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Investigation of the Printing Evaluation of Gloss Ink Holdout of Finished Papers

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"INVESTIGATION OF THE PRINTING EVALUATION OF GLOSS INK HOLDOUT ON FINISHED PAPERS"

by

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ABSTRACT

Gloss ink holdout is a description of an end result of a process involving many variables. The variables are the receptivity or absorbancy of the sheet for ink, the rate of penetration of the ink into the sheet, and the amount and type of ink used.

This experiment kept the amount and type of ink constant and looked at the absorbancy of the sheet and the penetration of the ink into the sheet.

The IGT Printability Tester was used to apply the ink, an infrared heat lamp to dry the sample, and the Hunterlab Glossmeter to measure the gloss. The sample sheets were evaluated after different ink penetration periods.

The results showed that as penetration time increased the ink gloss decreased. The longer the ink was on the press, the lower the ink gloss. Also the amount of adhesive in the coating and the type of sheet, whether offset, letterpress, or rotogravure, influences the results.

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INTRODUCTION

The purpose of this experiment was to investigate the property gloss ink holdout. The methods used in the past were investigated and discussed and were found lacking in their ability to truely define this mechanism. The method used here was of our own design but using available equipment. The results are discussed and compared to results from the K & N test, which is the most popular test method used today.

HISTORICAL BACKGROUND

Since the ink gloss of the sheet seemed to be dependent on its relation to the vehicle in the ink; measurement of gloss ink holdout began with the oil absorption tests.

One of the first tests was the oil drop test where a drop of oil was placed on a sheet and the time for complete penetration was measured (1). In some cases, the change in light transmission was measured. Another method was the oil flotation test which involved setting a sample on a bath of oil and measuring the time needed for penetration through the sheet (2).

Since complete penetration or heavy penetration of oil is not encountered in the actual printing process, the previous test methods give results that do not mean much as far as printing is concerned.

The Vanceometer was developed to measure the loss in gloss of a sample that had a certain amount of oil applied to it. The test measured the change in gloss from the moment of application until complete penetration occurred. The use of oil allowed the base gloss to show through and this influenced the results. Thinned inks have been used to try to overcome the influence of the base gloss, but the thinned inks were not representative of inks used in printing. So what meaning the results could have were questioned. Also the ink or oil film produced was too thick and nonuniform to give precise results (1).

Many ink absorption tests have been developed to try to give more meaningful results. One test involved placing a paper sample in a pool of ink and measure the time for complete penetration. Another method placed a drop of ink on a sheet and then rolled a cylinder over it. Then observing the pattern produced. Another test applied a thick layer of ink to a sample and after certain time intervals, blotted the excess off. Absorbancy was then determined by gravimetric procedures (1).

These test results did not correlate well with actual printing results, probably because the test methods did not approach printing conditions. Problem areas were the inks used, ink thickness, and printing pressures and speeds.

Porosity measurements, which are an indication of the pore structure of the sheet ,have been used as an indication of gloss ink holdout. But correlation studies show that they are not effective for predicting gloss ink holdout tendencies (3).

The K & N ink test is one of the most popular methods used today for testing ink receptivity (4). This test is run by smearing or drawing down a thick film of ink on the sheet and after a designated time (two minutes) the ink is removed from the sheet, by wiping it off, leaving an ink stain. This ink stain is then evaluated by eye or with an optical instrument. This test gives a good indication of a sheet's ink absorbing properties, but the test results may vary with the person running the test and so this puts the reproducability and reliability of the test in doubt.

The use of a printing press has also been used to apply the ink as a testing method, and then measuring the time for complete disappearance of gloss or measuring the loss of gloss after specified intervals. This test best compares with actual printing conditions, but the gloss cannot be measured for ten to twenty seconds after printing and this can be considered the critical period (3).

There are numerous other testing methods used which are related to the before mentioned tests. Each of those mentioned and not mentioned has its advantages and disadvantages and does not seem to fulfill the requirements of a standard testing procedure that fully describes the gloss ink holdout mechanism.

EXPERIMENTAL DESIGN

The specific equipment used was that available or easily attainable. Other methods of measuring gloss, for example, could have been used.

The IGT Printability Tester was chosen as the means of applying the ink to the sheet. It has the capability of controlling the ink film thickness, the printing pressure, and the printing speed. The actual operation of transferring the ink to the sample simulated an offset press.

After printing the samples and letting the ink penetrate for designated time periods, the samples were dried by an infrared heat lamp. The lamp was placed five inches above the samples and turned on for ten seconds of drying time for each sample. The object of using the heat lamp was to be able to stop the ink penetration quickly after different time intervals.

The Hunterlab Multipurpose Glossmeter was used for measuring the gloss of the base sheets and the ink gloss of the printed sheet. The measurement of gloss was chosen over other measurements because it was felt that gloss measurement would reveal more about the gloss holdout mechanism than any others.

