CC: Mr. R. R. Cole
Mr. R. S. Weatherly
Mr. Paul Logue
Mr. F. N. Williams
Mr. H. F. Weaver
Mr. F. A. Barker
Mr. W. G. Krummrich (2)
Mr. F. E. Hubbard

TRIP REPORT 214

WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY
East Pittsburgh, Pennsylvania
October 14-15, 1942

A meeting was held with men representing the Research, Engineering, and Purchasing Departments of Westinghouse at which revisions of the specifications for Aroclor 1254 (Inerteen 6935-1) were discussed in detail and certain agreements were reached; and a later meeting was held with the Research group (Insulation Division) corresponding to F. M. Clark's group at General Electric Company at which the question of air-cooled transformers vs. Inerteen-filled transformers was discussed and interest was aroused in certain of our new products.

In the following are notes on the two meetings. These are given in considerable detail, partly so as to have a reasonably complete record of what went on and also because these meetings were the first direct contact between Anniston Research and Westinghouse technical men in something over ten years.

MEETING OF OCTOBER 14

Present: Dr. R. N. Evans, Insulation Division of Research Laboratory
Dr. L. J. Berberich, Insulation Division of Research Laboratory
Mr. P. E. Demmler, Engineer, Feeder Department
Mr. R. E. Marbury, Engineer Switch-gear Department (Circuit Breakers and Protective devises)
Mr. C. V. Fields, Engineer Switch-gear Department (Circuit breakers and Protective Devices)
Mr. Gilbert Remley, Purchasing Department
Dr. R. L. Jenkins, Monsanto

Messrs. Marbury and Fields were introduced as interested in design and manufacture of capacitors, although their department and activity were given in the directory as shown above.

The meeting was arranged by Mr. H. H. Hartness, of the Purchasing Department of Westinghouse, through Mr. Weatherly.

In preparation for tank car shipments of Aroclor 1254 (capacitor Inerteen), Westinghouse is installing a 15,000 gallon storage tank and a fuller's earth treater and filter for the individual batches (about 150 gallons each) to be withdrawn from the storage and delivered to the capacitor impregnating units.

Their existing treating and handling equipment has been satisfactory for handling Aroclor 1254 received in drums. It is interesting to note that they "sucked," rather than pumped, the Aroclor from the drums and through a "tall bed" of fuller's earth to their charging tanks for the capacitor treaters.

DSW 331019

They are planning to draw the Aroclor from the tank car into the storage tank by vacuum and to hold the Aroclor at a temperature above ordinary temperatures in the storage tank and at a vacuum of around 28" of mercury. The design calls for a catch tank to collect any condensate between the storage tank and the vacuum pump.

The plan was to hold the Aroclor while in storage at 85°C. They expressed concern about fractional evaporation of the Aroclor that might affect the properties of the product. Later Dr. Berberich remarked that he had carried out tests on this point and had found that a little evaporation improved (decreased) the power factor which was regarded as the most important property. The possible change (increase) in viscosity, specific gravity and dielectric constant as a result of evaporation in storage was regarded as of less importance.

I suggested they drop the temperature somewhat below 85°C so as to avoid excessive fractional evaporation. Marbury agreed that they would try 50°C and even go lower provided their transfer system would then still handle the material.

They anticipate consumption of two tank cars of Aroclor 1254 per month. If the inventory in the storage tank is maintained at from one-half full to full, this will mean a relatively slow turnover in the hot storage. They particularly asked whether I had any reason to believe that the hot storage would be harmful to the Aroclor in any respect other than possible fractional evaporation of the Aroclor. I know of no harmful effect. If any iron is picked up it would presumably be removed by their fuller's earth treatment between the storage tank and the capaciter treaters.

Specifications:

The primary object of the meeting was revision of specifications which they thought desirable for tank car shipment. Actually, the real reason for their renewed interest was presumably the new arrangement (not mentioned during the meeting) whereby we will sell direct to Westinghouse rather than through the General Electric Co. Marbury presented a detailed graph of the data as given in Monsanto's test certificates for shipments of Aroclor 1254 from October 1937 to February 1942 and pointed out that apparently our own data showed the shipments frequently fell outside our specifications. Specifically the graph indicated the following:

Specific gravity always within specifications.
Pour point within specifications, except certificate of November 14, 1940.
Viscosity within specifications only 10 times out of 25 shipments (this point was cleared up in the discussion the next day with Dr. Evans).
Color OK
Acid number OK
Heat loss OK

DSW 331020

Distillation range completely within specifications only twice out of 25 shipments.
Dielectric constant within specifications only 11 times out of 22 shipments.
Resistivity always within specification but quite variable (100 to 1500 x 10^9 ohms/cm.^{3}).

