for placing the "short" termination and not for technical reasons.

3. METHOD OF MEASUREMENT AND TEST EQUIPMENT REQUIRED

3.1 Two methods of measurement are discussed in REA TE & CM-445, "How to Make Structural Return Loss Measurements". The first uses the conventional discrete single frequency method between 200 to 3500 Hz while the second method uses white noise as the test signal. The same two methods can also be used for making the one-man SRL measurements described herein except that the frequency range is between 1000 to 3700 Hz. When using the noise method, the expected one-way loss is approximately .45 db for every one hundred ohms (0.9 db per 100 ohms round-trip) of cable resistance and it should be noted this is the value which also applies at mid-band when making the single frequency measurements. The advantage of the noise measurement is that one reading only is required and, therefore, the measurements can be made more rapidly. Its disadvantage is that it does not allow as many loading sections to be measured accurately as the single frequency technique. This is because the effective band of the noise method is 500 to 2500 Hz, approximately, and while several types of irregularities can show up in this frequency range, several other types do not. Therefore, the white noise method becomes, in general, more limiting than the single frequency method. Assuming accurate load spacing, good cable mutual capacitance and 0.5 end-sections (at both ends) the noise measurement could be used for H-88 loaded plant.

3.2 When using the single frequency method the following equipment will be needed: one oscillator, one a.c. voltmeter, one coil hybrid, one D-66 precision balancing network and one variable capacitor. This test equipment and/or its equivalent are shown in Figures 3 and 4. A Siemens-Halske level tracer or its equivalent can be used in place of the oscillator, the a.c. voltmeter and the hybrid coil.

3.3 When using the noise method the following test equipment will be needed: one noise generator, one noise measuring set, one coil hybrid, one D-66 precision balancing network and one variable capacitor. This test equipment and/or its equivalent are shown in Figures 5 and 6.

3.4 The basic theory underlying structural return loss measurements is discussed in REA TE & CM-445 and reference should be made to that section. The step-by-step measurement procedure, however, as it applies to this section of the manual for the "one-man" SRL tests are shown in Figures 3 through 5. It should be noted that the only difference between the measurements shown in these Figures and those in Section 445 is that no precision balancing network is used at the far cable end when using the "one-man" method. In all other respects, the measurement procedure is identical.

4. EXPECTED MEASURED RESULTS

4.1 The theoretical expected measured open circuit structural return loss is shown in Figures 1 and 2 for uniform 24 gauge and 22 gauge cables, respectively, D-66 loaded. The information given in the Figures apply equally well to the frequency-by-frequency method or to the noise measurement. The chart is arranged so that it can be used by knowing either the d.c. loop resistance in the outside plant or the number of loading coils. For example, assuming that a 22-D-66 loaded cable having 13 loading points was under test, the expected open circuit structural return loss by reference to Figure 2 is 18 db. Both Figures 1 and 2 assume that the far end-section is 2250 feet in length or approximately so.

4.2 When testing D-66 loaded cables consisting of mixed gauges, the expected measured open circuit structural return loss should be two times 0.45 or 0.9 db for every one hundred ohms outside plant d.c. loop resistance including the d.c. resistance in the loading coils. This value is also based on the far-end section being 2250 feet in length or approximately so.

4.3 As indicated above, the measured open circuit return loss expected can only be as accurate as the degree to which the d.c. loop resistance is known. In order to obtain the desired degree of accuracy of the d.c. loop resistance (including load coils) for both the acceptance tests and other purposes, particularly those related to future maintenance record requirements, careful coordination of engineering activities and construction is necessary. Such coordination can materially reduce the time required in obtaining the necessary data for conducting the tests. Accurate records of cable route lengths, for determining circuit lengths, based on cable sequential marking should be maintained and in some instances actual loop resistance measurements may be obtained at time of construction using a Wheatstone bridge or a Simpson Voltmeter or equivalent with an accuracy of ± 5 percent. (Such actual measurements at time of construction may serve several purposes, i.e., provide for SRL tests, verify cable lengths, and provide data for future maintenance testing.) Accurate records of cable route length based on cable sequential marking provide an excellent means for determining d.c. loop resistance accurately because sequential cable marking accuracy is approximately ± 0.5 percent. In other instances cable records based on actual d.c. loop resistance measurements will also result in excellent accuracy because the usual Wheatstone bridge accuracy is ± 0.1 percent. When existing plant records are used care should be taken to determine and verify their accuracy. The method for making d.c. loop resistance measurement when using the Wheatstone bridge is shown in REA TE & CM-451, Figure 15.

4.4 In loaded cables, the attenuation changes by about one percent for every 5 degrees Fahrenheit change in temperature. Therefore this factor should be accounted for when making measurements at different times of the year. The temperature effect will be of greater importance to aerial cables than to buried ones because the temperature variation in buried cables is minimal ranging from 30°F. to 55°F. annually. Therefore for buried cables a temperature of 55°F. can normally be assumed unless other, more reliable data is available such as direct ground measurement at cable depth. For aerial cables the air temperature can be used to estimate conductor temperature inside the sheath unless better data on conductor temperature is available. For desert areas temperatures as high as 140°F. are not unusual inside the cable sheath.

4.5 The length of the far-end section will affect the expected measured results. If the end section is between 2000 to 4000 feet, the information in paragraphs 4.1 through 4.4 above applies with good accuracy. Where the end sections are longer than 4000 feet but not exceeding 12,000 feet, a good approximation is obtained by adjusting the expected open circuit structural return loss value downward by approximately one db. Where part of the far end-section of the loaded cable consists of open wire conductors, the open wire portion should be treated as having an equivalent length of one-tenth its measured physical length. Thus, an open wire end-section of 20 KF has an equivalent capacitance of 2 KF of exchange cable.

4.6 The most practical limiting factor when making the open circuit structural return loss measurements is the electrical length of the loaded cable under test. When the loss of the cable becomes sufficiently great, it becomes difficult to detect the presence of irregularities near the far ends of the line. This is because of the high amount of the attenuation which will always be intervening. Even in the longest cables under test, however, irregularities closer in toward the testing end will always be visible and, therefore, valid results are obtained. From a voice frequency repeater standpoint, this is very desirable because the repeater will become unstable, and sing for irregularities much closer to it than those electrically more distant. The following practical rule of thumb can be used: When the one-way loss of the loaded cable under test becomes 10 db or greater it will be, in general, difficult to predict the presence of irregularities at the far end of the line. With lines having shorter electrical length than this it will be still difficult to determine the presence of a long end section less than 10 KF. End-sections which are longer than 12 KF can be identified reasonably well. This will be of particular importance where the line is only partially loaded. Several examples which are analyzed in paragraph 5.0 below, help illustrate these points.

4.61 Theoretically the most limiting factor when making the one-man structural return loss test is the structural return loss proper of the cable (that is, that return loss which would be limiting at the critical frequency when the line is being measured with PBN's at each end). It will not be possible, for example, to get meaningful results on a line whose one-way attenuation is 30 db because its two-way structural return loss becomes controlling. This consideration, however, tends to be more of academic interest rather than of practical value because in actual subscriber loop applications the electrical one-way loss of the cable will be the controlling factor. With laboratory type artificial loaded lines having extremely high structural uniformity cases have been observed where the two-way structural return loss becomes the limitation on very long circuit lengths (starting at 3200 ohms approximately) not the electrical loss of the line as shown in Figure 2, dotted line.

4.7 Where circuits must be measured which are longer than the accuracy range of the one-man method the cable must be cut (or opened at pedestal or other access points) and the remaining portion tested by itself. The one-man SRL measurement can be made at either the Central Office end or the field location provided that the end section the test hybrid is looking into is 0.5 or approximately so when the measurement is made at the field location. It is also possible for these longer circuits to employ the standard two-man method discussed in Section 445 using precision balancing networks at both ends. The two-man method will in all cases yield poor results, however, used at a field location when the test hybrid looks into a "long" end-section (longer than 2500 to 3000 feet for the purposes of this measurement) because the loaded cable impedance at that point will tend to behave similar to a non-loaded cable impedance and the return loss will, obviously, be poor. In such cases the excess end-section must be disconnected or cut. Where the end-section is shorter than 2250 feet it can be built-out to this value with a building-out capacitor.

4.8 Where field mounted intermediate repeaters are being planned it is necessary to make the one-man SRL measurement at the repeater location (not at the central office) because the circuits will be electrically long when viewed from the Central Office as an entire line. In this case the measurement is made at the repeater location first looking into the cable portion facing the Central Office (with the Central Office equipment toothpicked-out) and in the second measurement looking into the cable facing the field or subscriber end. The results for each measurement should be analyzed separately. Measurements at the field location pose no difficult problems, inasmuch as battery powered oscillators, noise generators, and a.c. voltmeters are readily available. When measuring at a field location and the end-sections at that location are "longer" or "shorter" than 2250 feet the procedure discussed in the last three sentences of paragraph 4.7 above should be used.

4.9 Best results will be obtained (that is, good correlation between the expected results with the values measured) when the cable is of one gauge, one size, same manufacturer, and also the far end-section is approximately 0.5. Mixing gauges, cable sizes, (and in some instances cable of different manufacturers) will result in undesirable small reflections whose frequency characteristic and magnitude cannot be accurately predicted. Because in subscriber loop applications the gauge may be uniform but the size most likely will not (because the cable size is tapering off towards the subscriber) some downward adjustment of the expected value will be necessary to account for this. A downward adjustment value of 1 db is considered adequate. When adding to the above the additional effect of long "end sections" the correlation can be considered good if the over-all value measured is within 2 to 3 db less than that expected. It is not always possible to assess the possible effects of mixing cables made by different manufacturers. This is because although the average value of the cable may be similar, the variations between individual pairs can be very much greater.

4.91 In some instances expected results may not materialize due to bridge taps at the Central Office. Where the practice of bridged pairs at the office is employed bridge tap isolators (BTI's) are used as discussed in REA TE & CM-429, "Application and Use of Bridged Tap Isolators". The bridged tap including the BTI, which may be connected at the Central Office to a loaded pair, must be totally disconnected (removed) when testing the loaded pair. BTI's connected at the far-end (after the last loading point) need not be disconnected when the measurement is made from the central office because in the unsaturated condition (no d. c. loop current through them) they present a high enough impedance which does not affect the measurement. Such field mounted BTI's must be disconnected, however, if the measurement is made at a field location.

4.92 In most instances it will be entirely adequate to measure between 1000 to 3700 Hz. Any irregularities present will easily show up in this frequency region. In some other instances where mixed gauges are involved or where the circuits are extremely long or where phase relationships become complex, it may be well to consider a lower frequency starting value such as 500 Hz. For the overwhelming majority of the applications the 1000 to 3700 Hz range will be adequate.