The ink used was a black, heat set, offset ink. Heat set ink is a type that dries quickly after the application of heat. The specific type used was obtained from Inmont Corporation and had the code:

734-1676/B-1676

The actual testing procedure is described in the following paragraphs.

The IGT Printability Tester is set at 30 kgf printing pressure for rotogravure sheets, and 35 kgf for offset and letterpress sheets. The printing speed is set to be constant and at one m/s.

The heat lamp is placed so it will be five inches above the samples.

One cm^3 of ink is applied to the right side of the IGT inking section and the rolls are allowed to run for four minutes and then the rubber roll is reversed and then allowed to run for another four minutes to distribute the ink evenly.

The three cm wide disc is set on the inked rolls and let run for 1 1/2 minutes.

The paper sample (previously cut at 1 3/4" X 12") is placed on the IGT printer.

After printing four strips, 0.15 cm^3 of ink is added to the rolls and they are allowed to run for four minutes to again distribute the ink. The disc is then reinked for another 1 1/2 minutes prior to printing.

The procedure is repeated until 16 strips have been printed, then the inking rolls and disc must be totally cleaned and then totally reinked.

The samples are allowed to dry, since some parts of the strips may not have been dried by the heat lamp, and then they are measured on the glossmeter at 75° angle.

The paper samples used are listed below:

	Parts Adhesive	Type of Adhesive	Type of Sheet
A	18-20	starch	letterpress
B	8	protein - latex	rotogravure
C	8	protein - latex	rotogravure
D	17	starch - latex	offset
E	19	starch - latex	offset

DISCUSSION

Gloss ink holdout depends on a balance between stock and ink properties, plus a time element that influences this balance. Printing conditions, such as ink film thickness, also play a part (5).

Gloss is the capacity of a surface to reflect light. On a printed surface the gloss is thus dependent on the base sheet gloss and the sheets ink receptivity characteristics. The sheet characteristic of greatest importance to gloss ink holdout is the pore structure. This structure is different on the surface than it is below. The relative size and number of pores or capillary elements in the sheet regulates the amount and rate of ink penetration. The surface pore structure can be changed by sizing, calendering, or other treatment.

The ink used is an important factor in the final print appearance. The ink is made up of pigment, vehicle and drier. The pigment gives the ink color and other characteristics such as light resistance. The vehicle is the medium the pigment is dispersed in, it can be a mineral oil, varnish , or a volatile solvent. The drier helps to dry the ink after application.

The ink can be thought to be a network of capillaries formed by the pigment particles in the ink. This capillary size controls the rate of penetration of vehicle into the sheet. That is after the initial penetration caused by printing pressure. The inks drying time is also important and is dependent on the type of vehicle used and the nature of the drier. The penetration of the vehicle depends on the balance between the pore structure and the setting time of the ink (3).

These variables, ink drying time, ink penetration, and the absorbancy (pore structure) of the sheet, all determine the gloss ink holdout (6). They determine the amount of vehicle that will penetrate the sheet and the amount that will be left on the surface. This amount left on the surface determines the ink gloss of the sheet. High holdout keeps more vehicle on the surface with the pigment particles to give a high gloss when dry. Low holdout permits more of the vehicle to penetrate the sheet leaving less on the surface with the pigment and producing a low ink gloss. The balance of ink penetration rate, ink drying time, and the sheet's ink absorbancy needed for good gloss ink holdout makes it difficult to analyze a sheet for holdout properties, since the ink plays such a big part.

There are other factors that affect gloss ink holdout. Temperature is one of the more important; although it doesn't directly affect the mechanism. It affects the viscosity of the ink which can change its penetration rate. Humidity and pressure also affect holdout, but to such a small degree that they can easily be controlled (7).

The way that this experiment approaches the problem of measuring gloss ink holdout is to control the variables that may indirectly affect the results (temperature, etc.). To keep constant variables such as ink film thickness, printing pressure, and printing speed. Then to make the ink application simulate actual printing conditions as much as possible.

Running the experiment in a humidity lab kept humidity, temperature and other atmospheric conditions constant. The use of the IGT Printability Tester made it possible to control the printing pressure and speed and its printing process is very similar to the offset process.

Only one ink was used to prevent ink variations from affecting the results. A black, offset, heat set ink was used.

An infrared heat lamp was used to dry the printed samples. The combination of the heat lamp and the heat set ink made it possible to completely stop the ink penetration whenever desired.

By letting the ink penetrate into the sheet for different lengths of time, it was possible to look at the sheets receptivity characteristics. That is how fast will the sheet absorb the ink, and how much will it absorb.

The measurement of gloss at these different lengths of penetration time (for this experiment, times of 5, 10, 15, 20, 25, 30 seconds and one day were used) shows the rate of decrease of gloss over time which is an indication of the sheet's gloss ink holdout.