They were seriously concerned as to whether we would supply them a uniform product within specification although they had to admit that the product had been satisfactory in actual service and consequently the apparent deviations in properties of the product were not serious.

They were also concerned that they be given as good a grade of Aroclor 1254 as their chief competitor and I assured them that the same material has been and will be supplied to them as we supply to other electric companies.

I told them that I did not usually see any of the test certificates and therefore was not in a position to discuss the variations shown on their chart, but I would check up on this question and write them. I pointed out that some of the test data that they complained about were incompatible with other data on the same sample. For example, the certificate of November 14, 1940 showed a high pour point (one point or 2°C above the maximum specification) and yet the viscosity and specific gravity were normal, which would indicate an error in the determination or in copying the data. There were four errors in the chart in designating abscissas and ordinates (which, however, did not change the conclusions), and I judged that it had been very hurriedly drawn up by Mr. Marbury for the meeting.

Specification Revision

Copies of Westinghouse present specifications for Interteen 6935-1 (Aroclor 1254) and of proposed new specifications were presented and discussed in detail. With the group as large as it was, it was impossible to reach definite agreement on the various items and it was agreed that I would take the various suggestions, go over the proposed specifications, check with our Operating and Sales Departments, and send them our revision for their consideration. Correspondence should be directed to Dr. Evans with copies to Dr. C. F. Hill (Evan's superior), Mr. Marbury, and Mr. Remley.

Actually few changes in specification will be necessary in order to satisfy Westinghouse. Dr. Evans said they did not want to place unduly strict specification limits on the product which were not warranted and which would work a hardship on us.

The data shown by their graph, described above, must be checked to ascertain the apparently wide discrepancies between our test results in certain instances and our specifications, particularly with respect to distillation range and dielectric constant. The matter of viscosity was cleared up in a discussion with Dr. Evans the next morning and it was agreed that the specification would be changed from the G. E. value of 45 to 49 seconds to 44.5 to 47.5 seconds which is the range obtained with our calibrated viscosimeter on normal Arodor 1254. All shipments to Westinghouse since 1937 have comformed to the latter limits.

In general Westinghouse would like to have the specifications narrowed up although again they expressly stated they do not want to place any undue hardship upon us.

Following are notes on their suggestions on specific items, which are numbered below as in their proposed new specification sheet:

1. Description. They want a more accurate description than "Pentachlor-Di-Phenyl - a pale yellow, viscous liquid at room temperature." Suggestion: A mixture of chlorinated diphenyls having an average chlorine content approximately that of Pentachlor-diphenyl and possessing the chemical and physical properties described in sections 3 to 14 inclusive below.

2. Section stating that no change in quality shall be made without approval - no comments.

3. Acidity. Dr. Evans suggested that the limit of 0.01 be lowered. According to their graph the acid numbers of all shipments since October 1937 have been 0.007 or lower and since November 1939 have been below 0.005.

Dr. Evans pointed out that the acid number data are not comparable with the figures for free chlorides assuming both are due to HCl. An acid number of 0.01 is equivalent to free chlorides of 8.88 ppm. Since our free chlorides do not run over 0.15 ppm, there must be some acid other than HCl in the Aroclor or, alternatively, the extraction method for free chlorides catches only a very small portion of the HCl or acid chlorides present. I believe that the latter has been disproved at St. Louis by successive extraction tests.

We have been aware of these facts for a long time, but are dealing with such minute quantities of impurities (0.01 acid number is equivalent to 0.001% HCl or 0.01% of an acid monohydroxy-pentachlorodiphenyl) that chemical methods of identifying the acid or acids present is at least difficult.

Dr Evans pointed out that ferric chloride added to the Aroclor in an amount equivalent to 0.15 ppm of chlorides imparts a very high dielectric loss to the Aroclor. Conseqnently, he argued that the chlorides cannot be present as ferric chloride with which I agreed upon the bases of the other evidence.