4.93 Noise is not normally expected to be a problem when making the one-man structural return loss measurements because the test levels are sufficiently high at approximately 0 dbm input to the line. Even for the longest loop under test this should result in a very high signal-to-noise ratio. For example, if the noise level at the subscriber location is 25 dbrnc-C and the one-way loss of the loop is 10 db then the signal-to-noise ratio at the test location is 55 db which is extremely good (25 dbrnc minus the line loss is subtracted from 90 minus twice the line loss). Nevertheless, in those very few cases where abnormally high noise levels are present (where the signal-to-noise ratio becomes 20 db or less) inductive coordination steps discussed in REA TE & CM-451 should be taken prior to the one-man acceptance tests.

5. ILLUSTRATIVE EXAMPLES AND ANALYSIS OF RESULTS

5.1 As a guide for analyzing the results of the one-man tests illustrative examples are shown. Illustrative Examples 1 - 5 use the single frequency method, whereas in Examples 6 and 7 the noise method is used. For the single frequency examples the reason that all peak and valley frequencies are shown is only for illustration. In actual practice only that frequency where the return loss is the poorest (worst value) need be recorded as shown in the Data Sheets, Table I and in Illustrative Example 4. For Examples 1 and 2 the Siemens-Halske Level Tracer has been used because it was available. Examples 3 - 5 use the more conventional oscillator and a.c. voltmeter equipment which will be the case in most instances.

5.2 Illustrative Example 1 shows a 10 section (8.52 miles) 24-D-66 loaded cable with a short end section whose expected measured return loss is 21.4 db. The example demonstrates the effect on return loss when one loading coil at a time is removed (or reversed) consecutively. Figure (a) shows the return loss first when coil No. 1 is missing, next with coil No. 2 missing, and finally with the 3rd coil missing. It is noted that this irregularity is immediately evident at the testing end because the return loss is approximately 2.5, 6, and 8 db respectively. (The SRL value is obtained from the trace by algebraically adding the REC. level shown on the vertical scale with the db value corresponding to the frequency desired) In Figure (b) coils 4, 5 and 6 are missing, one at a time. Again, this becomes immediately apparent upon measurement because the resulting return loss is low; 11.5, 13, and 15.5 db respectively. With coil Nos. 7 and 8 missing as in Figure (c) the return loss improves, as would be expected, and the new values are now 17.5 and 19.4 respectively. When coil No. 9 is missing as in the bottom solid curve in Figure (d) the return loss is approximately 20.7 db. This is only a .7 db lower than the expected value and the conclusion is, therefore, that this type of irregularity is not readily visible at the test end. The same observation is evident from the dotted curve which represents the condition with coil Nos. 9 and 10 missing which is equivalent to having a 11.25 KF end section. The return loss in this case is also 21.7 db, approximately, at 3400 Hz, approximately. Thus, as has been discussed previously "long" far-end sections (but not longer than 12 KF) cannot readily be identified at the test end. On the other hand when coils 8, 9, and 10 are missing (equivalent to a 16.5 KF end section) this irregularity becomes much more readily apparent because the resulting return loss is now 18.6 db (at 2400 Hz approximately) which is considerably less than the expected value of 21.4 db. In Figure (e) all 10 coils are in place. It can be seen that the difference between this curve and the bottom curve in Figure (d) is only about .5 db. Having coil number 10 in place does not improve the return loss appreciably because the electrical length is rather long at approximately 11 db. The above clearly demonstrates the inherent limitation with the one-man test method. That is, when the circuit one-way attenuation is 10 db or greater it is difficult to detect the presence of long-end section types of irregularities at the test end. If greater precision is required, the two-man method discussed in REA TE & CM-446 must be used. This situation is shown in Figure (f) with PBN's used at each end. The solid line shows the case where all 10 coils are in place and the dotted curve is with coil No. 10 missing. The return loss is approximately 36 db at 500 Hz with all the coils in place and 19 db at the same frequency when coil No. 10 is missing. Therefore, the two-man method is an excellent tool for detecting the presence of even small irregularities which the one-man method cannot do.

5.3 In Illustrative Example 2 a 24-D-66 line is shown with a short end-section and 5 loading sections only. The expected return loss is 11 db, approximately. Figure (a) shows the return loss to be 3 and 5.5 db with coils Nos. 1 and 2 missing, respectively. With coils 3 and 4 missing the return loss is 7.5 and 10 db respectively and this is shown in Figure (b). Figure (c) shows the conditions with all 5 coils in place and with coil number 5 missing. It should be observed that there is no great deal of difference between the two conditions so that it would be rather difficult to determine the existence of a long end section, 6.75 KF in this instance. With coils 4 and 5 missing and with coils 3, 4, and 5 missing as shown in Figure (d) it becomes easier to detect the presence of far-end irregularities at the test end. Again, using the two-man method even a 6.75 KF end section is easily detected as shown in Figure (e). With all five coils in place the return loss is 37 db at approximately 900 Hz and this value drops to 13.5 db approximately when coil number 5 is missing. Therefore, with the two-man method it is very easy to detect the presence of a long end-section.

5.4 Illustrative Example 3 shows several D-66 loaded cable pairs in an actual borrower's project all using 22 gauge exchange cable. The number of loading points for these loops varies from 6 to 16. The measured O.C. SFSRL is shown at the frequencies of peaks and valleys (maximum and minimum readings) between 200 to 4000 Hz in this instance. The minimum SRL value for each pair is given. This value is marked with an asterisk. Comparing this minimum SRL value with the computed (i.e., expected measured) value, it is seen that good correlation exists. In pair number 71 with the short-end section, the correlation is within .2 db which is excellent (this is the difference between 16 and 16.2 db). In pair 76 the correlation is 0.5 db which is also very good. In cable pair 53 the correlation is 0.3 db despite the long end section. The longer loops having 14 to 16 loading points also show good correlation, the worst value being 2.3 db for pair 52 and the best correlation 0.3 db for pair 53. The conclusion from the analysis of the data is the pairs are acceptable and no corrective action needs to be taken.

5.5 In Illustrative Example 4 the results of the acceptance tests for an entire office are shown tabulated in the Data Sheets, Table I. The outside plant is all 24-D-66 cable with "short" end-section. Several interesting points become apparent when analyzing the results. It should be noted that in column five, under d. c. loop resistance, the values shown are the ones at the ground temperature of 43oF.

(a) All pairs tested check out good with the exception of pairs 205 and 345, which contain irregularities.
(b) Most of the values measured are within 2 db of the value expected. There are several pairs which are very close to the expected value and these are shown by an asterisk.
(c) No measured value exceeds 20 db (pair 503) demonstrating the limitation with the one-man method when the one-way circuit attenuation becomes 10 db or greater.

The conclusion from reviewing the data in Example 4 is that the outside plant meets the expected results and it is therefore acceptable. The exception to this is pairs 205 and 345 which need correction. It can be seen from the accompanying schematic for cable routes 33, 34, 35, 43, and 44 that both the consulting engineer and the contractor have done a good job in designing and constructing plant with only two pairs showing difficulty.

5.6 In Illustrative Example 5 an EAS trunk has been tested using the one-man method. The plant is 48.13 KF 24-D-66 cable and the expected loss is approximately 21 db. Reference to the lower curve in that figure indicates that a value of 20 db is obtained which is entirely acceptable. When the same pair is tested using PBN's at both ends the worst value for structural return loss becomes 34.5 at 3500 Hz.

5.7 In Illustrative Example 6, the noise generator is used. The facility makeup of the loops in question is shown in Table III and the data in Table II. The correlation between the measured values and the computed or expected values is also shown. The correlation varies from .5 db for pair number 726 which has a "short" end section to 1.0 db for pair 261 which has a rather long end section. Again it should be pointed out that where the noise method is most effective is where circuit lengths tend to be electrically short. That is, for loop resistance which is less than 2000 ohms. Where the cable pairs tend to have more resistance than this, the measurement is not as accurate because irregularities can exist at the far end of the line under test, but this does not become evident at the measuring end.

5.8 An additional example of the noise method is shown in Illustrative Example 7 with the data also tabulated in Table II. There the plant was essentially 22 gauge and the longest loop is 1506 ohms. In this instance, the far end sections were rather short. For this reason, the expected measured results correlate rather closely with the measured values. The worst correlation is only .6 db for pair number 18. This again helps in demonstrating that where the end sections are "short" rather good results can be expected if the loops are also electrically short.

6. RECORDING RESULTS OF THE MEASUREMENTS

6.1 In order that a meaningful evaluation of the results can be made, the data should be entered in the data sheets provided. These are Table I for the open circuit single frequency structural return loss and Table II for the open circuit echo structural return loss. A sketch of the loop configuration is entered in Table III. A systematic recording of the data not only aids the analysis of the results but it also provides the project with a record which can be used for testing these lines on a routine basis thereafter, or when problems arise.

6.2 The variation in engineering and construction practices, the procedure for obtaining the basic data necessary for making these structural return loss measurements, must be carefully planned in advance when acceptance tests on contract construction is contemplated. Some of the considerations are as follows:

6.21 During the course of staking and construction it would be advantageous to accurately record the total loop length of each loaded loop on which tests are to be made. These then can be readily converted, by calculation, into the loop resistance required.

6.22 In some instances the contractor may desire to check or measure loop resistance at the time of splicing. This could serve to verify calculated resistance measurements as well as the installed lengths of cable. Such measurements could then be used in the acceptance tests.

6.23 In some instances it may be possible and advantageous to coordinate the loop resistance measurements with the station installation forces, which in turn will provide the resistance data for the acceptance tests. This method also would be adaptable to the procedures outlined in TE & CM-445 where such tests are necessary.

6.24 In other instances existing cable or subscriber record data, as to loop resistance, may be available for the acceptance tests. However, it may be necessary to verify the accuracy of such data prior to their use.