For example, the ink glosses of two sheets may be similar after a certain penetration time, but at a later time one could be considerably higher than the other. This tells more about a sheet's receptivity characteritstics than just knowing the glosses at only one of the times.

The order of printing, that is whether it was printed in the first or last part of each run of 16 samples, seemed to also effect the samples results. This could be an indication of the sheets suitability for printing. Meaning that slight variations in either ink film thickness or ink characteristics, caused by the length of time the ink is on the press, affect some papers more than others in their ink glosses.

The results obtained show that you can look at the ink gloss after different penetration times and that there is a relationship between ink gloss and penetration time that is different for different papers.

The theory that the amount of vehicle left on the sheet's surface determines its gloss, is shown (figure 1) in that as the ink penetration time is increased the ink gloss decreases. It is better shown when looking at the effect of penetration time on the increase in gloss (figure 2). In the case of each sample there is a downward trend of gloss as penetration time increases. Simply then, the more the ink is allowed to penetrate the less vehicle that will remain on the sheet's surface and the lower the ink gloss.

Samples A and B (figure 2) have similar increases in gloss after five seconds of penetration, but after thirty seconds, sample A has a much higher increase in gloss compared to B. After thirty seconds you would be much more sure that A has a higher gloss ink holdout than B than after only five seconds. This shows the advantage of observing the gloss at different times.

When comparing gloss and printing order (figure 3 and 4), there is a slight downward trend of gloss as the printing order increases. Or that samples printed in the latter part of each run have, on the average, lower glosses than the samples printed in the beginning of each run. This is due to either a change in ink characteristics as the ink begins to dry on the rollers, for example causing tackiness and thus increased ink viscosity, or that as each sample is printed the ink content on the rollers decreases sufficiently to cause each subsequent disc to have a lower ink film thickness and so a lower ink thickness on the printed strips. And the addition of 0.15 cm^3 of ink after the printing of every four strips was insufficient to fully replenish the supply of ink on the rolls. In either case, the ink gloss would decrease.

Another observation (figures 3 and 4) was that the results were in some cases erratic. Rising and falling with no predictability. This could be due to the random fashion that the samples were printed. So in one run, a sample might have been printed eighth and its ink penetration time was thirty seconds. The next run the same sample could be printed ninth with a penetration time of five seconds. The sample with penetration time of five seconds would most likely have a higher gloss than the other even though it was printed later.

The order of the results was interesting in that the two offset sheets (E and D) had the highest ink glosses, the letterpress sample (A) followed, and the two rotogravure sheets (B and C) had the lowest glosses. It also showed much about each separate sample's receptivity toward ink and their holdout ability, E having the greatest gloss ink holdout and B the worst.

Three of the samples A, B, and E were tested a second time (nearly two weeks later) to see how reproducible the results were (figures 5 to 8). The second run had slightly higher glosses than the first. There seemed to be a larger difference at the higher glosses. For example, the lower penetration times of each sample had greater gloss differences between the first and second runs than the higher penetration times where the ink glosses were lower, and the differences were larger for sample E than B. This could be due to an instrument problem, which is possible because there were problems in calibrating the glossmeter for the second run. A faulty bulb could also have changed the readings.

Another observation (figures 7 and 8) is that the second run of results are less erractic than the first. This could be because more tests were run on the samples to the second run than the first, giving better averages. Or the operator was more experienced and had developed a better procedure.

Other than the observations already cited, the results compared well enough to say that the test is reproducible. And the discussion about the first holds for the second.

Since the K & N test is today perhaps the most popular in use, it was necessary to compare the results we obtained with results from using the K & N test.

The same samples that were used by our method were tested using the K & N ink test (figure 9). The rotogravure sheets (B and C) had the lowest ink glosses in our method and they also had the lowest holdouts with the K & N test. The letterpress sheet (A) had the highest gloss ink holdout with the K & N test and was ranked third in our method, below the two offset sheets (D and E). E had the highest ink gloss and D was ranked second with our test. With the K & N test D was again ranked second but E was ranked third. So only samples A and E showed much change in ranking between the tests. Sample A is a letterpress sheet and the test method we used is similar to an offset press. This in itself could be the reason that A has the highest holdout with the K & N test and is ranked only third by our method. Sample E is ranked third by the K & N holdout test and has the highest ink gloss by our method. Since E is very similar to sample D, except in the coating, and sample D was ranked second in both tests, the reason for the difference in results between D and E must be the coating. The reason for sample E having better results in our method than the K & N, as far as ranking, is due to a combination of many things. Compared to sample D, which had similar results in both test methods, sample E had a higher adhesive content in the coating, its basis weight was five pounds heavier, and its coating contained delaminated clay and titanium dioxide where sample D did not. This combination gave sample E higher ink gloss readings than D by our test method.