I pointed out to Dr. Evans that Aroclor 1254 with an acid number less than 0.01 and free chlorides test not over 0.15 ppm had been proved satisfactory for capacitors; that the specification limits whatever their real significance as to impurities, had been found quite satisfactory indications

of useable Aroclor from several years of experience.

He understood this point but emphasized the fact that he could make up an Aroclor by adding minute amounts of, say, ferric chloride that would pass both the acid number and free chlorides tests and yet could be quite unsatisfactory as a dielectric. I agreed that this was true but pointed out that other tests (specifically resistivity, power factor or dielectric loss) would catch such a situation.

I agreed to discuss with Operating Departments of Anniston and Plant B a possible lowering of the specification limit on acid number. However, I do not recommend a change in this specification.

4. Chlorides. Discussed above. The test method and specification limit was worked in cooperation with G. E. Co., and I would not recommend a change from our present "0.15 ppm max." which should replace Westinghouse's specification of "none."

At Dr. Evans Request, I agreed to aske the Analytical Laboratory to test the pH of the water extract for a series of shipments and report the results to him.

5. Distillation Range. Discrepancies between our test results and specifications as shown on Westinghouse's graph should be checked up. Actually the 1 per cent point, not now included in the specification might well be added.

6. Condition - No comment.

7. Specific Gravity - No comment.

8. Viscosity. Since Westinghouse do not run viscosity themselves and plan to continue to rely upon our test results the specification should be amended to the range (44.5 to 47.5 seconds) that we get on our calibrated viscosimeter.

9. Color. This was not discussed but should be amended to read on the APHA scale and probably 150 APHA max. to conform with the tentative specification of G. E. Co.

10. Pour Point. No comments

11. Electrical Resistivity. No change in items (a) and (b) which conform to G. E.'s standard specifications. Check as to whether voltage we use conforms. Item (c) states that samples used for electrical resistivity

tests "may be treated by contact with XXF Florex B absorbent or approved equivalent . . . ." This should be omitted or made mandatory, preferably omitted. If mandatory, the exact treating procedure should be opacified.

22. Dielectric Constant. Specification limits should not be changed but the reason why half of the shipments as shown on the Westinghouse graph fell outside specifications should be checked up and Westinghouse assured of future conformance with specifications.

13. Power Factor. I told them that we do not usually determine power factor and they did not insist on our doing so.

Even though we are not likely to be called upon to determine power factor, the specification should be included. The exact procedure for treating with clay prior to the test must be specified and the frequency (they give 60 cycles) in the actual test must be agreed upon.

14. Heating Loss. Specification is 0.4% max. Since no shipment (according to their graph) has shown greater than 0.01 since October 1937, I see no reason against acceding to their suggestion to lower the limit. They are interested in this item because of their plans for hot storage under vacuum. The Analytical Laboratory should have a standard rotating shelf oven for their test.

15. Packing - No comments.

16. Drums - No comments.

17. Bung - No comments.

18. Marking - No comments.

19. Marking for Tank Cars - No comments.

20. Inspection. This section provides that a "certified test report be supplied with each shipment. By this they meant a certificate sworn to before a notary. I told them we could have each report notarized if they insisted but I thought it unnecessary. I recommend we omit the word "certified" in our revision to be sent to Westinghouse.

The list of tests to be included in our test report should be amended (a) by changing color from NPA to APHA scale and (b) omit power factor

The list of tests to be included in our test report will then be as follows:

Specific Gravity at 65°C/15.5°C
Color (APHA)
Condition
Acidity

Free Chlorides
Pour Point
Viscosity at 98.9°C
Distillation Range
1% point (?)
10% point
50% point
90% point
Dielectric Constant
Resistivity

21. Shipment. This section provides that shipment may be made without approval provided our tests show the product to be within all specifications. The test report is forwarded to Westinghouse at the time of shipment.

In case the product fails to meet any specification test, the test report is forwarded to Westinghouse and shipment is withheld until approval is given.

I see no need for revision.

22. Rejection clause.

Westinghouse reserves the right to reject . . . material that does not conform to the above specification in every particular . . . ."

It should be mentioned that, while Westinghouse will depend upon us for tests of the Aroclor before shipment, they plan to sample the tank car before dumping and test for resistivity and power factor.

