3 MAGNETIC COMPUTER TAPE (REHABILITATION) PROCEDURES AND RESULTS 6

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SUMMARY

Cleaning and testing are reviewed, and processes are suggested to rehabilitate used tapes at one-third the cost of new tapes. Tables of the results of pilot runs are included.

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INTRODUCTION

This report is a compilation of the results obtained from a study of methods developed by Goddard Space Flight Center (GSFC) for the rehabilitation of magnetic computer tape. Private industry developed the wet and dry methods of tape cleaning which were further developed and refined by GSFC. The most effective combination of these methods was determined by this study. The study was performed to determine the most efficient method whereby used tapes could be rehabilitated and inserted into a tape library for re-use, to obtain an understanding of the physical changes in the tape during rehabilitation, to measure the quality of processed tapes, and to ascertain the level of quality needed to assure sufficient yield.

There is a continuing need to measure the efficiency of tape rehabilitation. The testing methods, forms, and data reduction formulas developed in this report are designed to permit future updating of data and statistical comparisons between equipment and procedure changes.

DROP-OUTS

Loss of signal (drop-out) is a serious operational problem in the use of magnetic tapes. Signal loss that occurs when the oxide coating on the magnetic tape fails to make perfect contact with the read or write heads on a recorder/reproducer is called "separation loss". This loss may be due to poor head alignment, improper guiding, a build-up of dirt on the heads, or poor quality tape. Only tape quality is considered in this report since the other factors fall under the jurisdiction of computer maintenance and housekeeping practices. Any tape condition which increases the spacing between the oxide coating and the head is significant. The amplitude of signal which can be read back is accurately described by the formula:

$$\text{Loss in db} = 54.5d/\lambda$$

where:

d = separation distance in inches

λ = wave length of recording (packing density)

At 800 bits-per-inch, a separation of 0.0014 inch corresponds to a 6 db signal loss (50 percent).

Loss of signal to 50 percent of the expected return is considered a drop-out for Grade A tape. Tape grading will be discussed later in this report. Before an accurate study can be performed on the efficiency of tape cleaning, the causes of the drop-outs must be identified and classified.

The General Kinetics Inc. Model 7A Magnetic Tape Tester was selected for this study because of the convenience of the viewing station. Because of the angle at which light hits the tape, the identification of causes based on three geometric axes of the tape is most logical.

Geometrically, magnetic tape may be divided into three axes and one plane, as shown in Figure 1. These axes are the longitudinal axis along the length of the tape, the lateral axis along its width, and the transverse axis through the thickness. The major plane is considered to be the oxide side.

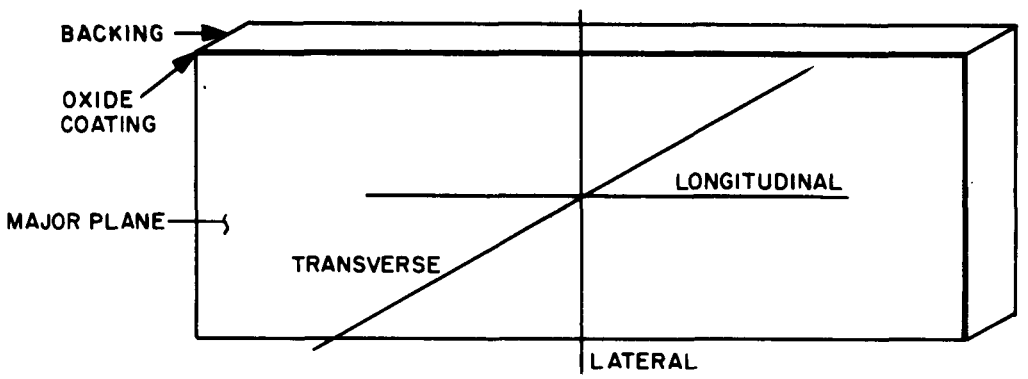

Figure 1. Magnetic Tape Geometry

TYPES OF DROP OUTS

The three-axis references can be used to catalog the errors into three basic types and twelve subtypes. Percentages following type designation indicate distribution of failures in a 103-tape study. Distribution of drop-outs is illustrated in Figure 2.

TYPE I DROP-OUTS, CONTAMINATION

Contamination of the major plane along the transverse axis causes 58.7 percent of all drop-outs. This contamination causes the tape to be separated from the head with corresponding loss of signal. These contaminants may be completely imbedded in, adhered to, or lie loose on the major plane.

The major cause of deterioration of magnetic tape is the redeposit of wear products and dirt on the major plane. The heat generated when the tape passes over the stationary head often tightly adheres these products to the oxide surface of the tape.

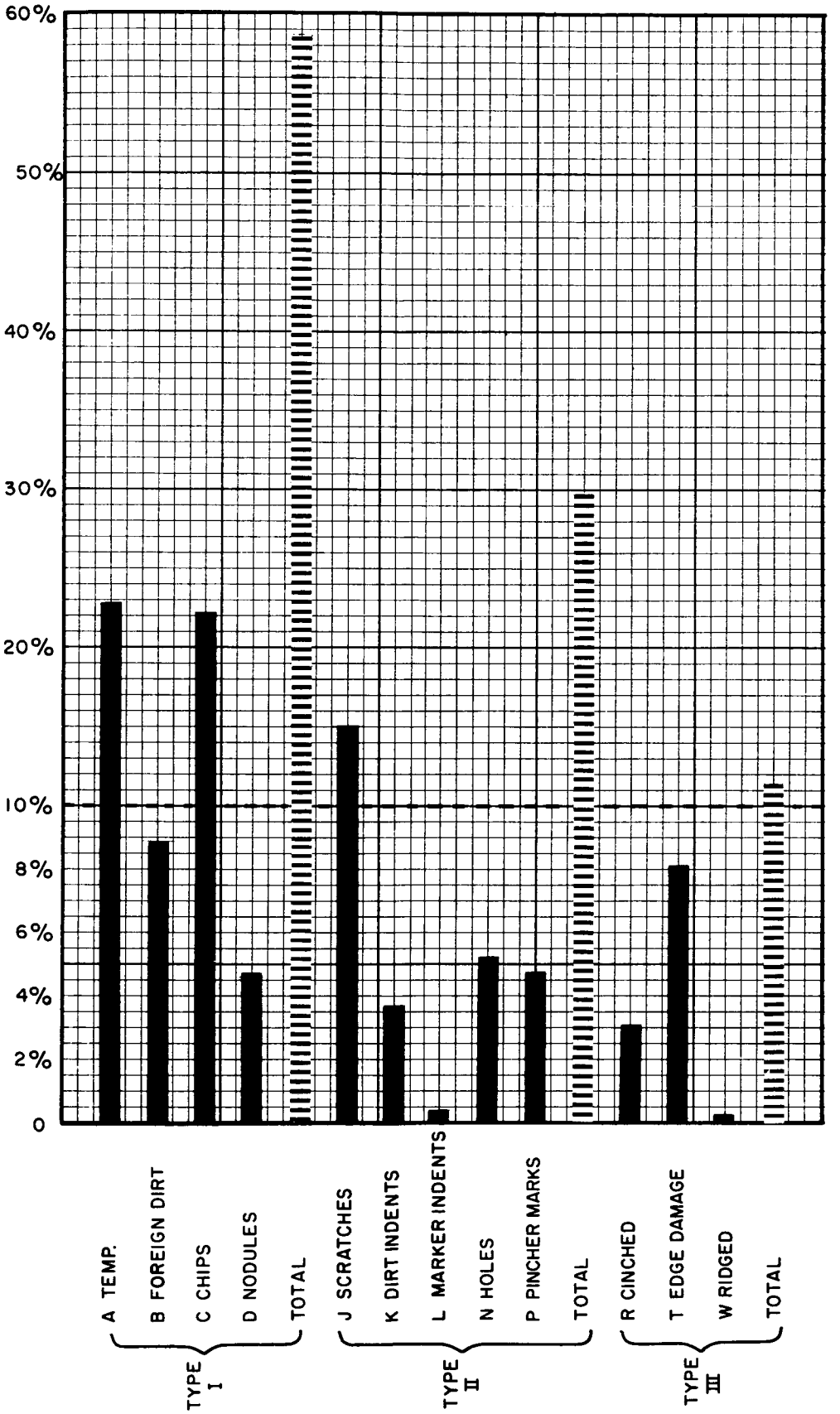

Figure 2. Percentage of Dropouts by Cause

Subtype IA, Temporary Drop-outs

Temporary drop-outs make up 22.9 percent of the total. These drop-outs are caused by dirt or dust which falls off the tape before it reaches the viewing station. These drop-outs cannot be redetected or identified.

Subtype IB, Foreign Dirt

Foreign dirt (Figures 3, 4, and 5), which makes up 8.9 percent of total drop-outs, is caused by unclean tape handlers, or possibly just oxide powder worn off the coated surface.

Subtype IC, Chips

Chips (Figure 6) make up 22.3 percent of the drop-outs. Usually these are pieces of backing which have chipped off and are deposited on the tape during the slitting process, but they also can come from a ragged edge of the tape. In the passage of the tape through the guides or only as a result of the frequent starts and stops of the tape during usage, these chips break off and fall on the oxide surface.

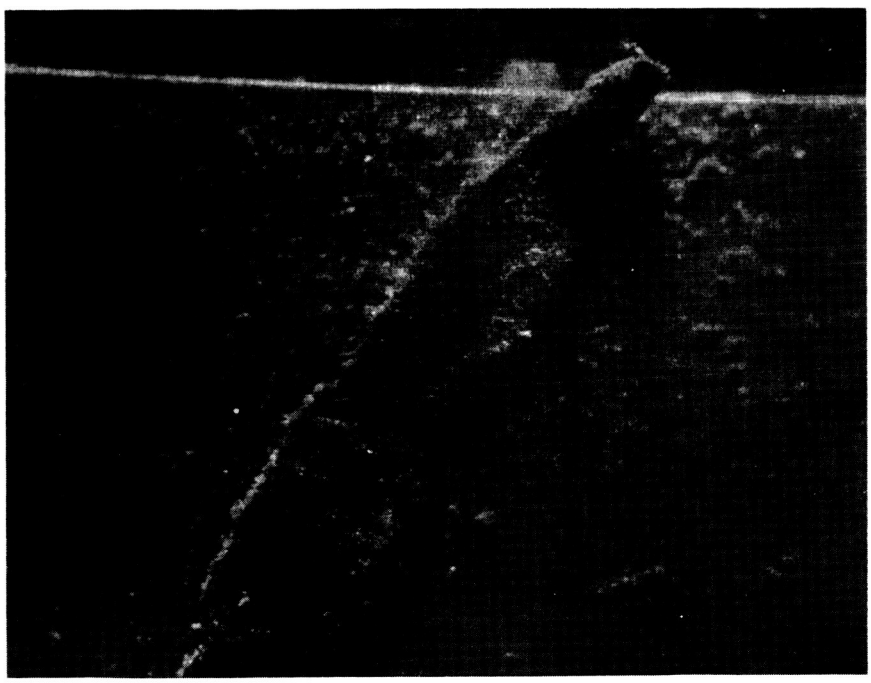

Figure 3. Type IB Drop-out, Deposit, at 70X Magnification

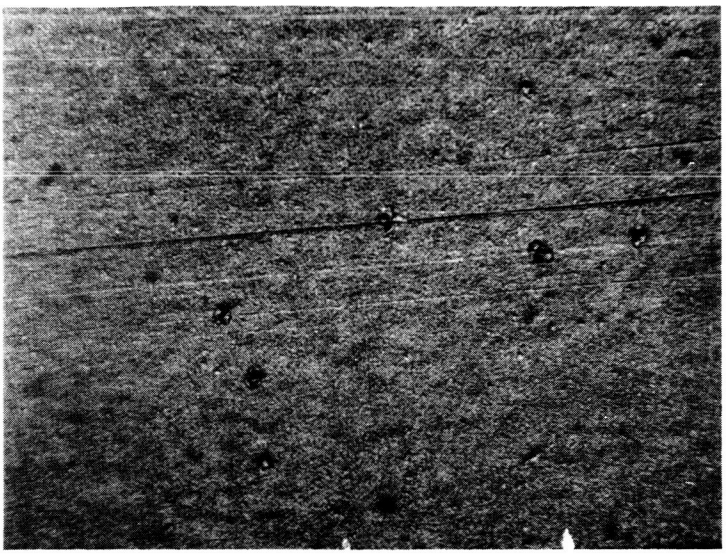

Figure 4. Type IB Drop-outs, Liquid Spattered on Tape

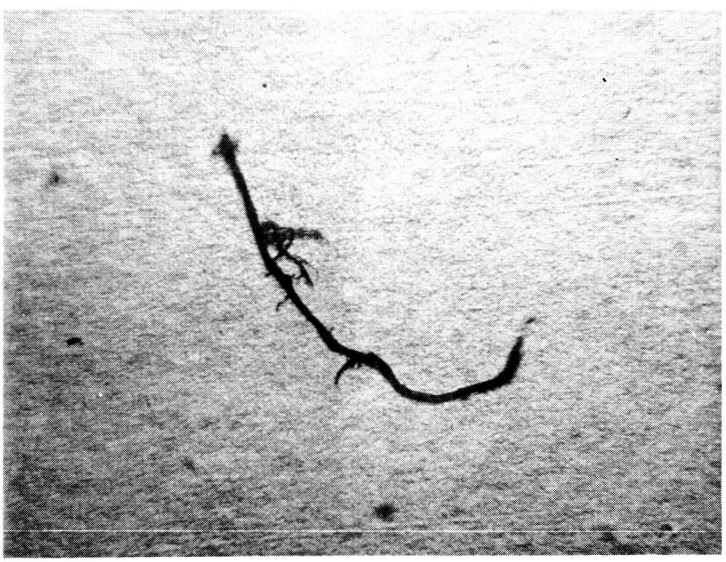

Figure 5. Type IB Drop-out, Fuzz

Figure 6. Type IC Drop-out, Chip Imbedded

Subtype ID, Nodules

Nodules (Figure 7) are a build-up of oxide above the major plane and represent 4.6 percent of the total drop-outs. These may result from a failure of the polishing process or may be grown on the tape from adhered dirt or chips.

Figure 7. Type ID Drop-out, Nodule

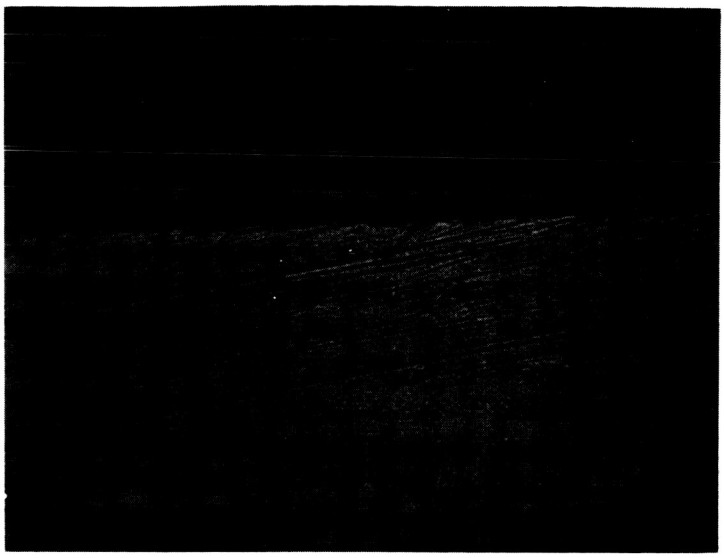

Figure 9. Type IIJ Drop-outs, Scratches

Subtype IIP, Pincher Marks

Pincher marks, which form 5.3 percent of total drop-outs, are lateral grooves caused by a tape handler which uses a pincher to couple the tape to a capstan. Some permanent drop-outs will be bracketed by pincher marks caused when the tape handler was retracing that drop-out.

Subtype IIN, Holes

Holes, caused where a portion of the oxide has been removed from the backing, constitute 4.7 percent of the drop-outs (Figure 10).

TYPE III DROP-OUTS, BACKING DAMAGE

Damage to the Mylar backing causes 11.4 percent of the total drop-outs.

Subtype IIIR, Cinched

Cinching occurs in 3.1 percent of the total drop-outs and is caused when tape is pulled beyond its yield strength or crumpled by handlers. Reels wound without sufficient tension can cause cinching.

TYPE II DROP-OUTS, OXIDE ROUGHNESS

Oxide roughness occurs along the transverse axis, but below the surface of the major plane, and causes 29.9 percent of the drop-outs.

Subtype IIJ, Scratches

Self and foreign dirt on stationary parts of the tape handlers scratch the tape surface along the longitudinal axis (Figures 8 and 9). Most drop-outs are caused by the ridge along the scratch rather than the depth of the trough and contribute 15 percent of total drop-outs.

Subtype IIK, Dirt Indentations

These indentations, which comprise 3.7 percent of total drop-outs, occur when large pieces of foreign dirt get wound into the layers of tape. Because of the cold-flow properties of Mylar, this impression will be telescoped through several layers.

Subtype IIL, Load-marker Indentations

Load-marker indentations, caused by tight winding, occur in 1.2 percent of the drop-outs. The load marker makes indentations through the tape layers near the hub.

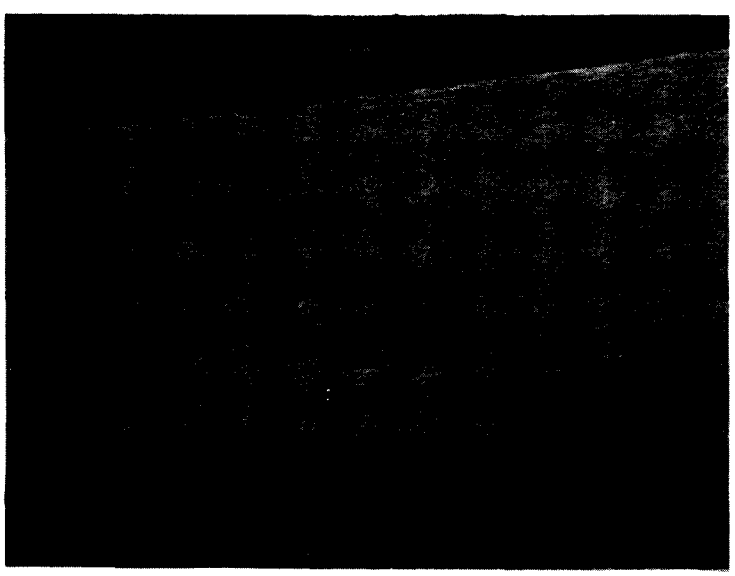

Figure 8. Types IB and IIJ Drop-outs, Foreign Matter and Long Scratch

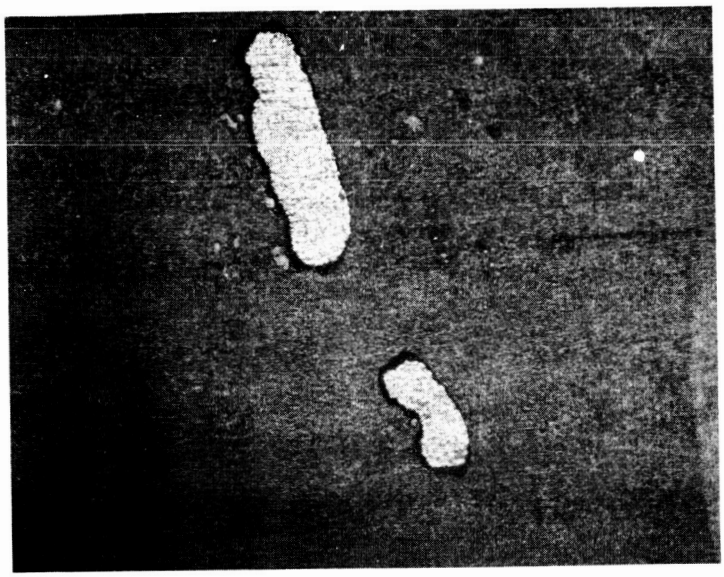

Figure 10. Type IIN Drop-outs, Holes in Oxide

Subtype IIIT, Edge Ripple and Damage

Edge ripple and damage (Figures 11 and 12) cause 8.2 percent of total drop-outs. Edge ripple is a wave on the edge of the tape, caused by excessive tension and poor guide alignment. Edge damage occurs when the edge of the tape is bent or torn as a result of uneven rewind or careless handling, or both.