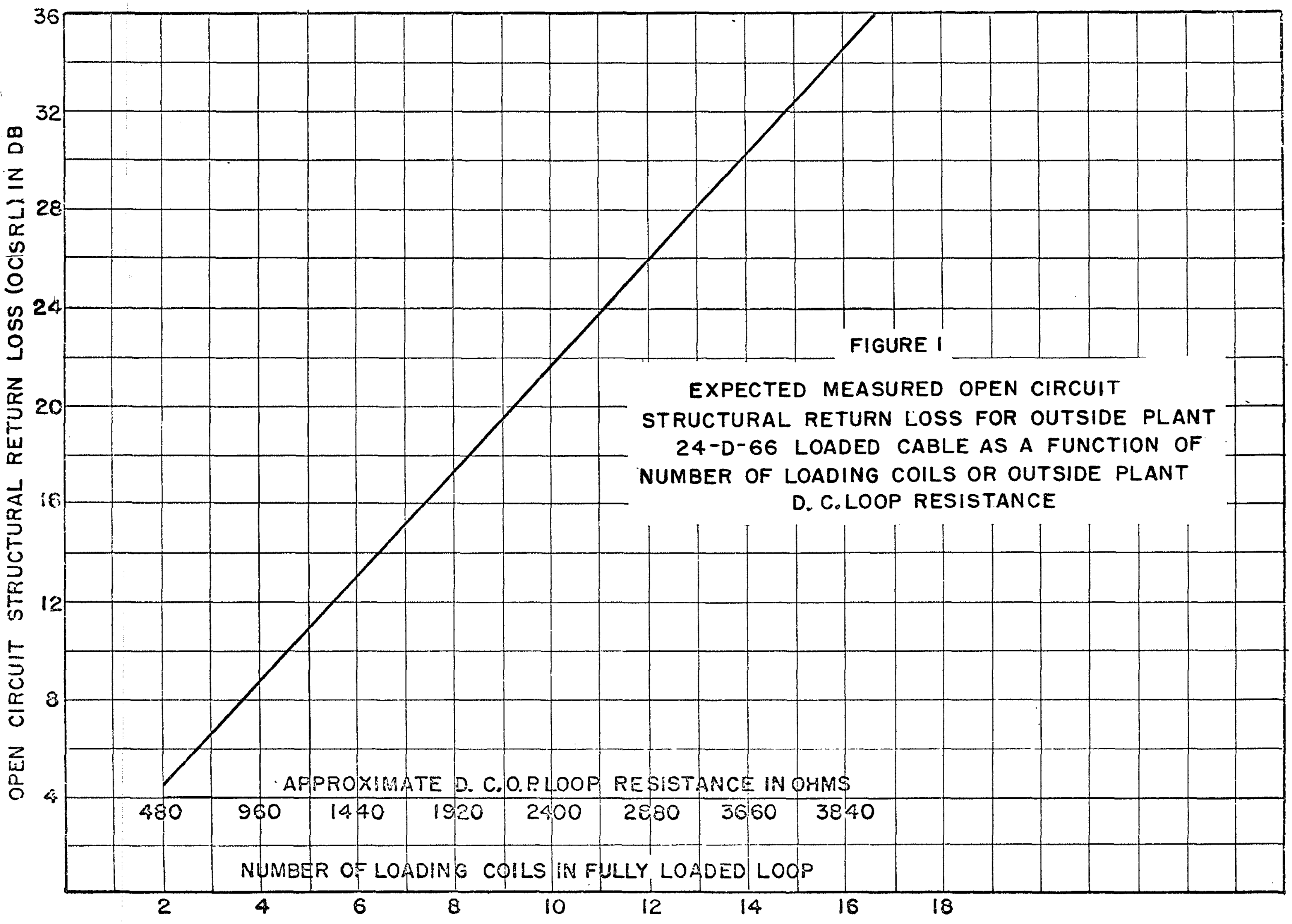


FIGURE I

EXPECTED MEASURED OPEN CIRCUIT STRUCTURAL RETURN LOSS FOR OUTSIDE PLANT 24-D-66 LOADED CABLE AS A FUNCTION OF NUMBER OF LOADING COILS OR OUTSIDE PLANT D. C. LOOP RESISTANCE

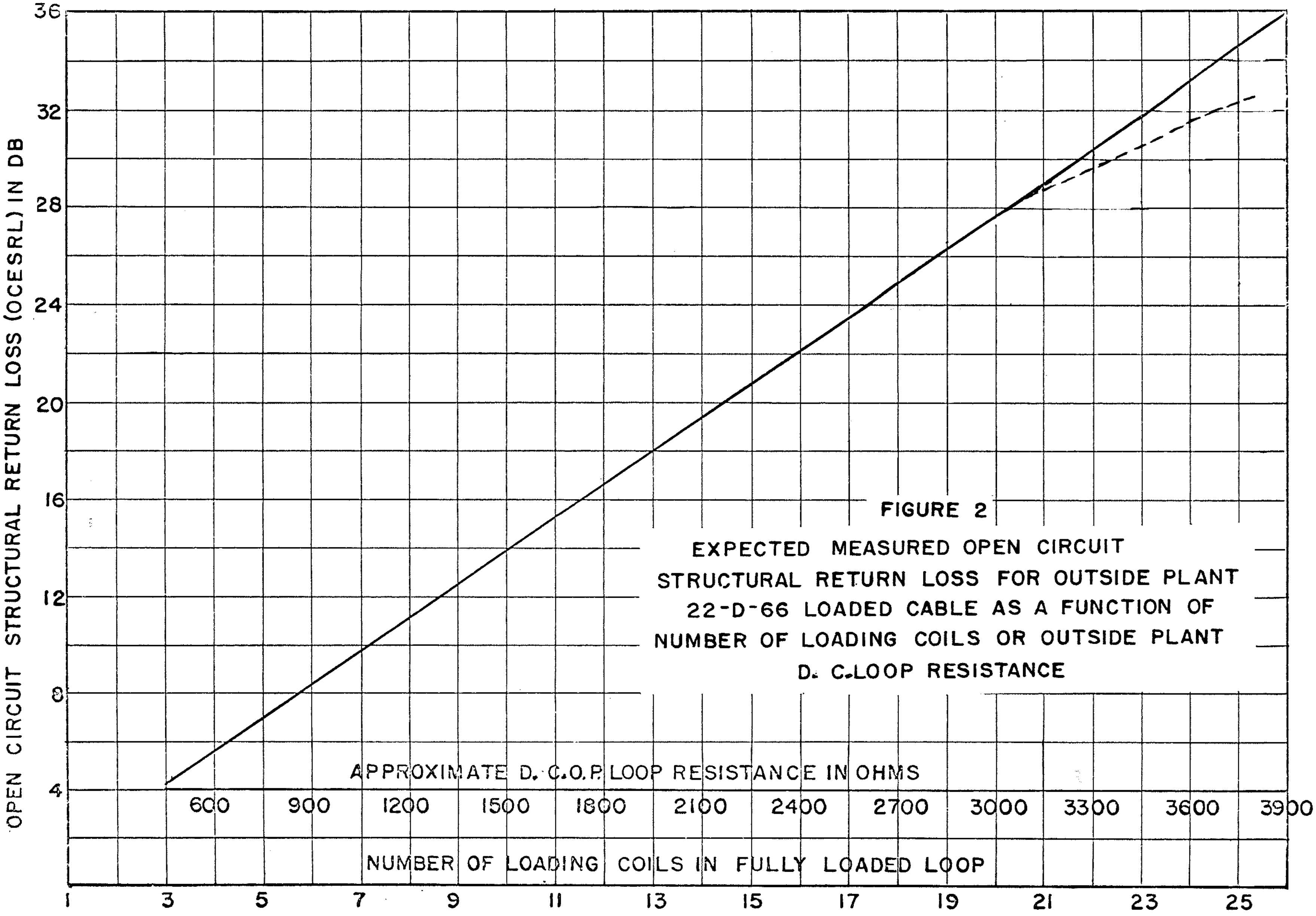
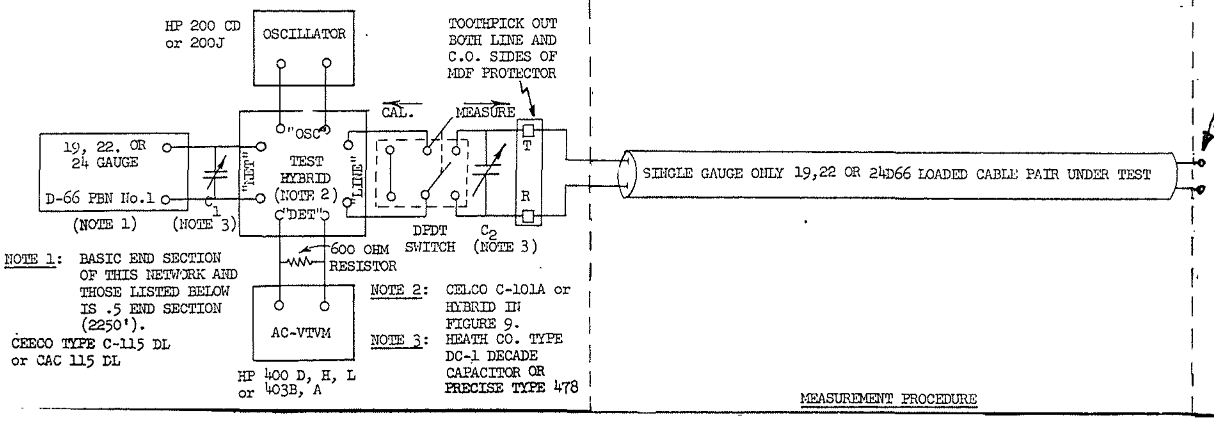


FIGURE 2

EXPECTED MEASURED OPEN CIRCUIT STRUCTURAL RETURN LOSS FOR OUTSIDE PLANT 22-D-66 LOADED CABLE AS A FUNCTION OF NUMBER OF LOADING COILS OR OUTSIDE PLANT D. C. LOOP RESISTANCE



NOTE 1: BASIC END SECTION OF THIS NETWORK AND THOSE LISTED BELOW IS .5 END SECTION (2250').
CEECO TYPE C-115 DL or CAC 115 DL

NOTE 2: CELCO C-101A or HYBRID IN FIGURE 9.