A comparison of test methods show that the K & N test uses no pressure to apply the ink, a thicker layer of ink, and the ink was wiped off. Our test method used a much thinner ink layer, a pressure transfer, and the ink was dried. There is less room for error in our test.

The test method employed for this experiment shows promise in that ink penetration can be stopped and investigated after certain times. The ink film thickness can be controlled along with the printing speed and pressure, and it simulates the action of an offset press.

There are many areas that could be improved. The use of an infrared lamp did not seem to harmfully affect the results but it may well have. The testing time is limited, since the ink begins to dry and pick on the sheets after approximately forty-five minutes of running. The test method does not seem to be suited for testing rotogravure sheets very well.

A standard test could be developed from the work started here. Many mills now use IGT testers to run pick tests and they could easily be modified to test for gloss ink holdout, if the test is proven worthwhile.

Areas in which more work could be done would be the type of ink used, to find an ink that is more stable on the press. The use of another method for drying the sheet. The amount of ink to apply. And other methods for evaluating the samples other than the glossmeter.

CONCLUSIONS

The ink gloss is dependent on the amount of time the ink is given to penetrate the sheet. The longer the ink penetrates the lower the ink gloss.

The ink gloss is dependent on the length of time the ink is on the press. The longer it is on the press the lower the ink gloss.

The method used in this experiment gives fairly reproduciable results.

The method for measuring changes in gloss for different penetration times shows promise as use in the future as a standard test procedure. But more work needs to be done in this area. The paper mills and printers of the future are going to need closer cooperation and better communication to produce most efficiently paper that will print and run well.

There is a relationship between the amount of adhesive and the presence of other materials in the coating to gloss ink holdout.

There is probably a relationship between the type of sheet tested and the offset test method used. Since the offset sheets had the highest glosses and the rotogravure sheets the lowest.

Figure 9

Comparison of K & N Values With Our Method

K & N	AVERAGE GLOSSES 1st Run	AVERAGE GLOSSES 2nd Run
A = 69.8	E = 70.7	74.2
D = 66.1	D = 68.6	
E = 64.5	A = 64.7	66.8
B = 59.0	C = 62.5	
C = 56.5	B = 61.9	61.5

BASE PAPER GLOSS (AVE.)

D	= 57.6
B	= 54.9
E	= 54.3
A	= 54.3
C	= 54.0

BIBLIOGRAPHY

1. Zettlemoyer, Fetsko, Walker, TAPPI 36(2):161-9A, (Feb. 1953).
2. Grantham, Ure, Paper Trade Journal 101(12):29-33, (1935).
3. Fetsko, Zettlemoyer, TAPPI 45(0):670-80, (Aug. 1962).
4. King, Inland Printer, 126(2):61.3, (Nov. 1950).
5. Fetsko, TAPPI 41(2):56-8, (Feb. 1958).
6. Fetsko, TAPPI 42(2):110-21, (Feb. 1959).
7. Paper Trade Journal, 109 (15):19-26, (1939).
8. Pihl, Svensk Papperstidhing, 55:358-62, (1952).
9. Voet ,Brand, Paper Industry 28(3):428,430, (June, 1946).
10. Larocque, Pulp and Paper Magazine of Canada 38 (2):77-74, (1937).
11. Vallandighan, TAPPI, 123 (17):39-42, (1946).
12. Smith ,Paper Industry, 16:626, (1934).
13. Paper Trade Journal, 100 (6):41, (Feb 7, 1935).
14. TAPPI, 50(1):61-7A, (Jan. 1967).
15. Walsh, TAPPI 50 (1):70-2A, (Jan. 1967).
16. Kirk, Baker, TAPPI 53 (11):2126-8, (Nov. 1970).