Figure 11. Type IIIT Drop-out, Edge of Tape Damaged by Slitting Process

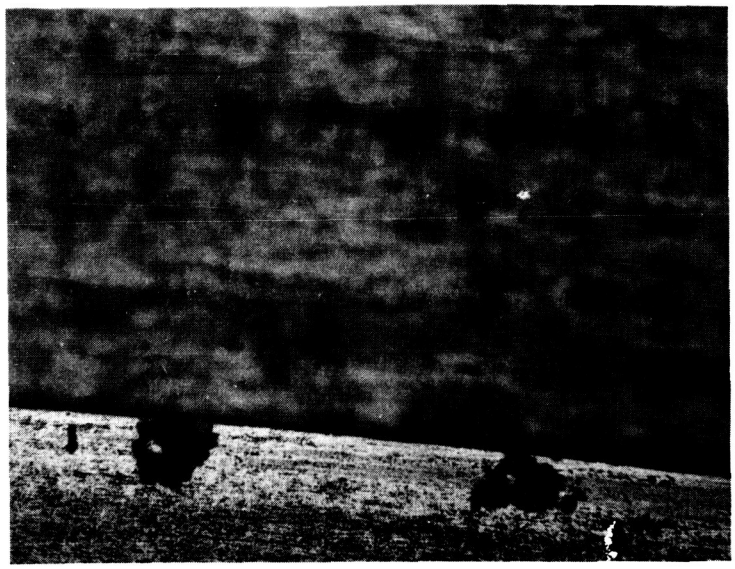

Figure 12. Type IIIT Drop-outs, Oxide Torn Loose at Edge of Tape

Subtype IIIU, End Damage

End damage which is caused by improper tape handling involves the last 25 or 50 feet of tape. End damage was not considered in the analysis of cleaning efficiency in this study. The ends of the tape are merely cut off as one of the last processing steps.

Subtype IIIW, Ridged Impressions

Only 0.1 percent of the drop-outs can be attributed to ridged impressions, which are the build-up through the layers of ridges next to scratches. Plastic flow gives tape a distorted form.

Figure 2 shows a tabulation of drop-outs by cause. A report by the General Services Administration, "Magnetic Computer Tape", dated 1 September 1966, states "45% had one or more forms of distortion and 55% had dirt deposits." If the findings listed in Figure 2 were grouped into the same two categories, they would be 41 and 51 percent, respectively, indicating that the findings of this study are consistent with the findings of diversified tape users.

CLEANING AND TESTING METHODS

Two different cleaning methods, classified as dry cleaning and wet cleaning, were investigated. Although the most effective cleaning is achieved by a combination of both types of cleaning, the methods will be discussed individually.

WET CLEANING

The equipment used for wet cleaning is the General Kinetics Inc., Model CT-2 Kinesonic Tape Cleaner (Figure 13). Tapes are cleaned by passing them through a transducer containing a mild, filtered detergent fluid at a temperature of 120°F. Continuous cavitation is caused in this fluid with accompanying wide-band sonic and ultrasonic agitations. These agitations will, in many cases, pull imbedded particles from the oxide coating. After the tape passes through the transducer, it is subjected to a heated air flow which dries it prior to a high tension wind on a storage reel. The tape is then given a 48-hour relaxation storage. During this storage period, the tape dries and is allowed to regain its equilibrium.

Wet cleaning removes 60 percent of the errors classified as Type I and III drop-outs, but has no effect on Type II. About 75 percent of Type I errors are moved around on the tape. Imbedded chips are the hardest to remove by wet cleaning. Average time to clean one reel is 13 minutes.

DRY CLEANING

The Cybetronics, Inc., Model E-2 Magnetic Tape Cleaner, shown in Figure 14, is used to dry clean tapes. This cleaner places the tape under 8-ounce tension, scrapes the emulsion with a carbide-edged blade, and then wipes both sides of the tape with a treated tissue. During a normal cycle the tape cleans in one direction, stops at the end-of-tape marker, reverses, and cleans in the opposite direction. This process takes 6 minutes.

The operator, at his option, can take control of the process to reclean a portion of tape any time during the cleaning process. A minor disadvantage of this type machine is manifested when cleaning a very dirty tape. Unless manually advanced, the treated tissue will present the same surface to the tape throughout a complete run in one direction. Cleaning efficiency of that surface can deteriorate rapidly as it becomes dirty.

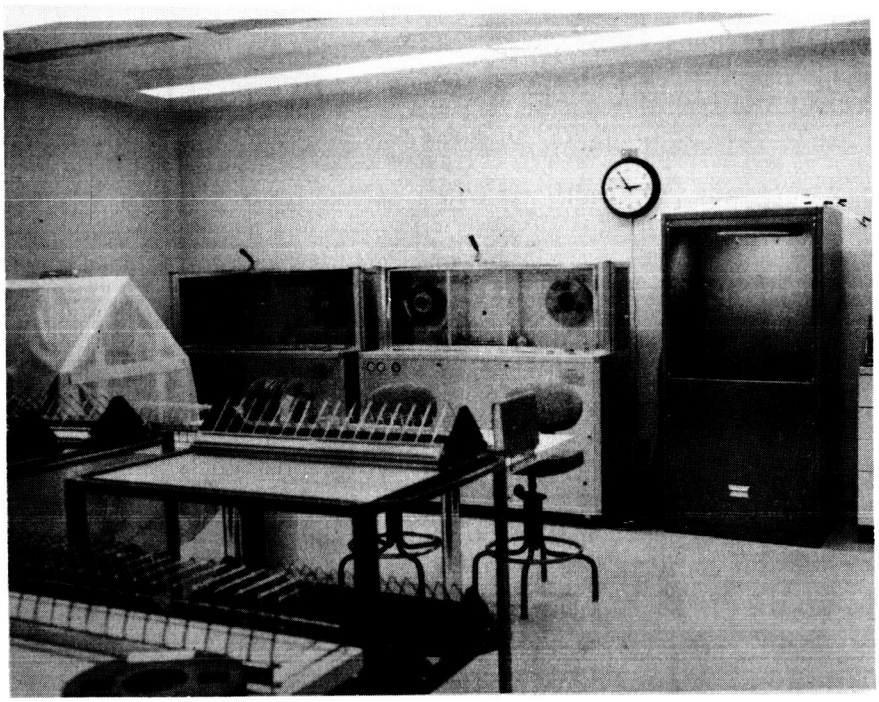

Figure 13. White Room Wet-cleaning and Relaxation Storage Area

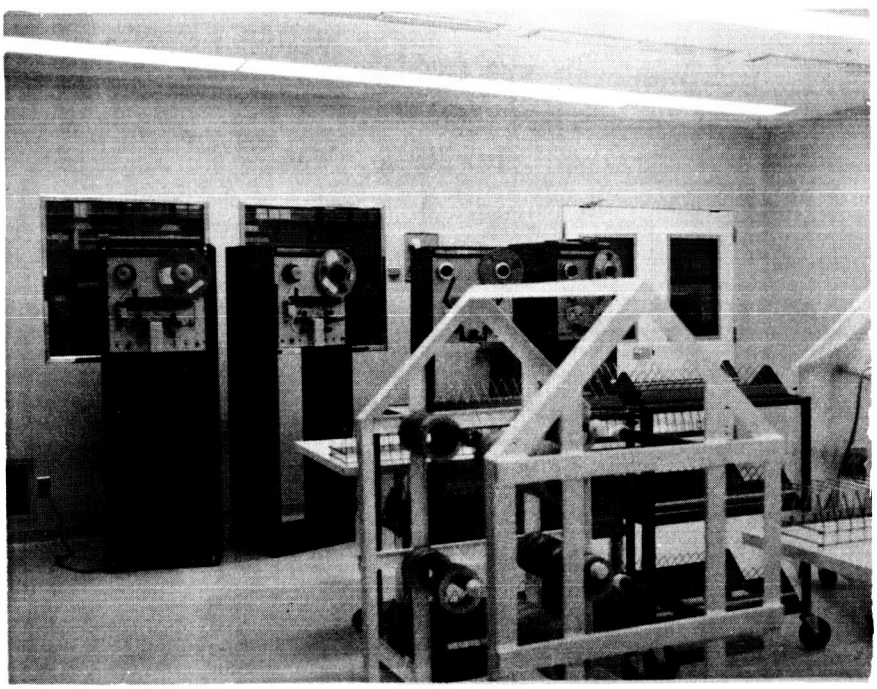

Figure 14. White Room Dry-cleaning Area

Dry cleaning removes 70 percent of the drop-outs. Type II drop-outs are removed by cutting the ridges on each side of a scratch. Although dry cleaning is more efficient in removing drop-outs, one-half of the remaining drop-outs are consistent. Studies have shown that nonrepairable errors fall in a range of 3 to 5 percent of the input errors. This leaves from 10 to 12 percent drop-outs which would have to be removed manually. Manual removal requires a tester/certifier which will automatically locate drop-outs, mark them magnetically, and stop the tape on a work table. This table contains a variable intensity lamp and adjustable magnifiers. Type I drop-outs can then be removed with a scalpel or with Freon TF and a very stiff pig-hair brush.

TESTING

The tester/certifier used in this study is a General Kinetics Model 7A Magnetic Tape Tester, shown in Figure 15. This tester contains the provisions mentioned above for manual inspection and cleaning. Average time to identify and remove a drop-out is 30 seconds.

The Model 7A Tester locates drop-outs by two different methods, noise and signal. In the noise test, the tape is saturated with a permanent magnet. Any anomalies in the emulsion will cause a flux change which will be picked up by the playback head. The signal test is performed by writing and reading back seven tracks of information at 556 or 800 bits-per-inch. The drop-out circuits have adjustable thresholds to set the detection level desired, such as 50 percent of average signal return.

A drop-out detected by either type test causes two other circuits to function. The defect marker circuit magnetically marks the tape so the tester can automatically stop for identification/removal on the return run of the tape. A graphic recorder makes a mark on a chart indicating the footage from the beginning of the reel at which a drop-out occurs. The time necessary to test one tape without any manual cleaning of the tape is 7 minutes, including loading and unloading.

CLEANING EVALUATION

To determine the most effective method of tape rehabilitation, 103 tapes were tested, and the drop-outs classified and divided into two groups of equal magnitude of drop-out count. It was not possible to get an even distribution of drop-out classes.

Figure 15. White Room Certification Area Showing
Two General Kinetics Model 7A Tape Testers

The tapes subjected to the dry-cleaning series had more scratches and cinched tape, but less chips and dust than the tapes which were wet cleaned first. Fifty-one tapes were selected for the dry cleaning cycle. These tapes were dry cleaned, tested, dry cleaned, tested, wet cleaned, tested, and then dry cleaned and tested. The other 52 tapes were subjected to the wet-cleaning cycle which consisted of wet cleaning, testing, dry cleaning, and testing. Thirteen of these 52 tapes still required cleaning and were again wet cleaned, dry cleaned, and tested. During the testing section of each cycle the drop-outs were classified and the location of each drop-out was noted. It could then be determined whether a drop-out was removed or just moved around on the tape.

The drop-out count before and after cleaning is noted in Tables 1 and 2. The following abbreviations are used in the tables:

- No. = Tape control number assigned by laboratory
- A = After
- B = Before
- C = Cleaning

- W = Wet cleaned
- D = Dry cleaned

(Example: AWDC = After wet and dry cleaning)

Tape No. Suffix M = Memorex A = Ampex I = IBM

The tapes with high numbers were extremely dirty; that is, the number of Type I drop-outs was higher than normal. The majority of drop-out increases after cleaning was due to ridges and edge ripple, reflecting the comparative inexperience of the operators. As operator proficiency increased, the number of drop-outs generated during the cleaning process decreased. These drop-outs were predominantly edge ripple, ridges, and cinching. There is no correlation between the magnitude of the drop-outs before and after dry cleaning.

Due to the range of drop-outs per reel (0 to 248), high magnitude tapes would completely obscure an arithmetic total. Table 3 shows the standard distribution of the drop-out counts per reel before and after cleaning. The statistical parameters shown on this chart were computed with the following formulas:

- $S = \sum \sqrt{\frac{(X-M)^2}{N}}$

where:

N = Number of reels

M = Mean drop-out count of the average tape

X = Total drop-outs on tapes under consideration

- UCL (Upper control limit) = M + S
- % = Percentage of tapes that fall under the UCL

To obtain a more accurate determination of cleaning efficiency, expected drop-outs, and consistent drop-outs, only the tapes which fell under the upper control limit were classified in the detailed analysis. Only the classified drop-outs were used to determine the cleaning efficiency. At the bottom of each table of cleaning analysis (Tables 4 through 31) is a notation of unclassified drop-outs; these were on tapes which fell above the upper control limit.

During the cleaning/testing cycles, the certifiers were set to indicate as a drop-out any signal which was less than 50 percent of the expected return level. Modulation noise of the testing equipment and the tape generally runs close to 10 percent

of the signal levels. This 10 percent variation can cause nonrepeatability of the drop-out count. The second pass of a tape generally detects drop-outs which did not appear on the first pass.

To average this inaccuracy, two separate computations are used. In the first computation, the number of drop-outs after cleaning is subtracted from the number of drop-outs present before cleaning, and the difference is divided by the drop-outs before cleaning. This figure is a cleaning efficiency percentage. In the second computation, newly located drop-outs which appeared after cleaning, but not before, are added to the precleaning count. The number of drop-outs which disappeared during the cleaning, instead of the after-cleaning count, is then divided by the sum of the precleaning and post-cleaning figures to reach a second cleaning efficiency percentage. The mean of these two computations may then be used for a comparison of cleaning methods. To reduce the multitude of figures used in this report, and because the sample sizes are small in many cases, only the first computation was used.

Abbreviations and terms used in the illustrations and tables are as follows:

- BC = Before cleaning
- AC = After cleaning
- Ratio = Number of drop-outs due to a specific cause per 100 total drop-outs
- CE = Cleaning efficiency = $\frac{BC-AC}{BC}$
- EDO = Expected drop-outs = Ratio - (Ratio x CE)
- BC&AC = Drop-outs which were present at the same position before and after cleaning
- % = Percentage of drop-outs that are consistent per cause = $\frac{BC \ \& \ AC}{BC \times 100}$
- CDO = Consistent drop-outs = Ratio x %

DRY-CLEANING CYCLE

The first 51 tapes were subjected to the dry-cleaning cycle. A comparison of cleaning efficiency indicates that the dry cleaning cycle removed more drop-outs, but the reject rate is higher with this method.

Dry Cleaning

The first dry cleaning removed 69 percent of the drop-outs. Of the remainder, 58 percent were consistent. Characteristics of the different manufacturers' tapes are immediately evident, although a more detailed study would be required to clearly define all the tape characteristics. Memorex tape does not scratch easily, nor do dirt and dust adhere to it as readily as to IBM and Ampex tapes. There were a number of very small slits in the tape about one-eighth-inch long that were labeled "holes". Only 65 percent of the drop-outs on Memorex and Ampex tapes were removed by the first dry cleaning. Ampex tapes display an affinity for gathering dirt and dust. IBM tape scratches easily; however, most of the IBM tape in this group displayed signs of heavy usage. Due to the efficiency of the dry-cleaning process in removing the ridges on either side of a scratch, the first dry cleaning removed 74 percent of the drop-outs on IBM tape. These tapes had almost three times as many pincher marks as the others. Normally, pincher marks will bracket a permanent drop-out and indicate an area in which tape handlers had been looking for parity.

Dry-Dry Cleaning

The second dry cleaning achieved an overall cleaning efficiency of 85 percent. The number of consistent drop-outs also decreased considerably, to a total of 23 for all tapes in this group.

Dry-Dry-Wet Cleaning

After the second dry cleaning, the tapes were subjected to a wet cleaning. Efficiency decreased to 79.5 percent. This was due to a number of reasons. All Type I drop-outs except nodules increased. Wet cleaning loosens and redeposits dust left on the tape by the dry cleaner. Scratches and marker indentations increased, as well as edge damage and ridges, due to the tight wind incurred in the wet cleaning. Although cleaning efficiency decreased for all three types of tape, the consistent drop-out count dropped slightly to 21.

Dry-Dry-Wet-Dry Cleaning

The dry cleaning process after the wet cleaning removed 55 percent of the remaining drop-outs, but the consistent drop-out count increased to 25. The predominant increase was in Type III consistent drop-outs on Memorex tapes, indicating that they were caused by excessive handling. Cleaning efficiency reached 91 percent, but the remaining drop-outs were sufficient to cause rejection of 20 tapes.

The pattern of drop-outs throughout this method indicated that the wet cleaning process loosens the deposits and removes a large volume of dirt, after which the dry cleaner scrapes the loosened deposits off the major plane of the tape and wipes the tape clean. The second method of cleaning sequences, wet cleaning and then dry cleaning, substantiates this.

WET-CLEANING CYCLE

The wet-cleaning cycle, while not as efficient as the dry cleaning, yields more usable tapes.

Wet Cleaning

The initial wet cleaning only removed 52 percent of the drop-outs, but there were less consistent drop-outs. Less of the total drop-outs were removed than in the initial dry cleaning, but more drop-outs were moved around on the tape.

Wet-Dry Cleaning

A subsequent dry cleaning increased cleaning efficiency to 80 percent, and decreased the consistent drop-out count to 21, or 3.3 percent, well within the permanent drop-out range of 3 to 5 percent. Within the limits of available cleaning equipment this method offers the most effective tape rehabilitation procedure. Although the expected drop-outs had been lowered to 20 percent, the yield in reels of tape was only 72 percent. This statistic indicated that certain reels of tape should be processed through another cycle.

Wet-Dry-Wet-Dry Cleaning

Those 15 reels of tape which did not pass a zero drop-out level test at 40 percent were sent through another wet-dry cleaning cycle. This additional cleaning increased the cleaning efficiency to 90 percent, halved the expected drop-out percentage, and reduced the consistent drop-outs to a count of 15. This resulted in the rejection of only 8 reels of tape. Of the total of 28 rejected tapes for both methods of cleaning, 15 were rejected on Type III failures, most of which appeared during the cleaning processes.