NOTE 3: HEATH CO. TYPE DC-1 DECADE CAPACITOR OR PRECISE TYPE 478

1

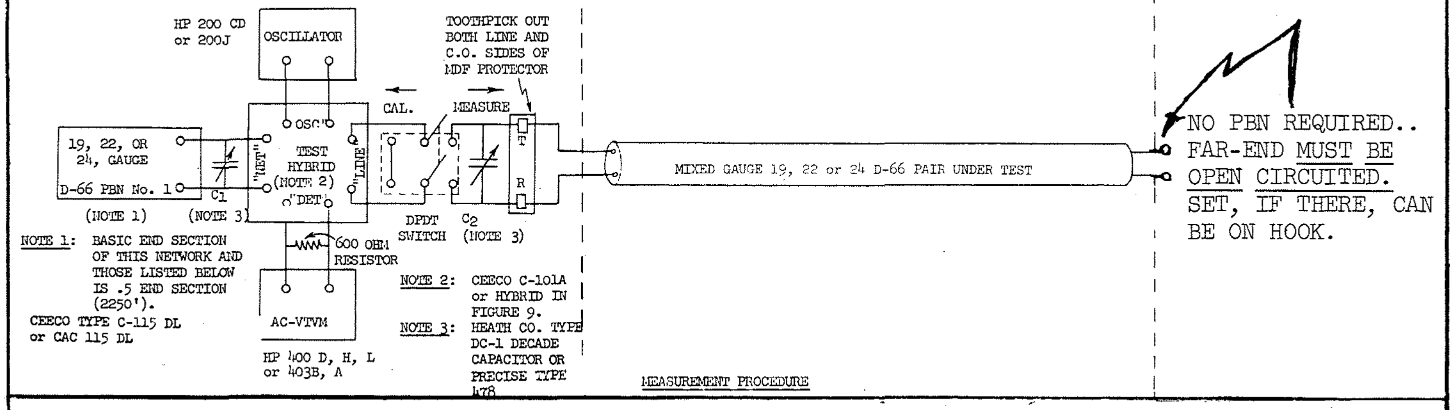
NO PBN REQUIRED.. FAR-END MUST BE OPEN CIRCUITED. SET, IF THERE, CAN BE ON HOOK.

MEASUREMENT PROCEDURE

DO NOT ATTEMPT MEASUREMENTS BEFORE READING ENTIRE PARAGRAPH 8, SECTION 445

1. Connect the test equipment and cable pair under test as shown above. Be sure to strap or set PBN "gauge terminals" for same gauge as gauge of cable being measured.
2. Throw DPDT switch to "CALIBRATE" position. Set oscillator frequency to 2000 Hz and vary output level until A.C.-VTVM reads 0 dbm (zero dbm); this completes calibration. Throw DPDT switch to "MEASURE" position. Do not change oscillator output level control. Set C_2 to build-out cable end section to 2250' total.
3. Vary oscillator frequency vernier, slowly, between 1000 to 3700 Hz and note the frequencies which give consecutive maximum (peak) and minimum (valley) readings on the A. C. Voltmeter. Read each peak and valley frequency and the minus dbm reading on the A. C. Voltmeter corresponding to each and enter the results in the "Data Sheets--Open Circuit Structural Loss," Table I.
4. Increase value of C_2 from that in step (2) and repeat step (3). Note whether SRL becomes better or worse. (SRL becomes better as readings on A. C. Voltmeter get more negative). If SRL gets better this means that end section is electrically less than 2250 feet (though by length alone it is 2250 feet). Vary C_2 until the value is found that gives the best SRL.
5. If by increasing C_2 in step (4), SRL gets worse, this means that the cable end section is longer than 2250 feet electrically. Return C_2 to its original value in step (2) (to give 2250 feet end-section total). Increase C_1 until the best possible SRL is obtained. Record the results in the "Data Sheet--OPEN CIRCUIT STRUCTURAL RETURN LOSS, Table I.
6. If by increasing C_1 or C_2 SRL gets worse, this means that the end section as built out in Step (2) to 2250 feet is not only 2250 feet in length but also 2250 feet electrically, which is the important thing. If this is the case, continue with the measurement as per item (3) and record the data in the "Data Sheet--Structural Return Loss Measurements."

Figure 3
OPEN CIRCUIT SINGLE FREQUENCY STRUCTURAL RETURN LOSS (O.C. SFSRL) MEASUREMENT OF ONE UNIFORM GAUGE ONLY FOR ENTIRE CIRCUIT LENGTH (19, 22 OR 24-D-66)



NOTE 1: BASIC END SECTION OF THIS NETWORK AND THOSE LISTED BELOW IS .5 END SECTION (2250').

CEECO TYPE C-115 DL or CAC 115 DL

NOTE 2: CEECO C-101A or HYBRID IN FIGURE 9.

NOTE 3: HEATH CO. TYPE DC-1 DECADE CAPACITOR OR PRECISE TYPE 478

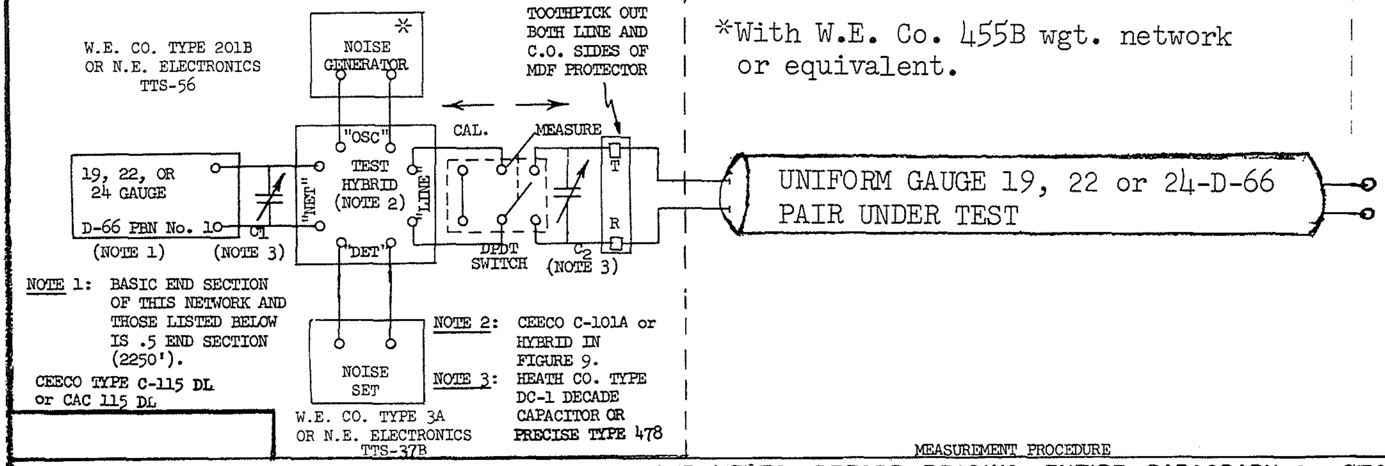
NO PBN REQUIRED.. FAR-END MUST BE OPEN CIRCUITED. SET, IF THERE, CAN BE ON HOOK.

MEASUREMENT PROCEDURE

DO NOT ATTEMPT MEASUREMENTS BEFORE READING ENTIRE PARAGRAPH 8, SECTION 445

1. Connect the test equipment and cable pair under test as shown above. Set gauge of PBN for most predominant gauge adjacent to hybrid.
2. Throw DPDT switch to "CALIBRATE" position. Set oscillator frequency to 2000 Hz and vary output level control until A.C. voltmeter reads 0 dbm (zero dbm); this completes calibration. Do not change oscillator output level control. Throw DPDT switch to "MEASURE" position. Set C_2 to build-out cable end section to 2250' total.
3. Vary oscillator frequency vernier, slowly, between 1000 to 3700 Hz and note the frequencies which give consecutive maximum (peak) and minimum (valley) readings on the A.C.-VTVM. Read each peak and valley frequency and the minus dbm reading on the A.C.-VTVM corresponding to each. Change gauge of PBN (if it is set for 19 gauge in step (1), change it to 22 or 24) and note if this improves the SRL. If it does, leave set for new gauge setting; if not, change back to original gauge. (VARYING GAUGE OF PBN WILL BE NECESSARY, DEPENDING ON ACTUAL CABLE LAYOUT, TO OBTAIN BEST SRL.) Record best SRL in the "Data Sheet--Open Circuit Structural Return Loss," Table I.
4. Increase value of C_2 from that in step (2) and repeat step (3). Note whether SRL becomes better or worse. (SRL becomes better as readings on A.C.-VTVM gets more negative.) If SRL gets better this means that end section is electrically less than 2250 feet (though by length along it is 2250 feet). Vary C_2 until the value is found that gives the best SRL.
5. If by increasing C_2 in step (4), SRL gets worse, this means that the cable end section is longer than 2250 feet electrically. Return C_2 to its original value in step (2) (to give 2250 feet end-section total). Increase C_1 until the best possible SRL is obtained (especially between 2500 to 3000 cps). Record the results in the "Data Sheet--Open Circuit Structural Return Loss.
6. If by increasing C_1 or C_2 SRL gets worse, this means that the end section as built out in step (2) to 2250 feet in length but also 2250 feet electrically, which is the important thing. If this is the case, continue with the measurement as per item (3) and record the data in the "Data Sheets."

Figure 4
OPEN CIRCUIT SINGLE FREQUENCY STRUCTURAL RETURN LOSS (O.C. SFSRL) MEASUREMENT OF D-66 LOADED CABLES WITH MIXED 19, 22 or 24 GAUGES



NOTE 1: BASIC END SECTION OF THIS NETWORK AND THOSE LISTED BELOW IS .5 END SECTION (2250').

NOTE 2: CEECO C-101A or HYBRID IN FIGURE 9.

NOTE 3: HEATH CO. TYPE DC-1 DECADE CAPACITOR OR PRECISE TYPE 478

*With W.E. Co. 455B wgt. network or equivalent.

NO PBN REQUIRED. FAR-END <u>MUST BE OPEN CIRCUITED</u> IF TESTING ENTIRE LEAD TEL. SET CAN BE <u>ON</u> HOOK.

MEASUREMENT PROCEDURE

DO NOT ATTEMPT MEASUREMENTS BEFORE READING ENTIRE PARAGRAPH 8, SECTION 445

1. Calibrate the 3A NMS by itself and the 201B by itself before proceeding with the measurement according to Calibration instructions.

2. Connect the test equipment and cable pair under test as shown above. Be sure to strap or set PBN "gauge terminals" for same gauge as gauge or cable being measured.