Please note that no suggestion was made by Westinghouse to include a specification for water content. Even though this test is not included in the Westinghouse specification, I recommend it be run by us as a plant control test for all lots of Aroclor 1254 to be sent to Westinghouse and as protection to ourselves.

Contamination of Tank Cars

Westinghouse will attach breathers to the tank cars so as to avoid entrance of moisture during unloading.

They particularly asked about cleanliness of returned cars as received by us from other customers, particularly whether we drained any heel and cleaned the car. I told them that we carefully inspected the car and if it had an appreciable heel (we usually find as much as 50 gallons) this heel is sampled and tested. If okay, the car is then filled. If not or if the car is not perfectly clean, it is thoroughly cleaned before filling.

Complaints:

Mr. Marbury mentioned our use of a different type of drum in a shipment of about December 1941. This drum had a crimped-on head of a type that would not stand a severe blow without parting at the crimp. He claimed some 25 drums had been received with sufficiently large holes to admit moisture to the Aroclor. I found that a complaint had been made through the proper channels and dropped the matter.

Mr. Marbury also claimed that shipments in 1942 have shown a decided increase in accumulations of Aroclor in their vacuum lines. They impregnate their paper-spaced capacitors with a vacuum of around 260 to 300 microns. They did not specify temperature. I suggested we could check up on any change in the Aroclor that might have caused this trouble by comparing evaporation loss tests and distillation temperatures at 1% and 10%. They did not have the data available. The follwoing day Dr. Berberich told me he thought that there had been no change in the Aroclor and that the production men had just begun to notice the accumulations in their vacuum lines which had always occurred. I am inclined to believe Dr. Berberich.

The complaint was made by Mr. Marbury that beginning in 1942 they had had trouble with increased dielectric loss. This had begun in January and was at a peak in April 1942. The situation has their paper spacer that was in part responsible but, over and above that, he felt there had been some change in the Aroclor that was partly the cause for the high dielectric loss of condensers made during this period. I offered to try to get sufficient samples of Aroclors made in 1941 and during the bad period (April) of 1942 so that exact electrical comparisons could be made. He did not want me to send them now. The following day, the matter was discussed with Dr. Hill who felt that the trouble was due to other factors mainly their paper, and not due to the Aroclor.

If I recall correctly, Clark of G. E. ran into similar troubles some 5 years ago and actually had to make a study of paper manufacture and finally tell the manufacturers how to improve their paper.

Special Tests and Test Methods

Westinghouse uses a continuous resistivity tester which is set directly in their Aroclor pipe lines. Marbury said it was very simple--only a cell like our resistivity cell set in the line with axis parallel to the flow of the Aroclor and connected to the usual testing equipment. He suggested we put it in our line to storage tank or tank car.

Dr. Evans asked for our data on resistivity vs. moisture content of Aroclor 1254. This will have to be obtained from St. Louis.

Dr. Evans suggested we look into the A.S.T.M. method for free mineral acidity as a possible procedure for distinguishing between HCl and organic acids in our Aroclor. He will send us further information.

Dr. Evans asked about our opinion of the cloud point method for determining moisture content. I told him we had long ago abandoned it in favor of the Fischer method and he was entirely in agreement. However, he remarked that they had a method which he regarded as more satisfactory than even the Fisher method but did not give it to us.

Chlorine Supply

Marbury particularly asked whether I knew any reason why they should be concerned about supply of chlorine for their increased requirements of Aroclor 1254. I told them that nothing that I knew indicated a shortage at present. There is a rumor of a huge new war demand for chlorine that may break at any time, but I have taken this rumor with a grain of salt and thought it unwise to mention it to them.

Crystals in Aroclor 1254

Dr. Evans told me that in some of their Aroclor 1254 pipe lines there had been found crystals containing copper, iron, and an organic material that could be extracted with benzene and that crystallized before evaporation of the benzene. A sample was obtained.

Power Factor

Dr. Berberich was particularly interested in F. M. Clark's curve (U. S. Patent) showing a minimum power factor at the pentachlor stage in the Aroclor series. Neither he nor Dr. Hill (whom I saw the following day) believed the curve correct and asked for fresh samples of Aroclors with higher and lower chlorine contents so as to check the data. Two- quart xamples have been sent of Aroclors 1242, 1248, and 1260.