Memorex tapes started out with the least number of drop-outs, but at the completion of cleaning they had the most drop-outs.

CLEANING EFFICIENCY

When analyzing the cleaning efficiency of the different methods on a specific cause a definite correlation cannot be achieved. The cleaning efficiency of small sample sizes of specific drop-out causes cannot be accurately measured. Nodules are one example. Not only were there a small number of them, but they were disguised physically. Nodules have a tendency to accumulate the contamination which has gathered on the stationary heads. With the heat generated, they tend to fuse and grow. When some of the dirt is removed they become more pronounced. Often nodules are not detected by the tester until after the tape has been wet cleaned.

Figures 16 through 22 show the relationship of the cleaning efficiency of the different cleaning methods on specific causes and also the cleaning efficiency of the different methods on the different tape types. The ranges between cleaning methods for a specific cause vary greatly. In the Type I drop-outs, temporary drop-outs vary only 2 1 percent in the dry cycle and 27 percent in the wet cycle, while foreign dirt varies 30 percent in the dry cycle and 38 percent in the wet cycle due to its adherence to the oxide surface. Nodules, for the reasons stated, have an overall variation of 77 percent.

Type I and II drop-outs have almost the same response to cleaning. Geometrically, a Type II drop-out occurs along the transverse axis but away from the reading head. Type II drop-outs are easier to locate visually than Type I, thereby possibly creating an error in the original collection of data. Marker indentations and end damage are normally cut off the tape as a part of the rehabilitation process.

Type III drop-outs increase during the rehabilitation process. As the operators become more experienced and learn to perform preventive maintenance more effectively on the equipment used, the incidence of Type III drop-out increases was not so great.

The only effective rehabilitation for Type III drop-outs is precision rewind and storage or cutting. Again, the data accuracy of Type III drop-outs has been affected by the small sample sizes. Type III drop-outs are normally located in conjunction with a Type I drop-out. For instance, a tape which has a small ridge will not indicate a drop-out until a small chip becomes lodged in the trough of the ridge. Type III drop-outs are also extremely sensitive to signal level. One ridged tape had over 500 drop-outs at 50 percent of the expected signal level and none at 35 percent.