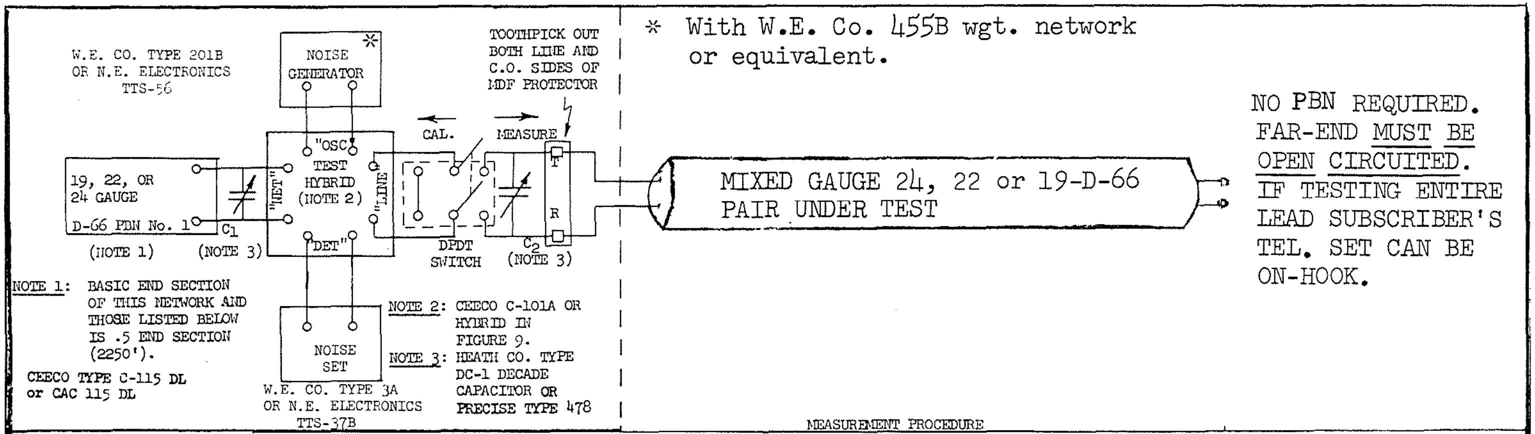
3. Throw DPDT switch to "CALIBRATE" position. Set "OUTPUT ATTEN." pad of 201B noise generator to the 8 db position and note the reading on the 3A NMS. 3A should read 89 dbrn-C. (Function switch of 3A must be in "NM 600" position and "C-Message Network" must be plugged in.) If 3A reads slightly higher or lower than this adjust "OUTPUT ATTEN." pad of 201B until the 89 dbrn-C is obtained on the 3A NMS. This completes calibration. Throw DPDT switch to "MEASURE" position. <u>Do not change 201B output level control</u>.

4. Read dbrn-C reading in 3A NMS. Vary C_2 and/or C_1 until lowest (best) reading is obtained in 3A NMS. This is the best reading and it is the one which should be recorded.

5. The echo open circuit structural return loss (ESRL) in db is the difference between: (ESRL = 89 - dbrn-C reading, step (4) in db.

6. Record the data in DATA SHEET - ECHO STRUCTURAL RETURN LOSS (ESRL) FOR D-66 LOADING, TABLE II

FIGURE 5, OPEN CIRCUIT ECHO STRUCTURAL RETURN LOSS (O.C. ESRL), UNIFORM 24, 22, 19 D-66



NOTE 1: BASIC END SECTION OF THIS NETWORK AND THOSE LISTED BELOW IS .5 END SECTION (2250').

NOTE 2: CEECO C-101A OR HYBRID IN FIGURE 9.

NOTE 3: HEATH CO. TYPE DC-1 DECADE CAPACITOR OR PRECISE TYPE 478

* With W.E. Co. 455B wgt. network or equivalent.

NO PBN REQUIRED. FAR-END MUST BE OPEN CIRCUITED. IF TESTING ENTIRE LEAD SUBSCRIBER'S TEL. SET CAN BE ON-HOOK.

MEASUREMENT PROCEDURE

DO NOT ATTEMPT MEASUREMENTS BEFORE READING ENTIRE PARAGRAPH 8, SECTION 445

1. Calibrate the 3A NMS by itself and the 201B by itself before proceeding with the measurement according to Calibration instructions.

2. Connect the test equipment and cable pair under test as shown above. Be sure to strap or set PBN "gauge terminals" for same gauge as the cable gauge.

3. Throw DPDT switch to "CALIBRATE" position. Set "OUTPUT ATTEN." pad of 201B noise generator to the 8 db position and note the reading on the 3A NMS. The 3A should read 89 dbrn-C. (Function switch of 3A NMS must be on "NM 600" position and "C-Message Network" must be plugged in.) If 3A reads slightly higher or lower than this, adjust "OUTPUT ATTEN." pad of 201B until the 89 dbrn-C is obtained on the 3A. This completes calibration. Throw DPDT switch to "MEASURE" position. <u>Do not change 201B output level pad</u>.

4. Read dbrn-C reading in 3A NMS. Vary C_2 or C_1 until lowest (best) reading is obtained on 3A. Next, vary the gauge of PBN No. 1 until the reading on 3A becomes the <u>lowest</u> possible. (This procedure involves varying C_1, C_2, gauge of PBN No. 1 until the combination is found which produces the <u>lowest</u> reading on the 3A NMS.) The <u>lowest</u> reading on the 3A is the reading to record.

5. The open circuit echo structural return loss (ESRL) in db is: (ESRL = 89 - dbrn-C reading, step (4) in db.

6. Record the data in DATA SHEET - ECHO STRUCTURAL RETURN LOSS (ESRL) FOR D-66 LOADING, TABLE II

FIGURE 6 OPEN CIRCUIT ECHO STRUCTURAL RETURN LOSS (O.C. ESRL) MIXED GAUGE 24, 22, 19, D-66

ILLUSTRATIVE EXAMPLE 1—10 SECTIONS 24-D-66 "SHORT" END-SECTION
EFFECT ON O.C. SFSRL DUE TO MISSING COILS AND "LONG" END SECTIONS
NOTE: EXPECTED MEASURED LOSS IS 21.4 DB, APPROXIMATELY

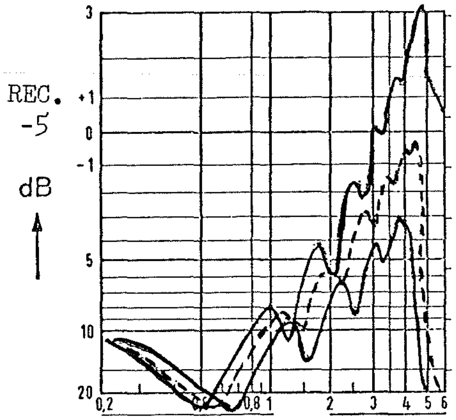


Fig.(a)
Top solid curve: Coil No. 1 missing
Dotted curve: Coil No. 2 missing
Bottom solid curve: Coil No. 3 missing

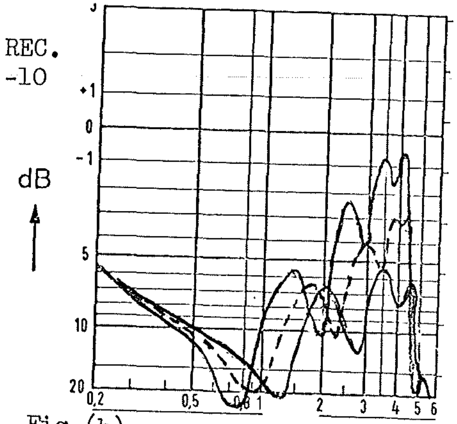


Fig.(b)
Top solid: Coil No. 4 missing
Dotted: Coil No. 5 missing
Bottom solid: Coil No. 6 missing.

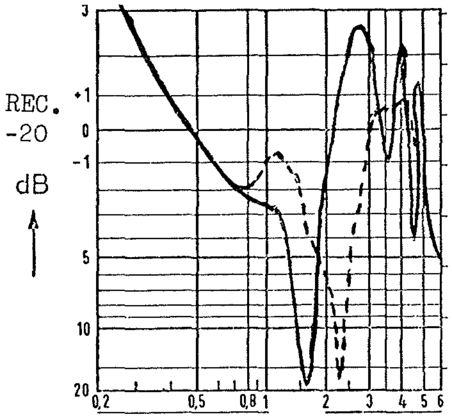


Fig.(c)
Solid: No. 7 missing
Dotted: Coil No. 8 missing

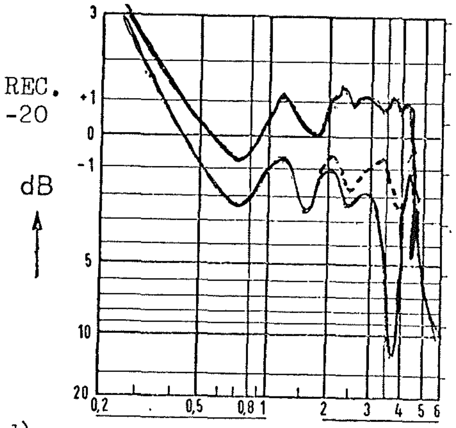


Fig.(d)
Bottom solid: Coil No. 9 missing
Dotted: Coils Nos. 9 & 10 missing
Top solid: Coils Nos. 8,9, & 10 missing

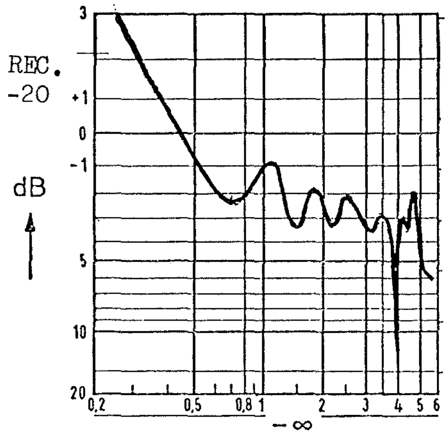


Fig. (e)
All coils in place

READ AS FOLLOWS:
For any frequency
add algebraically
REC. level value with
db in vertical scale
corresponding to
frequency.
Example: Fig. (e)
3500 Hz:
REC. -20 db
Vertical - 3.0 db
Total -23 db
O.C. SRL is 23 db

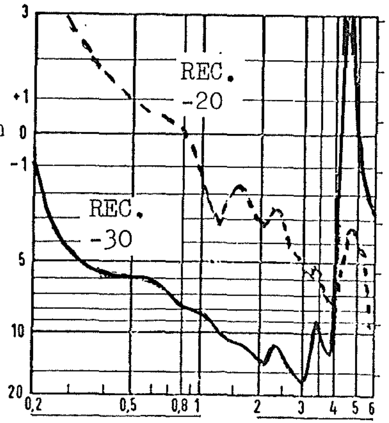


Fig.(f)
PBN's at each end.
Solid curve: All coils in place
Dotted: Coil No. 10 missing

ILLUSTRATIVE EXAMPLE (2). FIVE SECTIONS 24-D-66 "SHORT" END-SECTIONS
EFFECT ON O.C. SFSRL DUE TO MISSING COILS AND "LONG" END-SECTIONS
NOTE: EXPECTED MEASURED O.C. SFSRL IS 11 DB APPROXIMATELY.