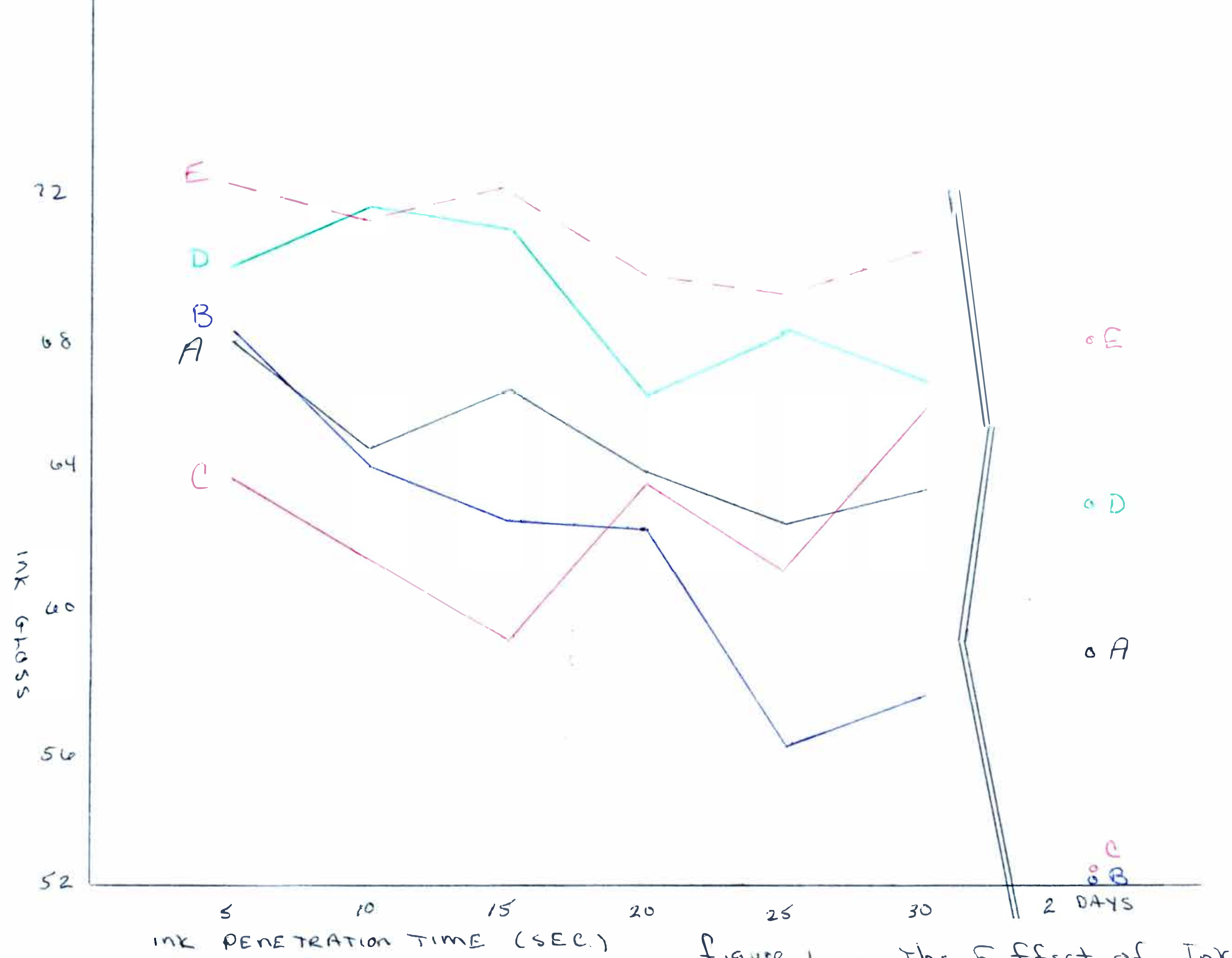

Figure 1 - The Effect of Ink Penetration on Ink Gloss

figure 2- The Effect of Ink penetration on the Increase in Gloss

Figure 3 - The Effect of Presstime* on Ink Gloss