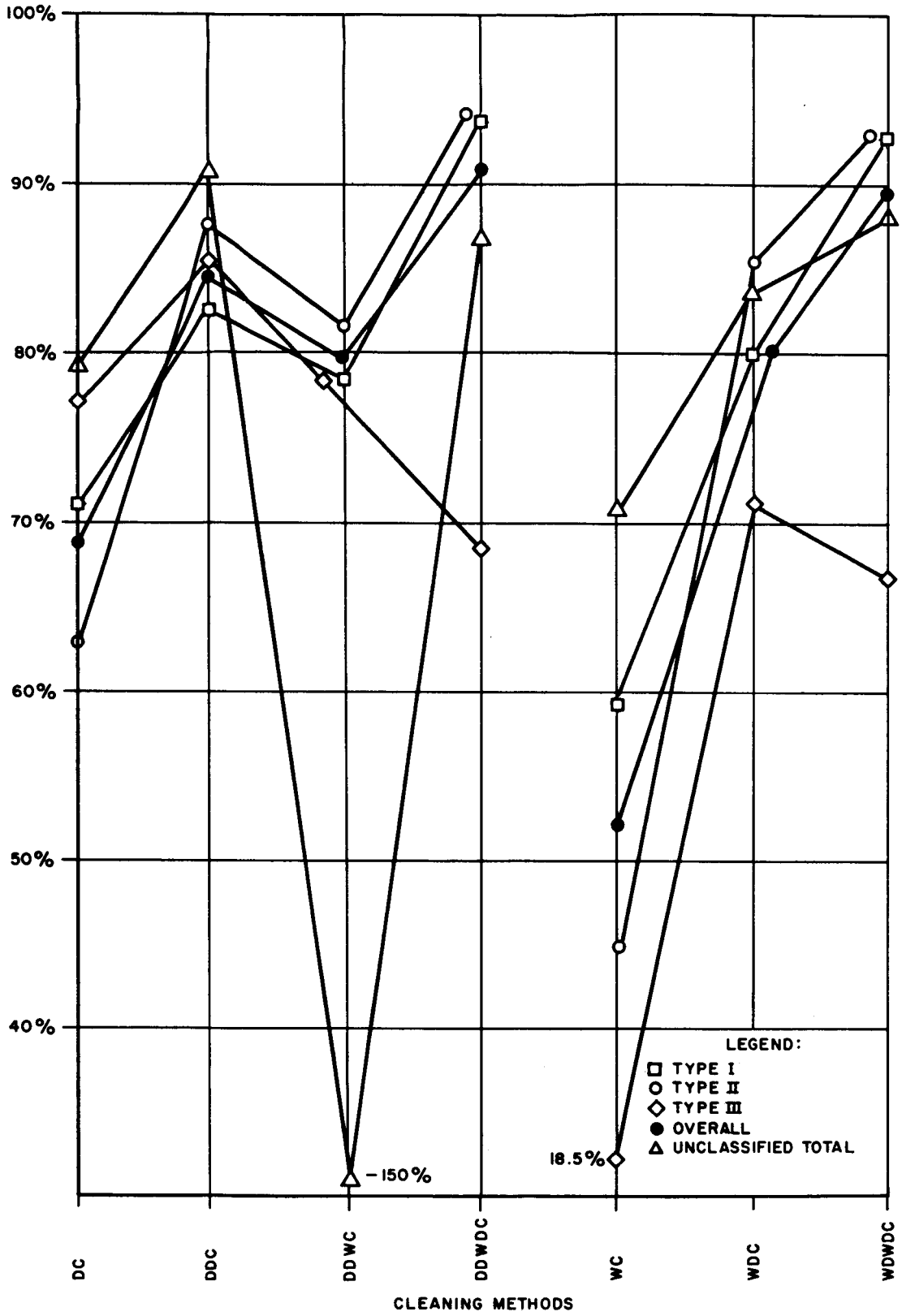

Figure 16. Cleaning Efficiency by Drop-out Types

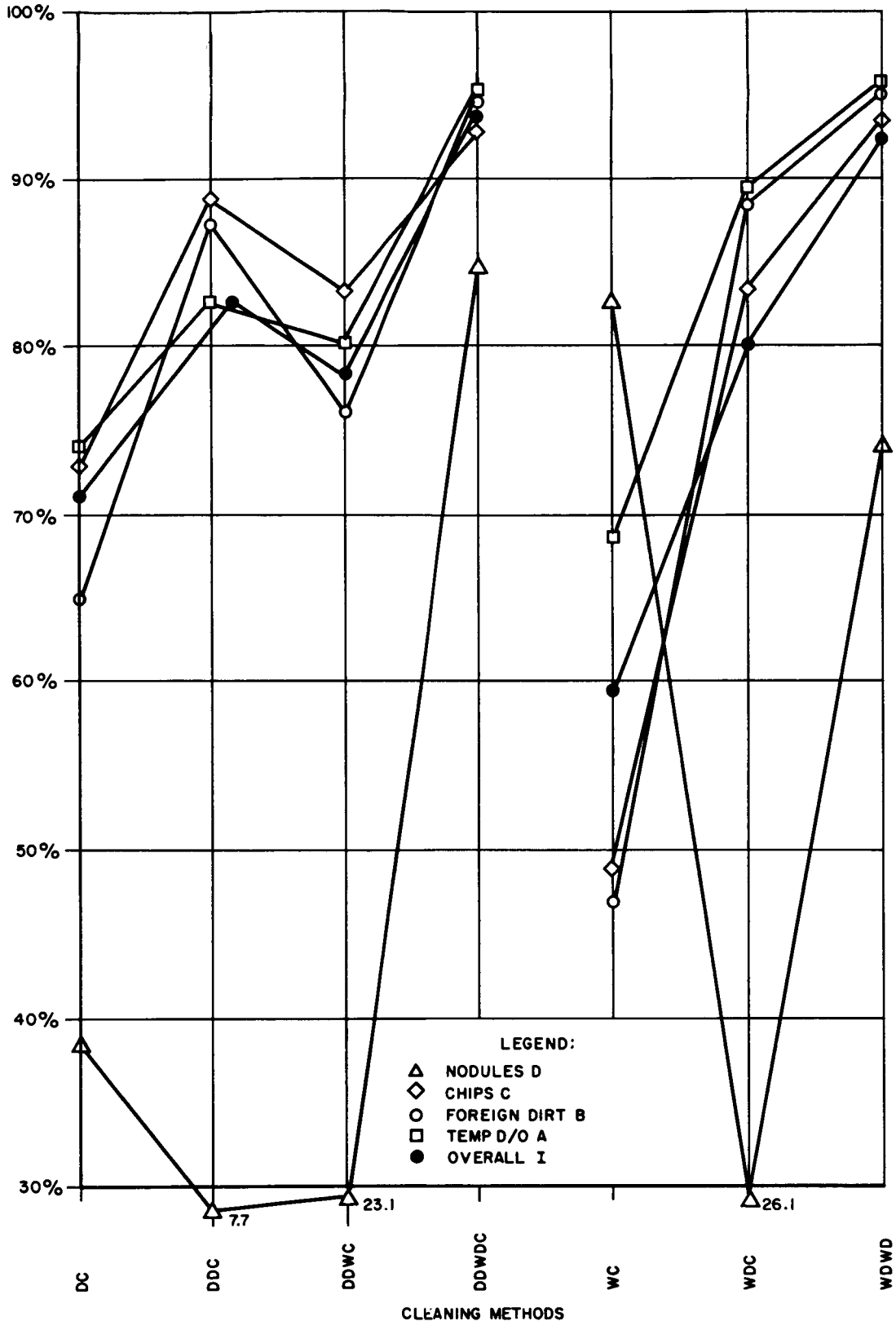

Figure 17. Cleaning Efficiency of Type I Drop-outs

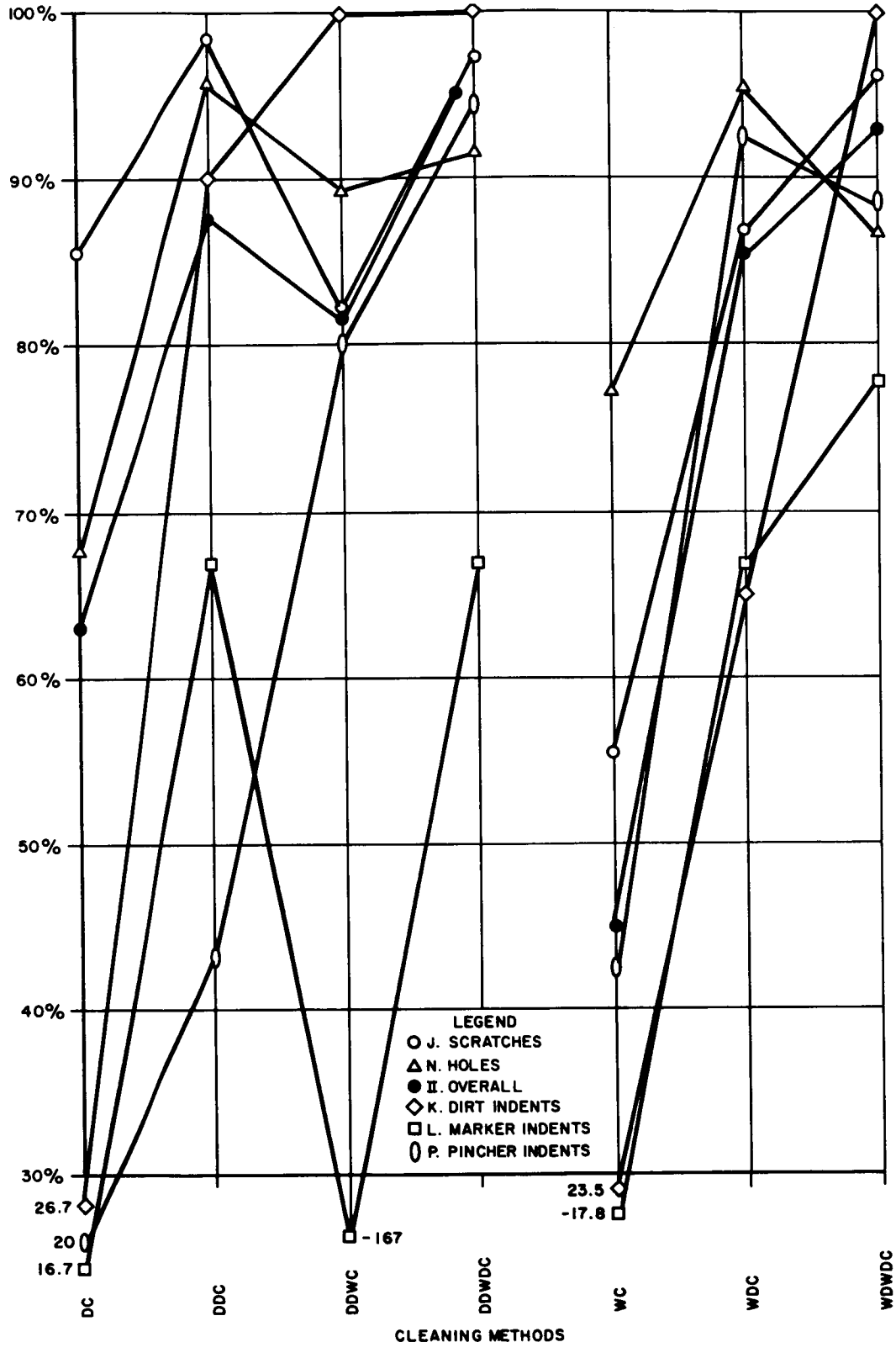

Figure 18. Cleaning Efficiency of Type II Drop-outs

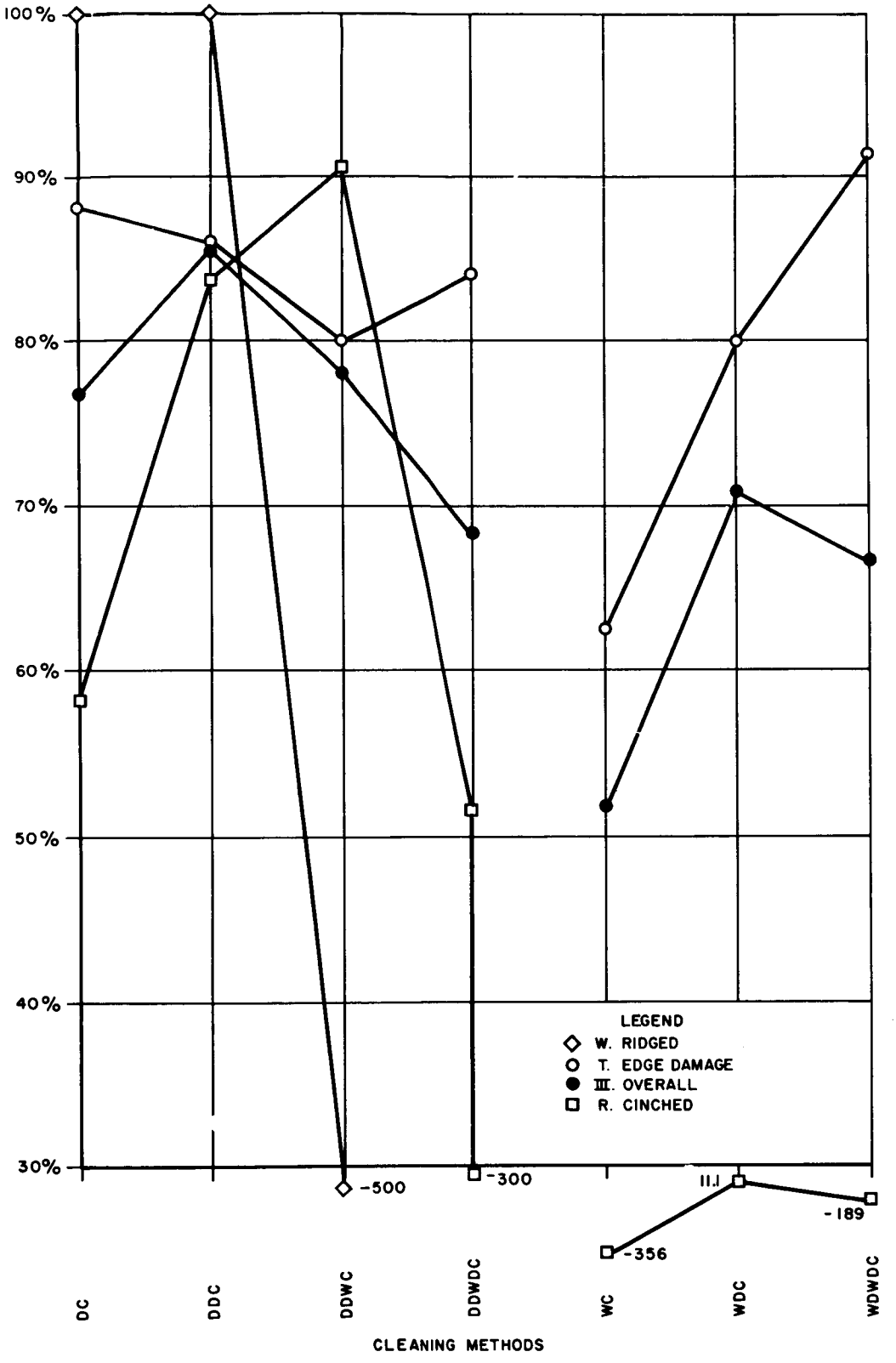

Figure 19. Cleaning Efficiency of Type III Drop-outs

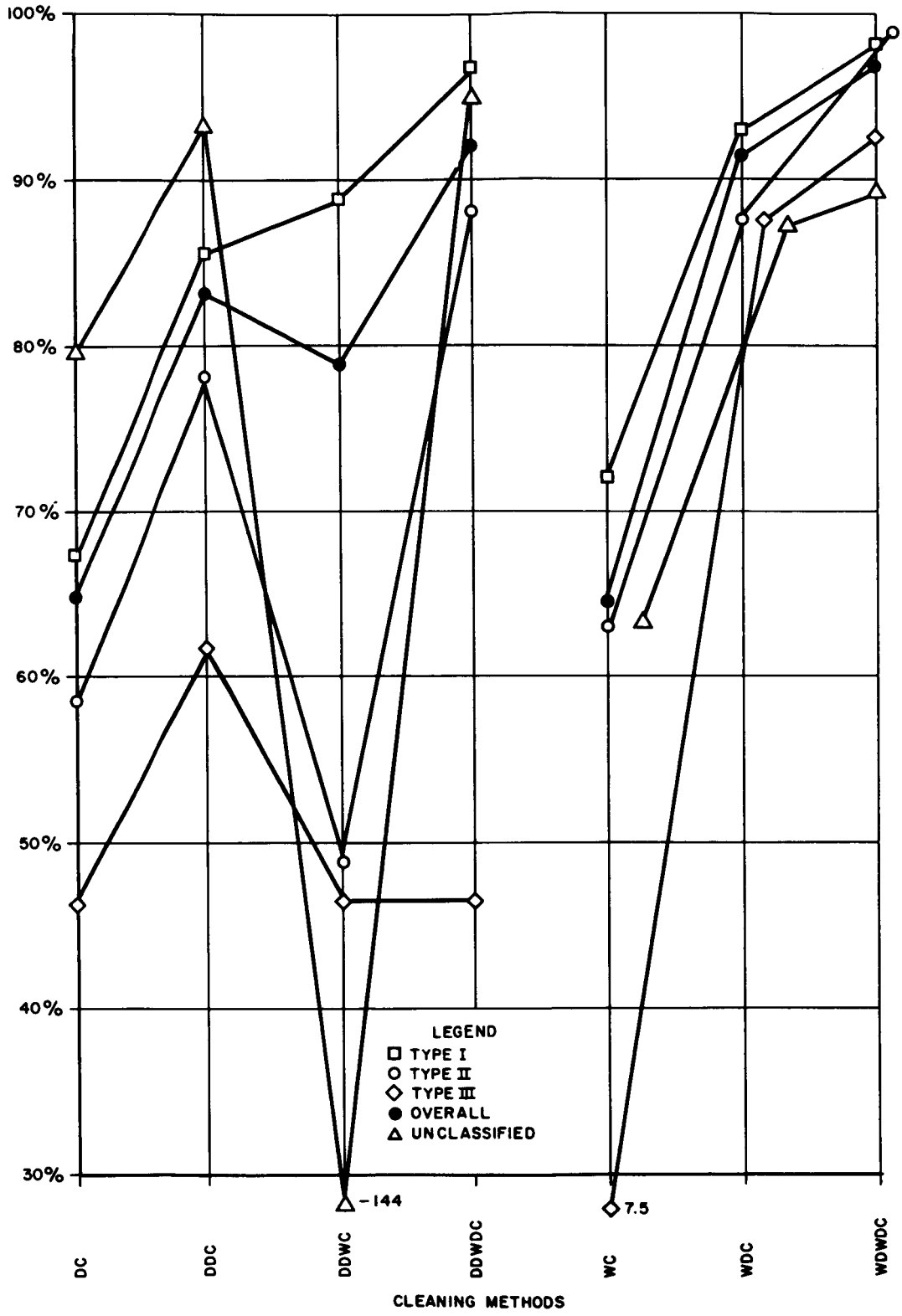

Figure 20. Cleaning Efficiency of Ampex Tapes

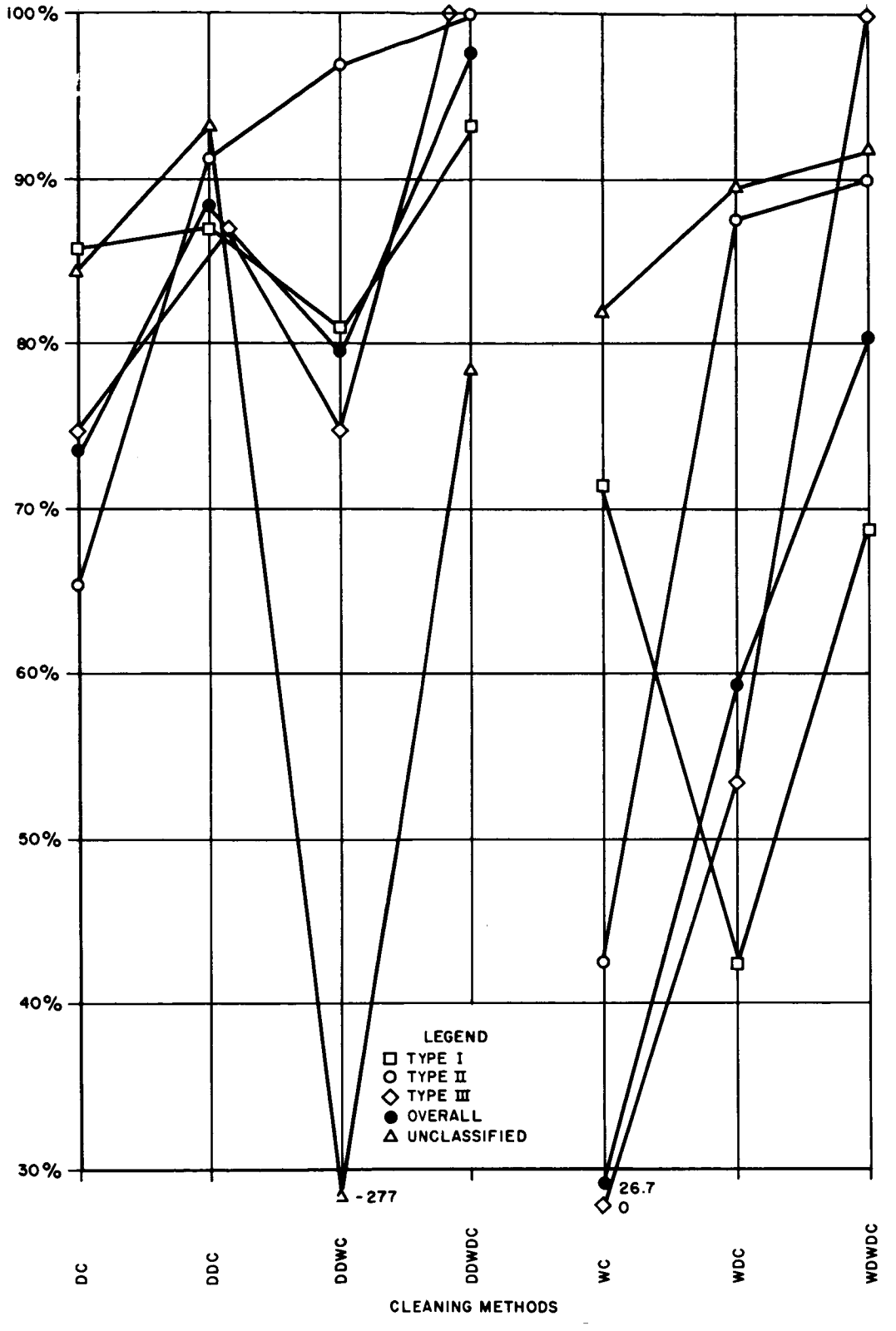

Figure 21. Cleaning Efficiency of IBM Tapes

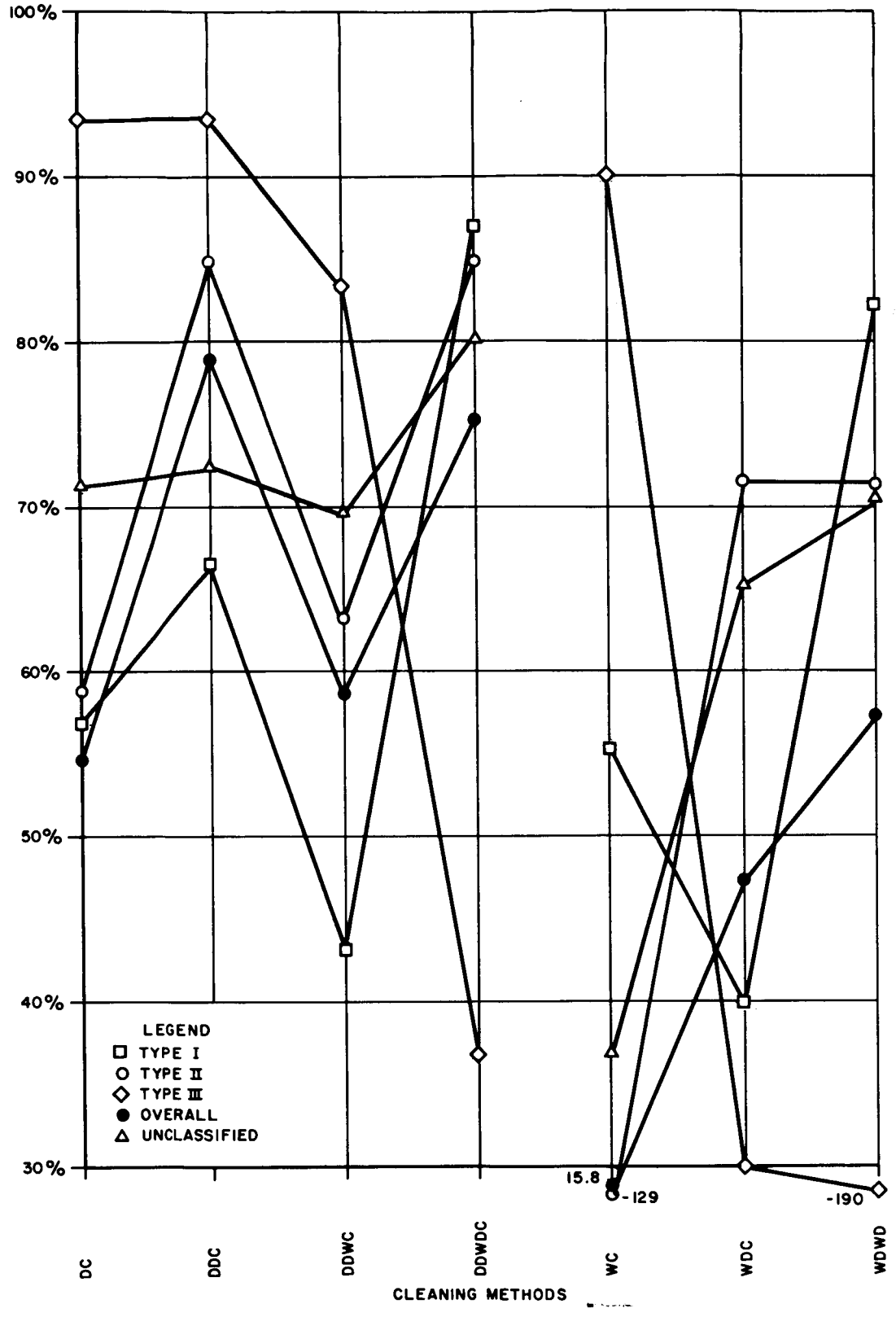

Figure 22. Cleaning Efficiency of Memorex Tapes

EXPECTED, CONSISTENT, AND TOTAL DROP-OUTS

Figure 23 shows the expected drop-outs after each cleaning method. Figure 24 shows the number of consistent drop-outs after each type of cleaning as well as the total number of drop-outs. Ampex tapes respond approximately the same to both types of cleaning, Memorex tapes respond better to the cycle starting with wet cleaning, and IBM tapes respond to the dry-cleaning cycle better.

QUALITY ASSURANCE

Tape certification is the quality control function in the rehabilitation process. Determination of rehabilitation effectivity can only be determined by the grade of tape produced. The system normally used (General Kinetics Inc., Report "The Tape Maintenance and Rehabilitation Process") divides the tapes into categories or error regions. After the tapes have been cleaned, all tapes with 6 drop-outs or less are rewound and stored for reuse while those tapes with 7 to 35 drop-outs are reworked to 6 or less. All tapes with over 35 drop-outs are rejected.

The system used in this report is slightly different. The drop-out count is first determined at 50 percent and the tape is then graded by determining at what signal level the tape is drop-out free. This system is illustrated in Figure 25. Grading tapes by their zero drop-out count has some advantages. The users of the tapes will receive no tapes which have severe permanent drop-outs. Drop-out-free tape at 50 percent can then be selected for the most critical applications. Quality control can be tightened if necessary on subsequent rehabilitation cycles. The results of this method of grading are tabulated in Tables 32 and 33.

When Grade C (40 percent) zero-drop-out count is used as the quality assurance level, the following yield of tapes results:

- Wet-Dry-Wet-Dry 85 percent
- Dry and Hand Clean 82 percent
- Dry-Dry-Wet-Dry 67 percent
- Wet-Dry 62 percent
- New Tape 58 percent
- Wet and Hand Clean 54 percent
- Dry-Dry-Wet 53 percent