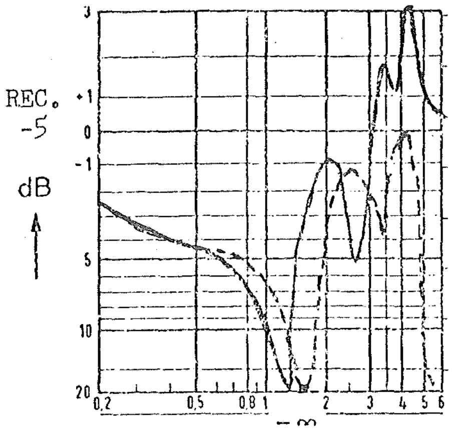


Fig.(a)
Solid curve: Coil No. 1 missing
Dotted curve: Coil No. 2 missing

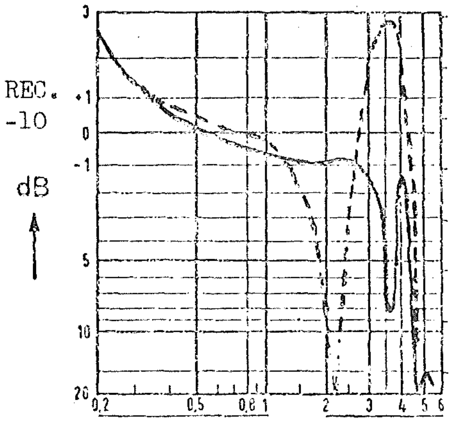


Fig.(b)
Solid : Coil No. 3 missing
Dotted: Coil No. 4 missing

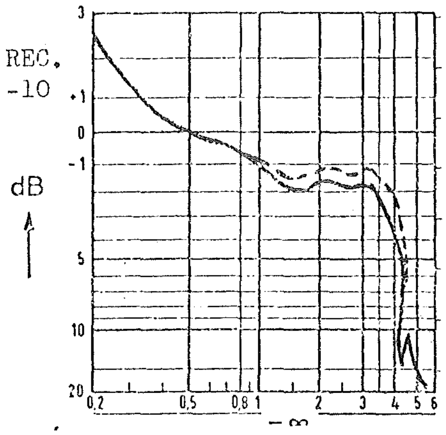


Fig.(c)
Solid : All five coils in place
Dotted: Coil No. 5 missing

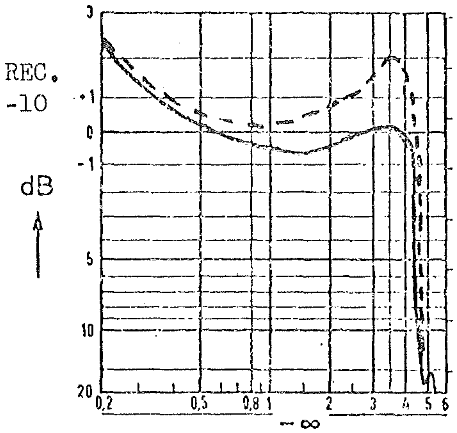


Fig.(d)
Solid : Coil Nos. 4 & 5 missing
Dotted: Coil Nos. 3, 4, & 5 missing

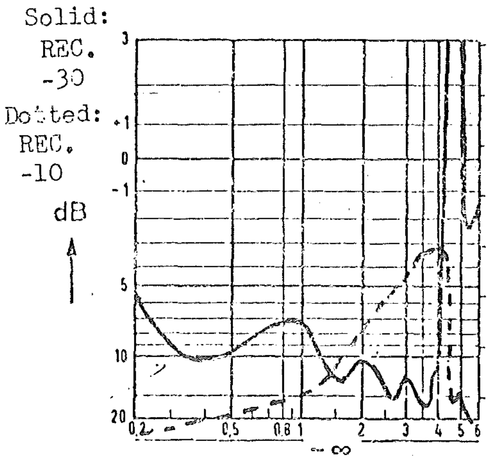


Fig.(e)
PBN's at each end
Solid Curve: All coils in place
Note: REC. Level is -30

Dotted Curve: Coil No. 5 missing
Note: REC. Level is -10

ILLUSTRATIVE EXAMPLE 3
CUNNINGHAM TEL. CO., KANSAS, 22-D-66 LOOPS

CABLE PAIR #57
14 LOAD POINTS
END SECTION 1620'
EXPECTED LOSS 18.9 db

Freq. Hz	OCSRL-db
530	22
770	18
1060	22.8
1340	17.9*
1610	22.2
1900	18
2100	21
2350	19
2550	21.5
2750	18.8
3300	22.5
3500	18
3650	30.5
3800	19
4000	35

CABLE PAIR #52
16 LOAD POINTS
END SECTION 3420'
EXPECTED LOSS 21.6 db

Freq. Hz	OCSRL-db
420	25.5
680	19.5
910	24.9
1140	19.3*
1380	25.2
1600	19.8
1840	26.5
2050	20.5
2250	26
2450	21.7
2650	26.5
2850	21.2
3100	27.5
3350	21.2
3500	50
3700	21.3
3800	47
3900	22.5
4000	26
4200	18

CABLE PAIR #53
14 LOAD POINTS
END SECTION 13,282'
EXPECTED LOSS 18.9 db

Freq. Hz	OCSRL-db
410	25.8
700	20.2
930	25.2
1200	19.5
1430	24.5
1700	19.2*
1900	24
2200	20.5
2400	22
2600	20.6
2800	23.5
3200	20.8
3500	30
3600	19.8
3800	36.9
4000	19.5

CABLE PAIR #13
6 LOAD POINTS
EXPECTED LOSS 8.1 db

Freq. Hz	OCSRL-db
650	13.8
1440	9.8*
2000	11
2500	9.8
3000	25
3500	11
4000	13

CABLE PAIR #76
7 LOAD POINTS
EXPECTED LOSS 9.5 db

Freq. Hz	OCSRL-db
750	13.8
1102	13.6
1940	14.5
3100	10*
4000	25

CABLE PAIR #51
16 LOAD POINTS
END SECTION 9418'
EXPECTED LOSS 21.6 db

Freq. Hz	OCSRL-db
350	27
600	19.5
860	27
1000	20*
1240	28
1430	21.5
1660	29.5
1900	22.5
2000	27
2200	24
2350	27.5
2600	23
2750	31
2950	23.5
3300	30.5
3500	21.2
3600	43
3750	22
3900	45
4000	22.5

CABLE PAIR #71
12 LOAD POINTS
END SECTION 1388'
EXPECTED LOSS 16.2 db

Freq. Hz	OCSRL-db
590	18.8
930	16.5
1260	21
1605	16*
1900	21.2
2200	18
2400	20
2700	17.5
3300	33
3400	21.5
3600	25.5
3800	17.5

✓

TABLE I
ILLUSTRATIVE EXAMPLE 4

OUTSIDE PLANT ACCEPTANCE TESTS DATA SHEET
OPEN CIRCUIT SINGLE FREQUENCY STRUCTURAL RETURN LOSS
(O.C. SFSRL) D-66 SUBSCRIBER LOOPS

(1) REA PROJ. DESIGN IA 523 F (2) EXCHANGE NAME Churdan (3) TEMP. AIR ______ (If Aerial), GD. 43 (If Buried) (4) TESTERS EES & RDM (5) DATE MEASUREMENTS 13/6/67 (6) OSC. HP 204B (7) A.C. VOLTMETER HP 403A (8) HYBRID C I DA (9) PBN No. 1 115DL (10) GA 24 OTHER: (11) C1 NONE MF (12) C2 NONE ______ MF (13) OSC. OUTPUT LEVEL ______ DBM (Directly into 600 ohm resistor)

In a line diagram in enclosed sheet (Table Ia) show: (a) Type of loading system, (b) All gauges and length of each, (c) As-built length of each full-loading section, (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if exisitng.

CABLE PR. NUMBER	CABLE LEAD OR ROUTE DESIGNATION	D.C. LOOP RESISTANCE IN OHMS			MINIMUM MEASURED		O.C. SFSRL IN DB COMPUTED
		COMPUTED		MEASURED	DB	FREQ.	
		68°F.	°F.	°F.			
3	12			2354	18.5	1.0	21.2
4	"			2349	18.8	1.0	21.1
5	"			2309	18.3	1.0	20.8
7	"			2246	18.4	2.9	20.2
9	"			1948	15.5	1.2	17.5
14	"			1805	15.6	1.2	16.3
15	"			1978	16.7	1.2	17.8
16	"			1921	16.0	1.2	17.3
18	"			1613	13.5	1.4	14.5
26	12A			1860	15.5	1.2	16.7
27	"			1851	15.0	1.3	16.7
28	"			1796	15.5	1.2	16.2
63	"			1786	14.5	1.3	16.1
64	"			1777	15.0	2.9	16.0
65	"				14.0	1.3	
69	13			1924	15.0	2.7	17.3
70	"			1722	15.2	1.3	15.5
71	"			1722	14.5	1.3	15.5
72	"						
204	2			1959	17.0	1.9	17.6
205	"			1890	9.5	2.8	17.0
206	"			1865	16.2	2.1	16.8
207	"			1831	14.8	3.0	16.5
208	"			1900	16.2	2.1	17.1
209	"			1812	16.5	1.3	16.3
203	"			2168	17.4	1.9	18.6
216	24			1623	13.7	3.2	14.6
217	"			1520	13.8	3.3	13.7

NOTE: To convert resistance to a different temperature adjust resistance by 1 percent for each 5 degrees F. change in temperature.

TABLE I

ILLUSTRATIVE EXAMPLE 4 (CON'T.)

OUTSIDE PLANT ACCEPTANCE TESTS DATA SHEET

OPEN CIRCUIT SINGLE FREQUENCY STRUCTURAL RETURN LOSS

(O.C. SFSRL) D-66 SUBSCRIBER LOOPS

(1) REA PROJ. DESIGN IA 523F (2) EXCHANGE NAME Churdan (3) TEMP. AIR ____ (If Aerial), GD. 43°F (If Buried) (4) TESTERS EES & RDM (5) DATE MEASUREMENTS 12/6/67 (6) OSC. HP 204B (7) A.C. VOLTMETER HP 403A (8) HYBRID C101A (9) PBN No. 1 115 DL (10) GA 24 OTHER: (11) C1 ____ MF (12) C2 ____ MF (13) OSC. OUTPUT LEVEL ____ DBM (Directly into 600 ohm resistor)

In a line diagram in enclosed sheet (Table Ia) show: (a) Type of loading system, (b) All gauges and length of each, (c) As-built length of each full-loading section, (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if exisitng.