* length of time of the ink on the press

figure 4 - The Effect of Presstime on the INCREASE in gloss

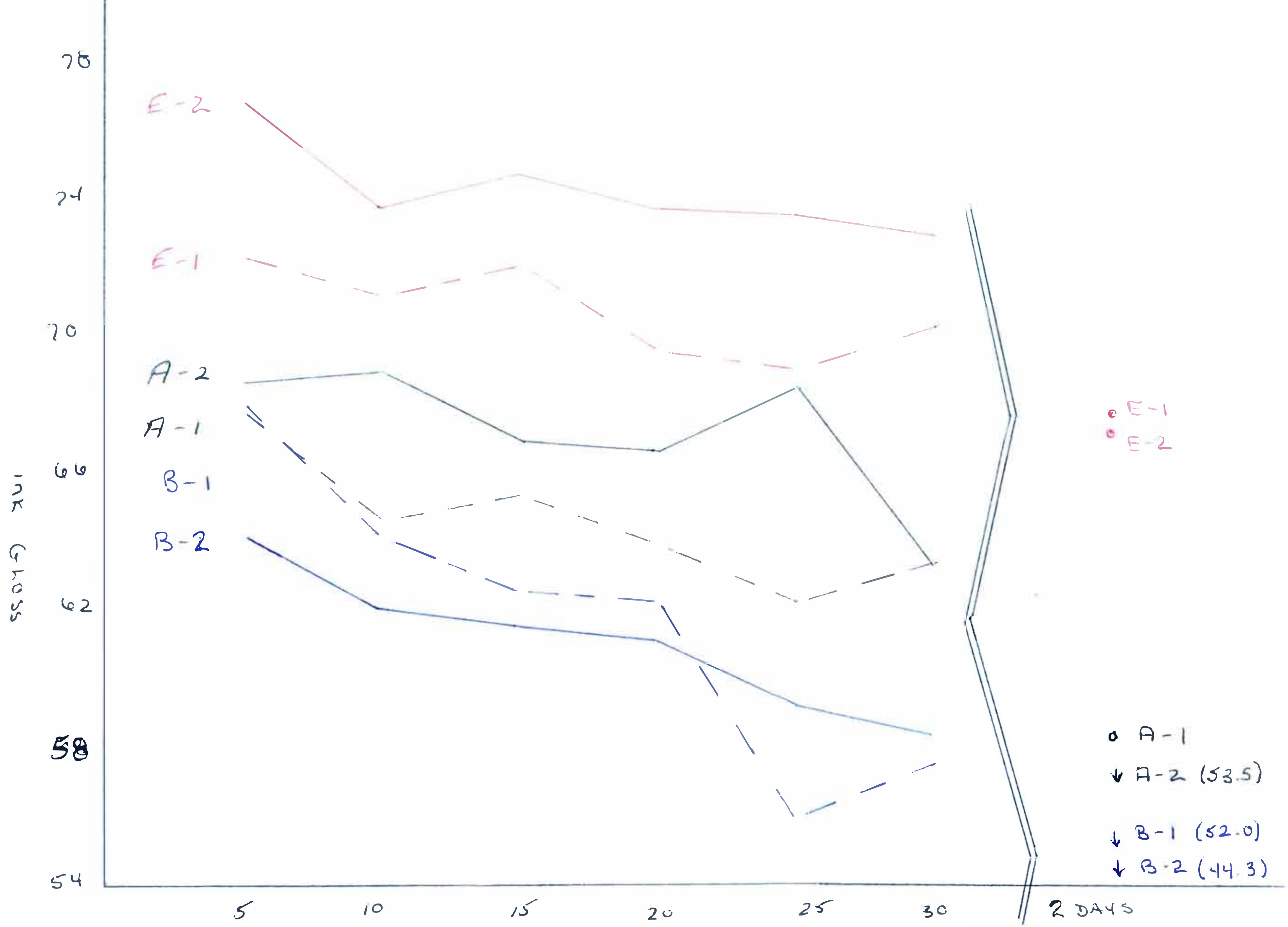

Figure 5- A comparison of the 1st and 2nd Runs on the effect of ink penetration on Ink Gloss