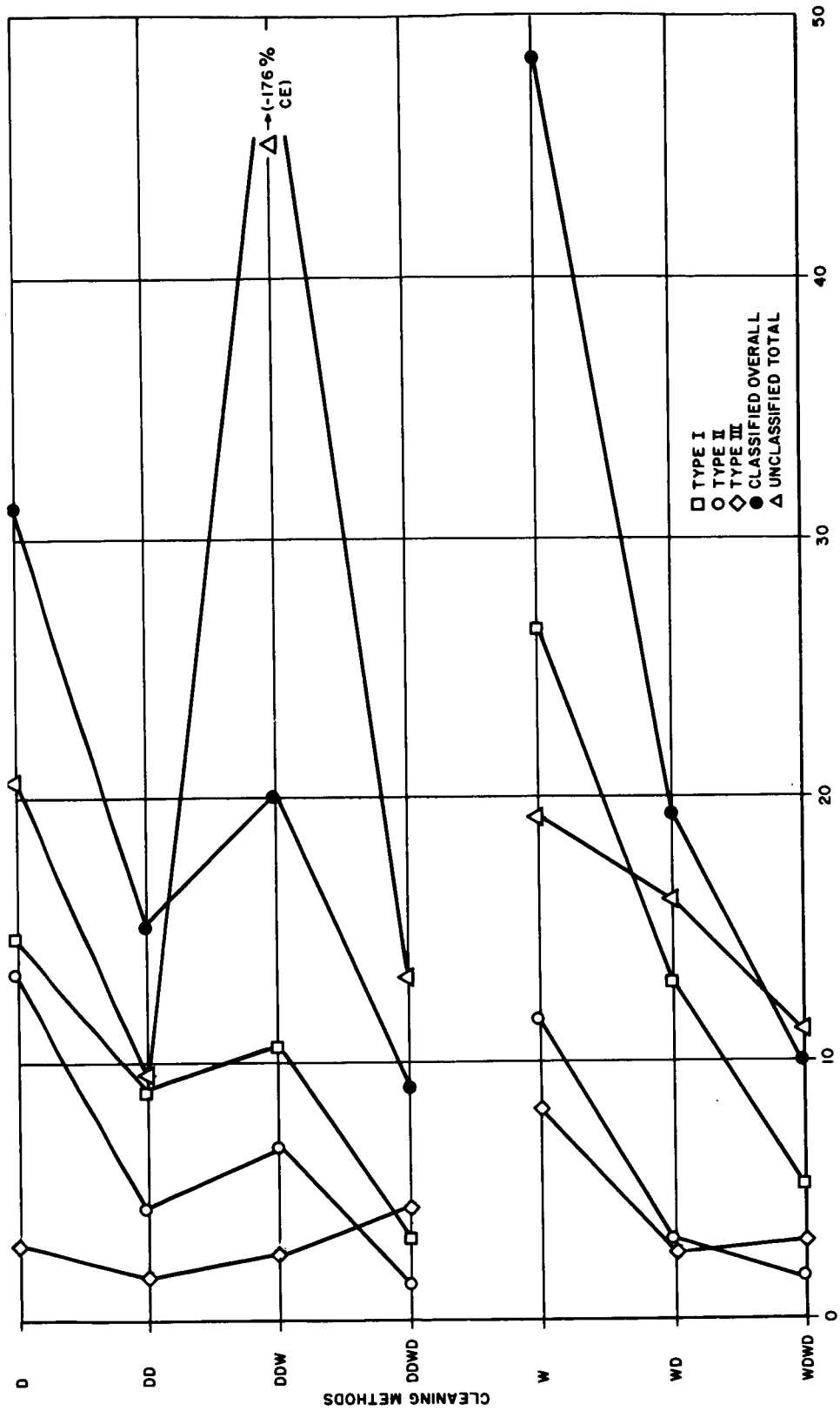

Figure 23. Expected Drop-outs After Cleaning

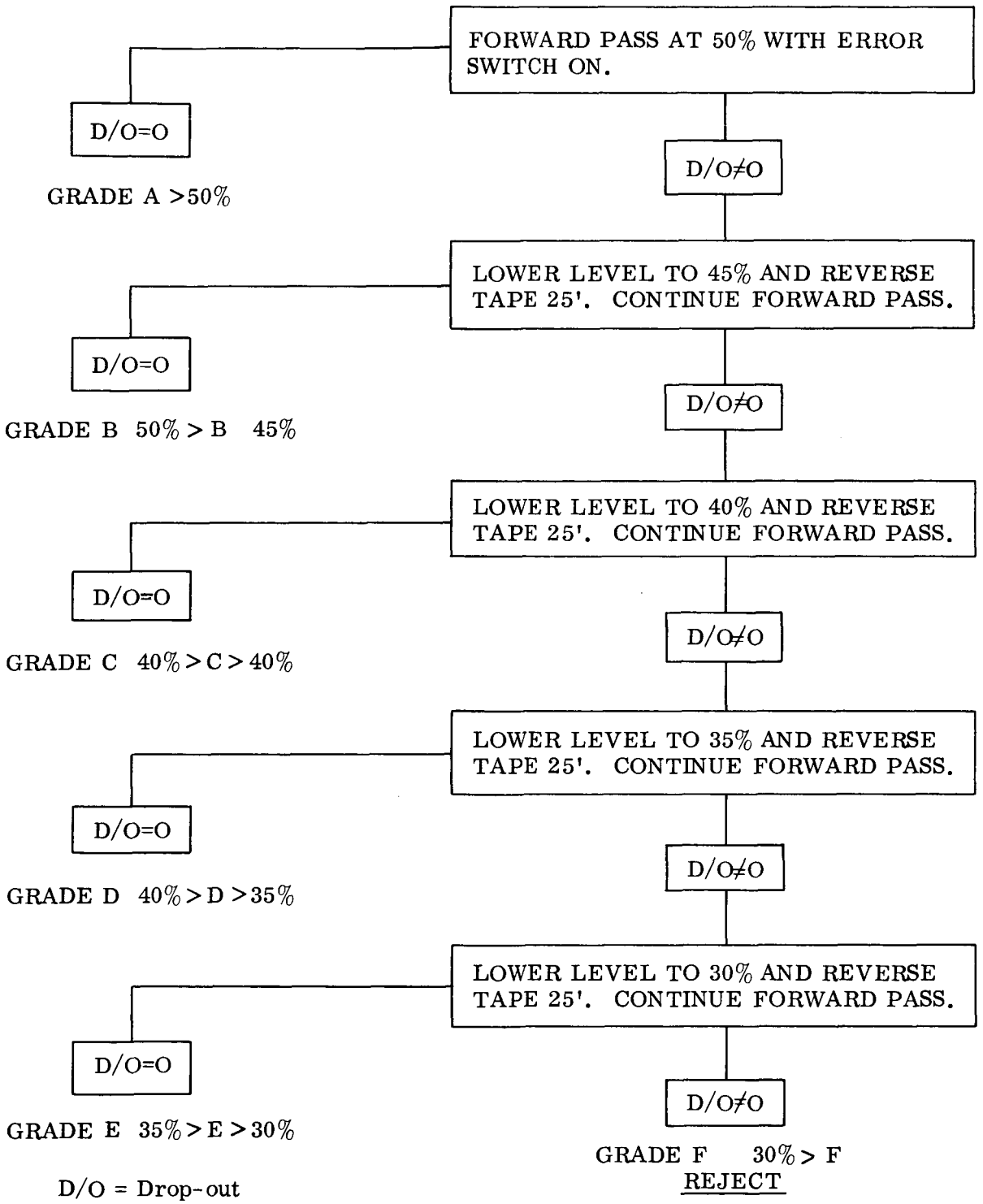

Figure 25. Quality Assurance Grading Process

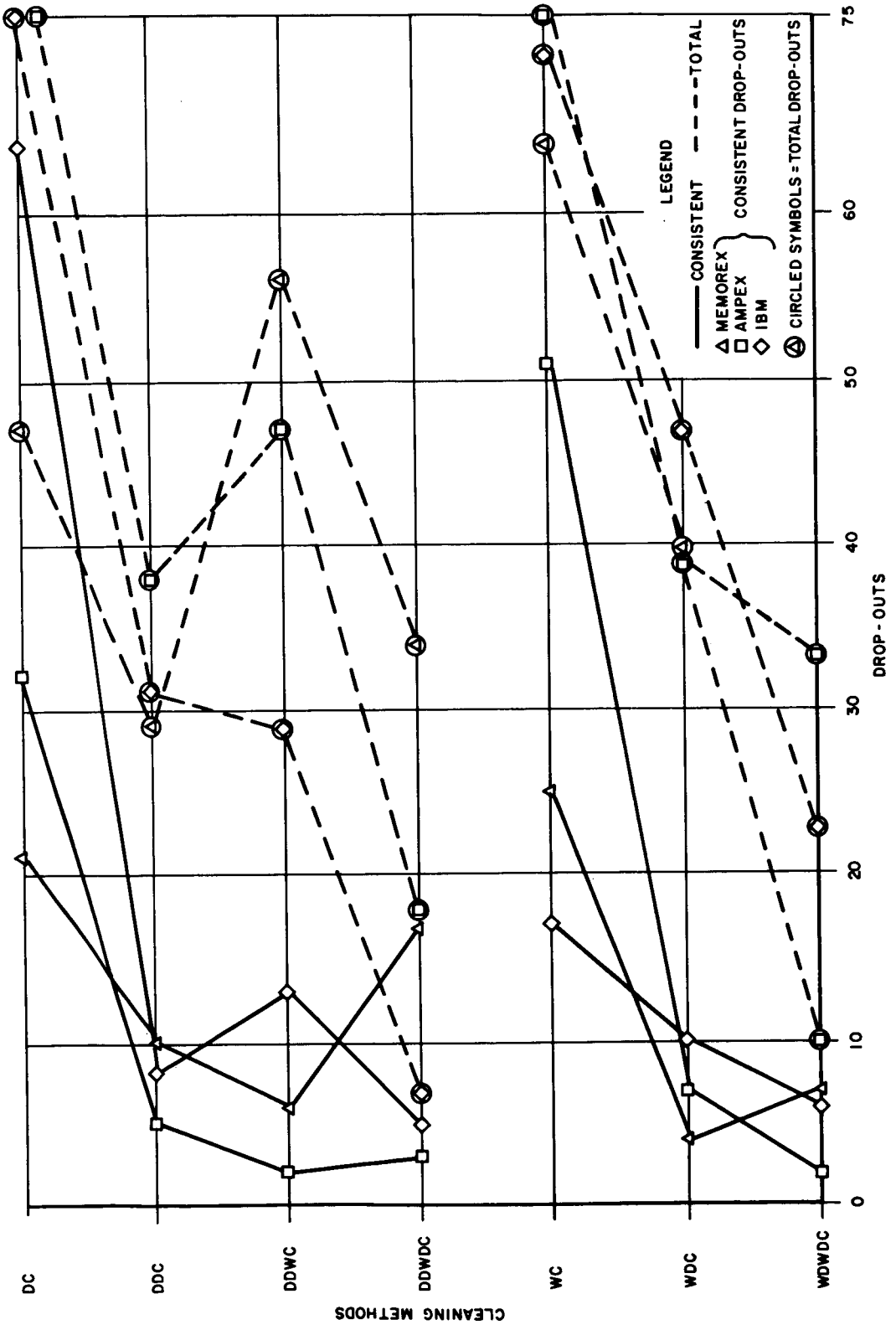

Figure 24. Number of Drop-outs After Cleaning

The percentages stated for the two methods combined with hand cleaning were obtained from a previous study. The multiple-cleaning methods do not include any hand work.

In a comparison of the cleaning efficiency of the two multiple methods against the single wet and single dry cleaning (Figure 26), the multiple method is clearly better for Type I and Type II drop-outs. The Type III drop-outs are increased by excessive handling.

If the grades of tape are given a weighting of 0 to 5 (F = 0, E = 1, D = 2, C = 3, B = 4, A = 5) and an average is determined for the different cleaning methods and types of tape, a clear-cut picture of the superior method develops, as shown in Figure 27.

REJECTS

Type III drop-outs represented only 11 percent of the original drop-outs, but contributed 50 percent of the rejection reasons. Tables 34, 35, and 36 summarize the rejects and their causes. Some of the Type I drop-outs are so firmly attached that the oxide is scraped off the binder in removing the error. Pincher-mark rejections for the most part were worn through the oxide surface. A combination of the three types of drop-outs is sufficient reason for rejection.

PILOT PRODUCTION

After completion of the basic study, a pilot-production run was established (Figure 28). This run included training technicians as well as tape study. The certification level was set at zero-drop-outs-per-reel at 50 percent level and end-cutting the tape was permitted up to 1200 feet-per-reel. Each drop-out was given three passes to determine consistency; then removing it by hand was attempted. Instead of the customary scalpel, freon and a very stiff pig-hair brush were used to good effect.

Three hundred reels were rehabilitated in this pilot run with a yield of 88 percent. Eighteen of the remaining reels were destroyed, but the other eighteen had high drop-out counts from dust accumulation on the read-write head. These reels were set aside for future study.

Production rates were very small during this pilot run, due to training requirements and establishment of a procedure for certifying to zero with existing equipment. A rate of 25-reels-per-shift-per-certifier was reached after the system had been fully implemented.

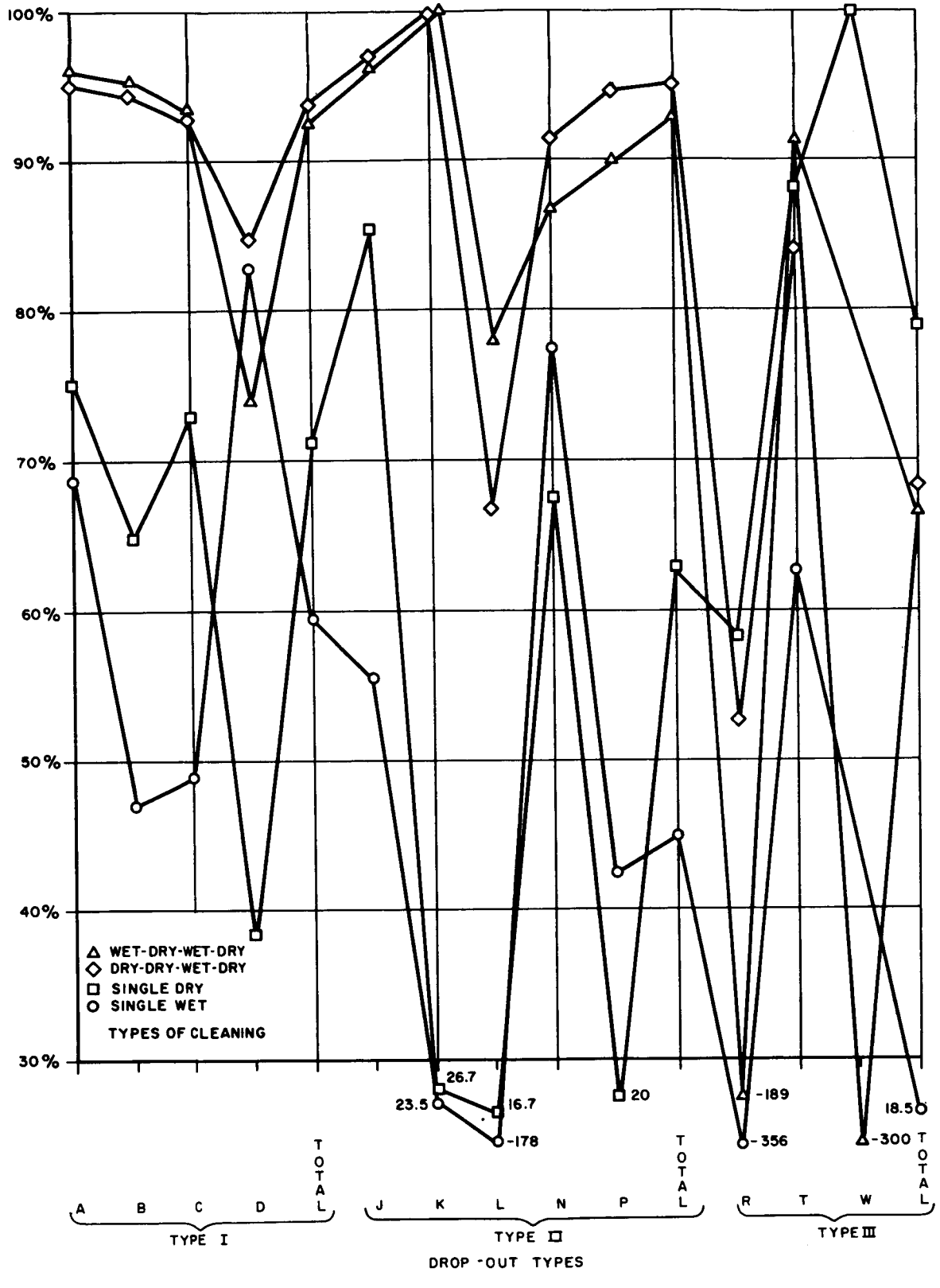

Figure 26. Comparison of Cleaning Efficiency by Drop-out Type

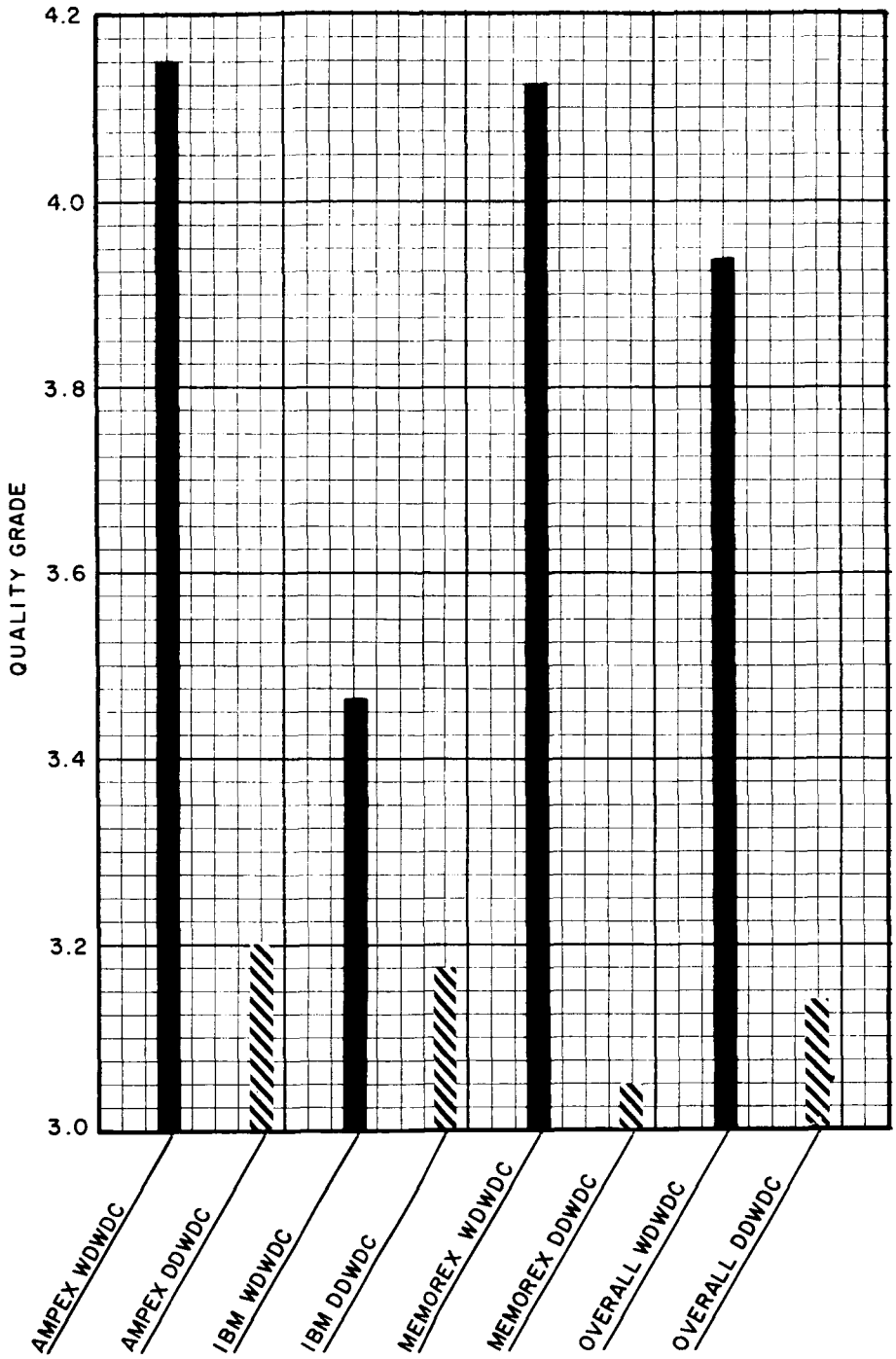

Figure 27. Comparison of Quality Grades

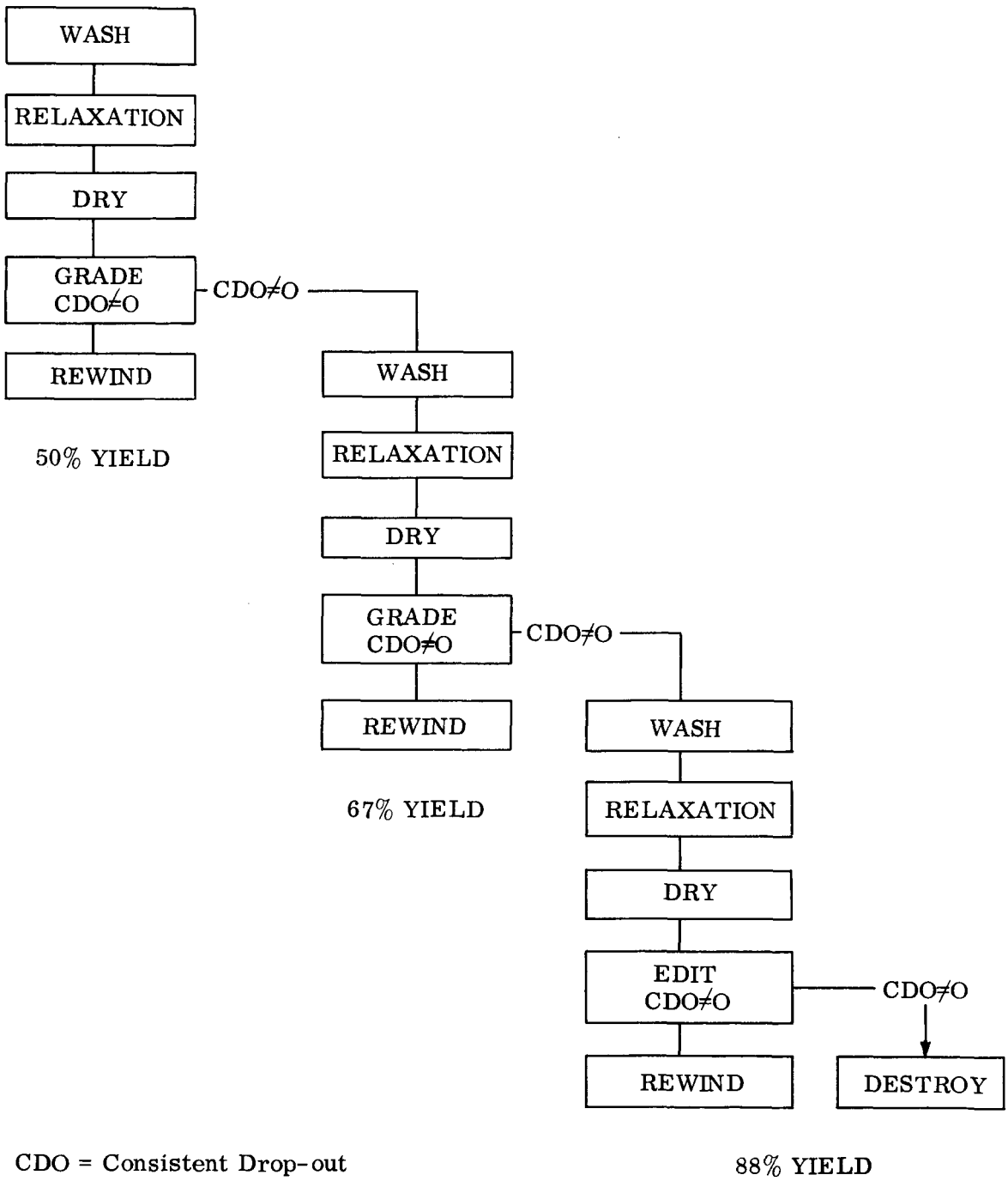

Figure 28. Pilot Production Step

PRODUCTION RUN

The second production step lasted approximately three months and processed over 1000 reels of tape. A quality-control level of 5 drop-outs at 50 percent level was established. The certifier operators, now more familiar with procedures, were given more leeway in operating; tape could be cut up to 1200 feet. Many programs employed by users of the rehabilitated tapes only occupy 800 to 1200 feet of tape. Therefore, three standard lengths of tape are shipped to customers: 1200 feet, 1800 feet, and 2500 feet.

The dust problem discovered during the pilot run was solved by passing these tapes over the dry cleaner with the blade removed, using only the wipers. The tapes from the pilot run which had been put in storage were wiped and all of them passed.

The procedure outlined in Figure 29 evolved in the second month and stabilized in the last (third) month. Production rates averaged 50-reels-per-shift-per-certifier. With the quality control level of 5 drop-outs at 50 percent level, yield reached 95 percent. Of the 48 reels rejected, 20 had edge damage which resulted from improper handling during the relaxation period.

CONCLUSIONS

The majority of the data resulting from this study points to the best method for rehabilitation of used computer tapes. Some of the sample sizes are too small for accuracy in some of the categories, but the overall sample size and data trends are highly indicative of what can be expected in a production process.

Neither of the single methods produces an effective system. Used alone, the wet cleaner leaves a large number of deposits on the tape; the dry cleaner does not wipe the tape as clean as necessary. Manual rework is time-consuming and therefore expensive.

The characteristics of the wet cleaner make it a good first choice. A large number of deposits are loosened, and can then be scraped off with the dry cleaner. The bulk of dirt and deposits is handled by the wet cleaner.

A second pass through the wet and dry cleaner should only be used to clean those tapes which failed the first inspection.