CABLE PR. NUMBER	CABLE LEAD OR ROUTE DESIGNATION	D.C. LOOP RESISTANCE IN OHMS			MINIMUM MEASURED		O.C. SFSRL IN DB COMPUTED
		COMPUTED		MEASURED			
		68°F.	°F.	°F.	DB	FREQ.	
249	22			1831	15.0	3.0	16.5
250	"			1965	14.8	3.3	17.7
251	"			1741	15.0	3.0	15.7
252	"			1643	14.3	3.2	14.8
345	3			2212	11.6	2.7	19.9
348	"			1667	14.0	1.4	15.0
349	"			1573	14.0	1.4	14.2
353	"			1663	14.2	1.4	15.0
354	"			1662	13.8	1.4	15.0
355	"			1607	13.7	1.4	14.5
326	35			1940	15.5	3.2	17.5
327	"			1776	15.0	3.5	15.9
328	"			1632	13.7	3.1	14.7
329	"			1677	14.6	1.4	15.1
311	34			2216	19.2	1.0	19.9
312	"			2152	17.6	1.1	19.4
313	"			2152	18.4	1.0	19.4
314	"			2300	19.5	1.0	20.7
315**	"			2176	19.5	1.0	19.6
316	"			2058	17.4	1.8	18.5
318	"			1811	16.7	2.0	16.3
319	"			1771	16.0	2.0	15.9
321	"			1544	14.0	2.3	13.9
538**	44			1717	15.2	2.1	15.5
539	"			1643	14.0	2.2	14.8
540	"			1596	14.0	2.2	14.4
503	4			2444	20.0	2.1	22.0
504	"			2400	19.4	2.1	21.6
505	"			2364	19.0	2.3	21.3

NOTE: To convert resistance to a different temperature adjust resistance by 1 percent for each 5 degrees F. change in temperature.

TABLE I
ILLUSTRATIVE EXAMPLE 4 (CON'T.)

OUTSIDE PLANT ACCEPTANCE TESTS DATA SHEET
OPEN CIRCUIT SINGLE FREQUENCY STRUCTURAL RETURN LOSS
(O.C. SFSRL) D-66 SUBSCRIBER LOOPS

(1) REA PROJ. DESIGN IA523F (2) EXCHANGE NAME Churdan (3) TEMP. AIR ______ (If Aerial), GD. 43 (If Buried) (4) TESTERS EES&RDM (5) DATE MEASUREMENTS 12/6/67 (6) OSC. HP204B (7) A.C. VOLTMETER HP 403A (8) HYBRID C101A (9) PBN No. 1 115 DL (10) GA 24 OTHER: (11) C1 — MF (12) C2 ______ MF (13) OSC. OUTPUT LEVEL ______ DBM (Directly into 600 ohm resistor)

In a line diagram in enclosed sheet (Table Ia) show: (a) Type of loading system, (b) All gauges and length of each, (c) As-built length of each full-loading section, (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if exisitng.

CABLE PR. NUMBER	CABLE LEAD OR ROUTE DESIGNATION	D.C. LOOP RESISTANCE IN OHMS			MINIMUM MEASURED		O.C. SFSRL IN DB COMPUTED
		COMPUTED		MEASURED			
		68°F.	°F.	43°F.	DB	FREQ.	
506	4			2172	18.2	3.0	19.6
507	"			2090	18.0	1.1	18.8
508	"			2112	19.3	2.2	19.0
509	"			2072	17.0	1.8	18.7
510	"			1820	15.5	2.0	16.4
511	"			1830	15.7	2.0	16.5
513	"			1726	14.3	2.1	15.5
514	46			2266	19.0	1.0	20.4
515	"			2310	19.8	2.3	20.8
516	"			2192	19.1	2.3	19.7
517	"			2192	19.2	2.3	19.7
518	"				17.0	1.8	
520	"			2132	19.0	2.4	19.2
521	"			1914	16.2	1.9	17.2
522	"			1831	15.5	2.0	16.5
524	"			1663	14.0	2.2	15.0
529	45			1955	16.2	1.2	17.6
530	"			2019	16.8	2.5	18.2
531	"			2009	17.5	2.5	18.1
532	"			1737	15.0	2.1	15.6
533	"			1598	13.5	2.3	14.4
579	42			1860	14.5	1.4	16.7
580	"			1772	13.8	1.4	16.0
581	"			1663	13.3	1.4	15.0
19					12.4	1.4	
8	12			2097	17.0	1.1	18.9
6	"			2246	18.5	1.0	20.2
17	"				14.5	2.9	
13	"			1974	16.5	2.5	17.8
10	"			1948	16.2	1.2	17.5

NOTE: To convert resistance to a different temperature adjust resistance by 1 percent for each 5 degrees F. change in temperature.

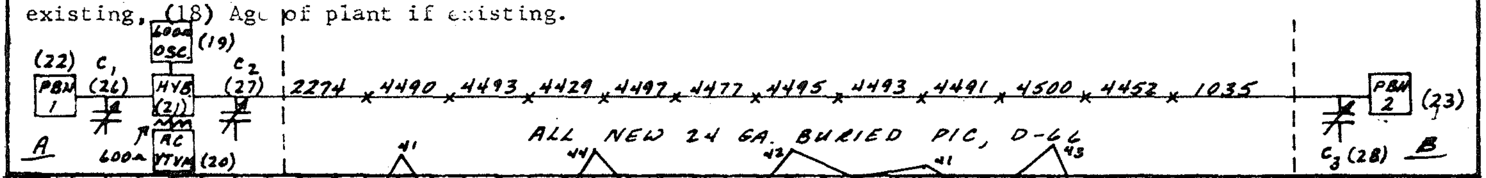
DATA SHEET - SINGLE FREQUENCY STRUCTURAL RETURN LOSS (SFSRL) For D-66 Loading

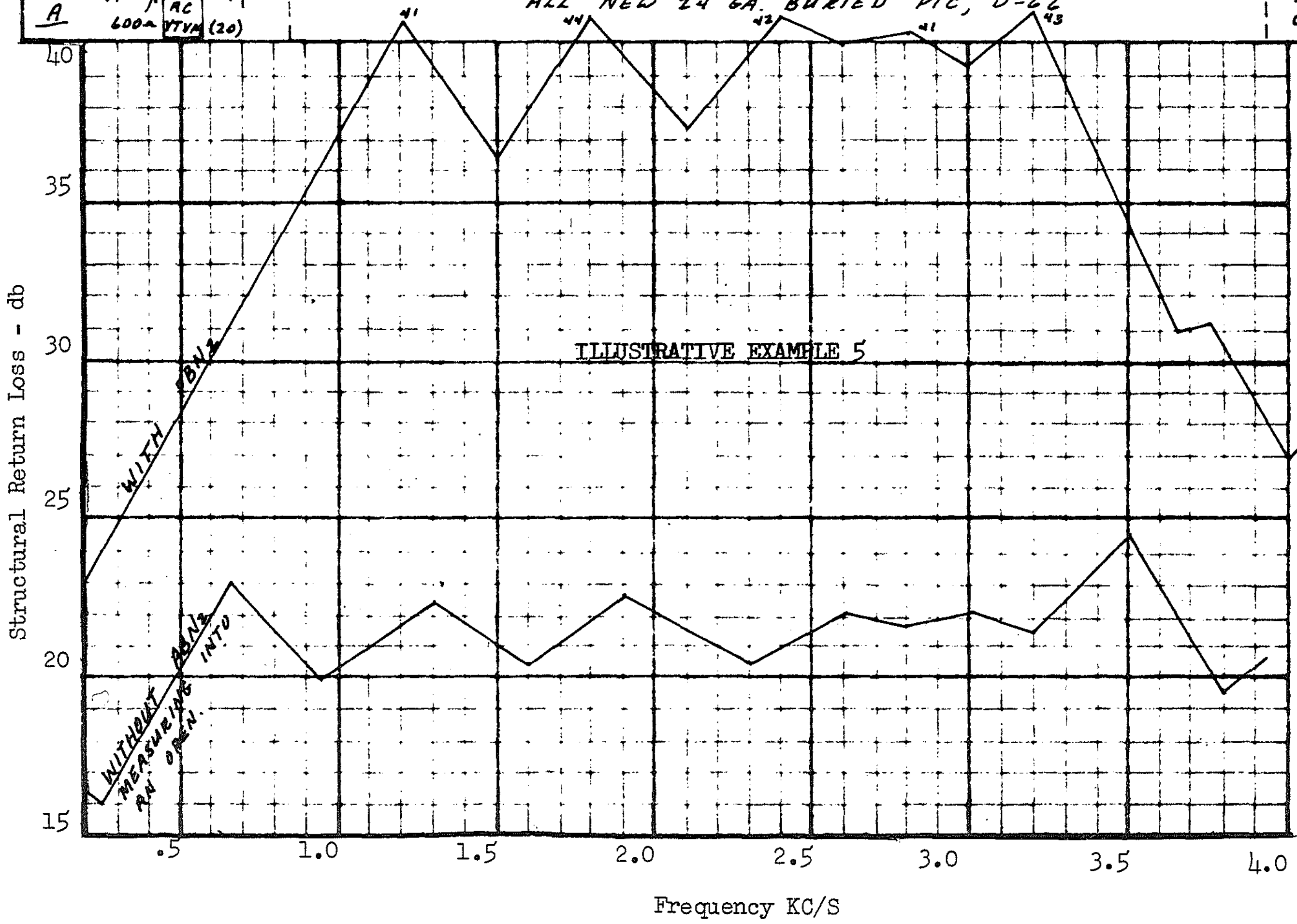
(1) REA PROJ. DESIGN. IOWA 523 E (2) TRK. GROUP CHURDAN TO SCRANTON (3) TOLL [✓ EAS], SPEC. (Circle One)

(4) MEASURING BETWEEN CHURDAN (A) TO PBN2 (B) (5) TRUNK No. LOC. A ______, LOC. B ____ (6) PAIR No. LOC A 310 , LOC. B ______ (7) TEMP. AIR (43°) °F (If Buried) (8) TESTERS EE S + RBM

(9) DATE MEASMS 12-6-67

In line diagram below show: (10) Type of loading system, (11) ALL gauges and length of each, (12) as-built length of each full-loading section, (13) As-Built length of each end-section, (14) CBO, amount and locations, (15) Junction Compensator, if used, (16) Plant buried or aerial, (17) Plant new or existing, (18) Age of plant if existing.