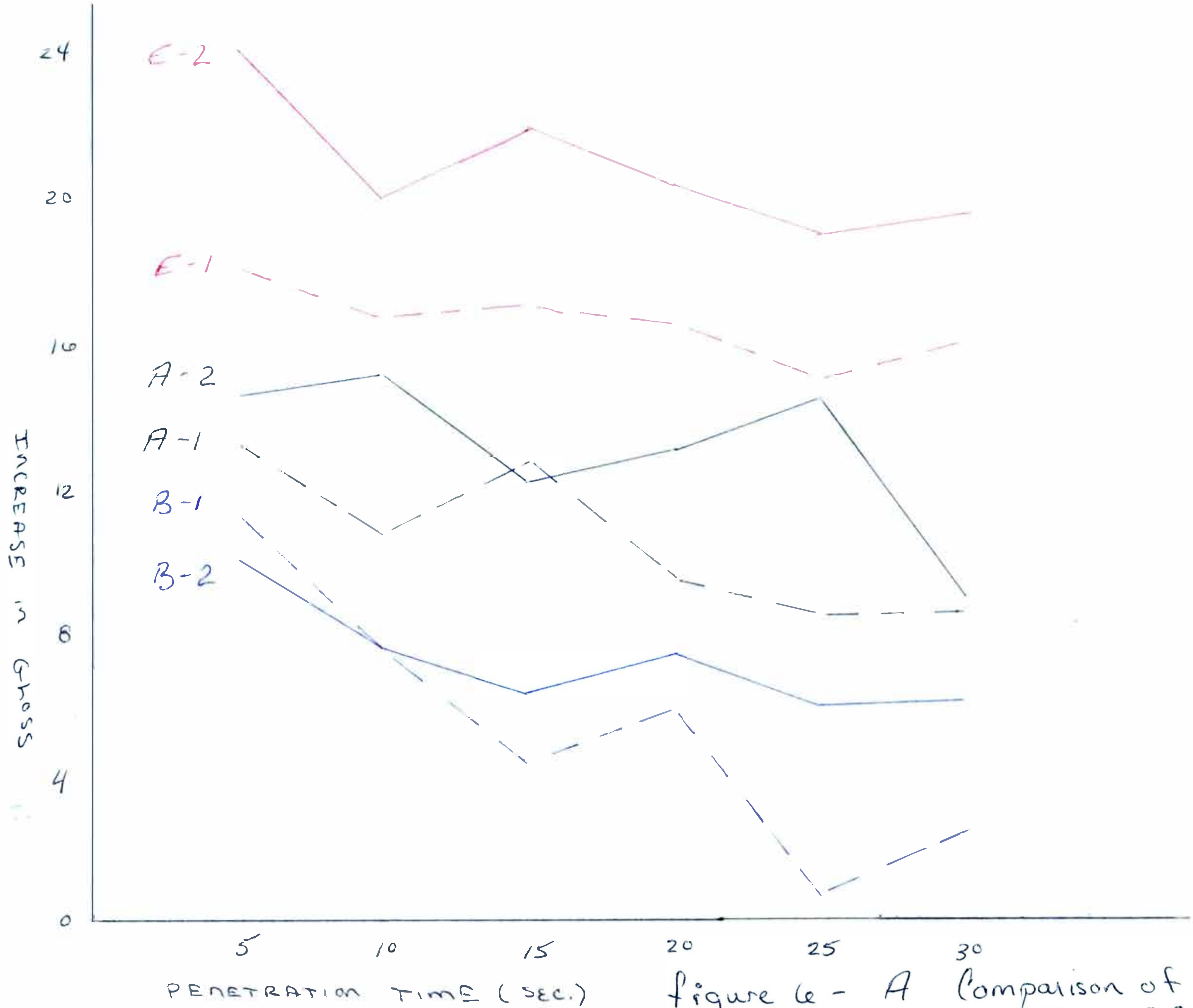

figure 6 - A Comparison of the 1st and 2nd Runs on the effect of penetration on the increase in gloss