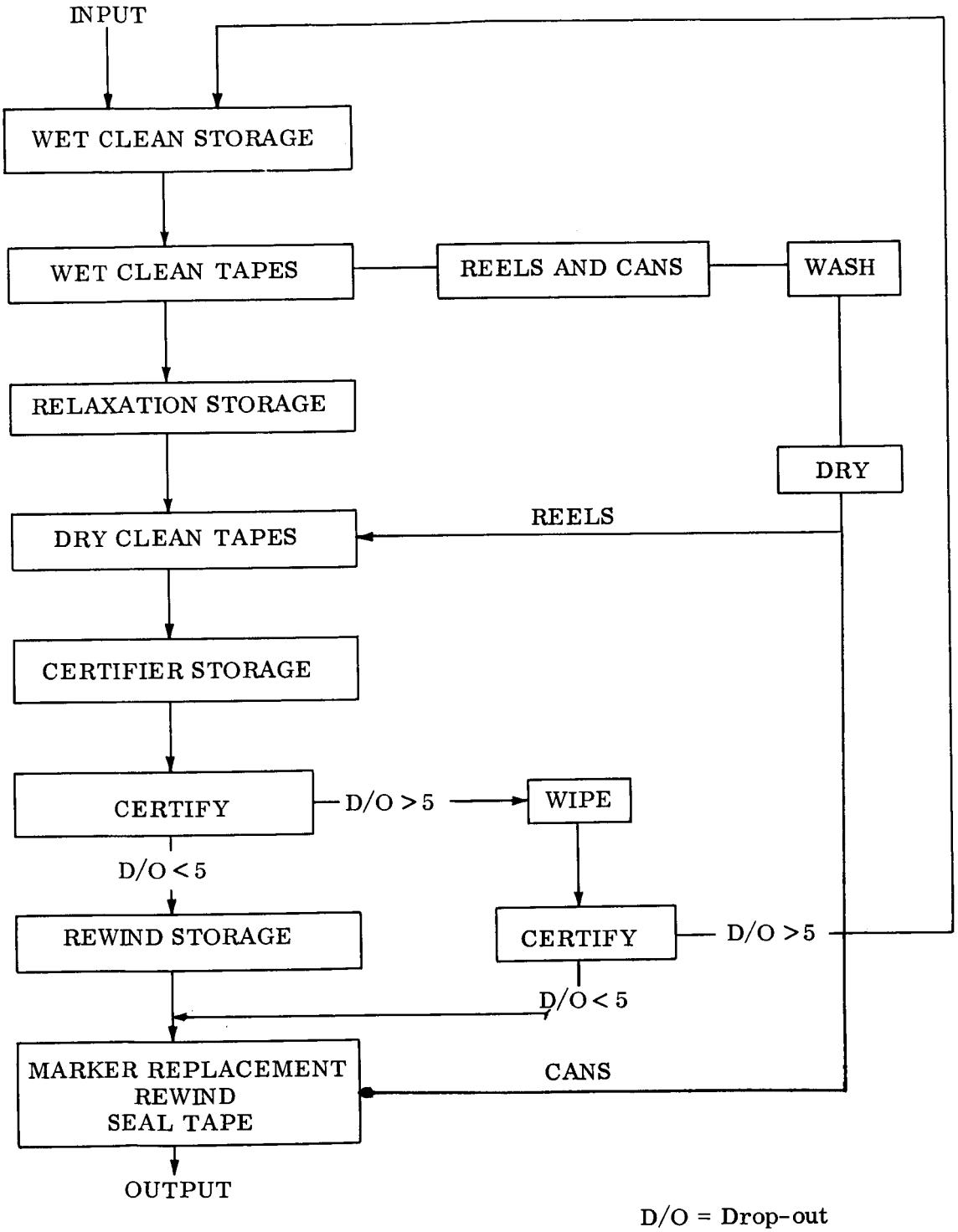

Figure 29. Tape Rehabilitation Process

The grading system used for quality control should reject all tapes having permanent drop-outs even through they have a low overall drop-out count.

Removal of damaged tape ends, resetting of load markers, and precision rewind should be included as the last steps of the rehabilitation procedure.

This rehabilitation program, when combined with a qualified products list, competitive and selective purchasing, and continuous emphasis on preventive maintenance by the users, will result in considerable savings. Cost of rehabilitation approaches $5.50 per tape, which is less than one-third the cost of new tapes.

Table 1
Drop-out Count Per Reel Before and After Wet Cleaning

CLEANING CODE					CLEANING CODE				
TAPE NO.	B C	A W C	A W D C	A W D W D C	TAPE NO.	B C	A W C	A W D C	A W D W D C
W 51 M	0	7	4	0	W 72 M	13	10	5	3
W 52 M	0	4	2	3	W 73 A	13	29	2	
W 53 M	2	3	5		W 74 A	14	9	3	
W 54 M	1	7	1		W 75 A	14	5	0	
W 55 M	2	7	1		W 76 M	15	4	2	
W 56 M	2	3	2	1	W 77 M	16	8	4	2
W 57 M	3	8	1		W 78 A	18	5	8	
W 58 I	3	6	1		W 79 A	22	26	6	
W 59 I	4	12	2	2	W 80 A	23	9	2	
W 60 I	4	6	2		W 81 A	25	22	12	0
W 61 M	5	2	6	156	W 82 A	26	7	2	
W 62 M	6	1	3		W 83 A	27	5	2	
W 63 I	7	33	12	0	W 84 M	28	15	5	12
W 64 M	8	10	3		W 85 M	34	2	3	
W 65 A	10	8	2		W 86 M	34	10	2	4
W 66 M	10	12	11	3	W 87 I	35	12	16	4
W 67 A	11	15	3		W 88 A	36	10	7	1
W 68 I	11	24	11	11	W 89 A	40	3	0	
W 69 I	12	5	37	2	W 90 A	42	5	4	
W 70 I	12	8	3	3	W 91 A	44	0	5	
W 71 A	12	9	6		W 92 A	42	23	4	7

Table 1 (Cont.)
Drop-out Count Per Reel Before and After Wet Cleaning

CLEANING CODE					CLEANING CODE				
TAPE NO.	B C	A W C	A W D C	A W D W D C	TAPE NO.	B C	A W C	A W D C	A W D W D C
W 93 A	50	46	6		W 98 I	124	11	4	
W 94 A	72	4	2		W 99 I	120	8	2	
W 95 I	53	2	2		W 100 A	145	6	8	
W 96 I	89	10	46	8	W 101 I	205	15	0	
W 97 I	114	17	3		W 102 I	212	12	15	0

Table 2
Drop-out Count Per Reel Before and After Dry Cleaning

CLEANING CODE						CLEANING CODE					
TAPE NO.	BC	ADC	ADDC	ADDWC	ADDWDC	TAPE NO.	BC	ADC	ADDC	ADDWC	ADDWDC
D 51 M	0	1	0	9	3	D 72 A	13	7	0	6	3
D 52 M	1	5	3	1	0	D 73 M	13	3	0	2	2
D 53 M	1	3	6	2	0	D 74 A	14	6	3	3	3
D 54 M	2	2	2	2	1	D 75 A	14	3	1	2	0
D 55 M	2	4	2	1	1	D 76 A	14	4	0	4	1
D 56 I	3	2	2	2	0	D 77 I	15	1	1	6	2
D 57 I	3	2	1	3	3	D 78 A	16	6	4	755	3
D 58 M	4	5	5	5	1	D 79 M	19	8	4	8	1
D 59 I	5	4	4	4	3	D 80 I	24	4	0	783	1
D 60 I	6	3	0	3	4	D 81 M	24	4	4	2	5
D 61 M	6	4	0	0	4	D 82 M	25	1	0	5	0
D 62 M	7	3	5	4	2	D 83 A	27	6	6	12	6
D 63 A	9	2	3	7	1	D 84 A	28	4	0	2	517
D 64 A	10	9	2	2	0	D 85 A	30	21	2	1	3
D 65 M	11	2	1	5	2	D 86 I	34	15	4	8	5
D 66 A	11	5	4	396	13	D 87 M	36	6	6	7	6
D 67 A	248	46	7	7	6	D 88 I	39	20	18	14	2
D 68 A	11	12	6	2	0	D89 M	40	12	9	18	11
D 69 A	12	12	0	7	2	D 90 M	48	19	7	8	8
D 70 M	12	0	3	2	0	D 91 A	44	8	2	2	1
D 71 M	13	7	3	6	11	D 92 M	46	10	27	6	5

Table 2 (Cont.)
Drop-out Count Per Reel Before and After Dry Cleaning

CLEANING CODE						CLEANING CODE					
TAPE NO.	B C	A D C	A D D C	A D D W C	A D D W D C	TAPE NO.	B C	A D C	A D D C	A D D W C	A D D W D C
D 93 I	50	5	5	7	0	D 98 A	122	11	5	15	1
D 94 A	80	7	4	6	0	D 99 A	143	13	10	10	7
D 95 I	57	11	2	981	93	D 100 I	153	7	8	6	7
D 96 I	63	17	0	22	18	D 101 I	212	12	2	2	6
D 97 A	108	12	4	129	1						

Table 3
Standard Distribution of Drop-outs

TAPE MFR	WET CLEANING															
	BC				AWC				AWDC				AWDWDC			
	N	M	UCL	%	N	M	UCL	%	N	M	UCL	%	N	M	UCL	%
MEMOREX	17	5	17	83	17	7	11	88	17	3	6	94	17	3	6	94
AMPEX	20	25	56	90	20	8	20	75	20	3	6	79	19	2	5	68
IBM	15	25	107	67	15	10	18	87	15	3	18	87	15	2	6	87
TOTALS	52	15	70	85	52	8	17	87	52	2	8	85	51	2	5	80

TAPE MFR	DRY CLEANING																			
	BC				ADC				ADDC				ADDWC				ADDWDC			
	N	M	UCL	%	N	M	UCL	%	N	M	UCL	%	N	M	UCL	%	N	M	UCL	%
MEMOREX	19	11	27	79	19	4	9	85	20	3	9	95	19	5	9	89	19	2	5	80
AMPEX	19	15	86	74	19	4	9	85	18	3	6	94	16	4	8	81	19	1	4	80
IBM	13	36	98	85	13	5	12	77	12	2	7	84	11	5	11	83	13	4	9	85
TOTALS	51	14	70	86	51	5	13	89	50	3	8	92	45	5	10	89	49	3	7	88

Table 4
Dry-cleaning Results for All Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	136	21.1	34	75	5.26	4	2.9	.61
	B	Foreign Dirt	54	8.4	19	64.8	2.96	7	13	1.09
	C	Chips	125	19.4	34	72.8	5.28	23	18.4	3.57
	D	Nodules	13	2.0	8	38.5	1.23	5	38.5	.77
	TOTAL TYPE I		328	50.9	95	71	14.76	39	11.9	6.06
II	J	Scratches	117	18.2	17	85.5	2.64	6	5.1	.93
	K	Dirt Indents	30	4.7	22	26.7	3.45	14	46.7	2.19
	L	Marker Indents	6	.9	5	16.7	.75	3	50	.45
	N	Holes	46	7.1	15	67.4	2.31	5	10.9	.77
	P	Pincher Marks	35	5.4	28	20.0	4.32	22	62.9	3.40
	TOTAL TYPE II		234	36.3	87	62.8	13.50	50	21.4	7.78
III	R	Cinched	31	4.8	13	58.1	2.01	21	67.7	3.25
	T	Edge Damage	50	7.8	6	88.0	.93	7	14	1.09
	W	Ridged	1	.2	0	100	0	0	0	0
	TOTAL TYPE III		82	12.7	19	76.8	2.95	28	34.1	4.33
Overall Total for 50 Reels			644		201	68.8	31.21	117	18.2	18.17
Unclassified Drop-outs			1290		195	84.9				
Grand Total for 52 Reels			1934		396	79.5				

Table 5
Dry-cleaning Results for Ampex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	95	42.6	21	77.8	9.5	3	3.2	1.4
	B	Foreign Dirt	25	11.2	12	52	5.4	4	1.6	1.7
	C	Chips	45	20.2	18	60	8.1	10	22.2	4.5
	D	Nodules	4	1.8	4	0	0	2	50	.9
	TOTAL TYPE I		169	75.8	55	67.5	24.6	19	11.2	8.5
II	J	Scratches	11	4.9	3	72.7	1.3	0	0	0
	K	Dirt Indents	10	4.5	1	90	.4	1	.1	.45
	L	Marker Indents	0	0	0	0	0	0	0	0
	N	Holes	16	7.2	12	25	5.4	4	25	1.8
	P	Pincher Marks	4	1.8	1	75	.4	1	25	.45
	TOTAL TYPE II		41	18.4	17	58.5	7.7	6	14.6	2.69
III	R	Cinched	7	3.1	4	42.9	1.8	3	42.8	1.42
	T	Edge Damage	6	2.7	3	50	1.3	4	67	1.8
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		13	5.8	7	46.2	3.1	7	53.8	3.12
Overall Total for 18 Reels			223		79	64.6	35.4	32	14.3	14.31
Unclassified Drop-outs			731		115	84.3				
Grand Total for 19 Reels			954		194	79.7				

Table 7
Dry-cleaning Results for Memorex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	20	14.7	10	50	7.35	1	5.0	.74
	B	Foreign Dirt	9	6.6	5	44.4	3.67	1	11.1	.73
	C	Chips	26	19.1	7	73.1	5.14	5	19.2	3.67
	D	Nodules	5	3.7	4	20	2.96	3	60	2.2
	TOTAL TYPE I		60	44.1	26	56.7	19.1	10	16.7	7.36
II	J	Scratches	1	.7	0	100	0	0	0	0
	K	Dirt Indents	9	6.6	10	-111	7.33	5	55.5	3.67
	L	Marker Indents	6	4.4	5	16.7	3.67	3	50	2.20
	N	Holes	28	20.6	3	89.3	2.20	1	3.6	.74
	P	Pincher Marks	2	1.5	1	50	.75	1	50	.75
	TOTAL TYPE II		46	33.8	19	58.7	13.96	10	21.7	7.33
III	R	Cinched	6	4.4	1	83.3	.73	0	0	0
	T	Edge Damage	23	16.9	1	95.6	.74	1	4.3	.73
	W	Ridged	1	.7	0	100	0	0	0	0
	TOTAL TYPE III		30	22.1	2	93.3	1.48	1	3.3	.73
Overall Total for 19 Reels			136		47	65.4	34.54	21	15.4	15.42
Unclassified Drop-outs			180		52	71.1				
Grand Total for 20 Reels			316		99	71.2				

Table 6
Dry-cleaning Results for IBM Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	21	7.4	3	85.7	1.06	0	0	0
	B	Foreign Dirt	20	7.0	2	90	.7	2	10	.7
	C	Chips	54	18.9	9	83.3	3.16	8	14.8	2.8
	D	Nodules	4	1.4	0	100	0	0	0	0
	TOTAL TYPE I		99	34.7	14	85.9	4.89	10	10.1	3.5
II	J	Scratches	105	36.8	14	86.7	4.89	6	5.7	2.1
	K	Dirt Indents	11	3.9	11	0	3.9	8	72.7	2.8
	L	Marker Indents	0	0	0	0	0	0	0	0
	N	Holes	2	.7	0	100	0	0	0	0
	P	Pincher Marks	29	10.2	26	10.3	9.15	20	69	7.0
	TOTAL TYPE II		147	51.6	51	65.3	17.9	34	23.1	11.92
III	R	Cinched	18	6.3	8	55.6	2.8	18	100	6.3
	T	Edge Damage	21	7.4	2	90.5	.7	2	9.5	.7
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		39	13.7	10	74.4	3.51	20	51.3	7.0
Overall Total for 13 Reels			285		75	73.7	26.3	64	22.5	22.45
Unclassified Drop-outs			379		28	92.6				
Grand Total for 13 Reels			664		103	84.5	15.5			

Table 8
Dry-dry-cleaning Results for All Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	136	21.1	24	82.4	3.71	0	0	0
	B	Foreign Dirt	54	8.4	7	87	1.09	4	7.4	.62
	C	Chips	125	19.4	14	88.8	2.17	5	4.0	.78
	D	Nodules	13	2.0	12	7.7	1.85	1	7.7	.15
	TOTAL TYPE I		328	50.9	57	82.6	8.86	10	3.0	1.53
II	J	Scratches	117	18.2	2	98.3	.31	1	.9	.16
	K	Dirt Indents	30	4.7	3	90	.47	1	3.3	.16
	L	Marker Indents	6	.9	2	66.7	.30	2	33	.3
	N	Holes	46	7.1	2	95.7	.31	0	0	0
	P	Pincher Marks	35	5.4	20	42.9	3.08	6	17	.92
	TOTAL TYPE II		234	36.3	29	87.6	4.50	10	4.3	1.56
III	R	Cinched	31	4.8	5	83.9	.77	1	3.2	.15
	T	Edge Damage	50	7.8	7	86	1.09	2	4.0	.31
	W	Ridged	1	.2	0	100	0	0	0	0
	TOTAL TYPE III		82	12.7	12	85.4	1.85	3	3.7	.47
Overall Total for 50 Reels			644		98	84.8	15.21	23	3.6	3.56
Unclassified Drop-outs			1290		87	93.3				
Grand Total for 52 Reels			1934		185	90.4				

Table 9
Dry-dry-cleaning Results for Ampex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	95	42.6	11	88.4	4.94	0	0	0
	B	Foreign Dirt	25	11.2	5	80	2.24	2	8	.9
	C	Chips	45	20.2	5	88.9	2.24	0	0	0
	D	Nodules	4	1.8	3	25	1.35	0	0	0
	TOTAL TYPE I		169	75.8	24	85.8	10.76	2	1.18	.89
II	J	Scratches	11	4.9	0	100	0	0	0	0
	K	Dirt Indents	10	4.5	0	100	0	0	0	0
	L	Marker Indents	0	0	1	0	.44	0	0	0
	N	Holes	16	7.2	0	100	0	0	0	0
	P	Pincher Marks	4	1.8	8	-200	3.6	3	75	1.35
	TOTAL TYPE II		41	18.4	9	78	4.04	3	7.3	1.34
III	R	Cinched	7	3.1	1	85.7	.44	0	0	0
	T	Edge Damage	6	2.7	4	33	1.81	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		13	5.8	5	61.5	2.23	0	0	0
Overall Total for 18 Reels			223		38	83.0	17.03	5	2.2	2.23
Unclassified Drop-outs			731		25	96.6				
Grand Total for 19 Reels			954		63	93.3				