EQPT. TYPE

(19) OSC HP 204B
(20) AC-VTVM HP 403A
(21) HYB C 101A
(22) PBN NO. 1 115DL
(23) PBN NO. 2 115DL

PBN NO. 1

(24) GA 24

PBN NO. 2

(25) GA 24

OTHER

(26) C_1 0 MF
(27) C_2 0 MF
(28) C_3 1200' MF
(29) OSC. OSL. LEV. 1 CAL. TO "0" DBM

ILLUSTRATIVE EXAMPLE 6

TABLE II

OUTSIDE PLANT ACCEPTANCE TESTS DATA SHEET
OPEN CIRCUIT ECHO STRUCTURAL RETURN LOSS
(O.C. ESRL) D-66 SUBSCRIBER LOOPS

(1) REA PROJ. DESIGN. N.C. 509 (2) EXCHANGE NAME COURTNEY
(3) TEMP. AIR ______ (If Aerial), GD. 45° (If Buried) (4)TESTERS HPP & WC (5) DATE MEASMS. 4/24/67 EQUIPMENT TYPE: (6) NOISE GEN. N.E TTS 56 (7) NMS NE TTS 37B (8)HYBRID ALTEC (9) PBN No. 1 C115DL
(10)GA 22/24 OTHER: (11) C1 — MF (12) C_2 — MF
(13) NOISE GEN. LEVEL. 90 DBRNC (Directly into Noise-metalic 600 ohm position.) In line diagram in enclosed sheet (Table IIa) show: (a) Type of loading system, (b) All gauges and length of each, (c) As-built length of each full-loading section, (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if existing.

CABLE PAIR NUMBER	CABLE LEAD OR ROUTE DESIGNATION	D.C. LOOP RESISTANCE(*) IN OHMS	OCESRL IN DB	
			MEASURED	COMPUTED
726		1385	12.0	12.5
70		1038	8.5	9.3
19		1172	10.0	10.6
261		1220	10.0	11.0
730		1309	11.5	11.8
71		1309	8.7	9.4

NOTE: (*)Circle one COMPUTED, MEASURED

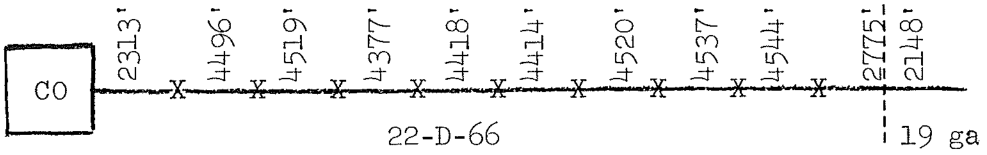
TABLE III - FACILITY SKETCH

In line diagram show: (a) Type of loading system, (b) All gauges and length of each, (c) As-built length of each full-loading section, (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if existing.

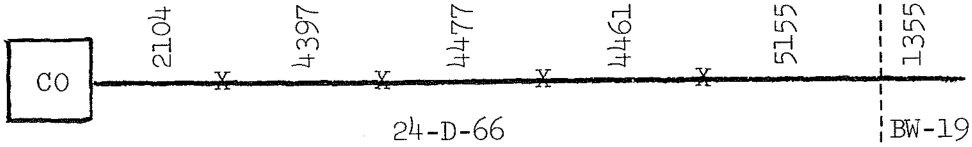
ILLUSTRATIVE EXAMPLE 6

OC ESRL MEASUREMENTS 22/24 GAUGE, D-66 LOOPS
YADKIN VALLEY TEL. MEMB. CORP. COURNEY EXCH.

Pair #726



Pair #70



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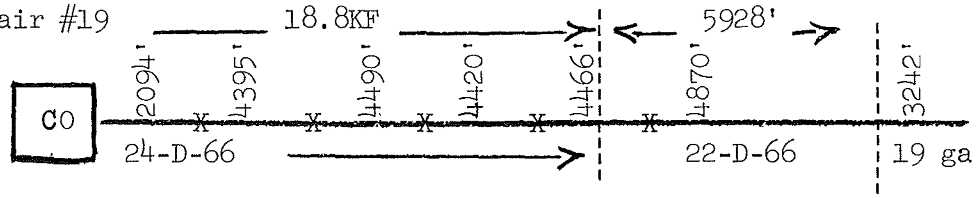

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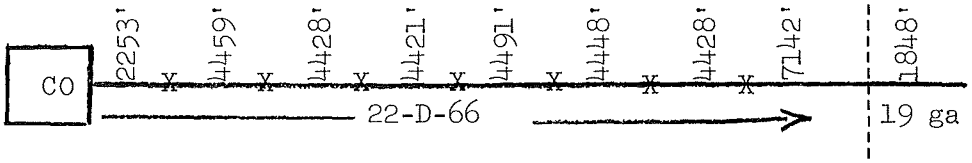
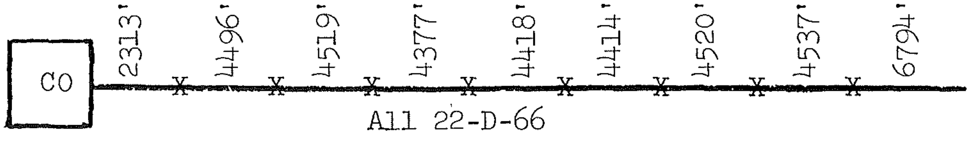
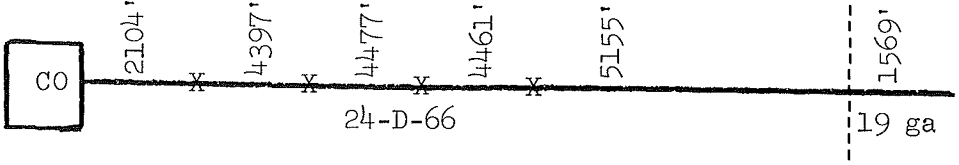


Pair #730



Pair #71



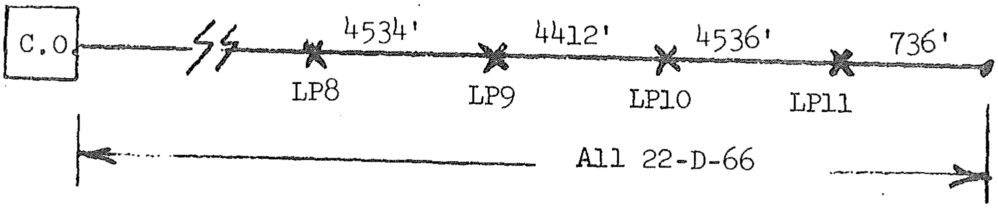
ILLUSTRATIVE EXAMPLE 7

TABLE II

OUTSIDE PLANT ACCEPTANCE TESTS DATA SHEET
OPEN CIRCUIT ECHO STRUCTURAL RETURN LOSS
(O.C. ESRL) D-66 SUBSCRIBER LOOPS

(1) REA PROJ. DESIGN. MINN. 541 (2) EXCHANGE NAME CYRUS
(3) TEMP. AIR ________ (If Aerial), GD. 58° (If Buried) (4) TESTERS HPP & BS (5) DATE MEASMS. 7/8/67 EQUIPMENT TYPE: (6) NOISE GEN. N.E TT: 56 (7) NMS N.E. TTS 37B (8) HYBRID ALTEC (9) PBN No. 1 C115DL
(10) GA 22 OTHER: (11) C1 — MF (12) C_2 — MF
(13) NOISE GEN. LEVEL. 90 DBRNC (Directly into Noise-metalic 600 ohm position) In line diagram in enclosed sheet (Table IIa) show: (a) Type of loading system, (b) All gauges and length of each, (c) As-built length of each full-loading section. (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if existing.

CABLE PAIR NUMBER	CABLE LEAD OR ROUTE DESIGNATION	D.C. LOOP RESISTANCE(*) IN OHMS	OCESRL IN DB	
			MEASURED	COMPUTED
20		1261	11.0	11.4
19		1278	11.0	11.5
18		1430	12.3	12.9
17		1439	12.5	13.0
16		1506	13.0	13.5
15		1500	13.0	13.5



PAIR NO.	END SECTION KF
20	2.25
19	2.83
18	2.51
17	2.51
16	0.73
15	0.73

NOTE: (*)Circle one COMPUTED, [✓ MEASURED]

TABLE I

OUTSIDE PLANT ACCEPTANCE TESTS DATA SHEET
OPEN CIRCUIT SINGLE FREQUENCY STRUCTURAL RETURN LOSS
(O.C. SFSRL) D-66 SUBSCRIBER LOOPS

(1) REA PROJ. DESIGN.__________(2) EXCHANGE NAME______________(3) TEMP. AIR______ OF (If Aerial), GD.______OF (If Buried) (4) TESTERS______________(5) DATE MEASUREMENTS______________(6) OSC.__________(7) A.C. VOLTMETER______________(8) HYBRID______________(9) PBN No. 1______________(10) GA__________OTHER: (11) C1__________MF (12) C2______MF (13) OSC. OUTPUT LEVEL______________DBM (Directly into 600 ohm resistor)

In a line diagram in enclosed sheet (Table Ia) show: (a) Type of loading system, (b) All gauges and length of each, (c) As-built length of each full-loading section, (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if exisitng.

CABLE PR. NUMBER	CABLE LEAD OR ROUTE DESIGNATION	L.C. LOOP RESISTANCE IN OHMS			MINIMUM		O.C. SFSRL IN DB COMPUTED
		COMPUTED		MEASURED	MEASURED		
		68°F.	°F.	°F.	DB	FREQ.	

NOTE: To convert resistance to a different temperature adjust resistance by 1 percent for each 5 degrees F. change in temperature.

✓

TABLE II

OUTSIDE PLANT ACCEPTANCE TESTS DATA SHEET
OPEN CIRCUIT ECHO STRUCTURAL RETURN LOSS
(O.C. ESRL) D-66 SUBSCRIBER LOOPS

(1) REA PROJ. DESIGN.______________ (2) EXCHANGE NAME______________________
(3) TEMP. AIR___________ OF (If Aerial), GD.__________ OF (If Buried) (4)TESTERS
_______________ (5) DATE MEASMS.______________ EQUIPMENT TYPE: (6) NOISE GEN.
_______________ (7) NMS______________ (8)HYBRID___________ (9) PBN No. 1________
(10)GA_______________ OTHER: (11) C1____________ MF (12) C_2_______________ MF
(13) NOISE GEN. LEVEL.____________ DBRNC (Directly into Noise-metalic 600 ohm position) In line diagram in enclosed sheet (Table IIa) show: (a) Type of loading system, (b) All gauges and length of each, (c) As-build length of each full-loading section, (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if existing.

CABLE PAIR NUMBER	CABLE LEAD OR ROUTE DESIGNATION	D. C. LOOP RESISTANCE(*) IN OHMS	OCESRL IN DB	
			MEASURED	COMPUTED

NOTE: (*)Circle one COMPUTED, MEASURED

TABLE III

In line diagram show: (a) Type of loading system, (b) All gauges and length of each, (c) As-Built length of each full-loading section, (d) As-built length of each end-section, (e) CBO, amount and location, (f) Plant buried or aerial, (g) Plant new or existing, (h) Age of plant if existing.