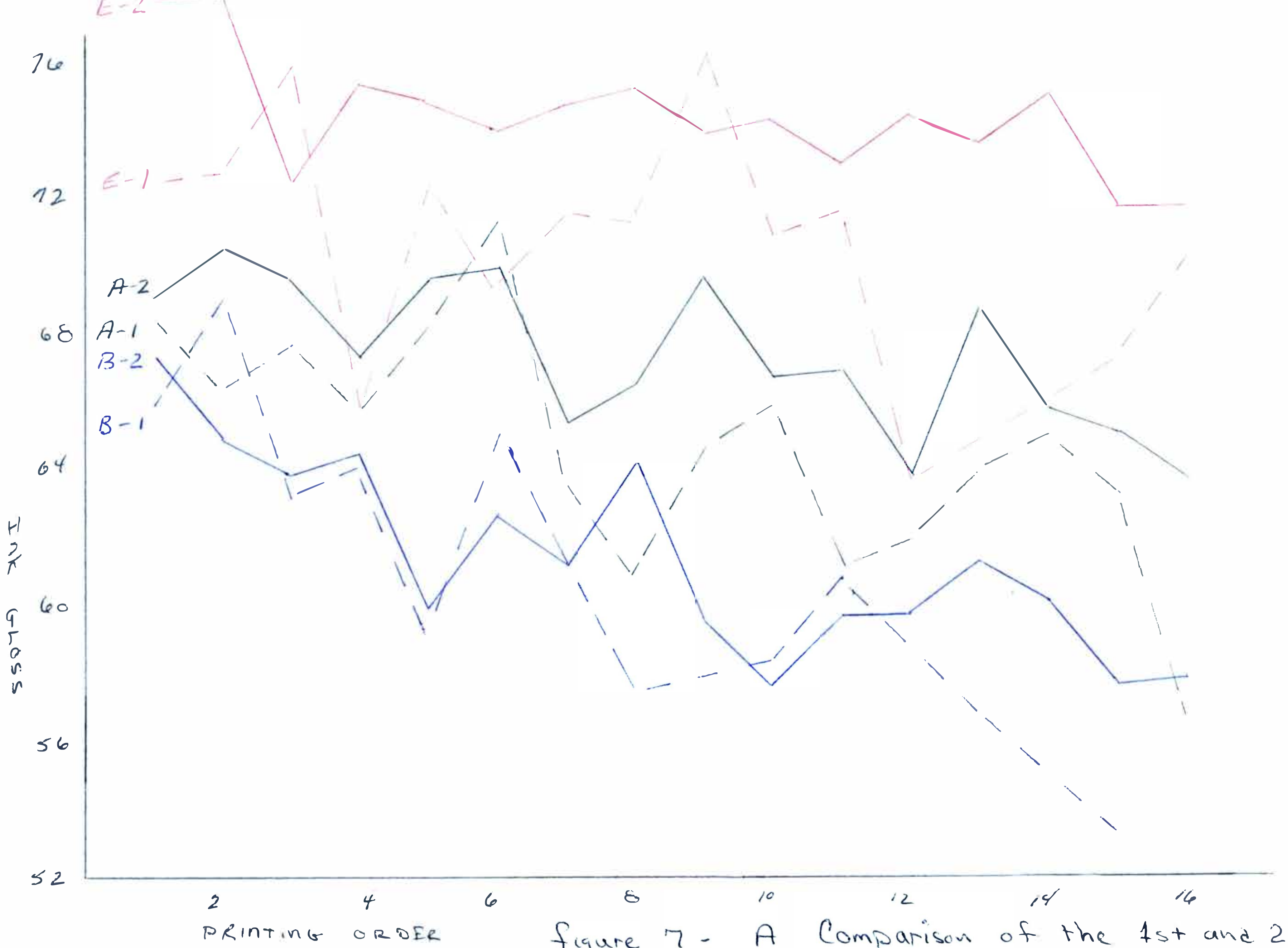

figure 7 - A Comparison of the 1st and 2nd Runs on the effects of Presstime on Ink Gloss

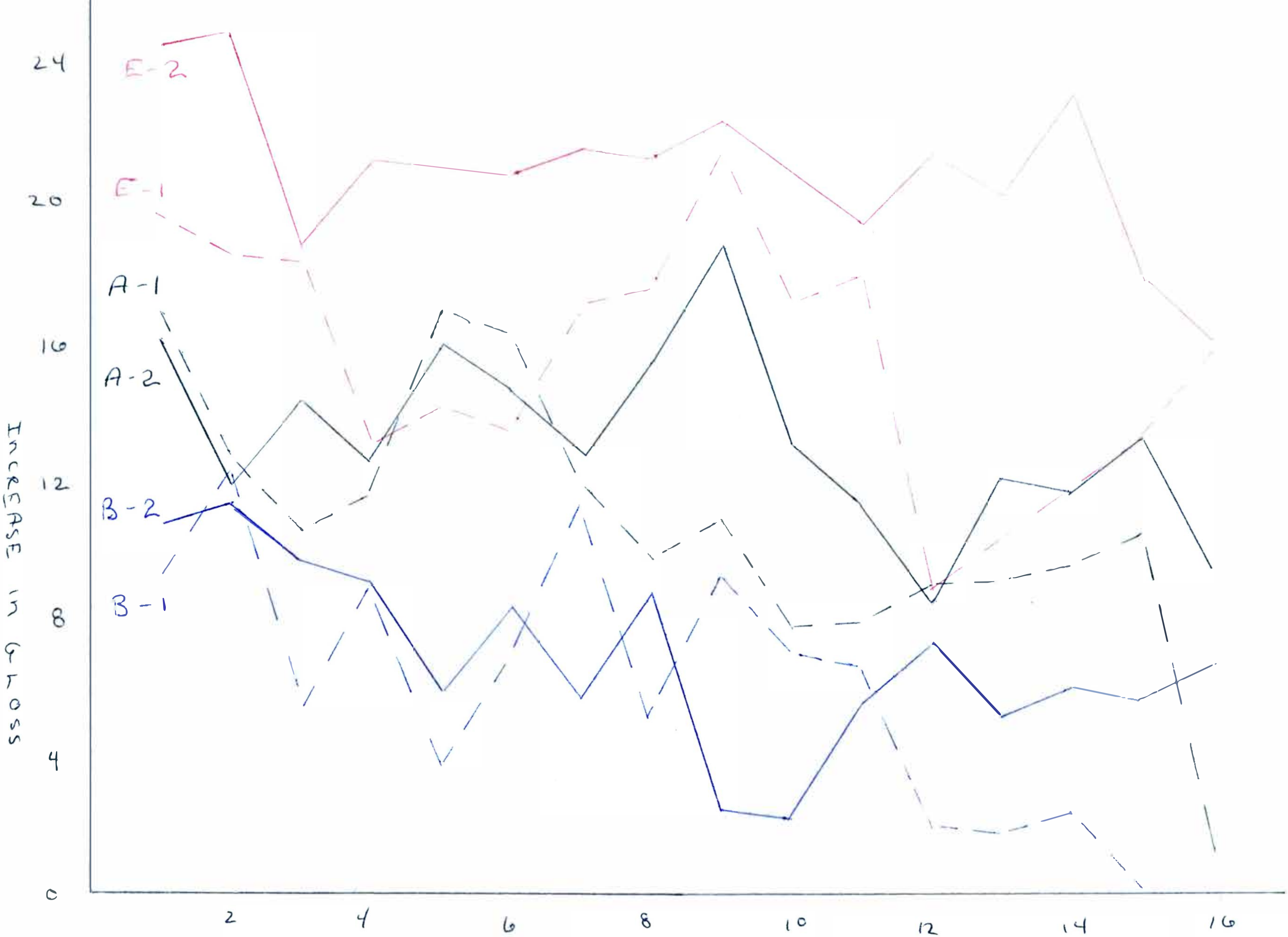

figure 8 - A comparison of the 1st and 2nd Runs on the Effect of Presstime on the Increase in Gloss