Table 10
Dry-dry-cleaning Results for IBM Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	21	7.4	5	76.2	1.76	0	0	0
	B	Foreign Dirt	20	7.0	1	95	.35	1	5.0	.35
	C	Chips	54	18.9	5	90.7	1.76	3	5.6	1.06
	D	Nodules	4	1.4	2	50	.70	0	0	0
	TOTAL TYPE I		99	34.7	13	86.9	4.55	4	4.0	1.39
II	J	Scratches	105	36.8	1	99	.37	1	.9	.33
	K	Dirt Indents	11	3.9	1	90.9	.35	0	0	0
	L	Marker Indents	0	0	0	0	0	0	0	0
	N	Holes	2	.7	0	100	0	0	0	0
	P	Pincher Marks	29	10.2	11	62.1	3.87	2	6.9	.70
	TOTAL TYPE II		147	51.6	13	91.2	4.54	3	2.0	1.03
III	R	Cinched	18	6.3	4	77.8	1.40	1	5.6	.35
	T	Edge Damage	21	7.4	1	95.2	.36	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		39	13.7	5	87.2	1.75	1	2.6	.36
Overall Total for 13 Reels			285		31	89.1	10.84	8	2.8	2.78
Unclassified Drop-outs			379		16	95.7				
Grand Total for 13 Reels			664		47	92.9				

Table 11
Dry-dry-cleaning Results for Memorex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	20	14.7	8	60	5.88	0	0	0
	B	Foreign Dirt	9	6.6	1	88.9	.73	1	11.1	.73
	C	Chips	26	19.1	4	84.6	2.94	2	7.7	1.47
	D	Nodules	5	3.7	7	-140	5.18	1	20	.74
	TOTAL TYPE I		60	44.1	20	66.7	14.69	4	6.7	2.95
II	J	Scratches	1	.7	1	0	.7	0	0	0
	K	Dirt Indents	9	6.6	2	77.8	1.47	1	11.1	.73
	L	Marker Indents	6	4.4	1	83.3	.73	2	33.3	1.47
	N	Holes	28	20.6	2	92.9	1.46	0	0	0
	P	Pincher Marks	2	1.5	1	50	.75	1	50	.75
	TOTAL TYPE II		46	33.8	7	84.8	5.14	4	8.7	2.94
III	R	Cinched	6	4.4	0	100	0	0	0	0
	T	Edge Damage	23	16.9	2	91.3	1.47	2	8.7	14.7
	W	Ridged	1	.7	0	100	0	0	0	0
	TOTAL TYPE III		30	22.1	2	93.3	1.48	2	6.7	1.48
Overall Total for 19 Reels			136		29	78.7	21.31	10	7.4	7.37
Unclassified Drop-outs			180		58	67.8				
Grand Total for 20 Reels			316		87	72.5				

Table 12
Dry-dry-wet-cleaning Results for All Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	136	21.1	27	80.1	4.20	4	2.9	.61
	B	Foreign Dirt	54	8.4	13	75.9	2.02	1	1.9	.16
	C	Chips	125	19.4	21	83.2	3.26	4	3.2	.62
	D	Nodules	13	2.0	10	23.1	1.54	1	7.7	.15
	TOTAL TYPE I		328	50.9	71	78.4	10.99	10	3.05	1.55
II	J	Scratches	117	18.2	21	82.1	3.26	0	0	0
	K	Dirt Indents	30	4.7	0	100	0	0	0	0
	L	Marker Indents	6	.9	10	-167	1.50	3	50	.45
	N	Holes	46	7.1	5	89.1	.77	0	0	0
	P	Pincher Marks	35	5.4	7	80	1.08	4	11.4	.62
	TOTAL TYPE II		234	36.3	43	81.6	6.68	7	2.99	1.08
III	R	Cinched	31	4.8	3	90.3	.47	3	9.7	.47
	T	Edge Damage	50	7.8	10	80	1.56	0	0	0
	W	Ridged	1	.2	5	-500	1.00	0	0	0
	TOTAL TYPE III		82	12.7	18	78	2.79	3	3.66	.46
Overall Total for Reels			644		132	79.5	20.46	21	3.1	3.09
Unclassified Drop-outs			1290		3179	-247				
Grand Total for Reels			1934		3311	-172				

Table 13
Dry-dry-wet-cleaning Results for Ampex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	95	42.6	12	87.4	5.37	0	0	0
	B	Foreign Dirt	25	11.2	4	84	1.79	1	4	.45
	C	Chips	45	20.2	3	93.3	1.35	1	2.2	.45
	D	Nodules	4	1.8	0	100	0	0	0	0
	TOTAL TYPE I		169	75.8	19	88.8	8.49	2	1.18	.89
II	J	Scratches	11	4.9	15	-136	6.67	0	0	0
	K	Dirt Indents	10	4.5	0	100	0	0	0	0
	L	Marker Indents	0	0	2	0	.95	0	0	0
	N	Holes	16	7.2	2	87.5	.90	0	0	0
	P	Pincher Marks	4	1.8	2	50	.90	0	0	0
	TOTAL TYPE II		41	18.4	21	48.8	9.42	0	0	0
III	R	Cinched	7	3.1	0	100	0	0	0	0
	T	Edge Damage	6	2.7	7	-117	3.16	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		13	5.8	7	46.2	3.12	0	0	0
Overall Total for 18 Reels			223		47	78.9	21.03	2	.89	.89
Unclassified Drop-outs			731		1327					
Grand Total for 19 Reels			954		1375	-144				

Table 14
Dry-dry-wet-cleaning Results for IBM Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	21	7.4	7	66.7	2.46	3	14.3	1.06
	B	Foreign Dirt	20	7.0	3	85	1.05	0	0	0
	C	Chips	54	18.9	6	88.9	2.10	3	5.6	1.06
	D	Nodules	4	1.4	2	50	.70	0	0	0
	TOTAL TYPE I		99	34.7	18	80.8	6.66	6	6.1	2.12
II	J	Scratches	105	36.8	1	99	.37	0	0	0
	K	Dirt Indents	11	3.9	0	100	0	0	0	0
	L	Marker Indents	0	0	0	0	0	0	0	0
	N	Holes	2	.7	0	100	0	0	0	0
	P	Pincher Marks	29	10.2	4	86.2	1.41	4	13.8	1.41
	TOTAL TYPE II		147	51.6	5	96.6	1.75	4	2.7	1.39
III	R	Cinched	18	6.3	3	83.3	1.05	3	16.7	1.05
	T	Edge Damage	21	7.4	3	85.7	1.06	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		39	13.7	6	84.6	2.11	3	7.7	1.05
Overall Total for 13 Reels			285		29	89.8	10.52	13	4.6	4.58
Unclassified Drop-outs			379		1812	-478				
Grand Total for 13 Reels			664		1841	-277				

Table 15
Dry-dry-wet-cleaning Results for Memorex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	20	14.7	8	60	5.88	1	5	.74
	B	Foreign Dirt	9	6.6	6	33	4.42	0	0	0
	C	Chips	26	19.1	12	53.8	8.82	0	0	0
	D	Nodules	5	3.7	8	-160	5.92	1	20	.74
	TOTAL TYPE I		60	44.1	34	43.3	25.00	2	3.3	1.46
II	J	Scratches	1	.7	5	-500	3.5	0	0	0
	K	Dirt Indents	9	6.6	0	100	0	0	0	0
	L	Marker Indents	6	4.4	8	-133	5.85	3	50	2.2
	N	Holes	28	20.6	3	89.2	2.22	0	0	0
	P	Pincher Marks	2	1.5	1	50	.75	1	50	.75
	TOTAL TYPE II		46	33.8	17	63	12.51	4	8.7	2.94
III	R	Cinched	6	4.4	0	100	0	0	0	0
	T	Edge Damage	23	16.9	0	100	0	0	0	0
	W	Ridged	1	.7	5	-500	3.5	0	0	0
	TOTAL TYPE III		30	22.1	5	83.3	3.64	0	0	0
Overall Total for 19 Reels			136		56	58.8	41.2	6	4.4	4.40
Unclassified Drop-outs			180		39	78.3				
Grand Total for 20 Reels			316		95	69.9				

Table 16
Dry-dry-wet-dry-Cleaning Results for All Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	136	21.1	7	94.9	1.08	1	.7	.15
	B	Foreign Dirt	54	8.4	3	94.4	.47	1	1.9	.16
	C	Chips	125	19.4	9	92.8	1.40	7	5.6	1.08
	D	Nodules	13	2.0	2	84.6	.31	1	7.7	.15
	TOTAL TYPE I		328	50.9	21	93.6	3.26	10	3.05	1.55
II	J	Scratches	117	18.2	4	96.6	.62	1	.9	.16
	K	Dirt Indents	30	4.7	0	100	0	0	0	0
	L	Marker Indents	6	.9	2	66.7	.30	1	16.7	.15
	N	Holes	46	7.1	4	91.3	.62	0	0	0
	P	Pincher Marks	35	5.4	2	94.3	.31	2	5.7	.31
	TOTAL TYPE II		234	36.3	12	94.9	1.85	4	1.71	.45
III	R	Cinched	31	4.8	15	51.6	2.32	5	16.1	.77
	T	Edge Damage	50	7.8	8	84	1.25	6	12.0	.94
	W	Ridged	1	.2	3	-300	.60	0	0	0
	TOTAL TYPE III		82	12.7	26	68.3	4.03	11	13.4	1.70
Overall Total for 50 Reels			644		59	90.8	9.14	25	3.88	3.70
Unclassified Drop-outs			1290		199	84.6				
Grand Total for 52 Reels			1934		258	86.7				

Table 17
Dry-dry-wet-dry-cleaning Results for Ampex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-out		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	95	42.6	4	95.8	1.79	0	0	0
	B	Foreign Dirt	25	11.2	2	92	.90	1	4	.45
	C	Chips	45	20.2	0	100	0	0	0	0
	D	Nodules	4	1.8	0	100	0	0	0	0
	TOTAL TYPE I		169	75.8	6	96.4	2.73	1	.6	.45
II	J	Scratches	11	4.9	3	72.7	1.34	1	9.1	.45
	K	Dirt Indents	10	4.5	0	100	0	0	0	0
	L	Marker Indents	0	0	1	0	0	0	0	0
	N	Holes	16	7.2	0	100	0	0	0	0
	P	Pincher Marks	4	1.8	1	75	.45	1	25	.45
	TOTAL TYPE II		41	18.4	5	87.8	2.24	2	4.9	.90
III	R	Cinched	7	3.1	4	42.9	1.77	0	0	0
	T	Edge Damage	6	2.7	2	66.7	.90	0	0	0
	W	Ridged	0	0	1	0	0	0	0	0
	TOTAL TYPE III		13	5.8	7	46.2	3.12	0	0	0
Overall Total for 18 Reels			223		18	91.9	8.1	3	1.3	1.35
Unclassified Drop-outs			731		33	95.5				
Grand Total for 19 Reels			954		51	94.7				

Table 18
Dry-dry-wet-dry-cleaning Results for IBM Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	21	7.4	1	95.2	.36	1	4.8	.36
	B	Foreign Dirt	20	7.0	0	100	0	0	0	0
	C	Chips	54	18.9	6	88.9	2.1	4	7.4	1.40
	D	Nodules	4	1.4	0	100	0	0	0	0
	TOTAL TYPE I		99	34.7	7	93.0	2.43	5	5.1	1.77
II	J	Scratches	105	36.8	0	100	0	0	0	0
	K	Dirt Indents	11	3.9	0	100	0	0	0	0
	L	Marker Indents	0	0	0	0	0	0	0	0
	N	Holes	2	.7	0	100	0	0	0	0
	P	Pincher Marks	29	10.2	0	100	0	0	0	0
	TOTAL TYPE II		147	51.6	0	100	0	0	0	0
III	R	Cinched	18	6.3	0	100	0	0	0	0
	T	Edge Damage	21	7.4	0	100	0	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		39	13.7	0	100	0	0	0	0
Overall Total for 13 Reels			285		7	97.5	2.43	5	1.75	1.77
Unclassified Drop-outs			379		137	63.9				
Grand Total for 13 Reels			664		144	78.3				

Table 19
Dry-dry-wet-dry-cleaning Results for Memorex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	20	14.7	2	90	1.47	0	0	0
	B	Foreign Dirt	9	6.6	1	88.9	.73	0	0	0
	C	Chips	26	19.1	3	88.5	2.2	3	11.5	2.20
	D	Nodules	5	3.7	2	66.7	1.23	1	20	.74
	TOTAL TYPE I		60	44.1	8	86.7	5.87	4	6.7	2.95
II	J	Scratches	1	.7	1	0	.7	0	0	0
	K	Dirt Indents	9	6.6	0	100	0	0	0	0
	L	Marker Indents	6	4.4	1	83.3	.73	1	16.7	.73
	N	Holes	28	20.6	4	85.7	2.95	0	0	0
	P	Pincher Marks	2	1.5	1	50	.75	1	50	.75
	TOTAL TYPE II		46	33.8	7	84.8	5.14	2	4.3	1.45
III	R	Cinched	6	4.4	11	-183	8.05	5	83.3	3.67
	T	Edge Damage	23	16.9	6	73.9	4.41	6	26.1	4.41
	W	Ridged	1	.7	2	-200	1.4	0	0	0
	TOTAL TYPE III		30	22.1	19	36.7	13.99	11	36.7	8.11
Overall Total for 19 Reels			136		34	75	27.91	17	12.5	12.51
Unclassified Drop-outs			180		29	83.9				
Grand Total for 20 Reels			316		63	80.1				

Table 20
Wet-Cleaning Results for All Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	159	24.8	50	68.6	7.8	15	9.4	2.3
	B	Foreign Dirt	60	9.3	32	46.7	4.9	4	6.7	.62
	C	Chips	162	25.2	83	48.8	12.9	34	21	5.3
	D	Nodules	46	7.2	8	82.6	1.3	6	13	.94
	TOTAL TYPE I		427	66.5	173	59.5	26.9	59	13.8	9.18
II	J	Scratches	76	11.8	34	55.3	5.3	10	13.2	1.56
	K	Dirt Indents	17	2.6	13	23.5	2.0	0	0	0
	L	Marker Indents	9	1.4	16	-178	2.5	7	77.8	1.09
	N	Holes	22	3.4	5	77.2	.8	1	4.5	.15
	P	Pincher Marks	26	4.0	15	42.3	2.3	6	23.1	.92
	TOTAL TYPE II		150	23.4	83	44.7	12.9	24	16.0	3.7
III	R	Cinched		1.4	32	-356	4.9	4	44	.61
	T	Edge Damage	56	8.7	21	62.5	3.3	6	10.7	.93
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		65	10.1	53	18.5	8.2	10	15.4	1.56
Overall Total for 46 Reels			642		309	51.9	48.0	93	14.5	14.46
Unclassified Drop-outs			1209		231	80.9				
Grand Total for 52 Reels			1851		540	70.8				

Table 21
Wet-cleaning Results for Ampex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	125	27.8	24	80.8	5.3	10	8	2.2
	B	Foreign Dirt	47	10.4	7	85.1	1.5	2	4.3	.44
	C	Chips	119	26.4	58	51.3	12.9	24	20.2	5.3
	D	Nodules	30	6.7	1	96.7	.22	0	0	0
	TOTAL TYPE I		321	71.3	90	72	19.9	36	11.2	7.99
II	J	Scratches	44	9.8	14	68.1	3.13	5	11.4	1.12
	K	Dirt Indents	12	2.7	12	0	2.7	0	0	0
	L	Marker Indents	2	.4	2	0	.4	0	0	0
	N	Holes	18	4	2	88.9	.44	0	0	0
	P	Pincher Marks	13	2.9	3	76.9	.67	1	7.7	.22
	TOTAL TYPE II		89	19.8	33	62.9	7.35	6	6.74	1.33
III	R	Cinched	4	.9	32	-800	8.1	4	100	.9
	T	Edge Damage	36	8	5	86.1	1.1	5	13.9	1.1
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		40	8.9	37	7.5	9.2	9	22.5	2.0
Overall Total for 20 Reels			450		160	64.4	36.45	51	11.3	11.32
Unclassified Drop-outs			217		86	60.4				
Grand Total for 20 Reels			667		246	63.1				

Table 22
Wet-cleaning Results for IBM Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	22	19	15	31.8	12.9	2	9.1	1.73
	B	Foreign Dirt	7	6	14	-200	12	2	28.6	1.72
	C	Chips	25	21.6	16	36	13.8	4	16	3.46
	D	Nodules	7	6	2	71.4	1.7	1	14.3	.86
	TOTAL TYPE I		61	52.6	47	22.9	40.6	9	14.7	7.73
II	J	Scratches	27	23.3	12	55.6	10.3	3	11.1	2.59
	K	Dirt Indents	0	0	0	0	0	0	0	0
	L	Marker Indents	0	0	0	0	0	0	0	0
	N	Holes	0	0	0	0	0	0	0	0
	P	Pincher Marks	13	11.2	11	15.4	9.5	5	38.5	4.31
	TOTAL TYPE II		40	34.5	23	42.5	19.8	8	20	6.90
III	R	Cinched	0	0	0	0	0	0	0	0
	T	Edge Damage	15	12.9	15	0	12.9	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		15	12.9	15	0	12.9	0	0	0
Overall Total for 9 Reels			116		85	26.7	73.3	17	14.7	14.63
Unclassified Drop-outs			889		96	89.2				
Grand Total for 15 Reels			1005		181	82				

Table 23
Wet-cleaning Results for Memorex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	12	15.8	11	8.3	14.5	3	25	3.95
	B	Foreign Dirt	6	7.9	11	-183	14.5	0	0	0
	C	Chips	18	23.7	9	50	11.9	6	33	7.8
	D	Nodules	9	11.8	5	55.6	5.2	5	56	6.6
	TOTAL TYPE I		45	59.2	36	20	47.4	14	31	18.3
II	J	Scratches	5	6.6	8	-160	10.6	2	40	2.64
	K	Dirt Indents	5	6.6	1	80	1.3	0	0	0
	L	Marker Indents	7	9.2	14	-200	18.4	7	100	9.2
	N	Holes	4	5.3	3	25	4.0	1	25	1.32
	P	Pincher Marks	0	0	1	0	1	0	0	0
	TOTAL TYPE II		21	27.6	27	-129	35.6	10	47.6	13.14
III	R	Cinched	5	6.6	0	100	0	0	0	0
	T	Edge Damage	5	6.6	1	80	1.3	1	20	1.32
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		10	13.2	1	90	1.32	1	10	1.32
Overall Total for 17 Reels			76		64	15.8	84.32	25	32.9	32.76
Unclassified Drop-outs			103		49	52.4				
Grand Total for 17 Reels			179		113	36.9				

Table 24
Wet-dry-cleaning Results for All Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	159	24.8	17	89.3	2.65	1	.6	.15
	B	Foreign Dirt	60	9.3	7	88.3	1.09	0	0	0
	C	Chips	162	25.2	27	83.3	4.21	10	6.2	1.56
	D	Nodules	46	7.2	34	26.1	5.32	5	10.2	.73
	TOTAL TYPE I		427	66.5	85	80.1	13.23	16	3.7	2.46
II	J	Scratches	76	11.8	10	86.8	1.56	3	3.9	.46
	K	Dirt Indents	17	2.6	6	64.7	.92	0	0	0
	L	Marker Indents	9	1.4	3	66.7	.47	1	11.1	.16
	N	Holes	22	3.4	1	95.5	.15	0	0	0
	P	Pincher Marks	26	4.0	2	92.3	.18	0	0	0
	TOTAL TYPE II		150	23.4	22	85.3	3.44	4	2.7	.63
III	R	Cinched	9	1.4	8	11.1	1.24	1	11.1	.16
	T	Edge Damage	56	8.7	11	80.4	1.71	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		65	10.1	19	70.8	2.94	1	1.5	.15
Overall Total for 46 Reels			642		126	80.4	19.61	21	3.3	3.24
Unclassified Drop-outs			1209		175	85.5				
Grand Total for 52 Reels			1851		301	83.7				