Treating Clay

Westinghouse uses a "hard burned" fuller's earth which had been treated to 900°F during the calcining process. It is obtained as 100 mesh material from the Florida Co. and is designated as XXF Florex B adsorbent. Before use it is heated to 225°-250°C for 24 hours and is then stored in a room at 100°C until needed.

They have found it much more effective than Attapulgus earth, particularly in lowering the power factor of the Aroclor.

We will obtain samples.

Mr. Marbury asked for a copy of the Aroclor booklet. I left my copy with Dr. Evans.

MEETING OF OCTOBER 15.

The entire afternoon of October 14 was taken up with discussions of specifications and related subjects. I went back the following morning on invitation of Dr. C. F. Hill, manager of the Insulation Division of Research, who is an old friend. Dr. Berberich and Dr. Evans were present part of the morning.

Dr. Berberich gave some details of the evaporation tests he had mentioned the day before. Actually there were distillation tests using an A. S. T. M. distillation flask without fractuating column and at 1 mm pressure. Weights were not given.

	Distilling Range	Power Factor	Light Transmission (Percent)	Cl Per Cent
Original Aroclor 1254	-	.13	not given	54.9
Fraction 1	100°-134°C	.20	79.2%	52.5
Fraction 2	134°-140°C	.09	79.0	53.6
Fraction 3	140°-147°C	.08	77.9	55.4
Residue	-	.13	50.5	58.0

The test showed that removal of a low boiling fraction reduced (improved) the power factor but it seems to me a much more direct and practical test could be devised for determining the effect of hot vacuum storage on power factor of Aroclor 1254.

Dr. Hill remembered that the lower Aroclors are not as stable electrically as Aroclor 1254.

Dr. Berberich has observed that the color of Aroclor 1254 is removed* from some samples and not from others and was particularly interested in just what the color is due to. This is a point on which we have little information except that it is not due to ferric chloride (which imparts a similar color to white Aroclor) and is probably due to minute traces of highly colored organic compounds. I told them a spectrographic study is now being made of Aroclor 1254. (It should be noted that the German equivalent of Aroclor 1254 - Clophen - is water white).

I was impressed by the difference in attitude of Hill's group as compared to Clark's group at G. E. Co. The former is inclined toward the academic research approach with a yen for detail and a desire to know the reason why for each new observation while Clark is more the practical application man who is satisfied once he has obtained the desired result.

There is a real rivalry between the two laboratories. In spite of the fact that Westinghouse and General Electric have had a cross-licensing agreement for many years each wants to come out first with a new development and each is inclined to minimize the new things developed by the others.

*By their fuller's earth treatment.

I avoided mention of G. E. Co., but Dr. Hill insisted on bringing up the subject, telling me once that on these occasions when Westinghouse had beat G. E. to a new development, Clark would usually work for a period of time to get something better and then often had to give up and take a license from Westinghouse after all. He said laughingly that sometimes the tables were turned.

At another time, he said that Swann had offered Westinghouse the Aroclor development before he had offered it to G. E. Co., but Westinghouse had not seen fit to follow it up at that time, in part because Swann had wanted Westinghouse to put capital into it. This does not seem to me entirely accurate.

Air-Cooled Transformers

F. M. Clark of G. E. Co. has mentioned on several occasions that Westinghouse was pushing air-cooled or nitrogen-filled transformers in place of Aroclor-filled transformers. Clark has insisted that Westinghouse are off on the wrong track.

I asked Hill what they were doing in air-cooled transformers. He said they were pushing them and were selling quantities for use on shipboard and for use in factories where it was not convenient to place the transformer in a fire-proof housing. I picked this up, saying that I understood the Underwriters Laboratories had approved Inerteen-filled transformers for use in any location without a fire-proof housing. He did not directly answer this comment but said that the Navy claims that any type of liquid-filled transformer is dangerous on shipboard. If the transformer is smashed in action any liquid, even non-flammable Inerteen, is a nuisance and even may be a real hazard.

He said he did not regard Inerteen -filled transformers as being safe even in factories or other indoor locations unless enclosed in a fire-proof housing. He cited the case of one such transformer located in an underground chamber not closed off from the basement of a building in New York (?), which had exploded due to a short within the transformer and had spread hot Inerteen and fumes into the basement.