Table 25
Wet-dry-cleaning Results for Ampex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	125	27.8	9	92.8	2.01	1	.8	.22
	B	Foreign Dirt	47	10.4	3	93.6	.67	0	0	0
	C	Chips	119	26.4	7	94.1	1.56	4	3.4	.35
	D	Nodules	30	6.7	4	86.7	.89	1	3.3	.87
	TOTAL TYPE I		321	71.3	23	92.8	5.13	6	1.9	1.35
II	J	Scratches	44	9.8	8	81.8	1.78	1	2.3	.23
	K	Dirt Indents	12	2.7	1	91.7	.22	0	0	0
	L	Marker Indents	2	.4	0	100	0	0	0	0
	N	Holes	18	4	0	100	0	0	0	0
	P	Pincher Marks	13	2.9	2	84.6	.45	0	0	0
	TOTAL TYPE II		89	19.8	11	87.6	2.45	1	1.1	.22
III	R	Cinched	4	.9	2	50	.45	0	0	0
	T	Edge Damage	36	8	3	91.7	.66	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		40	8.9	5	87.5	1.11	0	0	0
Overall Total for 20 Reels			450		39	91.3	8.69	7	1.6	1.57
Unclassified Drop-outs			217		45	79.3				
Grand Total for 20 Reels			667		84	87.4				

Table 26
Wet-dry-cleaning Results for IBM Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	22	19	6	72.7	5.19	0	0	0
	B	Foreign Dirt	7	6	2	71.4	1.72	0	0	0
	C	Chips	25	21.6	13	48	11.23	5	20	4.32
	D	Nodules	7	6	14	-200	12	2	28.6	1.72
	TOTAL TYPE I		61	52.6	35	42.6	30.19	7	11.5	6.04
II	J	Scratches	27	23.3	1	96.3	.86	2	7.4	1.72
	K	Dirt Indents	0	0	1	0	1.0	0	0	0
	L	Marker Indents	0	0	3	0	3.0	0	0	0
	N	Holes	0	0	0	0	0	0	0	0
	P	Pincher Marks	13	11.2	0	100	0	0	0	0
	TOTAL TYPE II		40	34.5	5	87.5	4.31	2	5.0	1.72
III	R	Cinched	0	0	2	0	2	1	0	1.0
	T	Edge Damage	15	12.9	5	66.7	4.3	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		15	12.9	7	53.3	6.02	1	6.7	.86
Overall Total for 9 Reels			116		47	59.5		10	8.6	8.6
Unclassified Drop-outs			889		108	87.9				
Grand Total for 15 Reels			1005		155	89.2				

Table 27
Wet-dry-cleaning Results for Memorex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	12	15.8	2	83.3	2.64	0	0	0
	B	Foreign Dirt	6	7.9	2	66.7	2.63	0	0	0
	C	Chips	18	23.7	7	61.1	9.22	1	5.6	1.33
	D	Nodules	9	11.8	16	-178	21.0	2	22	2.6
	TOTAL TYPE I		45	59.2	27	40.0	35.52	3	6.7	3.96
II	J	Scratches	5	6.6	1	80	1.32	0	0	0
	K	Dirt Indents	5	6.6	4	20	5.28	0	0	0
	L	Marker Indents	7	9.2	0	100	0	1	14.3	1.32
	N	Holes	4	5.3	1	75	1.33	0	0	0
	P	Pincher Marks	0	0	0	0	0	0	0	0
	TOTAL TYPE II		21	27.6	6	71.4	7.89	1	4.8	1.32
III	R	Cinched	5	6.6	4	20	5.28	0	0	0
	T	Edge Damage	5	6.6	3	40	3.96	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		10	13.2	7	30	9.24	0	0	0
Overall Total for 17 Reels			76		40	47.4	52.65	4	5.3	5.28
Unclassified Drop-outs			103		22	78.6				
Grand Total for 17 Reels			179		62	65.4				

Table 28
Wet-dry-wet-dry-cleaning Results for All Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	159	24.8	7	95.6	1.09	0	0	0
	B	Foreign Dirt	60	9.3	3	95.0	.47	0	0	0
	C	Chips	162	25.2	11	93.2	1.71	5	3.1	.78
	D	Nodules	46	7.2	12	73.9	1.88	2	4.3	.31
	TOTAL TYPE I		427	66.5	33	92.3	5.12	7	1.6	1.06
II	J	Scratches	76	11.8	3	96	.47	0	0	0
	K	Dirt Indents	17	2.6	0	100	0	0	0	0
	L	Marker Indents	9	1.4	2	77.8	.31	1	11.1	.16
	N	Holes	22	3.4	3	86.4	.46	0	0	0
	P	Pincher Marks	26	4.0	3	88.5	.46	1	3.8	.15
	TOTAL TYPE II		150	23.4	11	92.7	1.71	2	1.3	.30
III	R	Cinched	9	1.4	17	-189	2.65	5	55.6	.78
	T	Edge Damage	56	8.7	5	91.1	.77	1	1.8	.16
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		65	10.1	22	66.1	3.42	6	9.2	.93
Overall Total for 15 Reels			642		66	89.7	10.3	15	2.3	2.29
Unclassified Drop-outs			1209		143	88.2				
Grand Total for 52 Reels			1851		209	88.7				

Table 29
Wet-dry-wet-dry-cleaning Results for Ampex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	125	27.8	3	97.6	.67	0	0	0
	B	Foreign Dirt	47	10.4	1	97.9	.22	0	0	0
	C	Chips	119	26.4	1	99.2	.21	1	.8	.21
	D	Nodules	30	6.7	1	96.7	.22	0	0	0
	TOTAL TYPE I		321	71.3	6	98.1	1.35	1	.3	.21
II	J	Scratches	44	9.8	0	100	0	0	0	0
	K	Dirt Indents	12	2.7	0	100	0	0	0	0
	L	Marker Indents	2	.4	1	50	2.0	0	0	0
	N	Holes	18	4	0	100	0	0	0	0
	P	Pincher Marks	13	2.9	0	100	0	0	0	0
	TOTAL TYPE II		89	19.8	1	98.9	.22	0	0	0
III	R	Cinched	4	.9	0	100	0	0	0	0
	T	Edge Damage	36	8	3	91.7	.66	1	2.8	.22
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		40	8.9	3	92.5	.67	1	2.5	.22
Overall Total for 3 Reels			450		10	97.8	2.2	2	.4	.43
Unclassified Drop-outs			217		61	71.9				
Grand Total for 20 Reels			667		71	89.4	10.6			

Table 30
Wet-dry-wet-dry-cleaning Results for IBM Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	22	19	1	95.5	.86	0	0	0
	B	Foreign Dirt	7	6	0	100	0	0	0	0
	C	Chips	25	21.6	8	68	6.91	4	16.0	3.46
	D	Nodules	7	6	10	-142	8.66	1	14.3	.86
	TOTAL TYPE I		61	52.6	19	68.9	16.36	5	8.2	4.31
II	J	Scratches	27	23.3	1	96.3	.86	0	0	0
	K	Dirt Indents	0	0	0	0	0	0	0	0
	L	Marker Indents	0	0	0	0	0	0	0	0
	N	Holes	0	0	0	0	0	0	0	0
	P	Pincher Marks	13	11.2	3	76.9	2.59	1	7.7	.86
	TOTAL TYPE II		40	34.5	4	90	3.45	1	2.5	.86
III	R	Cinched	0	0	0	0	0	0	0	0
	T	Edge Damage	15	12.9	0	100	0	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		15	12.9	0	100	0	0	0	0
Overall Total for 5 Reels			116		23	80.2	19.8	6	5.2	5.17
Unclassified Drop-outs			889		63	92.9				
Grand Total for 15 Reels			1005		86	91.4	8.6			

Table 31
Wet-dry-wet-dry-cleaning Results for Memorex Tapes

DROP-OUT CLASSIFICATION			RESULTS AND CALCULATIONS							
			Overall					Consistent Drop-outs		
Type	Sub Type	Description	Before Cleaning	Ratio	After Cleaning	Cleaning Efficiency	Expected Drop-outs	BC&AC	%	Consistent Drop-outs
I	A	Temporary	12	15.8	3	75	3.95	0	0	0
	B	Foreign Dirt	6	7.9	2	67	2.61	0	0	0
	C	Chips	18	23.7	2	88.9	2.63	0	0	0
	D	Nodules	9	11.8	1	88.9	1.31	1	11	1.3
	TOTAL TYPE I		45	59.2	8	82.2	10.54	1	2.2	1.3
II	J	Scratches	5	6.6	2	60	2.64	0	0	0
	K	Dirt Indents	5	6.6	0	100	0	0	0	0
	L	Marker Indents	7	9.2	1	85.7	1.32	1	14.3	1.31
	N	Holes	4	5.3	3	25	3.98	0	0	0
	P	Pincher Marks	0	0	0	0	0	0	0	0
	TOTAL TYPE II		21	27.6	6	71.4	7.89	1	4.8	1.32
III	R	Cinched	5	6.6	17	-340	22.44	5	100	6.6
	T	Edge Damage	5	6.6	2	60	2.64	0	0	0
	W	Ridged	0	0	0	0	0	0	0	0
	TOTAL TYPE III		10	13.2	19	-190	25.08	5	50	6.6
Overall Total for 7 Reels			76		33	56.6	43.4	7	92	9.2
Unclassified Drop-outs			103		19	81.6				
Grand Total for 17 Reels			179		52	70.9	29.1			

Table 32
Quality-assurance Results Per Reel, Dry Cleaning

CLEANING CODE						CLEANING CODE					
TAPE NO.	BC	ADDWC		AWDWDC		TAPE NO.	BC	ADDWC		AWDWDC	
D 51 M	0	5	A	3	D	D 71 M	13	3	A	0	A
D 52 M	1	1	A	1	A	D 72 A	13	3	A	1	B
D 53 M	1	2	E	0	A	D 73 M	13	0	A	1	B
D 54 M	2	2	A	0	A	D 74 A	14	1	A	2	B
D 55 M	2	1	F	2	F	D 75 A	14	1	A	0	A
D 56 I	3	2	B	0	A	D 76 A	14	2	D	1	B
D 57 I	3	2	B	0	A	D 77 I	15	1	A	0	A
D 58 M	4	1	B	2	D	D 78 A	16	775	F	1	F
D 59 I	5	2	E	0	A	D 79 M	19	2	C	0	A
D 60 I	6	0	A	4	C	D 80 I	24	784	F	5	C
D 61 M	7	3	B	0	A	D 81 M	24	0	A	5	F
D 62 M	6	2	F	0	A	D 82 M	25	2	B	0	A
D 63 A	9	2	E	1	D	D 83 A	27	10	E	5	C
D 64 A	10	1	A	0	A	D 84 A	28	0	A	517	E
D 65 M	11	3	D	4	C	D 85 A	30	0	A	1	A
D 66 A	11	396	F	9	F	D 86 A	34	1	A	1	A
D 67 A	248	2	B	3	C	D 87 M	36	5	F	4	D
D 68 A	12	6	D	0	A	D 88 I	39	9	F	2	F
D 69 A	11	1	D	1	A	D 89 M	40	17	F	8	F
D 70 M	12	2	B	0	A	D 90 M	48	3	F	11	F

Table 32 (Cont)
Quality-assurance Results Per Reel, Dry Cleaning

CLEANING CODE						CLEANING CODE					
TAPE NO.	BC	ADDWC		AWDWDC		TAPE NO.	BC	ADDWC		AWDWDC	
D 91 A	44	1	A	2	E	D 97 A	108	129	D	3	C
D 92 M	46	5	F	3	F	D 98 A	122	7	F	1	B
D 93 I	50	4	A	0	A	D 99 A	143	9	F	2	F
D 94 A	80	2	A	0	A	D 100 I	153	3	F	1	D
D 95 I	57	1181	F	75	F	D 101 I	212	0	A	4	D
D 96 I	63	22	D	6	C						

Table 33
Quality-assurance Results Per Reel, Wet Cleaning

CLEANING CODE						CLEANING CODE					
TAPE NO.	BC	AWDC		AWDWDC		TAPE NO.	BC	AWDC		AWDWDC	
W 51 M	0	3	E	0	A	W 72 M	13	2	B		
W 52 M	0	1	D	2	B	W 73 A	13	0	A		
W 53 M	2	3	B			W 74 A	14	2	A		
W 54 M	1	0	A			W 75 A	14	0	A		
W 55 M	2	0	A			W 76 M	15	0	A		
W 56 M	3	1	F	1	F	W 77 M	16	3	F	2	A
W 57 M	3	0	A			W 78 A	18	0	A		
W 58 I	3	0	A			W 79 A	22	1	A		
W 59 I	4	2	F	2	F	W 80 A	23	0	A		
W 60 I	4	0	A			W 81 A	25	7	F	0	A
W 61 M	5	4	E	156	F	W 82 A	26	1	A		
W 62 M	6	0	A			W 83 A	27	10	A		
W 63 I	7	4	D	0	A	W 84 M	28	4	F	0	A
W 64 M	8	1	B			W 85 M	34	0	A		
W 65 A	10	0	A			W 86 M	34	2	F	1	B
W 66 M	10	11	E	3	A	W 87 I	34	4	F	3	F
W 67 A	11	3	C			W 88 A	36	3	F	1	F
W 68 I	11	11	F	11	F	W 89 A	40	0	A		
W 69 I	12	3	F	2	A	W 90 A	42	3	C		
W 70 I	12	2	D	3	D	W 91 A	44	1	A		
W 71 A	13	4	F	1	F	W 92 A	42	2	D	7	F

Table 33 (Cont)
Quality-assurance Results Per Reel, Wet Cleaning

CLEANING CODE						CLEANING CODE					
TAPE NO.	BC	AWDC		AWDWDC		TAPE NO.	BC	AWDC		AWDWDC	
W 93 A	50	3	C			W 98 I	124	0	A		
W 94 A	72	0	A			W 99 I	120	0	A		
W 95 I	53	1	A			W 100 A	145	1	B		
W 96 I	89	46	F	8	F	W 101 I	205	0	A		
W 97 I	114	1	A			W 102 I	216	14	F	0	A

Table 34
Comparison of Rejects

DROP-OUT CLASSIFICATION			Dry Cleaning Series Rejects	Percentage (Reject Rate)	Wet Cleaning Series Rejects	Percentage (Reject Rate)	Production Rejects	Percentage (Reject Rate)
Type	Sub Type	Description						
I	A	Temporary	0	0	0	0	0	0
	B	Foreign Dirt	1	2.0	0	0	0	0
	C	Chips	2	3.9	1	1.9	3	.3
	D	Nodules	0	0	2	3.8	3	.3
	TOTAL TYPE I		3	5.9	3	5.8	6	.6
II	J	Scratches	1	2.0	0	0	0	0
	K	Dirt Indents	0	0	0	0	0	0
	L	Marker Indents	0	0	0	0	0	0
	N	Holes	2	3.9	1	1.9	6	.6
	P	Pincher Marks	3	5.9	0	0	2	.2
	TOTAL TYPE II		6	11.8	1	1.9	8	.8
III	R	Cinched	1	2.0	1	1.9	3	3
	T	Edge Damage	8	15.7	0	0	26	2.6
	W	Ridged	1	2.0	1	1.9	1	.1
	TOTAL TYPE III		10	19.6	2	3.8	30	3.0
Tape Too Wide							4	.4
TOTAL			19	37.2	7	13.5	48	4.8

Table 35
Wet-cleaning Grading and Rejects

TAPE NO.	GRADE	ACCEPT	REJECT	TAPE NO.	GRADE	ACCEPT	REJECT
W 51 M	A			W 74 A	A		
W 52 M	B	Ridged		W 75 A	A		
W 53 M	B	Ridged		W 76 M	A		
W 54 M	A			W 77 M	A		
W 55 M	A			W 78 A	A		
W 56 M	F		Ridged	W 79 A	A		
W 57 M	A			W 80 A	A		
W 58 I	A			W 81 A	A		
W 59 I	F		Pinch Marks Nodules	W 82 A	B	Chips	
				W 83 A	A		
W 60 I	A			W 84 M	A		
W 61 M	F		Ridged	W 85 M	A		
W 62 M	A			W 86 M	B	Pinch Marks	
W 63 I	A						
				W 87 I	F		Edge Damage
W 64 M	B	Nodules					
W 65 A	A			W 88 A	F		Holes
W 66 M	A			W 89 A	A		
W 67 A	C	Dirt		W 90 A	C	Chips Pinch Marks	
W 68 I	F		Nodules				
W 69 I	A			W 91 A	A		
W 70 I	D		Chips	W 92 A	F	Chips	
W 71 A	A			W 93 A	C	Nodules	
W 72 M	B	Dirt		W 94 A	A		
W 73 A	A			W 95 I	A		

Table 35 (Cont)
Wet-cleaning Grading and Rejects

TAPE NO.	GRADE	ACCEPT	REJECT	TAPE NO.	GRADE	ACCEPT	REJECT
W 96 I	F		Ridged	W 100 A	B	Holes	
W 97 I	A			W 101 I	A		
W 98 I	A			W 102 I	A		
W 99 I	A						

Table 36
Dry-cleaning Grading and Rejects

TAPE NO.	GRADE	ACCEPT	REJECT	TAPE NO.	GRADE	ACCEPT	REJECT
D 51 M	D		Dirt	D 73 M	B	Ridged	
D 52 M	A			D 74 A	B	Pinch Marks	
D 53 M	A			D 75 A	A		
D 54 M	A			D 76 A	B	Dirt	
D 55 M	F		Holes	D 77 I	A		
D 56 I	A			D 78 A	F		Edge Ripple
D 57 I	A			D 79 M	A		
D 58 M	D		Edge Damage	D 80 I	C	Edge Ripple	
D 59 I	A			D 81 M	F		Holes
D 60 I	C	Chips		D 82 M	A		
D 61 M	A			D 83 A	C	Chinched	
D 62 M	A			D 84 A	E		Edge Ripple
D 63 A	D		Scratches	D 85 A	A		
D 64 A	A			D 86 A	A		
D 65 M	C	Ridged		D 87 M	D		Ridged
D 66 A	F		Edge Ripple	D 88 I	F		Chips
D 67 A	C	Ridged		D 89 M	F		Chinched
D 68 A	A			D 90 M	F		Edge Damage
D 69 A	A			D 91 A	E		Dirt
D 70 M	A			D 92 M	F		Pinch Marks
D 71 M	A						
D 72 A	C	Edge Damage					

Table 36 (Cont)
Dry-cleaning Grading and Rejects

TAPE NO.	GRADE	ACCEPT	REJECT	TAPE NO.	GRADE	ACCEPT	REJECT
D 93 I	A			D 98 A	B	Holes	
D 94 A	A			D 99 A	F		Pinch Marks
D 95 I	F		Edge Ripple	D 100 I	D		Edge Damage
D 96 I	C		Edge Ripple	D 101 I	D		Pinch Marks
D 97 A	D		Chips				