I expressed surprise that an Inerteen-filled transformer would explode at all (in view of G. E. tests on this point--which I did not mention), but he insisted this may occur as a result of a bad arc within the case and would give rise to poisonous gases. I remarked that careful tests (by the Underwriters' Laboratories) had shown no highly toxic gas (phosgene) is formed by action of an arc on Aroclor. He admitted that might be true but HCl gas is formed, which is true. (G. E. Co. at one time talked of including an HCl absorber in the transformer. I do not know whether it is installed in current models)

I know that G. E. Co. have very carefully investigated the hazards in connection with Pyranol-filled transformers and I believe they are currently advertising the safety feature when such transformers are located adjacent to machines in factories, emphasizing that no protective housing need be employed. I plan to ask Clark when I next see him whether they have ever had any accidets with a Pyranol-filled transformer. The explosion referred to by Hill might have been with their old Inerteen formulation which contained chlorinated toluene in addition to the Aroclor--T.C.B. used by G. E. Co.

At present, Westinghouse can build air-cooled transformers for voltages up to only 13.8 kilovolts. These transformers must pass a test at 39 kilovolts but are considered safe for use only up to 13.8 kv. The reason for the limit is the relatively low dielectric strength of air as compared to oil or Iverteen. My impression had been that their transformers were sealed in a dry nitrogen atmosphere but the photographs did not so indicate and they did not offer any enlightening comments when I asked about nitrogen-filled transformers.

Dr. Hill remarked that G. E. Co. are now building air-cooled transformers--which was a surprise to me.

Santowaxes and HB-40

Santowaxes were discussed in considerable detail. There was no place where they saw they would fit for the moment, but Dr. Berberich asked for samples an will try ideas as they occur to him. The samples have been sent.

Dr. Hill was interested in HB-40 and particularly asked about its resistance to oxidation. A sample has been sent for his examination. He remarked that oxidation tests might be run by Dr. Balsbaugh of M.I.T. who has been running such tests for a group of electric-equipment manufacturers. He would not promise, but I believe he will make the arrangements.

Complete data sheets on Santowaxes and HB-40 will sent to Dr. Hill.

Aroclor 5442

I told Dr. Hill that Aroclor 5442 has the highest dielectric constant of any in the 5400 series and is comparable with Aroclor 1242 but of much lower vapor pressure and higher pour point. He was interested in a sample which will be sent.

Vinyl Terphenyl

While we were discussing Santowaxes, Dr. Evans asked whether we had made vinyl terphenyl (diphenyl styrene). I told him this was in our program but we had not yet made it. Dr. Hill then raised the question of Springfield's Styramic (about which I claimed no specific knowledge). He said if this material could be raised in softening point to 125°C, they would be much interested in it.

At lunch with Dr. Hill and Dr. Berberich, Dr. Hill brought the subject up again. He said they had made vinyl diphenyl (phenyl styrene) and had copolymerized it with styrene in an effort to raise the softening point of the polystyrene. (This is what Springfield plans to do. They have asked us to make vinyl diphenyl for this purpose). The polystyrene is of great interest to them as a low-loss dielectric but has too low a softening point. The vinyl diphenyl raised the softening point to about 92°C (from about 82°C for their polystyrene) but this was not enough and further it rendered the plastic too brittle. If plasticizers were added, the brittleness could be overcome, but the softening point was lowered.

I suggested the copolymerization of a very small amount of butadiene with the styrene-vinyl diphinyl mixture with the idea that this might overcome the brittleness without appreciably lowering the softening point.

Later, in Dayton, this was discussed with Dr. Thomas. He is to supply special samples of certain styrene copolymers that I will submit to Dr. Hill.

Dr. Hill had been interested in vinyl carbazole which they could polymerize to give a plastic with 150°C softening point. However the product was much too brittle. I suggested they try HB-40 as a plasticizer.

Rust Proofing

I took the liberty of asking Dr. Hill whether they were interested in a temporary rustproofing procedure for steel which we had worked out by us and which left no oil or grease on the surface of the metal. He knew of no need but will keep it in mind. He mentioned Mr. H. D. Holler of the Chemical and Metallurgical Division of the Research Laboratory as the man to contact on this, but I did not have an opportunity to do so.

R. L. Jenkins

AB
10-22-42